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EARLY-MIDDLE ORDOVICIAN LITHOSTRATIGRAPHY, BIOSTRATIGRAPHY, AND DEPOSITIONAL ENVIRONMENTS OF THE ILLINOIS BASIN.

by

THOMAS H. SHAW

VOLUME I

A dissertation submitted to the Graduate Faculty in Earth and Environmental Sciences in partial fulfillment of the requirements for the degree of Doctorate of Philosophy, The City University of New York.

1999

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10. February 1999 — Date

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Abstract

EARLY-MIDDLE ORDOVICIAN LITHOSTRATIGRAPHY, BIOSTRATIGRAPHY, AND DEPOSITIONAL ENVIRONMENTS OF THE ILLINOIS BASIN.

by

Thomas H. Shaw

Adviser: Professor B. Charlotte Schreiber

Biostratigraphic and sedimentological data from the early-Middle Ordovician of the Illinois Basin allows for identification of four genetic depositional sequences made up of a complex mosaic of time-transgressive, clastics, carbonates and evaporites. The synchroneity of these sequences with those of the Taconic foreland, eastern North America , and Arbuckle region, southern Midcontinent, strongly implies a common control, either tectonic and/or eustatic, for the creation of accommodation space. Lithostratigraphic units are mostly time-transgressive lithotopes indicative of specific inner shelf, restricted marine depositional subenvironments.

Examining the interaction of the Taconic foreland and Illinois Basin during the early-Middle Ordovician is hampered by the insufficient resolution of age determinations for the Ancell Group, and its regional equivalents, due to four factors. 1) Total stratigraphic ranges for the component faunas of the peritidal lower Ancell Group are still to poorly-known to be usable for graphic correlation. 2) Given the absence of biostratigraphic datum's within this peritidal interval, graphic age determination requires the assumption of constant net rock accumulation. This assumption is questionable based on evidence for the development of condensed interval(s), differential compaction and

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post-burial evaporite dissolution. 3) Higher resolution sampling is required in some sections to more adequately establish biostratigraphic control for parts of the basin. And, 4) formation contacts defined for outcrop-based stratigraphic units are difficult to identify in the subsurface and units widely recognized in the subsurface have not been tied in detail with their correlative surface exposures.

A key finding of this study is recognition of wide-spread, early-Middle Ordovician evaporite depositional which has been unappreciated due to the lack of sedimentological study of the St. Peter Sandstone in the subsurface, and the apparent dissolution of many of the soluble phases by meteoric groundwater. The presence of evaporites has important implications for the sourcing of brines and for subsidence modeling of the basin. Previously, mass balance required deep basinal sources for sulfur, and other ions, for mineralizing brines. Evaporite dissolution offers an alternative source at a shallower level within the basin, but complicates subsidence modeling in that back-stripping using simple compactional functions does not account for this loss of rock volume.

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INTRODUCTION

The interrelationship of orogenic tectonism on the plate margins and subsidence of interior cratonic basins has long been recognized, but the nature of this interaction is poorly understood. Previous studies of this relationship has been hampered by poor surface exposures and inadequate subsurface data sets for the basins, and the absence of detailed deformational models for related orogenic belts. This study examines the evolution of depositional patterns within the intracratonic Illinois Basin coeval with the initial stages of the Taconic Orogeny (latest-Early through Late Ordovician) and compares these patterns to those predicted by proposed models of basin subsidence.

The Illinois Basin of eastern North America affords an excellent opportunity for the study of cratonic basin subsidence and sedimentation. Detailed geologic investigations, commonly related to the development of economic resources, and the availability of extensive subsurface data make it possible to constrain the tectonic history of the basin. Petroleum and mineral exploration, development of subsurface gas storage facilities, engineering studies, and water resource recovery have resulted in the accumulation of subsurface data for over 2,000 wells penetrating early-Middle Ordovician rocks. In addition, development of mineral resources on the basin margins has resulted in detailed geologic mapping of the basin-bounding outcrop belts.

The subsidence history of the basin has been influenced by inherited structural features, a variable thermal history and orogenic tectonism on the plate margin. Tectonic deformation of the plate margin is preserved in the Appalachian-Ouchita Orogenic Belt. This orogenic belt developed from several episodes of Paleozoic convergence at the plate margin due to collision of the North American plate (Laurentia) with island arc systems

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and other continental plates (Baltica, Gondwana). The effects of the early Paleozoic Taconic Orogeny on sedimentation in the Illinois Basin can be readily documented because of the widespread development of fossiliferous carbonate depositional environments during the Ordovician, and preservation of this sedimentary cover. Furthermore, the extensive study of the Appalachian Orogen, as reported by other workers, provides an understanding of the evolution of the plate margin during the early-Middle Ordovician.

GEOLOGIC SETTING

Geographic and structural setting

The Illinois Basin is a spoon-shaped intracratonic basin located in the eastern interior region of North America (Figure 1). The basin contains up to 23,000 ft. (7,000 m) of Paleozoic sediments overlying at least 3,000 ft. (1,000 m) of pre-Middle Cambrian rift-fill sediments (Buschbach and Kolata, 1991; Bertange and Leising, 1991).

The outline of the basin has been roughly defined by the -500 ft. (152 m) structural contour on top of the Trenton Limestone (Figure 1). This geometry developed in the late Paleozoic due to the uplift of the Pascola Arch. Prior to the uplift of the Pascola Arch, the proto-Illinois basin was a southward opening embayment contiguous with the Black Warrior Basin (Kolata, 1990a).

This study has defined the basin as encompassing the basin and basin-ward flanks of the bounding arches and domes (Figures 2 and 3), an area defined between latitudes 34° N and 42° N, and from longitudes 84° W to 92° W. Therefore, the basin is bounded

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FIGURE 1: MAJOR TECTONIC ELEMENTS OF NORTH AMERICA MID - CONTINENT

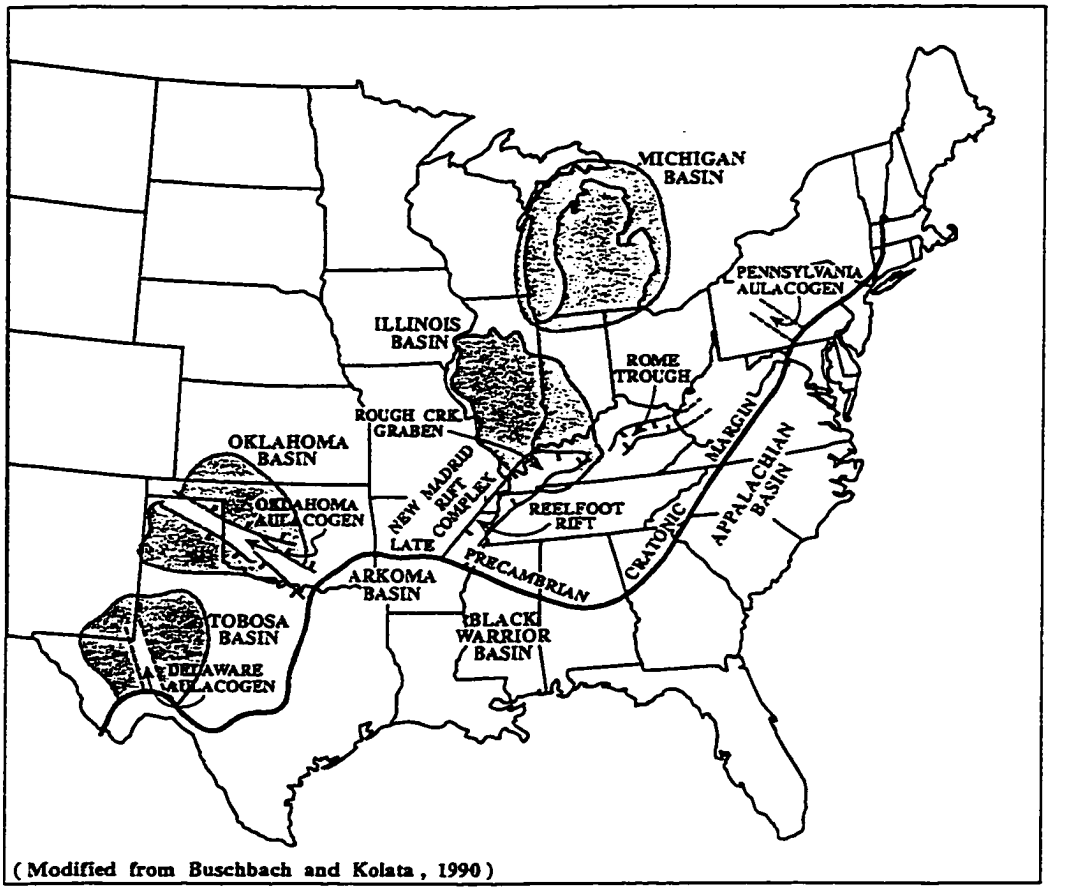

FIGURE 2: STUDY AREA

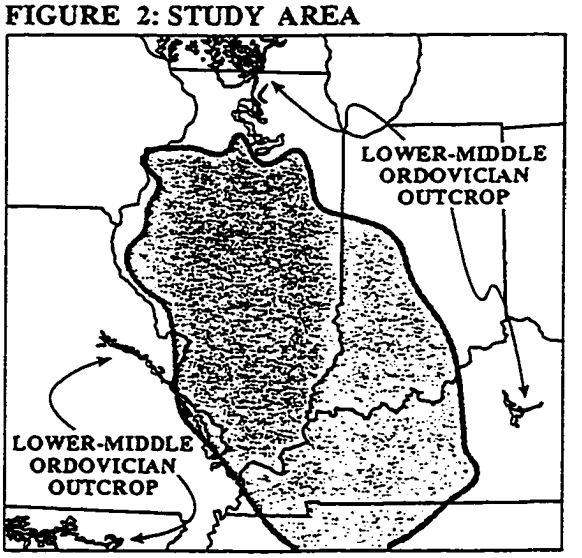

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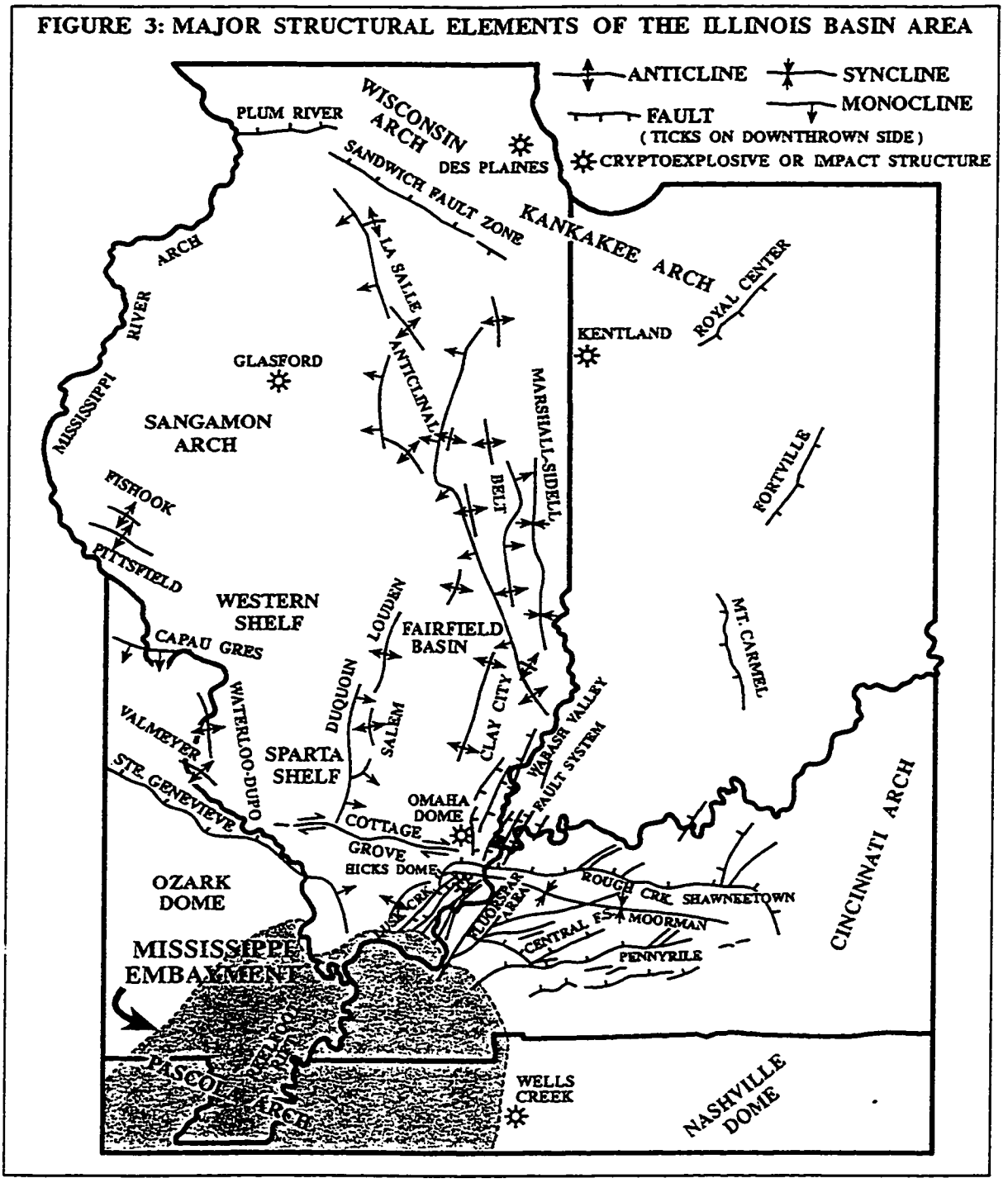
FIGURE 3: MAJOR STRUCTURAL ELEMENTS OF THE ILLINOIS BASIN AREA



(Modified from Buschbach and Kolata , 1990)

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by the Cincinnati Arch, Nashville and Jessamine domes on the eastern margin; the Kankakee and Wisconsin arches define the northern extent; the Mississippi Arch and Ozark Dome delineate the western margin; and the Pascola Arch bounds the basin to the south (Figure 3). With the exception of the late Paleozoic, or possibly Mesozoic (Symons, 1994) Pascola Arch, these features influenced sedimentation in the Illinois Basin throughout much of the Paleozoic due to their varying paleotopographic relationship relative to the basin depocenter resulting from their differing subsidence histories.

These varying paleotopographic relationships greatly influenced the nature and volume of clastic sediments deposited within the basin, water mass circulation patterns, and the lateral distribution of depositional environments. The basin depocenter for much of the Paleozoic is proximal to the now-buried late-Precambrian Reelfoot Rift Complex (Nelson and Lumm, 1984; Nelson, 1990).

New Madrid Rift Complex:

This apparent paleorift is believed to have developed along a boundary between two tectonic terrains: a northern layered terrane and a southern unlayered terrane. This boundary may represent the suture of the Central Plains (1600-1800 Ma) and Grenville (1000 Ma) Tectonic Provinces (Kisvarsanyi, 1976); a transform offset of the Grenville Front (Nelson and Zhang, 1991); and/or the northern margin of the Central Plains Orogen and an older terrane to the north (1400-1500 Ma)(Heigold and Kolata, 1993).

The paleorift has two major structural components: the Reelfoot Rift and Rough Creek Graben. The Reelfoot Rift (Ervin and McGinnis, 1975) is a north-trending structure extending from northeast Arkansas and western Tennessee into southern Illinois.

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The Rough Creek Graben (Figure 3) (Soderburg and Keller, 1981) is an eastward extension of the Reelfoot Rift in western Kentucky. These two features form a "dogleg" structure now buried beneath the Illinois Basin. Goetz and others (1992) have proposed that these two structural elements developed diachronously.

The Reelfoot Rift, a northeast trending graben that may contain over 20,000 ft. (6,100 m) of pre-Middle Cambrian sediment, is bounded by high-angle normal faults that penetrate basement (Howe and Thompson, 1984). Carboniferous reverse movement on the faults indicate they may have been reactivated under compressional stress (Nelson and Lumm, 1984; Bertagne and Leising, 1991).

The Rough Creek Graben is an asymmetrical half-graben with the greatest structural relief on its northern margin (Bertagne and Leising, 1991). The graben has a similar geometry to that of the Reelfoot Rift - a central graben bounded by listric normal faults infilled by pre-Middle Cambrian sediments. Up to 16,000 ft. (4900 m) of pre-Knox sediments may be present (Kuehn, 1997). Reactivation of the border faults, yielding flower structures in the overlying Paleozoic cover, is thought to explain the origin of the Rough Creek-Shawneetown and Pennyrile Fault Zones (Nelson and Lumm, 1984; Bertagne and Leising, 1991).

Based on seismic, gravity and magnetic data the overall crustal density within the rift region is higher than that of the adjacent platforms (Ervin and McGinnis, 1975; Mooney and others, 1983; Hildenbrand, 1985). The anomalous crustal density in the rift area is thought to be the result of rift-associated intrusion of lower crust by dense mantle material (Hildenbrand, 1985). Hildenbrand (1985), Kane and others (1981) and

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Hildenbrand and Hendricks (1982) observed that the distribution of plutons appears to be related to faults associated with the paleo-rift.

Other significant structures within the Illinois Basin relevant to this discussion, either because of their possible influence on early-Middle Ordovician sedimentation or their relationship to the present-day distribution of bedrock exposures of Middle Ordovician strata, include: the Fairfield Basin, Du Quoin Monocline, Cottage Grove Fault System, Rough Creek-Shawneetown Fault System, Pennyrile Fault System, Wabash Valley Fault Zone, Sandwich Fault Zone, La Salle Deformation Belt, and the Kentland and Wells Creek structures (Figure 3). In the following discussion a brief summary is provided.

Fairfield Basin:

The Fairfield Basin is a broad centrally located depression bounded by the Duquoin Monocline, La Salle Anticlinal Belt and the Rough Creek Fault Zone (Figure 3)(Bell and others, 1964). Most of the structural relief that defines the basin developed during the Pennsylvanian, but some structural definition is observable in Silurian through Mississippian rocks.

Rough Creek-Shawneetown Fault System:

This braided fault system approximates the northern boundary fault of the Rough Creek Graben (Figure 3)(Nelson, 1991). During the pre-Middle Cambrian rifting stage, an east-west trending listric fault system developed with vertical displacement of greater than 1,000 ft. (305 m). Reactivation of the faults occurred during the Devonian, Mississippian, Pennsylvanian and in post-Pennsylvanian time (Nelson, 1990). Based on seismic data, Bertagne and Leising (1990) showed that the Rough Creek-Shawneetown

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Fault System is the surface expression of a flower structure developed in response to reactivation and movement on the Rough Creek Graben boundary fault in the late Paleozoic.

Pennyrile Fault System:

The Pennyrile Fault System (Schwalb, 1975) is a system of en echelon, high-angle, dip-slip normal faults that trend east-northeast for 110 miles (178 km) through western Kentucky (Figure 3). This fault system is paralleled by the Central Fault System to the north (Nelson, 1990), and to the south by an unnamed fault system (McDowell and others, 1981). The en echelon pattern is the result of left-lateral strike-slip movement (Rose, 1963; Nelson, 1990). In addition, reverse faulting has been studied locally (Rose, 1963; Nelson, 1990).

The Pennyrile Fault System closely coincides with the southern faulted margin of the Rough Creek Graben, and seismic data from the area indicates that the faulting is due to movement on the graben border faults during Cambrian and post-Pennsylvanian time.

Cottage Grove Fault System:

The Cottage Grove Fault System is a wrench fault system that trends east-west for 70 miles (113 km) through southern Illinois (Figure 3). The master fault exhibits vertical and strike-slip movement (Nelson and Krause, 1981). Subsidiary normal faults trend north-south and exhibit both normal and reverse movement.

Although on trend with the Rough Creek-Shawneetown Fault System and possessing a similar surface expression of structure, the Cottage Grove Fault System exhibits predominantly lateral movement and does not appear to be linked to rift-related basement faulting (Nelson, 1991).

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Wabash Valley Fault Zone:

This fault system is a zone of high- angle, normal faults that trend north-northeast near the juncture of the Illinois, Indiana and Kentucky state borders (Figure 3)(Bristol and Treworgy, 1979). Nelson (1991) has suggested that the faulting is a result of post-Pennsylvanian crustal arching. Braile and others (1984) and Sexton and others (1986) have interpreted the system as being related to the reactivation of basement faults associated with a failed limb of the New Madrid Rift complex. Although an east-west COCORP seismic profile (1989) across the fault zone does not show any offset of basement reflectors (Pratt and others, 1989), Furer (1992) suggests that minor vertical adjustments on basement faults have influenced sedimentation in the Wabash Valley area since Cambrian time.

Du Quoin Monocline:

The Du Quoin Monocline delineates the western margin of the Fairfield Basin (Figure 3). The moncline trends northward from the Cottage Grove Fault Zone for approximately 55 miles (89 km); an eastern spur on trend with the Salem-Louden Anticline Belt develops 15 miles (24 km) north of the Cottage Grove Fault System. Structural thickening of Cambrian and Lower Ordovician strata from west to east provides evidence of its early Paleozoic development (Kolata and Nelson, 1991); additional structural relief developed during the Mississippian (Treworgy, 1985) and Pennsylvanian (Brownfield, 1954).

La Salle Deformation Belt:

The La Salle Deformation Belt is a series of sinuous monoclines that trend north-northwest for 225 miles (360 km) from Lawrence Co., southeastern Illinois, to

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Winnebago Co., northwestern Illinois (Figure 3)(Clegg, 1965; Nelson, 1991). Numerous small anticlines and domes are developed on the higher limbs of the monoclines.

High-angle normal faults with up to 400 ft. (120 m) of offset are present at depth but show little to no offset in strata younger than Ordovician. Although no basement-involved faulting has been documented, Nelson (1990) and Clark-McCracken and others (1997) have postulated a basement control based on rheological and geometrical considerations. Periods of vertical movement on the belt include Upper Ordovician (Kolata and Graese, 1983), Devonian (Clark-McCracken and others, 1997), Mississippian (Clegg, 1965), and Pennsylvanian (Jacobson, 1985); however, approximately half the movement occurred in post- Pennsylvanian time (Nelson, 1990).

Sandwich Fault Zone:

The Sandwich Fault Zone (Willman and Templeton, 1951) is a narrow belt of northwest trending high-angle faults in northern Illinois (Figure 3). On the hanging wall, rocks of Cambrian age have been uplifted into structural contact with rocks of post-Lower Ordovician age (Kolata and others, 1978). McGinnis (1966) proposed that the Sandwich Fault Zone is a reactivated boundary fault of a pre-Ordovician graben.

Most of the movement is thought to have occurred during post-Niagaran (Silurian) to pre-Illinoian (Pleistocene) time in association with the development of the La Salle Anticlinal Belt (Kolata and others, 1978). The local development of an angular unconformity between the Shakopee Dolomite (Lower Ordovician) and the St. Peter Sandstone (Middle Ordovician) demonstrates that the structure was active prior to deposition of the St. Peter Sandstone (Cady, 1920; Willman and Payne, 1943).

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Kentland and Wells Creek Structures:

The Kentland Disturbance, northwest Indiana, and the Wells Creek Cryptovolcanic structure, northwest Tennessee, are post-Ordovician impact structures in which early-Middle Ordovician strata are exposed in the central uplifted blocks (Figure 3)(Wilson and others, 1968; Laney and Van Schmus, 1978). The St. Peter Sandstone is exposed in a quarry within the Kentland Structure. This locality is one of the few where fossils from the clastic lithofacies of the Ancell Group have been studied (Shrock, 1937). The Wells Creek Dolomite is named for cutbank exposures on Wells Creek within the structure (Lusk, 1927).

Chronostratigraphy

A necessary component of a basin evolution interpretation is a time framework to constrain the temporal distribution of sediments. Currently two approaches to time-rock classification of the Ordovician are used in the Illinois Basin: a locally utilized threefold division and the internationally recognized fourfold division (Figure 4).

The Ordovician system is subdivided into three stages: Lower, Middle and Upper. The Lower Ordovician is equivalent to the Canadian Series, and the Cincinnatian Series is the standard for the North American Upper Ordovician. In North America, the Middle Ordovician Stage includes all post-Canadian and pre-Cincinnatian strata. The Middle Ordovician is either considered equivalent to the Champlainian Series, or it is subdivided into the internationally recognized Whiterockian and Mohawkian Series.

The base of the Whiterockian Series is defined by the first occurrence of either the Zone L brachiopod-trilobite assemblage (*Orthidiella* brachiopod zone), or by the graptolite *Isograptus victoriae*. The Whiterockian has been biostratigraphically

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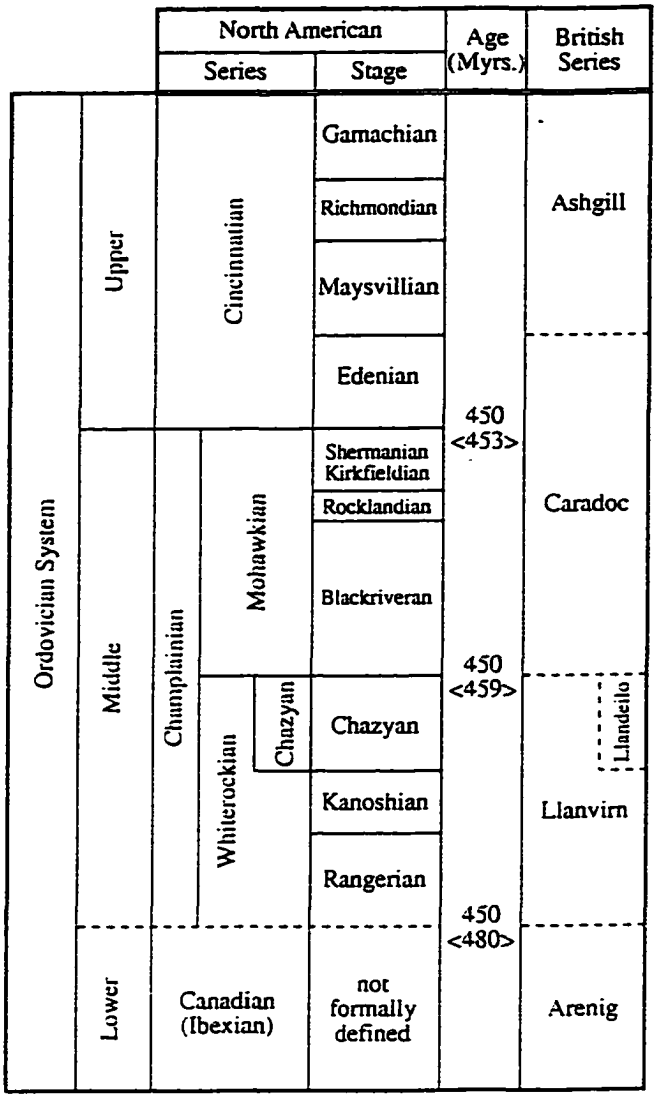

Figure 4: North American chronostratigraphic units for the Ordovician and their British Series equivalents. North American units from R. Ross, Jr., Dept. of Geology, Colorado School of Mines, Golden, Colo., written communication, 1992; Britsh units from Fortney and others, 1995. Absolute dates are from Ross and Harland and others (1992); those from Harland and others (1992) are in parentheses. Absolute age of Blackriveran-Rocklandian boundary based on absolute age of the Millbrig K-bentonite (Kunk and others, 1985; Tucker and others, 1990).

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subdivided into four trilobite-brachiopod assemblage zones (L, M, N and O) and six conodont biozones (Ross and others, 1982; Ross and Ethington, 1992a, 1992b).

The base of the younger Mohawkian Series is defined as the first occurrence of the conodont *Prioniodus gerdae* which defines that base of the *P. gerdae* subzone of the of the *Amorphognathus tvaerensis* conodont zone, and which approximates the base of the British series *Diplograptus multidens* graptolite zone (Ross and Ethington, 1992b). Leslie and Bergstrom (1995a) have proposed a subdivision of the Mohawkian Series in Stages in which the base of the *P. gerdae* Subzone would define the base of the Turinian Stage, and the Millbrig K-bentonite Bed, and its regional equivalents, would define the base of the Chatfieldian Stage.

Templeton and Willman (1963) applied the use of Champlainian to the Middle Ordovician of the Illinois Basin. Under their classification the Champlainian Series would be subdivided into three stages: Chazyan, Blackriveran and Trentonian. The stage classification of the Champlainian by Cooper (1956), which included the Whiterockian Stage, was not utilized in the Illinois Basin due to the absence of the diagnostic brachiopod faunas used by Cooper to define the stage boundaries (Templeton and Willman, 1963). The International Subcommission on Ordovician Stratigraphy (Ross and others, 1982) rejected the use of the Champlainian and subdivided the Middle Ordovician into the Whiterockian and Mohawkian Series. The Whiterockian includes those rocks previously assigned to the Whiterockian and Chazy Stages of Cooper (1956); the Mohawkian includes strata previously assigned to the Blackriveran, Rocklandian, Kirkfieldian and the Shermanian stages. The revised Mohawkian Series includes the lower Trentonian of Twenhofel (1954).

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The chronostratigraphic classification of Ross and others (1982) is utilized in this study. However, two aspects of Middle Ordovician chronostratigraphy currently used by Illinois and Indiana state geological surveys' should be addressed.

First, although the use of the Champlainian Series by the Illinois and Indiana state geological surveys has persisted (Willman and others, 1975; Buschbach and Kolata, 1990; Shaver and others, 1986), the rationale for its use is no longer valid. Published studies of conodont faunas from the type Whiterockian (Harris and others, 1979; Ross and others, 1991) provide a basis for recognition of the Whiterockian Series in non brachiopod- bearing strata. Studies of Whiterockian conodont faunas from the Everton Dolomite, St. Peter Sandstone and Dutchtown Formation in the Illinois Basin (see Table 6) provide a basis for recognition of the Whiterockian Series in the Illinois Basin and, therefore, the use of Champlainian should be abandoned.

Second, the base of the Upper Ordovician is defined as the base of the Cincinnatian Series, which in turn is defined as the basal contact of the Eden Shale in the Cincinnati region, southwestern Ohio (Sweet and Bergstrom, 1971; Ross and others, 1982; Bergstrom and Mitchell, 1986). This datum is also the top of the Mohawkian Series (Ross and others, 1982). For reasons that have not been justified, the COSUNA correlation charts, published by the American Association of Petroleum Geologists, place the base of the Upper Ordovician at the base of the Mohawkian and restrict the Middle Ordovician to rocks of Whiterockian (including Chazyan) age (Salvador, 1985).

The COSUNA chronostratigraphy is utilized by the Illinois (Buschbach and Kolata, 1990) and Indiana (Shaver and others, 1986) state geological surveys, and it has been widely adopted by the petroleum industry. Because the COSUNA subdivisions are

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inconsistent with the historical and international usage of the Upper Ordovician, the base of the Cincinnatian of Ross and others (1982) is used herein to define the upper limit of the Middle Ordovician.

Correlation of the North American Series subdivisions and the more internationally recognized British Ordovician Standard is problematic.

In Britain, the lower-Middle Ordovician is defined as the Llanvirnian Series (Fortney and others, 1995); prior to the recent redefinition of the Britsh Middle Ordovician by Fortney and others (1995), the lower-Middle Ordiovician of Britain was subdivided into the Llanvirnian and Llandeilian series. The type area for Llanvirn and Llandeilio series, located in Wales, U. K., is siliciclastic dominated and contains a trilobite-brachiopod faunal assemblage. In contrast, the North American succession is carbonate dominated and contains a gastropod-nautoloid assemblage (Berry, 1974; Wilcox and Lockley, 1981). Furthermore, biostratigraphically useful fossil groups used for international correlation (graptolites and conodonts) are either poorly known in Wales (graptolites and conodonts), or in North America (graptolites). In addition to the faunal contrasts, Whittington and others (1984) and Zalasiewicz (1984) observed that the lower-Middle Ordovician series type sections in Wales are poorly exposed and contain numerous discontinuities of undetermined magnitude.

Correlation of the Laurentian (North American) and Baltica (European) successions is further complicated by the marked faunal provincialism is exhibited by conodonts and graptolites during the Middle Ordovician. Bergstrom (1990) observed that the conodont faunal composition of the early-Middle Ordovician Dutchtown Formation in southeast Missouri has virtually nothing in common with the coeval faunas of Wales.

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Because of these differences, correlation of the British and North American standards remains tentative. Ross and others (1982) considered the Whiterock to be coeval with the upper Arenig and Llanvirn (Figure 4). Based on graptolites, Mitchell (1992) studied that the Arenig-Llanvirnian boundary is approximately coeval with the middle/upper Whiterock boundary (= base of Chazy) and within the upper *Histiodella holodentata* conodont zone (= upper fauna 4).

Fortney and others (1990) have suggested that if the post-Knox disconformity of eastern North America is the result of a eustatic sea-level change, then the disconformity at the base of the Llanvirn series in its type area may be correlative. However, Ross and others (1991) consider the post-Knox disconformity to be of tectonic origin and an unreliable chronostratigraphic datum.

In view of these difficulties and because the conodont biozonation used in this study is based on faunas from the North American Midcontinent Province, North American time-stratigraphic units are used in this discussion.

Paleotectonic setting

Paleogeography

The position of Laurentia (North America) relative to the equator and Baltica (western Europe) is of fundamental importance in understanding the role of climate and tectonics on sedimentation in the Illinois Basin.

There is a general agreement in Middle Ordovician paleogeographic reconstructions that Laurentia was in an equatorial position rotated 20°-30° counter-clockwise, and that the Illinois Basin was located 15°-25° south of the paleoequator (Figure 5A)

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(Scotese and others, 1979; Kanasewich and others, 1981; Smith and others, 1981; Droste and Shaver, 1983; Scotese and McKerrow, 1991). Gondwana and Baltica were situated poleward in the Southern Hemisphere during the Lower Ordovician and separated from Laurentia by the Iapetus Ocean, although an alternative intepretation places Baltica in an equatorially location with the Scandanavian margin pole-facing and opposite Siberia (Torsvik and others, 1996).

Based on the similar tectonic histories of the Appalachian-Ouchita and Famatinian (south-central South America) orogens, and Dalla Salda and others (1992) and Dalziel and others (1994) have proposed that the South American plate was rotated 180° counter-clockwise to its present position and that the Rio de la Plata Craton (present day northern Chile and Argentina) was located outboard of the Laurentian margin opposite the Ouchita Embayment (present-day south-central US) and partially separated Laurentia from Baltica (Dalziel and others, 1994, Figure 3).

Scotese and McKerrow (1991) paleogeographic reconstructions (Figure 5A) agree with respect to the rotation of South America relative to its present position and its paleolatitudinal position, but interpret the Andean margin as being out board of present-day western Laurentia and separated from Laurentia by the Panthalassic (proto-Pacific) Ocean.

The proposed paleogeographic reconstruction of Dalla Sada (1992) and Dalziel and others (1994) is in question because of the absence of late-Middle Ordovician K-bentonites, altered ash-beds, in the Ordovician succession of San Jaun carbonate platform, Argentina (Huff and others, 1995). If Argentina was located outboard of the Laurentian margin during the Taconic Orogen, the ash-beds that are widespread

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MIDDLE-ORDOVICIAN (LLANDELIO-CARADOC)

FIGURE 5A: PALEOGEOGRAPHY
(Scotese and McKerrow, 1991)

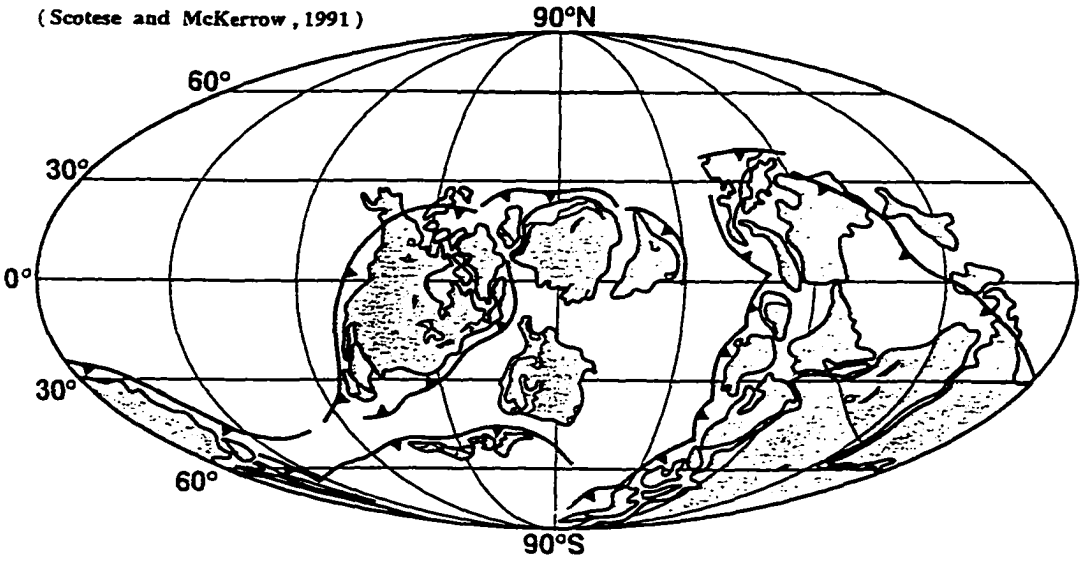
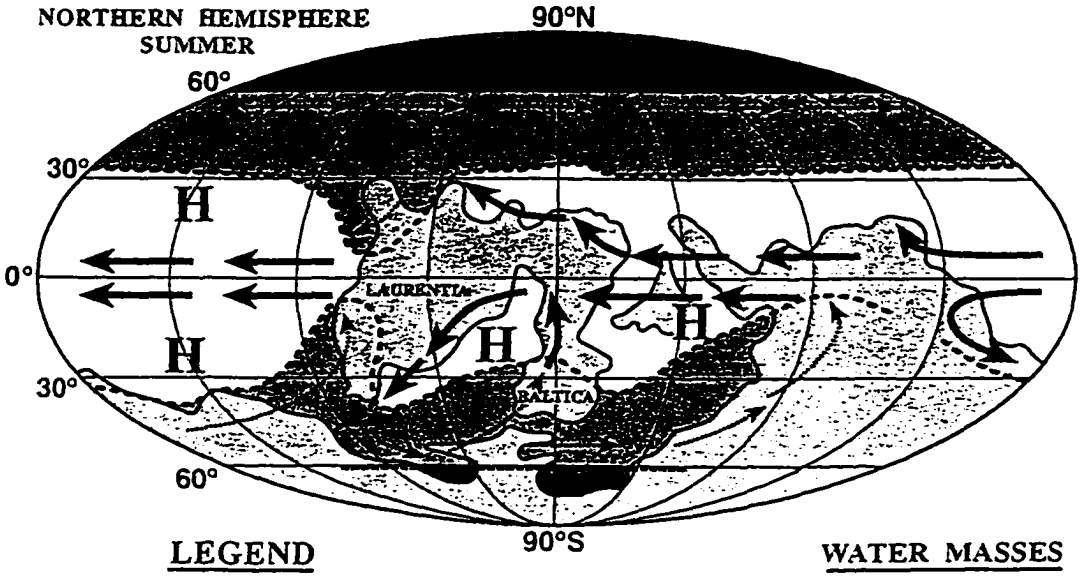


FIGURE 5B: PALEOCEANOGRAPHIC CIRCULATION
(Wilde, 1991)



LEGEND

- WARM CURRENTS
- COOL CURRENTS
- SUBTROPICAL CONVERGENCE
- POLAR CONVERGENCE
- H CENTER OF OCEANIC HIGH PRESSURE

WATER MASSES

- COLD
- COOL
- WARM

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throughout the southeastern United States and western Europe should be present in the Argentinian succession (Samson, 1996). Although it is possible that paleoclimatic patterns may have precluded transport of volcanic ash onto the San Jaun carbonate platform.

Thomas and Astini (1996) have offered a convincing alternative interpretation that the Argentine Precordillera is a Laurentian fragment that deteached from Laurentia along the Ouachita Rift, bounded by the Texas and Oklahoma-Alabama transforms, in the early Cambrian, and then docked with Gondwanaland in the Late Ordovician. Therefore, the Argentine Precordillera was not involved with the Taconic Orogeny and present-day South America was still out-board of the Laurentian margin. Based on the paleo-poles reported by Conti and others (1996), the Puna Oriental-Famatina craton (northwest Argentina) was still proximal to the Central Mobile Terranes in the Lower Ordovician and the separation of South American and Laurentia was on the order of 2000 km. The Central Mobile Terranes are island arc terranes accreted to the northern Laurentia margin in the Middle and Late Ordovician.

Ordovician paleogeographic reconstructions are constrained by a small number of Middle Ordovician craton paleopole measurements that indicate a southeast Pacific paleopole (Van der Voo, 1989). A more northern paleopole was studied for the Everton Dolomite, northeast Arkansas (Farr and Sprowl, 1990; Sprowl and Farr, 1991). As a consequence, using paleomagenetics to resolve the paleogeographic positions of Laurentia, Baltica and South America plates has been hampered by pole reversals, the lack of appropriate rock types, remagnetization during Late Paleozoic deformation and

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limited surface exposure of early-Middle Ordovician cratonic strata (Trench and others, 1991; Sun and others, 1993).

Scotese and McKerrow (1991) estimated the potential latitudinal uncertainty of their paleogeographic reconstructions to be $+15^{\circ}$, and the longitudinal uncertainty to be $+/-30^{\circ}$. Because paleolongitudinal positions cannot be determined using paleomagnetic data (Hillhouse, 1989), relative longitudinal positions are based on sedimentological and paleoecological considerations (Scotese and McKerrow, 1991).

Detailed comparisons of the South American, North American (Laurentian) and European (Baltica) Ordovician successions are currently unavailable, however, Mac Niocaill and others (1997) report that the celtic fauna brachiopods found in Argentina require a polar paleo-position during the Ordovician. In addition, in contrast to the Middle Ordovician retrogradational, relative sea level rise trend observed for Laurentia, the Puna Oriental-Famatina Terrane, northwest Argentina-northern Chile, is characterized by a progradational, overall relative sea level fall (Keller and others, 1993). Consequently, the hypothesis of Dalla Salda and others (1992) does not appear to be supported by the available stratigraphic and paleontological data, and this study utilizes the more completely documented paleogeographic model of Scotese and McKerrow (1991).

The observed differences in early-Middle Ordovician paleopole positions may be a function of the limited data set, imprecise age determinations for strata sampled, and/or reflect varying rates of movement for Laurentia during the Middle Ordovician. Scotese and McKerrow (1991) estimated that Laurentia was moving at a rate of 10-15 cm/yr.

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during the Lower and lower-Middle Ordovician before slowing to 6-8 cm/yr. by the upper-Middle Ordovician.

Based on paleomagnetic data, the width of the Iapetus during the Lower Ordovician is estimated at 5,500 km. (3,416 mi.) (Torsvik and Trench, 1991). As Baltica drifted northward, the paleolatitudinal separation of Laurentia and Baltica decreased to 3,300 km (2,050 mi.) in the Middle to Late Ordovician (Torsvik and Trench, 1991), and possibly as little as 2,000 km (1240 mi.) (Dunning (1972).

The decreasing width of Iapetus is reflected in the paleontological record by change from marked faunal provincialism in the Early Ordovician, to cosmopolitan faunas by the Late Ordovician. A marked faunal provincialism is noted for most major fossil groups during the Early Ordovician. This provincialism began to change during the Medial Ordovician, and it was absent in most groups by the late-Medial Ordovician. For example, conodont faunas found in the North American interior are assigned to the North American Midcontinent (NAMP) faunal province and are interpreted as warm and/or shallow marine faunas. While those found in western Europe are referred to the North Atlantic (NAtP) Province and are interpreted as deeper and/or cooler marine faunas (Sweet and Bergstrom, 1974; Bergstrom, 1990). Similar provincialism is developed in brachiopods, chitinozoans, graptolites, trilobites and stromatoporoids (Williams, 1973; Havlicek, 1976; Skevington, 1978; Webby, 1980; Neuman, 1984; Finney and Xu, 1990; Achab and others, 1992).

Cocks and Fortney (1982) proposed a biogeographic model in which dispersal of benthic and nektobenthic shelfal biotas is inhibited by deep oceanic basins. Tectonic closure of a basin, and/or development of intervening island arcs reduces the

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effectiveness of the basin as a barrier to faunal dispersal. Therefore, faunal provincialism has been used to determine tectonic separation using dispersal characteristics of related modern faunas. As an example, based on ecologic considerations for brachiopods, the width of the Iapetus basin is estimated at 1,000 km (625 mi.) during the upper-Middle Ordovician (Cocks and Fortney, 1982). This is considerably less than the 2,000-3,300 km (1250-2062 mi.) estimated from paleomagnetic data, but it is supported by dispersal patterns of Middle Ordovician ash falls that suggest a more reduced longitudinal separation between Laurentia and Baltica by the upper-Middle Ordovician (454 Ma)(Huff and others, 1992).

Skevington (1978) argued that the distribution of Ordovician pelagic and epipelagic fossil groups was controlled by water temperature and that, therefore, paleocurrents and latitidunal position of land masses were the controlling factors on faunal dispersion. This hypothesis is supported by stable isotope studies (Nd and Sr) that suggest that Iapetus was partitioned into two isotopically distinct water masses by a physical barrier (i.e., island arc or shoal platform) and that the observed faunal provincialism resulted from oceanic circulation patterns (Keto and Jacobson, 1987). In this model, a physical barrier served to partition Iapetus by its influence on circulation rather than providing a faunal dispersal pathway. If Iapetus was physically partitioned, an interpreted smaller paleolongitudinal separation of Baltica and Laurentia is consistent with the observed biofacies distributions.

In addition to controlling the distribution of organisms, the movement of Baltica toward an equatorial position, and toward Laurentia, also significantly influenced Middle Ordovician paleoclimate and paleoceanographic circulation (Wilde, 1991).

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Wilde (1991) proposed an oceanographic model for the Ordovician in which the progressive movement of Baltica and Gondwana into low latitudinal positions through the Middle Ordovician resulted in: (1) monsoonal climate patterns within the Iapetus region, (2) a salinity-stratified oceanic water mass due to restricted wind fetch as the Iapetus decreased in width, and (3) a deep oceanic circulation pattern characterized by the sinking of warm saline waters along the plate margins (Figure 5B). In this model, Laurentia was within an equatorial, tropical climate belt that extended from 30° south to 30° north.

Wilde's oceanographic model is also supported by the isotopic data and morphological character of brachiopod shells along an upper Middle Ordovician shelfal transect (Railsback, 1990; Railsback and others, 1990). These data indicate that the temperature of Middle Ordovician marine waters increased with depth and imply a salinity stratified ocean with relatively cool (13°-19°C), low-salinity surface waters and warm (28°-38°C) saline bottom waters. These data are also consistent with sedimentological and geochemical data from the Black River and Trenton Limestones of southern Ontario which suggest surface water temperatures of 8-12°C for the Trenton, and 17°C for the Black River (Brookfield, 1988).

Railsback and others (1990) suggested that the denser, warm bottom waters were derived from marginal epeiric seas circulated into deep marine basins by density driven currents, and that the surface waters were the result of minimal input from cool, brackish polar waters. This hypothesis is supported by studies of post-Paleozoic rocks (Berggren

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and Hollister, 1977) that suggest that in marine basins which are relatively isolated from polar regions, water masses become stagnant and salinity stratified.

Witzke (1980, 1990) proposed that during the Middle Ordovician the proto-Illinois Basin was located within an arid trade-wind belt with prevailing winds from the northeast, present coordinates, or east-west paleocoordinates. This prevailing paleowind direction is supported by mean cross-stratification orientation measured within eolian deposits in the St. Peter Sandstone (Dott and others, 1986), and is also consistent with Wilde's (1991) oceanographic model.

In summary, during the early-Middle Ordovician the proto-Illinois Basin occupied a subequatorial position with an east-west prevailing paleowind direction (Figures 5A and 5B). A possible monsoonal climate pattern resulted as land masses became concentrated at low latitudes. Because wind fetch was restricted and because the basin was distal from polar water masses, the Iapetus Ocean became salinity stratified. A marked faunal provincialism developed in most of the major fossil groups due to the separation of Baltica and Laurentia and/or circulation patterns in the Iapetus. Paleomagnetic and paleoecologic data support a progressive closure of the Iapetus Ocean as a result of the drift of Baltica, and/or possibly South America, toward Laurentia during the lower-Middle to lower-Upper Ordovician. Progessive closure of the Iapetus due to plate convergence resulted in the Taconic Orogeny.

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Taconic Orogen

The Taconic Orogen is thought to be the result of the accretion of the Ammonoosuc and West Carolina Volcanic arcs and/or microplates (Williams and Hatcher, 1982), at the time of attempted subduction of the Laurentian margin, at one or more oceanic trenches, during the Ordovician (Rowley and Kidd, 1981; Drake and others, 1989; Fyffe and Swinden, 1991; Tembley, 1992). The subsequent collision of Baltica, and later Gondwana, with the Laurentian margin resulted in the post-Ordovician Acadian and Alleghenian orogens. Other less geographically extensive orogens, such as the Silurian Salinian Orogeny (Cawood and others, 1994), deformed the the Laurentian margin locally. The composite deformational belt produced by these orogenies makes-up the Appalachian-Ouachita Orogen.

Associated with this orogenic belt are the Illinois and Michigan interior cratonic basins. Each basin is roughly elliptical to spoon-shaped, overlies a precursor paleorift, contains marginal-marine to marine basin-fill sediments, and has a stratigraphic succession that is interrupted by regional unconformities which decrease in magnitude basinward (Kolata and Nelson, 1991; Catacosinos and others, 1990). Development of regional unconformities and marked changes in rates of subsidence in the Illinois and Michigan basins are approximately coeval with initial stages of major orogenic phases (see Figure 30-3, Catacosinos and others, 1990; and Figure 18-1, Kolata and Nelson, 1991).

Taconic deformation, as currently recognized, contains at least three semi-contiguous phases: (1) Blountian phase (Medial to Late Cambrian), (2) Penobscottian phase (Early Ordovician), and (3) Taconic (sensu stricto) phase (Medial Ordovician to

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Silurian)(Drake and others, 1989). Structures associated with the Blountian and Penobscottian have been recognized in the Northern Appalachians and Newfoundland, but the effects of these events are difficult to differentiate from Taconic deformation in the central and southern Appalachians (Drake and others, 1989). This study is primarily concerned with strata coeval with the Taconic Orogeny sensu stricto.

Most workers accept, with some modification, the model presented by Rowley and Kidd (1981) and shown schematically in Figure 6. The Cambro-Lower Ordovician Laurentian margin was a rifted passive margin developed as a result of the break up of a late-Precambrian supercontinent between 625 and 555 myrs. (Bond and others, 1984). Deposition of marine clastics and carbonates on the passive margin was controlled by the interaction of thermal subsidence and glacio-eustatic, and/or tectonically driven, sea-level changes (Read, in Rankin and others, 1989). Island arcs and small back-arc marginal basins, such as the Baie Verte Basin (Kidd, 1977), were present outboard of the thermally subsiding Lauretian margin.

In the initial stages of the Taconic Orogeny, 491-480 Ma (Early to earliest-Medial Ordovician) the attempted subduction of the Laurentian margin beneath an outboard terrain resulted in the development of a subduction zone. Peak Taconic orogensis appears to have occurred in the earliest Medial Ordovician (463 Ma) in New England and Quebec, and progressed south along the paleomargin (Whitehead and others, 1996).

It has generally been interpreted that the subduction was eastwest dipping, but subsidence modeling suggests that subduction may have had an westward polarity by the late-Middle Ordovician (Coakley and Gurnis, 1995). If the observations of Coakley and Gurnis are valid, a model which reconciles the observed evidence for eastward

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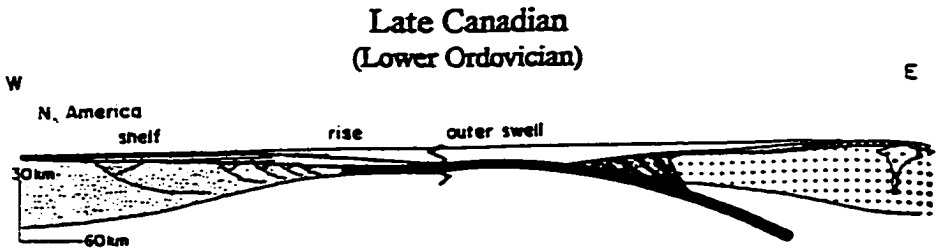
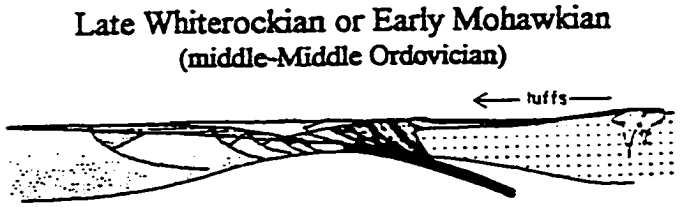
Figure 6: Schematic diagram of the Taconic Orogen.
(modified from Rowley and Kidd, 1981)



During the late Canadian, eastward (paleo-direction) subduction of the Laurentia (North American) beneath an island arc(s), or microplate is initiated. A peripheral bulge, or outer swell developed in response to the loading of the Laurentian plate margin by the Taconic accretionary prism.

As the thrust sheets approach the continental margin during the Whiterockian, much of the remaining oceanic crust was subducted, the peripheral migrated cratonward (west) uplifting the Knox carbonate shelf and exposed much of it to erosion, and initial island arc vulcanism deposited ash falls that are preserved locally on the post-Knox paleo-erosional surface.



At the end of the Whiterockian (includes Chazyan), the continued loading of the crust resulted in the collapse of the post-Knox shelf and the development of the Taconic foreland basin and the submergence of much of eastern North America due to flexural subsidence.

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subduction and the theoretical model for westward subduction was proposed by Washington (1994). In this model, subduction is initially to the eastward dipping but as back arc extension continues back-arc basins form, the old lithosphere thins and then fails, when the lithosphere the subduction zone migrates continentward and reverses polarity, and the back arc basin and volcanic arc are accreted to the continental margin. And as Gurnis and Coakley modeled, that the new subduction zone dips westward and the thermally buoyant, but old lithosphere initially maintains a low subduction angle.

As Iapetus continued to close, one or more island arcs, and associated back arc basins were accreted on to the Laurentian margin (Hatcher, 1989). The loading of the margin, by the stacking of thrust sheets within an accretionary prism associated with the subduction zone, resulted in lithospheric flexure, the development of a forebulge and uplift of the passive margin (Jacobi, 1981; Knight and others, 1991). With the exception of locally persistent depocenters where deposition was uninterrupted, possibly associated with irregularities in the plate margin (Lash, 1988), the peripheral uplift of the passive margin may have resulted in the regionally widespread, post-Knox disconformity and its associated karstification of the Cambro-Ordovician carbonate sequence within, and proximal to the Applachian Orogen (Knight and others, 1991). The position of the forebulge was controlled by the distribution of the thrust load on the plate margin; consequently, as the thrust load migrated cratonward, the forebulge also migrated cratonward (Beaumont and others, 1988). Therefore, the development of the post-Knox disconformity was diachronous within the orogen (Repetski and Harris, 1986; Knight and others, 1991).

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The development of the post-Knox disconformity across much of North America, beyond the Taconic Orogen, implies that although the forebulge influenced the development of the paleotopographic surface within the orogen, other tectonic and climatic factors influencing relative sea level were also operative.

Numerical modeling of the flexural deformation of the Laurentian margin indicates that constructive interference between the forebulges developed in response to the tectonic loading on the Laurentian margin and in response to sediment loading in the subsiding Illinois and Michigan basins. This interference resulted in uplift on the precursors to the Cincinnati, Wisconsin, Findlay and Kankakee Arches, and the Jessamine and Nashville Domes and isolated the Illinois and Michigan basins from the Taconic foreland (Quinlan and Beaumont, 1984; Beaumont and others, 1988).

Within the orogen, the abrupt change from shallow-marine carbonate environments, to deep-water foreland basin siliciclastic deposits in the early Mohawkian suggest that shelf margin collapsed with continued loading (Rowley and Kidd, 1982; Selleck and Bosworth, 1985). Subsequently, siliciclastic dominated, deep-water foreland basins developed in front of the advancing thrust sheets due to deflection of the crust in response to the thrust load (Lash, 1982; 1988). This flexural deformation of the lithosphere resulted in the extension of the upper crust between the forebulge and the foreland basin.

As the thrust load migrated toward the craton, a zone of brittle failure migrated cratonward from the convergent boundary and normal-fault bounded, tilted fault-blocks developed parallel to the thrust front within the western Taconic foreland (Bradley and

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Kidd, 1991). These tilted fault-blocks controlled the geomorphic development of the post-Knox paleosurface in the subsurface of east-central Ohio (Gustavo, 1991).

It is unlikely that the forebulge could have migrated much further to the west than the present day position of the Cincinnati Arch, Jessamine Dome and the Nashville Dome. These present-day geomorphic features reflect, in part, the loading of the plate margin by the lithostatic load of the Appalachian Mountains uplifted during the Alleghenian-Acadian Orogeny. The Alleghenian-Acadian orogeny was the result of continent-continent collision that was of considerably greater magnitude and geographic extent then the Taconic Orogeny. As a result, the present day distribution of arches and domes resulting from the Alleghenian-Acadian orogenic loading probably represents a maximum limit for the potential loading effects of Taconic tectonic loading.

This is consistent with detailed investigations of the Nashville and Jessamine domes, and the Cincinnati Arch which suggest that their position has varied over time, that the precursor positive structural elements associated with these domes and arches where located east of their present locations, and that uplift on these features and forebulge development may be diachronous and therefore, unrelated.

Diecchio (1993) has proposed, based on a revised interpretation of Middle Ordovician stratigraphy, that a positive structural axis (peripheral bulge) was developed within the Valley and Ridge Province of western Maryland and central West Virginia during upper-Middle and Late Ordovician time. Evidence for this feature is based on an east-west lithofacies change and an apparent stratigraphic thinning of the post-Middle Ordovician succession, and comparison with observed tectonic relationships in the Timor

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area north of Australia where the southern Indonesian Archipelago is accreting onto the northern Australian passive margin.

Stratigraphic thinning may be an unreliable indicator of structural activity within the Valley and Ridge due to complex thrust-faulting and differential compaction associated with lithostatic loading. As a result, paleogeologic maps of the post-Knox paleoerosional surface offer the greatest insights into the paleotopographic expression of the post-Knox surface and the position of the Taconic peripheral uplift. The pre-Tippecanoe Sequence (early Middle Ordovician) paleogeologic map presented by Coogan and Maki (1988) shows the axis of the early-Middle Ordovician Wooster-Waverly Arch east of the present-day position of the Cincinnati Arch in eastern Ohio, but west of the Diecchio's positive axis. Because increasingly older rocks are exposed on the post-Knox paleosurface toward the arch axis, as is the case with the modern Cincinnati Arch, it is probable that the axis of the paleo-arch was also a paleotopographic high.

These data appear to more clearly support the interpretation of the Wooster-Waverly arch as demarcating the development of the Taconic peripheral bulge during the Middle Ordovician, although it is possible that the bulge migrated eastward by the late-Middle Ordovician to the position proposed by Diecchio (1993) in response to a change in the distribution of the tectonic loading with the advancement of the thrust sheets and/or a change in the angle of subduction. This conclusion is supported by the reported asymmentric development of the Cincinnati Arch which developed 2/3's of it's present-day westward dip by the Late Ordovician but did not develop it's present-day eastward dip until post-Ordovician time (Dejong, 1997).

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The conclusion that the Taconic peripheral bulge was located eastward of present-day positive tectonic elements is also evident in eastern Tennessee. Reesman and Stearns (1990) and Stearns and Reesman (1986) have demonstrated that the Nashville Dome is the result of post-Paleozoic isostatic adjustment. They showed that the Middle Ordovician "Taconic" paleoarch was located approximately 100 km east of the present Nashville Dome, but it lacks present-day topographic expression because it is tectonically suppressed. Reesman and Stearns (1990) and Ettensohn and Kulp (1995) have speculated that basement structure controlled the location of the Middle Ordovician paleoarch and controls the position of the present day Jessamine Dome of central Kentucky. Modeling of foreland deformation by Waschbusch and Royden (1992) suggests that a peripheral bulge may become fixed in position by pre-existing crustal inhomogeneities and therefore, basement control is likely in heterogeneous continental crust.

With progressive loading of the margin and craton-ward movement of the thrust sheets, the interior basins become flexurally incorporated with the Taconic foreland in the upper-Middle Ordovician (Mohawkian). The yoking of interior basins with the Appalachian foreland is readily evident by the widespread, uniform distribution of carbonate depositional environments and the progradation of the Taconic clastic wedge over much of eastern North America (Beaumont and others, 1988, Figure 5C; Collinson and others, 1988, Figure 22).

The flexural deformation model is in agreement with the observed structural and stratigraphic relationships within the orogen, and it provides a conceptual framework for understanding the Ordovician deformation of the Laurentian margin. However, as Quinlan and Beaumont (1984) and Beaumont and others (1988) observed, the mechanism

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for coeval subsidence of the Illinois and Michigan basins, particularly during the initial stages of the orogeny is problematic, and the development of the post-Knox disconformity well beyond the orogen and onto the craton remains unresolved.

Based on a model developed by DeRito and others (1983), Braile and others (1986) and Kolata and Nelson (1991) proposed a subsidence model for the Illinois Basin in which in-plane stress significantly decreases the effective viscosity of the lower lithosphere due to nonlinear creep. Howell and Van der Pluijm (1990), have proposed a similar model for the Michigan Basin. In this model, as the viscosity of the lower lithosphere decreases in response to the application of in-plane stress, an isostatically uncompensated mass in the more rigid upper lithosphere will subside until an isostatic equilibrium is re-established (DeRito and others, 1983). During periods of low in-plane stress, basin subsidence is controlled by the general thermal regime and by lithospheric flexure.

When this model is applied to the Ordovician deposition history of the Michigan and Illinois basins, intraplate stress is greatest during the initial stage of the Taconic Orogeny. Rapidly subsiding depocenters developed where inferred buried paleorifts are present beneath the Michigan and Illinois basins. The high-density, rift-associated intrusives became isostatically uncompensated as effective viscosity of the lower-crust decreases. As in-plane stress was relieved by thrust faulting at the plate margin in the early Mohawkian, the effective lower-crust viscosity increased and subsidence slows. This model provides a mechanism by which depocenters located in interior basins form in association with lithospheric flexure, and it relates the subsidence of the interior basins to their precursors - buried paleorift basins.

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Middle Ordovician Sea Level Changes

As noted previously, relative sea-level variations played an important role in the development of the post-Knox disconformity, the distribution of sedimentary and early diagenetic environments, as well as the paleobathymmetry, in the Illinois and Michigan basins.

Recently, Ordovician coastal onlap curves (Figure 7) which can be interpreted in terms of relative sea-level variations, have been published for the Ordovician (Ross and Ross, 1992; Schutter, 1992). Coastal onlap is the progressive landward migration of coastal environments onto an underlying surface of deposition during a relative sea rise (Vail and others, 1977a). A contemporaneous rise in effective base level creates sediment accommodation space where sediment can be deposited. Conversely, during a relative sea-level fall, coastal depositional environments migrate basinward, sediments progressively downlap the basinward underlying surface of deposition, and effective base level falls. Associated diagenetic environments also shift with sedimentologic environments. An unconformity develops when the surface of sedimentary accumulation is coincident with depositional base level, or the elevation of depositiosal surface is above the erosional base level (Sloss, 1984).

In sub-equatorial interior marine basins, sedimentation rates readily exceed the rate at which sediment accommodation space is created by a rise in effective base level (Carozzi, 1986; Wilkinson and others, 1991), and the sediment water interface approximates sea level (Sloss, 1991; Sloss, 1992). Therefore, the decompacted thickness of the preserved sedimentary section approximates the magnitude of change in elevation of the shoreline.

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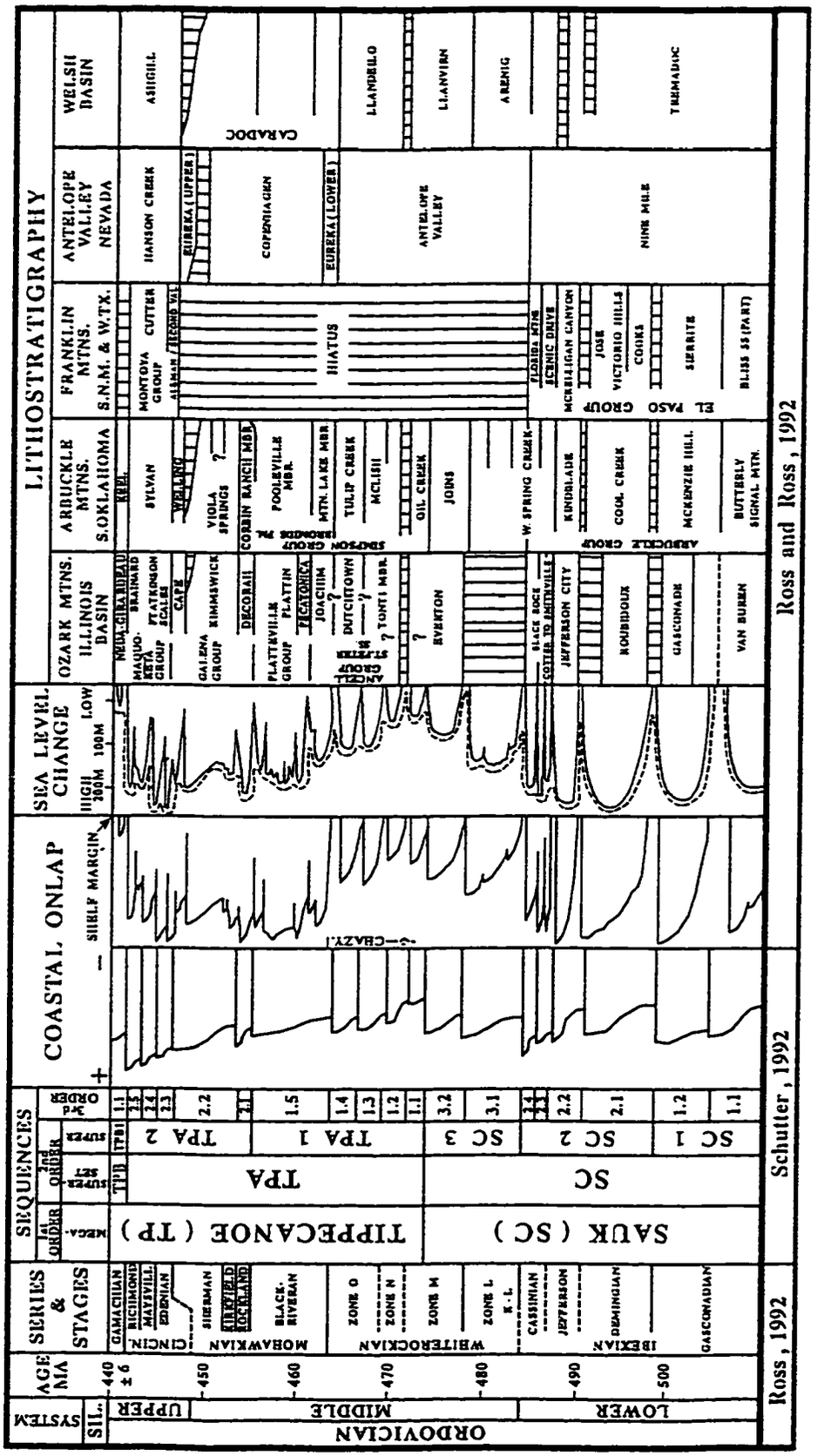
FIGURE 7: ORDOVICIAN COASTAL ONLAP CURVES FOR NORTH AMERICA



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A relative sea-level change is an apparent variation in the absolute sea level elevation with respect to the land surface (Vail and others, 1977a). Although the position of the shoreline on a subsiding platform is dependent on sea level at a given time, the direction in which the shoreline is moving is dependent on the rate of sea level change and the rate of subsidence at that location (Pitman and Golovchenko, 1991). A relative sea-level rise does not necessarily imply a change in paleobathymmetry, it only indicates that the paleoshoreline migrated toward the basin margin and that during a relative sea-level fall the shoreline migrated basinward.

The coastal onlap curves for the Middle Ordovician (Figure 7) show that for much of the early and medial Whiterockian relative sea level was falling. This trend that reversed during the late Whiterockian and subsequently, relative sea level continued to rise until the end of the Ordovician. Within these overall trends are depositional cycles bounded by surfaces of nondeposition, or minor erosional discontinuities.

Relative sea-level variations are the result of a complex interaction of climatic and tectonic processes, and the magnitude and origin of sea-level changes during the Ordovician remains controversial. Spjeldnaes (1961) proposed the first marine transgressive-regressive curve, now recognized as a coastal onlap curve, for the Ordovician. He attributed the observed deviations to climatic variation, associated with glaciations, and noted a crude correlation of sea level changes with orogenic activity. Spjeldnaes observed that both climatic and tectonic factors played a role in Ordovician sea-level changes; which of these factors predominated is still an area of considerable controversy.

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Subsequently, Vail and others (1977b) and Ross and Ross (1992) have proposed Ordovician eustatic sea-level curves for which global sea-level changes were driven by climatic variations. The similar timing of these short term "events" on carbonate platforms in the Virgina-Tennessee Appalachians, southern Canadian Rockies and Great Basin suggest a eustatic control (Bond and others, 1989; Kominz, 1995). Regionally extensive, Ordovician glacial deposits from Gondwanaland (West and South Africa, South America, southern Europe and the Middle East) provide indirect support for glacio-eustatic sea-level changes during the Ordovician (Bjorlykke, 1985; Hiller, 1992; Powell and others, 1994; Legrand, 1995).

Arguments against climatically controlled, eustatic Ordovician sea level variations are fourfold. First, the ages of Ordovician glacial deposits are poorly constrained (Ross, 1984), but they appear to be primarily lower-Lower and Upper Ordovician/Silurian in age. Bjorlykke (1985) argued that the unconformities in Scandinavia coeval with these glacial deposits are, for the most part, tectonic in origin and that there is little evidence for glacio-eustatic sea-level changes in excess of 20 m for most of the Ordovician.

Second, widespread, meter-scale cyclicity observed in Ordovician peritidal carbonates (i. e., Read and Goldhammer, 1988) have been attributed to eustatic sea level variations related to extraorbital-controlled climatic variations (Milankovitch cycles) (Ross and Ross, 1992). Drummond and Wilkinson (1993) have demonstrated that these peritidal depositional cycles exhibit thickness-frequency distributions that are exponential and therefore, the preservation of carbonate cycles in the geologic record is aperiodic and does not provide evidence for periodic phenomena (Milankovitch cycles).

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Third, the most significant Ordovician sea-level minima shown on the eustatic sea level curves of Vail and others (1977a) and Ross and Ross (1992) is coeval with the regionally extensive, post-Knox disconformity (early-Middle Ordovician). Several workers (i. e., Lash, 1988; Knight and others, 1991) have attributed the development of the post-Knox disconformity in eastern North America to tectonic processes.

Lastly, Donovan and Jones (1979) reviewed alternative mechanisms for isochronous eustatic sea-level changes, and concluded that variations in the volume of oceanic ridges, related to the rate of sea-floor spreading may be a possible mechanism for eustatic sea level variations. If the rate of sea floor spreading increased, the isostatic adjustment of the less dense and more buoyant, warm oceanic crust would have decreased the volume of oceanic basins and resulted in a relative sea level rise on the comparatively low-relief, bounding continental margins (Flemming and Roberts, 1973). Conversely, decreased rates of spreading would result in the isostatic adjustment of the less buoyant, cooler, denser oceanic crust and a relative sea-level fall (Flemming and Roberts, 1973). Chen (1988) attributed the minor fluctuations in Middle Ordovician sea-level observed on the Yangtze and Sino-Korean platforms to variations in rates of seafloor spreading.

However, as Ross (1984) observed, evidence for an isochronous, global sea-level fall produced either by global climatic variations, or changes in the volume of mid-oceanic ridges, coeval with the Lower\Middle Ordovician disconformity is lacking in areas outside of North America. Jaanusson (1972) studied that Middle Ordovician discontinuities in Baltoscandia (northwest Europe) are only locally developed as a result of differential isostatic movements of the Baltic craton. Chen (1991) showed that sea level tended to rise continuously from the mid-Lower through the Upper Ordovician, and

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that only minor variations in paleo-sea level are observed on the Yangtse and Sino-Korean platforms (eastern Asia). Nicolls and others (1988) studied a similar trend for Ordovician relative sea-level changes for the Larapintine Seaway that bisected the Australian plate during the Ordovician.

In contrast to the glacio-eustatic model, Sloss (1991) has offered an alternative view that vertical adjustments of the earth's crust, in response to regional stress fields and/or secular variations in radial heat flow, are the primary mechanisms for observed sea-level variations in cratonic settings. Preservation of sedimentary cover in cratonic settings is episodic; only when the rate of cratonic basin subsidence exceeds the rate of sedimentation is an apparent sea-level rise preserved in the sedimentary record. Conversely, when subsidence slows, a basin-full condition rapidly develops, the paleoshoreline progrades basinward and an apparent sea-level fall is preserved in the stratigraphic record. Consequently, Sloss (1991, 1992) has argued that rates of basin subsidence have greater influence on the sedimentary record of relative sea-level changes then glacio-eustatic processes. Based on their analysis of continental flooding through time, Algeo and Seslavinsky (1995) concur that the sedimentary record for Laurentia exhibits almost no eustatic component for relative sea level changes.

Cloetingh (1988) and Cathles and Hallam (1991) proposed that some smaller scale relative sea-level changes (3rd-order cycles) result from variations in in-plane stress acting on a lithospheric plate. The interaction of in-plane stress and sediment loading may result in negative deflection of the lithosphere (Cloetingh, 1988), and/or in-plane stress may reduce the effective viscosity of the lower plate causing an isostatic adjustment and variation in continental freeboard (Cathles and Hallam, 1991).

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Algeo and Wilkinson (1991) suggest that irrespective of the mechanism, the magnitude of a relative sea-level change is controlled by continental hypsometries, the distribution of area with respect to elevation (i.e., sea level) for a topographic surface, and the gradient of that surface. Coastal hypsometries vary with tectonic setting and age of the plate margin (Algeo and Wilkinson, 1991). Hence, active and transform margins have high gradients, and older passive margins have lower gradients. Areas of lower coastal gradients are more "floodable" than areas of higher gradients because small variations in sea level will inundate, or expose, larger continental areas. Algeo and Wilkinson (1991) observed that for passive margins, the lowest coastal gradient coincides with the period at which the continental crust of a passive margin has cooled significantly. Therefore, the transgressions preserved in the sedimentary record on the craton are a function of the extended thermal history of the margin.

Hallam (1977) and Seslavinsky (1991) also have observed that secular changes in the marine inundation of cratons are in phase with tectonic cycles. Each tectonic cycle relates to the breakup and assembly of a super continent and contains four phases: fragmentation (rifting), maximum dispersal (drift), assembly (convergence), and supercontinent stasis (Worsley and others, 1987). Paleogeographically, the period of passive margin cooling is associated with the transition from the fragmentation phase to the continental dispersal phase. The Middle Ordovician is a time during which this transition occurred after the 626-555 myr. break up of a Proterozoic super continent (Worsley and others, 1987). During the continental dispersal phase, continental freeboard decreases as the passive margin cools and the magnitude of sea level change required to flood the continental interior decreases (Harrison and others, 1981).

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It should be evident from the above discussion that although the importance of variations in relative sea level during the Ordovician is widely recognized, the mechanisms involved and their comparative importance for controlling relative sea-level are still controversial and incompletely understood. As a result, for the purposes of this study a change in "sea-level" is assumed to be relative change and the phrase is used solely as a descriptive term indicating the direction of movement of the paleoshoreline without a genetic implication.

LITHOSTRATIGRAPHY

Any discussion of regional depositional patterns requires that the temporal and lateral relationships of stratigraphic units be demonstrated. Middle Ordovician lithostratigraphic units in the Illinois Basin are based on outcrop studies of the basin-bounding Wisconsin Arch, Jessamine Dome, Ozark Dome and Nashville Dome. As a result, for both geological and historical reasons, a unique stratigraphic nomenclature has been developed in each outcrop area, and hybrid stratigraphic classifications are used in the subsurface.

In the following discussion the Middle Ordovician stratigraphy of the Illinois Basin will be developed by: (1) providing a brief summary of the lithic character and the historical usage of each unit, (2) describing the constituent lithofacies of these units, (3) iscussing the lateral relationships of these units based upon the conodont biostratigraphic framework developed in the course of this study, and (3) proposing a revision of stratigraphic nomenclature based on genetic stratigraphic concepts.

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Post-Knox Unconformity

The post-Knox unconformity is a regional hiatus that separates the Lower and Middle Ordovician throughout much of eastern North America (Mussman and others, 1987). The paleotopographic erosional surface developed during this hiatus is in the preserved stratigraphic record as a regionally extensive, unconformable contact between Lower and Middle Ordovician rock. The lithic character of the paleo-surface bedrock, and the relief developed on the paleo-surface, strongly influenced the volume and character of detrital sediments deposited, and the lateral distribution of depositional conditions in the early-Middle Ordovician. As a result, the development of the surface can be inferred by the age and lithic character of the bounding stratigraphic units, and/or the relief and gradient of the surface itself.

The base of the Middle Ordovician becomes older basinward from early Mohawkian in the Upper Mississippi Valley (Sweet, 1984; 1987) to late Whiterockian or early Mohawkian in north-central Illinois (Shaw, 1990), to early Whiterockian in southeastern Illinois (Norby and others, 1986). In southernmost Illinois and western Kentucky an additional 200-400 ft. (60-120 m) of Everton Dolomite may be present in the subsurface. Although this suggests that a more complete early-Whiterockian section is present in the central portion of the basin and that deposition may have been locally uninterrupted (Collinson and others, 1988), the recognition of karstified surface within the early-Medial Whiterockian succession of the Black Warrior Basin (Dwyer, 1997), which was more proximal to the Middle Ordovician paleo-margin, suggests that it is unlikely deposition was uninterrupted in the Illinois Basin.

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Beneath the unconformity, progressively younger strata are preserved basinward. In southern Wisconsin and northern Illinois the siliciclastic-dominated Ancell Group (Middle Ordovician) overlies carbonates of the Prairie du Chien Group (Lower Ordovician), Potosi and Eminence dolomites (Upper Cambrian to Lower Ordovician), or siliciclastics of the Potsdam supergroup (Cambrian)(Figure 8) (Willman and Buschbach, 1975; Mai and Dott, 1985).

In Iowa, the Ancell Group (Middle Ordovician) overlies the Shakopee Dolomite (upper-Lower Ordovician) in the south-east; the Oneota Dolomite (lower-Lower Ordovician) in east-central; and Cambrian sandstones in the northeast (Witzke, 1985). In northern and eastern Indiana the Ancell Group overlies the Oneota Dolomite, and it overlies the Shakopee Dolomite in west-central and southwest Indiana (Droste and Patton, 1985; Ethington and others, 1986). Drilling records on file at the Indiana Geological Survey indicate that locally the Ancell overlies units as old as the Potosi Dolomite (Cambrian) in northwestern Indiana.

In western Ohio, Middle Ordovician rocks overlie the Copper Ridge Dolomite (Coogan and Maki, 1988); the Copper Ridge contains a lower-Lower Ordovician conodont fauna similar to that of the Oneota Dolomite. Coogan and Maki (1988) showed that progressively older strata are exposed eastward on the post-Knox paleosurface.

Elsewhere in the Illinois Basin region the unconformity is underlain by the Shakopee Dolomite and its lateral equivalents. The age of the uppermost Shakopee decreases basinward from early-late Canadian in northern Illinois (Shaw, 1987) to latest Canadian in southwestern Illinois (Shaw and others, 1988). Reworked Lower Ordovician conodonts recovered from the basal St. Peter Sandstone (Readstown and Kress Members)

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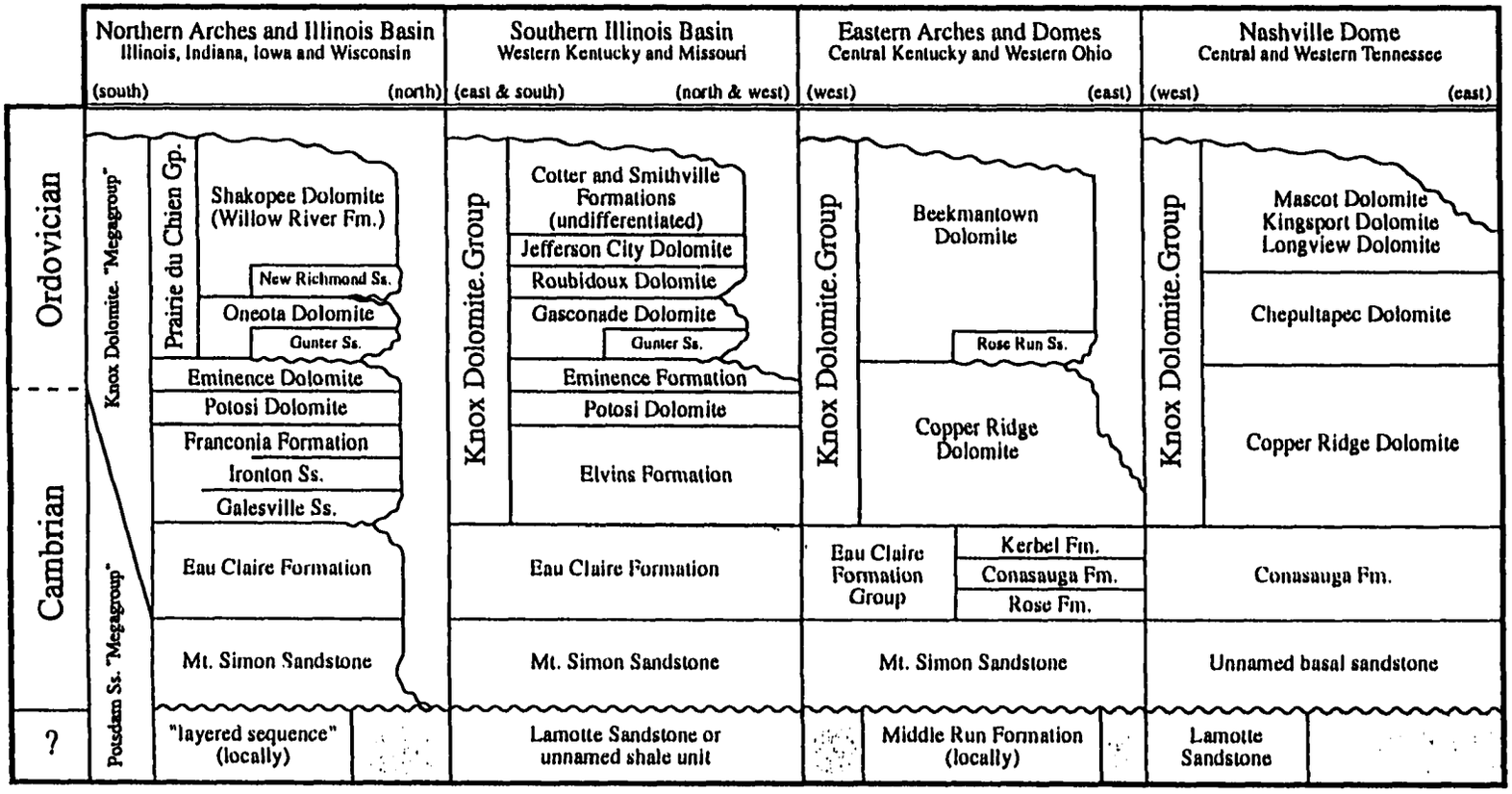
Figure 8: Sub-Ancell Group lithostratigraphic units in the Illinois Basin region.



(Milici, 1973; Willman and others, 1975; Janssens, 1973; Shaver and others, COSUNA, 1985; Sargent, 1990)

indicate that younger Shakopee strata were removed in northern Illinois and southern Wisconsin prior to deposition of the St. Peter Sandstone (Grether and Clark, 1982; Shaw, 1987).

Within the study area in southeastern Missouri, the Ancell Group overlies the Smithville (Figure 9) or Cotter dolomites (Shakopee Dolomite equivalents), but it overlies progressively older units to the west and northwest toward the Southeast Nebraska Arch (McCracken and McCracken, 1965; Ludvigson, 1985; Thompson, 1991). The lower Ordovician section shows progressive thinning to the northwest due to pre-Ancell erosion (McQueen and Greene, 1938; Thompson, 1991).

Subcrop maps of the post-Knox surface are unavailable for Kentucky; however, Coogan and Maki's (1988) geologic map of the post-Knox surface in Ohio suggests the development of a southward plunging antiform (Coogan and Maki, 1988, Figure 3) with increasingly younger strata preserved southward. Conodont data (this study) from Cumberland Co., south-central Kentucky indicate the age of the upper Knox Group is uppermost Lower Ordovician (upper *Oepikodus communis* Biozone). Derby (in Ross and others, 1982) studied the silicified brachiopods of probable uppermost Lower Ordovician age in well cuttings from the uppermost Knox Group in Fulton Co., Ky.

Relief on the disconformity is greatest near the basin margins and progressively decreases basinward. Relief progressively decreases southward from a maximum of 1,700 ft. (518 m), with a local average of 300-400 ft. (92-122 m) in southern Wisconsin (Mai and Dott, 1985), to a maximum of 400 ft. (122 m), with an average of 200 ft. (61 m) in northern Illinois (Buschbach, 1961; 1964), to an average of less than 100 ft. (30.5 m) of relief in central Illinois.

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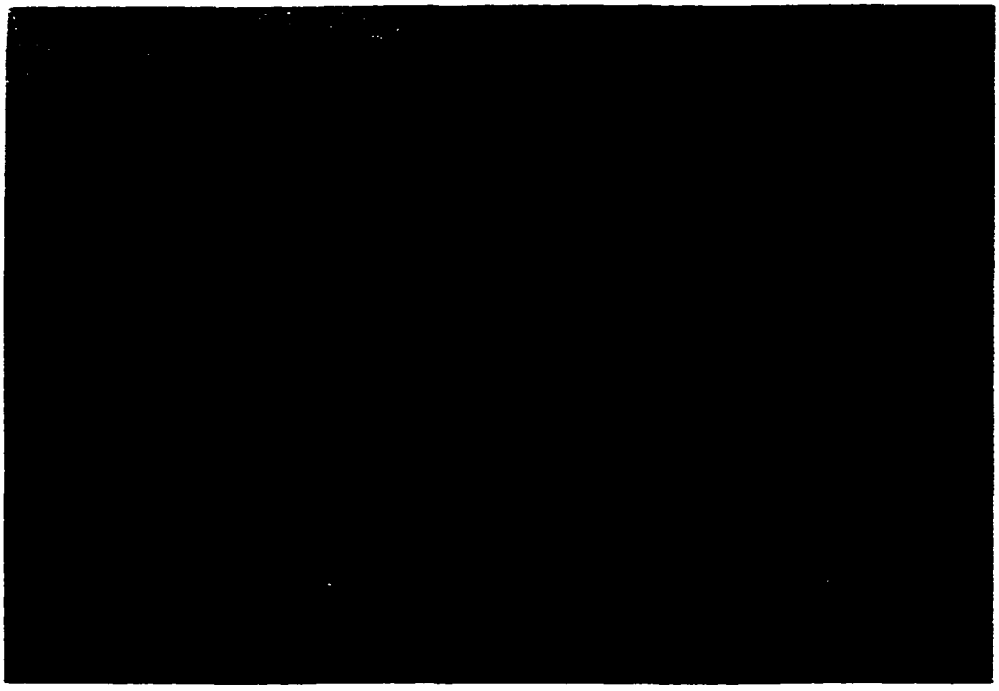

Figure 9: Road cut exposure of karstified Smithville Dolomite along U. S. Interstate 55 in southeast Missouri. Crumbly character is due to extensive development of vuggy porosity. Vegetated re-entrant just above base is developed due to differential erosion of argillaceous dissolution residuum. Conodonts from top of Smithville and nearby locality indicate an age of latest Canadian to earliest Whiterockian (upper Lower-Ordovician to lowermost Middle Ordovician).

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Up to 350 ft. (107 m) of Prairie du Chien Group strata are removed locally by pre-St. Peter erosion in eastern Iowa (Witzke, 1985). Locally, the St. Peter Sandstone thickens from an average of 30-60 ft. (9-18 m) to over 250 ft. (75 m); this variation is attributed to development of a high relief, karstic, post-Prairie du Chien Group paleosurface (Witzke, 1985).

In eastern Indiana and northern Kentucky the relief on the paleotopographic surface may exceed 200 ft. (61 m), but it averages 50-100 ft. (15-30.5 m) (Schmidt and Warner, 1964; Wolcott and others, 1972; Keller and Abdulkareem, 1980). Up to 500 ft. (152 m) of relief is present on the post-Knox Group erosional surface in north-central Tennessee (Stearns and Reesman, 1986), and up to 400 ft. (122 m) in south-central Kentucky (Gooding, 1992). In central Ohio, erosional relief on the surface averages 100-150 ft. (30-46 m)(Dolly and Busch, 1972).

Erosion of underlying strata provided a source for siliciclastic sediments during Ancell deposition (Mai and Dott, 1985). As a consequence, lithologies exposed on the paleoerosional surface control the volume and character of siliciclastic sediments during the Middle Ordovician deposition. The Lower Ordovician carbonates, 15-40% non-carbonate content (McCracken, 1952; Stevenson and others, 1975), have a considerably lower siliciclastic content then the Cambrian Potsdam Supergroup (>90% siliciclastics).

The topographic gradient of the paleoerosional surface is very low. The present regional gradient of the post-Sauk surface is 1-4 ft./mile (<1 m/km) in central Kentucky (Wolcott and others, 1972) and 18-25 ft./mile (5-8 m/1 km) in southern Wisconsin (Mai and Dott, 1985). If corrected for post-Ordovician subsidence, by subtracting the regional dip of the Deicke K-bentonite Bed (17.7 ft./mile or 3.35 m/km), an upper-Middle

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Ordovician marker horizon, the gradient of the paleo-erosional surface in Illinois is 8-24 ft./mile (1.5-4.5 m/km) or 0.25°.

Throughout much of the basin, the post-Sauk unconformity is overlain by either the Everton Dolomite or the St. Peter Sandstone; however, along the eastern and southern margins of the basin (eastern Indiana, western Ohio, western Tennessee and central Kentucky) the unconformity is overlain by carbonates of the Wells Creek Dolomite, Dutchtown Limestone or Joachim Dolomite (Stith, 1979; Droste and others, 1982).

Ancell Group

The Ancell Group (Templeton and Willman, 1963) is a disconformity-bounded stratigraphic unit considered to be the basal transgressive-regressive cycle, or subsequence of the Tippecanoe sequence (Witzke and Kolata, 1988). In the Upper Mississippi River Valley, the upper Whiterockian to early Mohawkian portion of the Ancell Group has subsequently been subdivided into four discrete "shallowing-upward" cycles by Witzke (1993). The Ancell is, in part, coeval with the lower High Bridge Group in central Kentucky, and the Stones River Group in central and western Tennessee. The stratigraphic nomenclature of the Ancell Group as currently constituted is shown in Figure 10.

Calvert (1963) proposed extending the term Simpson Group, defined on strata coeval with the Ancell exposed in Oklahoma, to the Illinois Basin. Templeton and Willman (1963) rejected this concept based on the difficulty of correlating the Simpson Group units across the Ozark Dome and Southeast Nebraska Arch where coeval rocks are

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Figure 10: Lithostratigraphic units of the Ancell, lower Platteville and lower Plattin groups.

Illinois Basin				Kankakee and Wisconsin Arches			Southeast Missouri		
Templeton and Willman, 1963; Willman and others, 1975						Willman and Kolata, 1978	Thompson, 1991		
"Mega-group"	Group	Formation	Member	Formation	Member		Group	Formation	Member
Ottawa Limestone	Platteville Group	Mifflin Formation	Briton	Mifflin Formation	Briton	Recommended members be abandoned	Plattin Group	Beckett Limestone	undifferentiated
			Hazelwood		Hazelwood			Bloomsdale Limestone	Establishment
			Establishment		Establishment				Brickeye
			Brickeye		Brickeye				Blomeyer
			Blomeyer		Blomeyer				
		Pecatonica Formation	Ogelsby	Pecatonica Formation	Ogelsby	Ogelsby	Ancell Group	Pecatonica Formation	Medusa
			Medusa		Medusa	Medusa			
			New Glarus		New Glarus	New Glarus			
			Dane		Dane	Dane			
			Chana		Chana	Chana			
			Hennepin		Hennepin	Hennepin			
	Ancelle Group	Joachim Dolomite	Metz	Glenwood Formation	Nokomis Ss. Harmony Hill	not studied		Joachim Dolomite	upper
			Matson		Loughridge				middle
			Defiance		Daysville				lower
			Boles	St. Peter Sandstone	Kingdom				
			Augusta		Starved Rock				
			Abernathy						
		Dutchtown Formation	Sharpsboro					Dutchtown Formation	Sharpboro
			Gordonville						Gordonville
		St. Peter Sandstone	Starved Rock					St. Peter Sandstone	Starved Rock
			Tonti		Tonti				Tonti
					Kress				Kress
Knox Dolomite	un-assigned	Everton Dolomite	undifferentiated	Absent due to post-Lower Ordovician erosion and/or nondeposition				Everton Dolomite	upper dolo.
									lower ss.
	Prairie du Chien Gp.	Shakopee Dolomite		undifferentiated		not studied	Knox. Gp	Cotter-Smithville Dolomites	undifferentiated

absent due to post-Ordovician erosion and/or nondeposition. Also, as observed by Leatherock (1945) and Suhm (1995), the Simpson includes rocks correlative with the Plattin and Platteville groups of the Illinois Basin region; the Plattin and Platteville groups overlie the Ancell in the Illinois Basin and, therefore, the Simpson is not wholly correlative with the Ancell. The abundance of quartz sand in the Ancell differentiates it from the coeval carbonate-dominated lower High Bridge Group of Kentucky, Black River Group of Ohio, (Templeton and Willman, 1963; Thompson, 1991).

Shaw and Schreiber (1991) recommended redefinition of the Ancell Group to include all strata overlying the regional Sauk-Tippecanoe unconformity, and those underlying the intraregional sub-Platteville disconformity. This definition expanded the concept of the Ancell Group to include the Everton Dolomite, which was excluded from the Ancell by Templeton and Willman (1963). Based upon the Everton's stratigraphic position overlying the post-Knox disconformity and its similar lithic character to the overlying units of the Ancell Group, the Everton does not appear to be genetically related to the Knox carbonates of the Sauk sequence. Although the Everton is separated from the overlying St. Peter Sandstone by a regional discontinuity, it is the author's opinion that the Everton is genetically related to the basal Middle Ordovician sequence and should be included in the Ancell Group.

The inclusion of the Everton Dolomite in the Ancell Group would also resolve the inconsistent usage in the Illinois Basin of the term Knox Group. Based on its dolostone content, Willman and others (1975) included the Everton as the uppermost unit of the Knox Dolomite Megagroup. Swann and Willman (1961) proposed the term "megagroup" to denote a lithostratigraphic unit of greater rank than group. Conceptually, it was

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proposed that a megagroup should have genetic significance and it should be reflective of a "major geologic event". The term supergroup is of equal rank and is the accepted term under the North American Stratigraphic Code (1983).

The definition of the Knox Dolomite Megagroup is based on the Knox Group, Knox Co., eastern Tennessee (Swann and Willman, 1961). In its type area, the Knox Group is defined as underlying the regional post-Knox unconformity (Milici, 1973). The Everton overlies this unconformity. Additionally, if the Knox Dolomite Megagroup is to be used in accordance with the intended use of the rank "megagroup", meaning an event related unit, then the Everton should be excluded from the Knox because the Everton is separated from the Knox by a regional disconformity (i.e., a "major event").

It should be noted that Derby and others (1991) proposed that the post-Oil Creek Formation discontinuity, correlative with the Everton Dolomite/St. Peter Sandstone contact, is the basal bounding discontinuity of the Tippecanoe sequence. However, Ross and Ethington (1992) show the post-Knox discontinuity to be of significantly greater duration than the post-Everton discontinuity. Additionally, faunal constituents of the Everton in northerneast Arkansas, indicative of warm, shallow semi-restricted marine conditions, have closer affinities to those found in the overlying Dutchtown Formation, and are only distantly related to those found in the underlying units. Repetski (1992; and personal. communication, 1992) and Derby (in Ross and others, 1981) showed that conodonts and brachiopods from the underlying uppermost Knox Group in western Tennessee and Kentucky are indicative of cooler and/or deeper water environments. Contrasting faunal constituents are thought to be a characteristic of sequence boundaries (Vail and others, 1977). Therefore, based on the magnitude of the post-Knox

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disconformity and faunal considerations, it is proposed herein that the Sauk-Tippecanoe sequence boundary should be placed at the base of the Everton Dolomite.

The Ancell Group is subdivided into four formations, in ascending order they are: Everton Dolomite, St. Peter Sandstone, Dutchtown Formation and Joachim Dolomite. In northern Illinois and Wisconsin, the carbonate-bearing Everton, Dutchtown and Joachim are absent and the St. Peter Sandstone is overlain by the clastic-dominated Glenwood Formation.

Everton Dolostone:

In the outcrop area in southeast Missouri, the Everton is subdivided into a lower, fine-grain quartz arenite and an upper, sandy dolostone with variable amounts of sandstone, shale and limestone (Thompson, 1991). Anhydrite and limestone are prevalent in the subsurface of southern Illinois and western Kentucky. Reworked chert, typically chert-replaced oolitic carbonate, and dolomite clasts are common above the unconformable contact with the underlying Lower Ordovician carbonates (Figure 11; Weller and St. Clair, 1928).

In southeast Missouri, the lower contact with the underlying Knox Group is clearly disconformable. However in western Kentucky, toward the Middle Ordovician depocenter, evidence for a disconformity is equivocal and the succession may be conformable. Paleontological data from the upper Everton indicate the magnitude of this hiatus decreases basinward (Norby and others, 1986; Shaw and others, 1988). In the southernmost Illinois and western Kentucky, the absence of distinctive changes in lithology at the contact between the Everton and the Knox Group, and the dramatic

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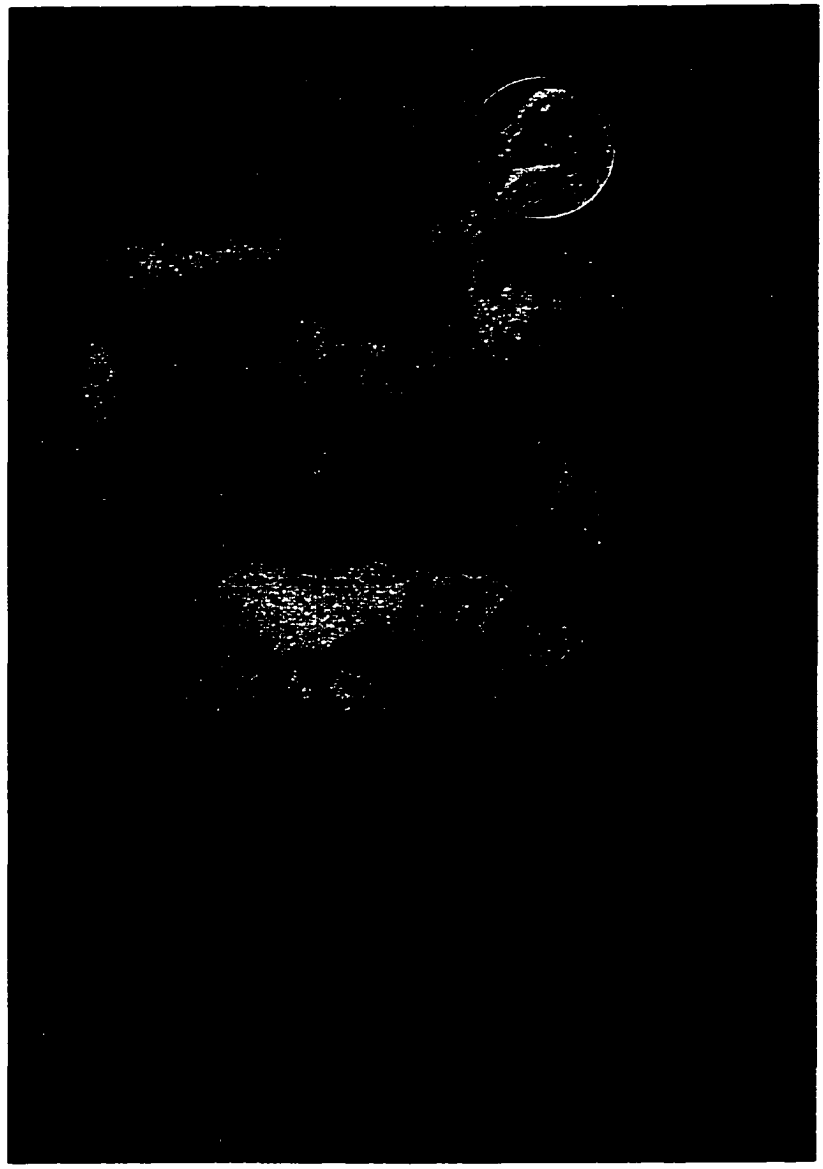

Figure 11: Fused chert residuum at base of Everton Dolomite, 3377 ft. (1029 m) , Illinois Power Co., King #1, Montgomery Co., Illinois. White to light-gray microcrystalline chert and green-gray argillaceous fraction are derived from underlying green-gray, siliceous argillaceous dolomudstones of the Shakopee Dolomite. Core diameter is 4-inches (10 cm).

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thickening of the Everton basinward further suggests that the sequence may be locally conformable.

In southeast Missouri the Everton is 5-85 ft. (1.5-26 m) thick, but it thickens rapidly basinward to greater than 400 ft. (120 m) in southern Illinois (Sargent, in Kolata, 1991). The carbonate lithofacies of the Everton are limited to southern Illinois, southwestern Indiana, western Kentucky and southeastern Missouri (Collinson and others, 1988). In St. Genevieve Co., southeast Missouri, carbonate lithofacies rarely exceed 20 ft. (6.1 m) in thickness and make up less than 20% of the unit (Weller and St. Clair, 1928).

Koenig (1966) studied Everton Dolomite present as far north as Audrain and Ralls counties, northeast Missouri, and Pike County, west-central Illinois. Conodont collections from carbonates immediately underlying the St. Peter Sandstone in Lincoln Co., Missouri, and the subsurface of Pike Co., Illinois, are of Lower Ordovician age and therefore, demonstrate that, at least locally, units older than the Everton disconformably underlie the St. Peter Sandstone in this area. This does not preclude the possibility that Everton strata may be preserved locally within paleotopographic lows.

Sandstones in the Everton Dolomite are difficult to differentiate from those that make up the St. Peter Sandstone and locally, sandstones coeval with the Everton Dolomite may be assigned to the lower St. Peter Sandstone (Rexroad and others, 1982; Droste and Shaver, 1983; Thompson, 1991; Treworgy and Sargent, 1992).

Weller and St. Clair (1928) differentiated the lower Everton Dolomite sandstones from those of the St. Peter Sandstone based on the slightly finer-grain character, thin-bedding and iron content of the lower Everton. In southeastern Missouri, the lower

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Everton sands tend to weather red-orange due to the presence of up to 0.5% iron. Typically, the St. Peter contains less than 0.1% iron and weathers from white to light-gray to light-yellow gray. Caution should be used in using ferroan content and/or color to differentiate these sandstones in outcrop because the St. Peter is locally stained red-orange due to weathering of the overlying Joachim Dolomite (Weller and St. Clair, 1928).

Conodonts have been studied from the Everton Dolomite by Golden (1968), Rexroad and others (1982), and Norby and others (1986). Ostracods and pelecypods are locally abundant in the upper carbonates.

Post-Everton Disconformity:

The upper contact with the overlying St. Peter Sandstone is thought to be disconformable (Templeton and Willman, 1963; Thompson, 1991). However, in the subsurface the contact appears transitional because of an increasing abundance of quartz arenite in the upper Everton, which is in turn overlain by quartz arenite of the St. Peter Sandstone (Shaw and Schreiber, 1991).

In northern Arkansas, the contact of the Everton and overlying St. Peter Sandstone is thought to be disconformable because of: (1) the "wavy" character of the St. Peter-Everton contact (Figure 12; see Glick and Frezon, 1956); and (2) 4-10 ft. (1.3-3.3 m) of relief on the top of the Everton developed locally (Glick and Frezon, 1956; Suhm, 1974); and (3) locally developed karst dissolution features within the Everton carbonates (Garrett, 1969).

In the Illinois Basin, evidence for a disconformity includes: (1) local angular relationships in the subsurface and outcrop (Templeton and Willman, 1963, 1992; this report, Figure 13) and interpreted northward truncation of upper dolomite unit of the

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Figure 12: Outcrop of Everton Dolomite, southbound lane of Interstate 55, Bloomsdale North section, southeast Missouri. Note "wavy" folds in lower half of exposure that decrease in relief up-section. Upper beds in outcrop are nearly flat lying.

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Figure 13: Angular truncation of gently dipping, medium-bedded dolostone beds of the upper Everton Formation by massive, *Skolithos*-bearing, St. Peter Sandstone, northbound lane of U. S. Interstate 55, Crystal City, southeast Missouri.

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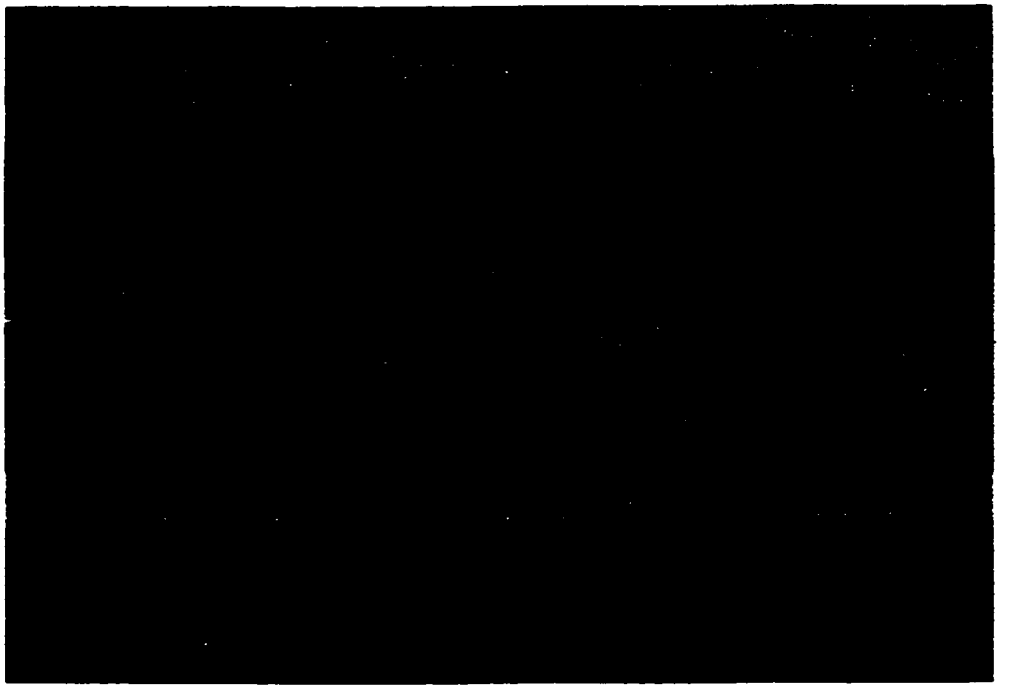

Figure 14: Thick succession of St. Peter Sandstone quartz arenites (white) overlying Everton Dolomite (gray-brown) in road cut along the northbound lane of Interestate 55, Bloomsdale North section, southeast Missouri. Sharp, nearly planar contact is demarcated by vegetated bench above Everton. Note irregular bedding in Everton and planar, massive bedding of lower St. Peter.

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Everton (Dapples, 1955), (2) sharp contact between the Everton Dolomite and St. Peter Sandstone (Figure 14)(Weller and St. Clair, 1928), (3) the highly variable thickness and lithic character of the Everton (Weller and St. Clair, 1928), and (4) a red-clay residuum, interpreted as a paleosol, identified at the contact of the Everton and St. Peter near Dutchtown, Mo. (Templeton and Willman, 1963).

Similar features can be developed on a conformable surface due to: carbonate dissolution along the contact by groundwater waters; facies relationships in a inner-shelf, mixed siliciclastic-carbonate environment; differential infill and compaction related to relief developed on the post-Knox disconformity; and penecontemporaneous karst due to dissolution of evaporites.

In outcrop, collapsed bedding and soft-sediment slumps demonstrate the occurrence of pre-lithification dissolution collapse. Dissolution along the St. Peter-Everton contact is evident in subsurface where stylobreccia and possible mudstone stylolaminites are locally developed. These diagenetic dissolution features may be related to groundwater influx through the St. Peter Sandstone that is thought to have occurred throughout the Phanerozoic. Such post-Ordovician dissolution features could be interpreted as paleokarst features, paleo-erosional surfaces and/or paleosols, and as evidence for a disconformity.

The observed variable thickness and lithic succession of the Everton Dolomite may be due to locally developed facies relationships. Garrettt (1969) demonstrated that there is considerable field evidence for the development of sand-filled channels, but because age relationships between the channel fill, channel-bounding carbonates and overlying St. Peter Sandstone have not been demonstrated, whether the erosion channels

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were penecontemporaneous (i.e., tidal channels) or due to post-Everton erosion is unknown.

Potentially, quartz arenites that infilled tidal channels in Everton Dolomite time may underlie the St. Peter Sandstone. Because the channel arenites of the Everton, for example the Newton Sandstone Member (Garrett, 1969), are similar in lithic character to those in the St. Peter Sandstone, differentiating the Everton and St. Peter quartz arenites is difficult. In addition to the quartz arenites in the Newton Member, it should be noted that the laterally extensive, upper carbonate lithofacies, 50-75 ft. (15-23 m) thick, of the Everton in Arkansas (Jasper Member) locally contains quartz arenites up to 45 ft. (14 m) thick (Suhm, 1974). Garrett (1969) and Suhm (1974) interpreted these sand bodies as infills of migrating tidal channels.

A possible shoreward facies relationship between the clastic facies of the Everton Dolomite and sandstones assigned to the lower St. Peter Sandstone has been suggested in various areas of the Illinois Basin (Weller and St. Clair, 1928; Rexroad and others, 1982; Droste and Shaver, 1983; Treworgy and Sargent, 1992). An abrupt shift in lithologic character due to such a facies relationship may also produce the apparent truncation of carbonate units studied by Dapples (1955) and Thompson (1991). In modern shallow marine environments, such as the Florida Embayment (Early and Goodell, 1968), Belize margin, and the western coast of Egypt (Wali and others, 1993) the carbonate-siliciclastic transitions are abrupt and the transition zone is less than 15 miles (25 km) wide.

The "wavy" irregular character and possible angular relationships of the Everton Dolomite and St. Peter Sandstone contact have been studied by Templeton and Willman (1963) and Thompson (1991). These apparent relationships may be the result of

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differential compaction of the Everton sediments on the post-Knox paleosurface, or they may result from prelithification kartstification due to evaporite dissolution. Dolly and Busch (1972) observed that antiform and synform structures are developed in sediments overlying the post-Knox disconformity due to differential compaction of these sediments over paleotopo-graphic features. Keller and Abdulkareem (1980) reported that in northern Indiana differential compaction of post-Knox sediments over highs on the post-Knox surface may produce antiform structures as high in the section as the Trenton Limestone. The apparent symmetry of these structures, initially thought to be the result of structural deformation, reflect the structurally-controlled development of paleo-topography on the post-Knox surface.

The lithic evidence for an unconformity at the contact is equivocal; however, biostratigraphic studies from outside the study area support a discontinuity at the stratigraphic level of the Everton-St. Peter contact. Sweet (1984) studied a discontinuity at the base of the McLish Formation in Oklahoma and within the Copenhagen Formation of the Great Basin, Nevada. Bauer (1987) studied the conodonts in the lowermost McLish Formation of Oklahoma and concluded that they are not indigenous, but reworked from pre-McLish strata. Based on conodonts (fauna 5-6, upper Whitrockian in age), the McLish and Copenhagen Formations are coeval, in part, with the St. Peter Sandstone and/or Dutchtown Formation of the Illinois Basin (Ethington and Clark, 1982; Sweet, 1984; Bauer, 1987). The discontinuity observed at the base of the geographically separated McLish and Copenhagen Formations suggest the discontinuity may be regionally developed and it is expressed in the Illinois Basin as the post-Everton discontinuity.

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Alberstadt and Repetski (1989, p. 237) studied that the Lower and Middle Ordovician carbonate sequence in the subsurface of the Black Warrior Basin, Monroe Co., Mississippi, does not contain biostratigraphically resolvable discontinuities. A faunal replacement similar to that described by Bauer (1987) occurs at a depth of 1,415 m (4,650 ft.) where species assignable to faunas 5-6 (*Histiodella holodentata* Biozone) abruptly replace those of fauna 4 (*Histiodella sinuosa* Biozone). This interval is lithically correlative with the Everton-St. Peter contact. Dr. J. Repetski (U. S. Geological Survey, personal communication, 1992) has observed a similar faunal replacement associated with a lag deposit in the carbonate sequence present in the Tennessee Valley Authority, Yellow Creek Core, T1S-R10E-Sec. 35, Tishimingo Co., northernmost Mississippi. Dwyer and Repetski (1995) showed that the post-Knox unconformity occurs within a peritidal sequence. Below the unconformity there are lithic indications of subaerial exposure that include solution pipes, internal sedimentation and erosional truncation, and evidence for a transgressive lag above the unconformity (reworked dolostone clasts, rounded and abraided quartz sand, and reworked conodonts).

Craig (1986) noted that the upper Everton contains a typical medial-Whiterockian fauna (fauna 4), and that the basal part of the Joachim of Arkansas, which includes the Dutchtown Formation of Missouri, contains faunal components of faunas 4 and 5. The presence of the conodont species *Phragmodus flexuosus* in the lower Joachim (=Dutchtown of Missouri) restricts its age to late Whiterockian (Craig, 1986).

The available biostratigraphic data support the development of a discontinuity between the Everton Dolomite and the St. Peter Sandstone. A preliminary interpretation would suggest that the discontinuity is coeval with upper conodont fauna 4 (medial-

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Whiterockian) due to a period of erosion and/or nondeposition that lasted less than 2 million years.

St. Peter Sandstone:

The St. Peter Sandstone is a white to light-yellow, fine- to medium-grain, pure quartz arenite the distribution of which extends over much of the North American midcontinent. On the Wisconsin Arch, where its composition has been studied in detail, the St. Peter averages less than 2% feldspar (Dapples, 1955) and less than 1% heavy mineral constituents (Thiel, 1935; Dapples, 1955). Where feldspar is more abundant (up to 5%) it is primarily in the coarse silt-sized fraction. Odom and others (1976) interpreted this silt-sized feldspathic fraction as being detrital material derived from precursor Cambrian feldspathic sands.

The provenance of the St. Peter Sandstone in the Illinois Basin has not ben studied in detail, based on the heavy minerals constituents, Tyler (1936) suggested that the St. Peter Sandstone sediments were derived Precambrian terranes exposed on the Wisconsin Arch, and/or reworked from the underlying Cambrian sandstones. Although undemonstrated, contribution of sediments from Precambrian and Cambrian rocks exposed on the Ozark Dome are likely. Recent isotope studies of the St. Peter in the Michigan Basin suggest multiple provenance areas, including an eastern Grenvellian source area and Precambrian terranes on the Wisconsin Arch (Winter and Johnson, 1993; Winter and Johnson, 1997).

The St. Peter Sandstone is the midcontinent stratigraphic subdivision of the Middle Ordovician quartz arenite lithotope with correlative strata found as far west as southern California, and extends cratonward into southern Canada (Ross and others,

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1989). In the Illinois Basin, the distribution of the St. Peter is limited to the western half of the basin with it's eastern limit extending north-south through western Indiana. Although occupying a similar stratigraphic position, sandstones called St. Peter in areas adjacent to the Cincinnati Arch are not in lateral continuity and differ in lithic character from the St. Peter of the Illinois Basin.

Willman and Templeton (1963) subdivided the St. Peter Sandstone into three members; in ascending order, they are the Kress, Tonti and Starved Rock members.

The **Kress Member** is a basal conglomerate containing pebble- to cobble-size chert and dolostone, derived from the underlying Knox Group, in a matrix of poorly sorted quartz arenite and/or green, waxy clay/siltstone (Willman and Templeton, 1963; Buschbach, 1964). A fused chert residuum is present at the base of the Kress in Missouri (Grover, in Thompson, 1991) and locally in central Illinois at the base of the Everton Dolomite (this study; Figure 15).

Conglomerate lithofacies are apparently only developed in paleotopographic lows on the post-Knox surface, and the Kress Member is more commonly a green-gray, waxy pyritic claystone. Locally, the claystones of the Kress are feldspathized and develop the distinctive brick-red color observable in the Readstown Quarry, southern Wisconsin (Figure 15; Woodard, 1972; Hay and others, 1988).

Because the Kress Member was named for lithologies only known from drill cuttings, Ostrom (1967) proposed the name Readstown for the same lithic unit based on a quarry exposure in southern Wisconsin. Although the Readstown Quarry exposure should be considered the principle reference section for the Kress, the name Kress has priority over Readstown (North American Stratigraphic Code, 1983).

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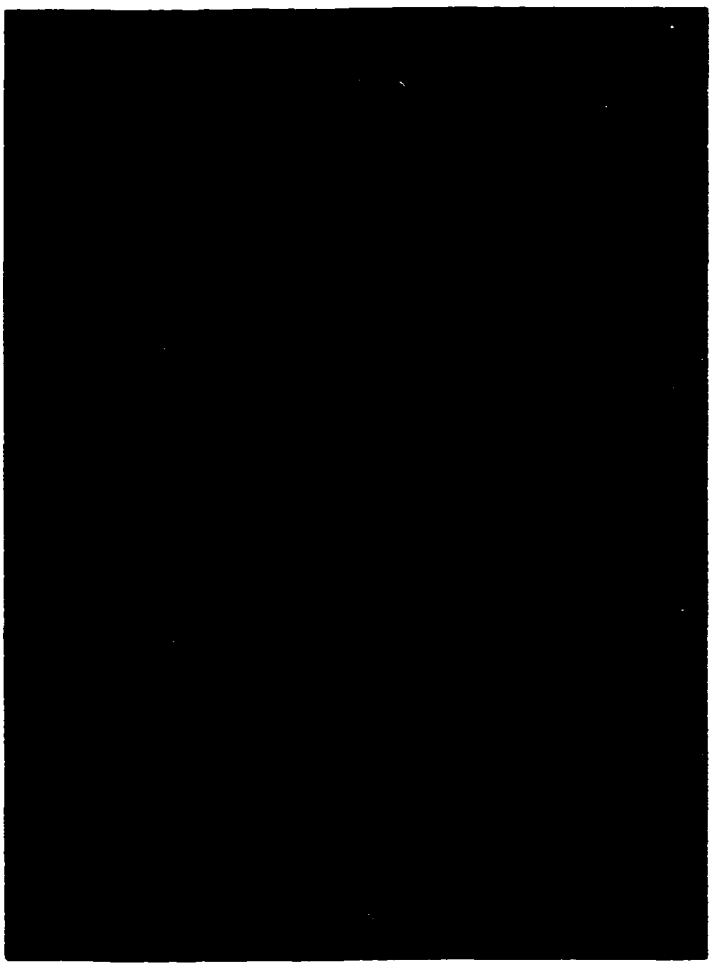

Figure 15: Core photo of conformable contact of Kress Member, predominantly red mudrocks, and quartz arenites of the lower Tonti Sandstone Member, La Salle County, north-central Illinois. Contact is placed at uppermost mudrock occurrence. Red mudrocks are feldspathic and whitish intervals contain abundant sanidine. Core diameter is 2-inches (5 cm).

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Grether and Clark (1982) and Shaw (1987) recovered reworked conodonts from the underlying Prairie du Chien Group from the Kress Member. No indigenous faunas are known.

The **Tonti Member** (Figure 16) is red-to-yellow in outcrop and light-gray to white in the subsurface. It is mostly fine- to medium-grain, moderately to well-sorted, quartz arenite that is thin- to massively bedded and locally cross-stratified. Commonly, the Tonti contains 1-2% detrital feldspar (Nunn, 1986). Locally, minor amounts of dolostone and green shale are present. The Tonti conformably overlies the Kress Member and makes up the bulk of the St. Peter Sandstone.

Conodonts have been studied from the basal sandy dolostones in northern Illinois (Shaw, 1990) and interbedded shales in northwest Iowa (Witzke, 1987). Macrofaunas have been studied from St. Paul, Minnesota, and Kentland, Indiana (Shrock, 1937; Sloan, 1987a).

The **Starved Rock Member** differs from the Tonti in that it is consistently a coarser-grained quartz arenite and lacks even trace amounts (<1%) of feldspar (Nunn,1986).

The Starved Rock Sandstone is distributed in a belt trending northwest from Kansas City, Missouri, to Chicago, Illinois. Although coarse-grain quartz arenites studied from southeastern Missouri have been assigned to the Starved Rock (Templeton and Willman, 1963; Bell and others, 1964), these arenites are from the Dutchtown Formation (this study). Quartz arenites in the Dutchtown differ from those in the Starved Rock Sandstone in that Dutchtown arenites have abundant interstitial carbonate, generally lack cross-stratification, and may contain sparse to abundant biomolds.

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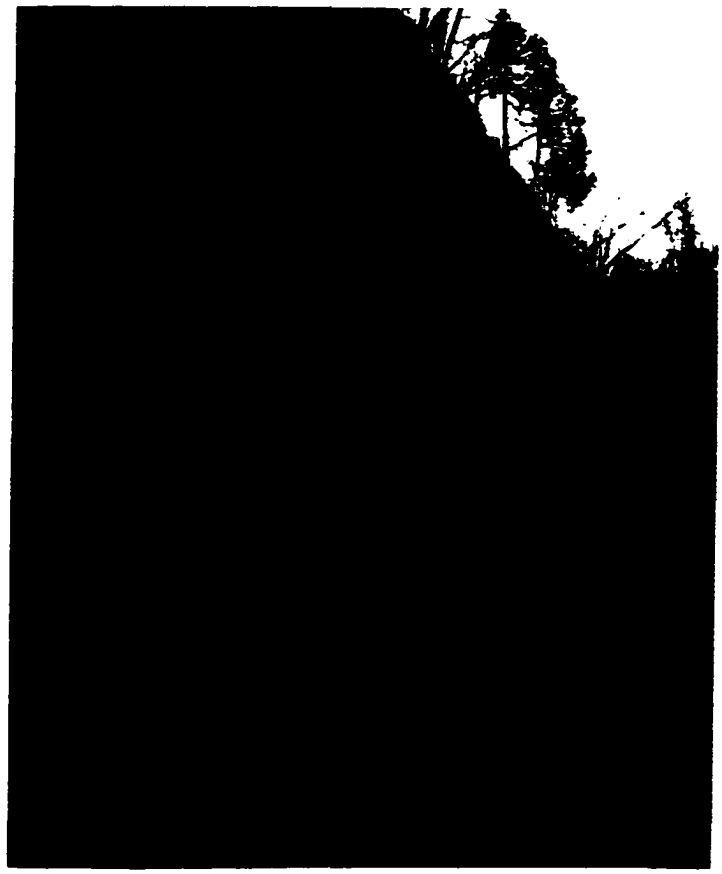

Figure 16: Massive, medium- to thick-bedded quartz arenites of the Tonti Sandstone Member, Tonti Sandstone Member type locality, French Canyon, Starved Rock State Park, La Salle Co., Illinois.

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Glenwood Formation:

The Glenwood Formation consists of light-green-gray, poorly-sorted quartz arenite; green-gray argillaceous dolostone; and blue-green clay/siltstone that have a maximum aggregate thickness of 75 ft. (22.9 m) (Templeton and Willman, 1963; Willman and others, 1975; Fraser, 1976). Locally, ferroan ooid grainstone (Schutter, 1996) and organic-rich mudrocks (Schutter, 1992; Jacobson and others, 1988) are present.

Based on the proportion of clay-, silt- and sand-size fractions, and carbonate content, Templeton and Willman (1963) subdivided the Glenwood into six members, in ascending order they are: Kingdom Sandstone, Loughridge Sandstone, Nokomis Sandstone, Harmony Hill Shale, Henepin Dolomite, and Daysville Dolomite.

Ostrom (1969) and Fraser (1976), based on lithic similarity, reassigned the Hennepin Dolomite Member of the overlying Pecatonica Formation to the Glenwood Formation. Choi and Simo (1997) recognize a ravinement surface at the base of the Glenwood in eastern Wisconsin, and consider it to be genetically related to the Pecatonica Member of the Platteville Formation. This is consistent with Schutter's (1992, 1996) interpretation of the Glenwood as a sediment starved, condensed section associated with a wide-spread transgressive event in the early Mohawkian.

The aggregate thickness of the Glenwood Formation rarely exceeds 20 ft. (6.1 m); however, Willman and Templeton (1963) and Buschbach showed that locally the Daysville and Loughridge members are over 50 ft. (15.2 m) thick in northern Illinois. In Wisconsin, because the unit is thin and dominated by clastic constituents, the Glenwood is considered to be the uppermost member of the St. Peter Sandstone (Mai and Dott, 1985).

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Fraser (1976) observed that these seven members are essentially depositionally-controlled lithofacies within the Glenwood and have limited stratigraphic utility. The resolution afforded by the subdivision of the Glenwood is unwarranted for this study, and, consequently, the members are not identified in this study.

The Glenwood Formation is locally disconformable with the Tonti Member of the St. Peter Sandstone, and locally disconformably overlain by the Platteville Group (Elder, 1936, Thiel, 1937; Templeton and Willman, 1963). As Schutter (1996) observed the disconformities are only of local extent and of minor magnitude.

The Glenwood has a lateral facies relationship with the Starved Rock Sandstone, which typically conformably overlies the Glenwood (Figure 17), and the geographic distribution of the Glenwood is limited to north of the Starved Rock depositonal trend.

Although Glenwood lithologies are present in northwest Indiana (Keller and Abdulkareem, 1980; Dawson and Patton, 1969), they have been reassigned to the Joachim Dolomite (Droste and others, 1982).

Fossils are uncommon in the Glenwood Formation (Schutter, 1996), but conodonts (Stauffer, 1933, 1935; Weber, 1966; Guldenzopf, 1967; Clark, 1971; Votaw, 1972), chitinozoans (Cutler, 1983), and the brachiopod *Lingula* (Elder, 1936) have been studied. Shrock (1937) studied a moderately diverse macrofauna from the Glenwood exposed at the Kentland Quarry, Kentland, Indiana.

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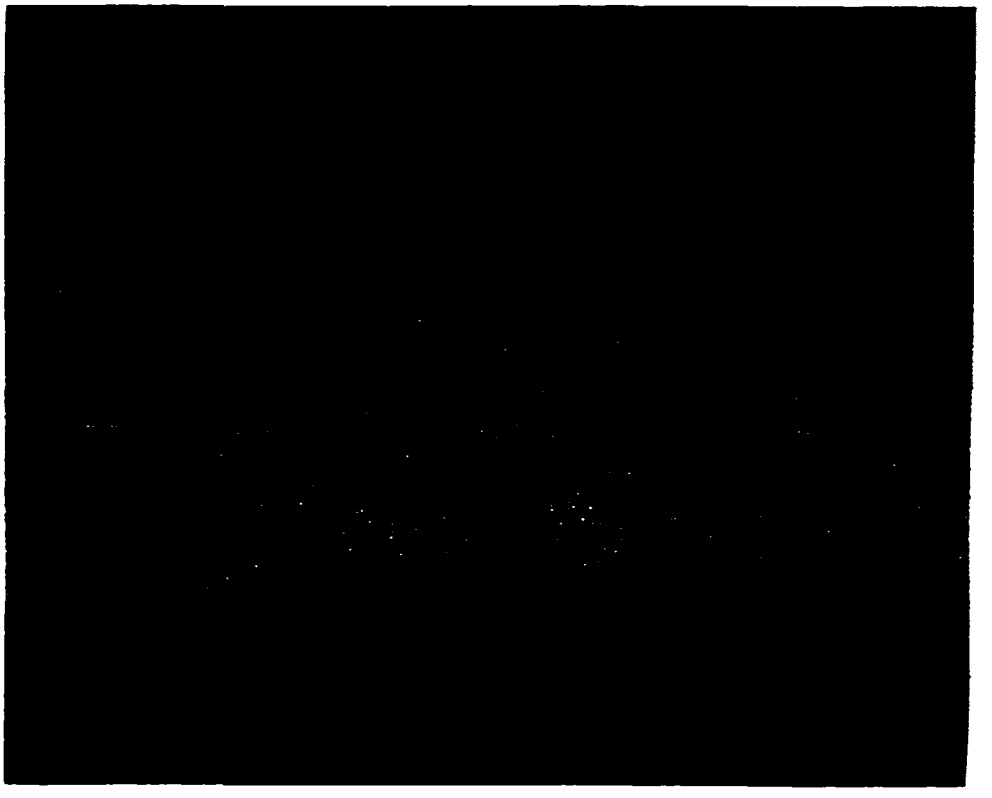

Figure 17: Upper Ancell Group exposed at Clay Hollow section, southwest Wisconsin. Massive Tonti Sandstone Member, with large scale cross-stratification, overlain by thin Glenwood Shale (arrow) which forms re-entrant and is in-turn conformably overlain by medium-bedded, cross-stratified quartz arenties of the Starved Rock Sandstone Member. Rounded, pebble- to cobble-size clasts of Tonti are incorporated in the basal Glenwood.

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Dutchtown Formation:

McQueen (1937) defined the Dutchtown Formation on the basis of dark-brown to black, fossiliferous limestone, dolostone and dolomitic sandstone containing disseminated organic-matter exposed near Cape Girardeau, Missouri. Martin and others(1961) studied that outcrops of Dutchtown are limited to Scott, Cape Girardeau and Perry counties, southeast Missouri, where the formation thins from 170 ft. (51.8 m) in southern Cape Girardeau County to 20 ft. (6.1 m) in northeast Scott County.

McQueen (1937) informally subdivided the Dutchtown into three members based on insoluble residues. Subsequently, Templeton and Willman (1963) subdivided the formation, on the basis of limestone content, an easily recognizable field criteria, into two members: the lower, dolomitic and sandy Gordonville Member and the overlying Sharpsboro Member predominated by limestone. The Sharpsboro Member includes McQueen's upper two members.

The Dutchtown is the most fossiliferous unit in the Ancell Group. McQueen (1937), Cullinson (1938), Martin and others (1961) studied that gastropods, ostracods, pelecypods, bryzoans and cephalopods are locally abundant. Cullinson (1938), Younquist and Cullinson (1946), Repetski (1972), and Klapper and Bergström (1984) have studied on its conodont fauna. Although McQueen (1937) initially studied a Lower Ordovician age for the Dutchtown, the formation is recognized as lower-Middle Ordovician (late Whiterockian) in age (Ross and others, 1981).

The Dutchtown Formation is poorly exposed in its type area, but has been widely identified in the subsurface (McQueen, 1937; Templeton and Willman, 1963; Thompson, 1991). The lithic character of the formation is primarily known from a 15.5 ft. (4.7 m)

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thick exposure located in an abandoned quarry near Dutchtown, Missouri, that serves as its type section (McQueen, 1937; Thompson, 1991). It should be noted that this section represents less than 15% of the total thickness of the Dutchtown in its type area.

A more complete section (21 m) is exposed in road cuts along the northbound lane of U. S. Interstate 55 just north of mile marker 131, west of Perryville, Missouri (Figure 18). This section was identified by Thacker and Satterfield (1977) as Everton Dolomite, but conodont collections (this study) indicate these strata are coeval, in part, with the Dutchtown in its type area.

Unfortunately, exposures containing the upper and lower contacts of the Dutchtown with either the St. Peter Sandstone or the overlying Joachim Dolomite are unknown in southeast Missouri, and the stratigraphic relationship of the Dutchtown to the Joachim and St. Peter in southeast Missouri is poorly understood.

Based on a study of well cuttings, McQueen (1937) considered the Dutchtown to have a lateral facies relationship with the St. Peter Sandstone, and a disconformable relationship with the overlying Joachim Dolomite. Templeton and Willman (1963) considered the Dutchtown-Joachim contact to be conformable, and that the disconformity observed by McQueen is a locally developed diastem due to uplift of the Ozark Dome prior to Joachim deposition. They also considered the Dutchtown to have a lateral depositional relationship with the Starved Rock Sandstone. Treworgy and Whitaker (1992) studied that the Dutchtown may have a facies relationship with the lower Joachim Dolomite.

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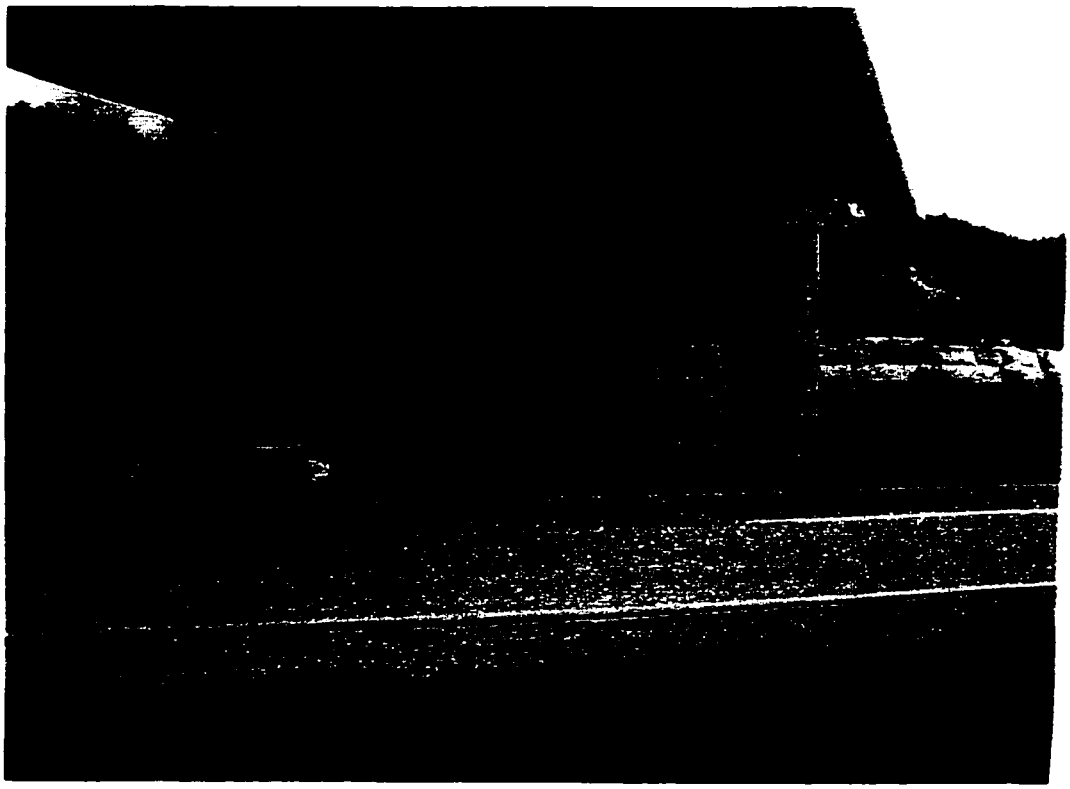

Figure 18: Partial exposure of Dutchtown Formation along northbound lane of U. S. Interstate 55, West Perryville section, southeast Missouri. Approximately 22 meters of flat lying Dutchtown are exposed between mile marker 129.6 and 131.3. These exposures are recommended to serve as the principal reference section for the lower Dutchtown Formation.

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Templeton and Willman (1963) extended the use of the Dutchtown Formation into southern Illinois where Willman and others (1975) reported it is limited to the area south of Marion County. Although only a few meters thick, lithologies typical of the Dutchtown are recognizable as far north as Montgomery Co., Illinois (this study).

Abdulkareem (1982) and Droste and others (1982) showed that the Dutchtown Formation is the basal unit of the Ancell Group in eastern Indiana and that it overlies the St. Peter Sandstone in western Indiana. In easternmost Indiana, it has a lateral relationship with the Wells Creek Dolomite. The Dutchtown in Indiana is shown to extend much farther north than the Dutchtown in Illinois (Droste and others, 1982).

With the exception of a study of an endemic conodont fauna by Ethington and others (1986), no fossils have been studied from the Dutchtown in Indiana or Illinois.

Joachim Dolostone:

Winslow (1894) named the Joachim Dolostone for argillaceous, dolomitic limestone with shale exposed in the cutbanks Plattin Joachim Creek, Jefferson Co., Missouri. Although the type section is located on Plattin Creek, Winslow assigned the name Joachim because he had misidentified the locality (Grohskopf, 1948).

Winslow's initial definition included all strata overlying the Crystal City Sandstone and underlying the Plattin Limestone (Plattin Group of this study). The Crystal City Sandstone included the St. Peter Sandstone and the Dutchtown Formation. Only 3 ft. (1 m) of Joachim is exposed at its type section; the rest of the section described by Winslow is mostly St. Peter Sandstone and possibly includes carbonates correlative to the Dutchtown Formation.

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Because the Joachim Dolomite is poorly exposed along either Plattin or Joachim creeks, Templeton and Willman (1963) proposed a composite reference section based on exposures west of Cape Girardeau, Missouri. Thompson (1991) showed that the Joachim in the Cape Girardeau area is atypical and recommended reference sections for the Augusta, Boles, Defiance and Matson members in road cuts along Interstates 44 and 55, and at the Berg Quarry located 2 miles (3.2 km) west of their type sections

The Joachim Dolostone is predominantly a blue-green-gray and light-brown, argillaceous dolomudstone with thin interbeds of brown to green-gray shale. Fine-grain, well-rounded quartz arenites are present but decrease in abundance upsection; locally, a fine-grain, well-sorted quartz arenite may be present near the base of the formation (Abernathy Member). In the subsurface, the Joachim typically contains 10-50% anhydrite (Okhravi and Carozzi, 1983).

Based on the varying sand and clay content, and the predominance of dolomite versus limestone, Templeton and Willman (1963) subdivided the Joachim into six members, in ascending order they are: Abernathy, Augusta, Boles, Defiance, Matson and Metz members.

Bell and others (1964) subdivided the Joachim in the subsurface of the Illinois Basin into a lower sand/shale-bearing carbonate (=Aberanthy and Augusta members), and an upper anhydrite-bearing carbonate (=Boles and Defiance members). In their type log, Bell and others (1964, Figure 5) excluded the Matson and Metz members from the Joachim and assigned them to the Pecatonica Formation.

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Thompson (1991) referred the Abernathy and Augusta members to the "lower" Joachim, the Boles and Defiance member to the "middle" Joachim, and the Matson and Metz members to the "upper" Joachim. The contacts between members are gradational.

The **Abernathy Member** (Figure 19))is mainly composed of silt- and sand-bearing dolostone, but is characterized by a laterally persistent "St. Peter-like" sandstone unit. Brown dolostone and limestone are locally present (Templeton and Willman, 1963). Brown laminae, typically classified as shale, are common.

The **Augusta Member** (Figure 19) is a silty, thick-bedded dolostone that lacks the disseminated quartz sand-grains and "shale" of the Abernathy Member. This description is problematic in that in its type section, quartz sand makes up 10-40% of the lithologies present in the lower 16.5 ft. (5 m) of the Augusta Member.

The **Boles** and **Defiance** (Figure 20) members are argillaceous dolostones differentiated from the underlying Augusta and Abernathy members by the absence of quartz sand. The medium-bedded Defiance is differentiated from the Boles by the abundance of shale and thin bedding in the Boles. As observed by Thompson (1991) these two units are commonly indistinguishable where exposures are thin or poorly exposed, but they are readily identifiable as an aggregate "middle" unit.

The **Matson Member** (Figure 21) is a relatively pure algal-laminated dolostone that grades basinward into a dark-brown limestone; its massive and relatively pure character differentiates it from the other members of the Joachim. In southeast Missouri, it is readily confused with the "Pecatonica Formation" that shares its massive

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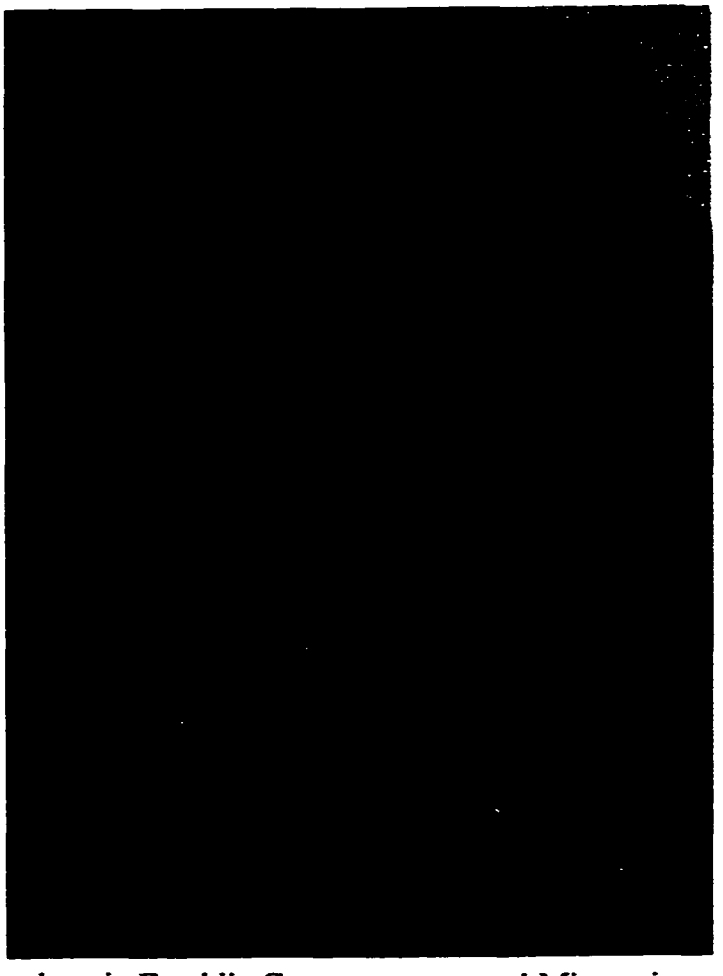

Figure 19: Rail road cut in Franklin County, east-central Missouri exposing the upper Ancell Group 100 m west of the type section for the Abernathy Sandstone Member of the Joachim Dolomite showing the sharp, planar contact, at yellow-orange horizon in middle of photo, of the Abernathy and underlying Tonti Sandstone Member of the St. Peter Sandstone. The uppermost portion of the section exposes the Augusta Dolomite Member of the Joachim.

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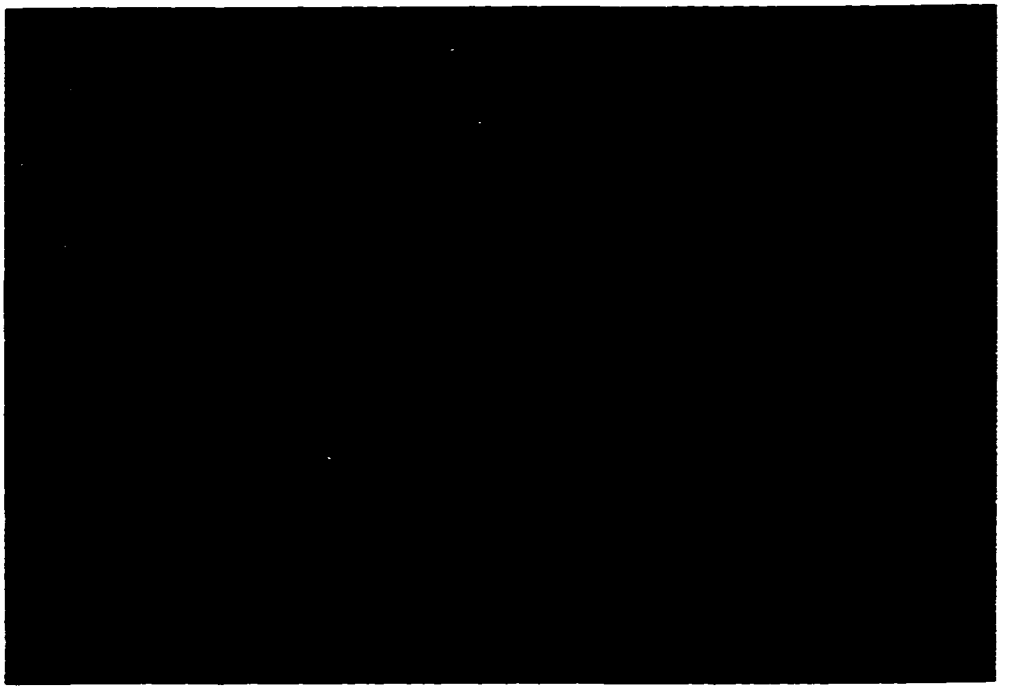

Figure 20: Weber Hill road cut exposing Boles, Defiance and Matson members of the Joachim Dolomite. Upper Boles, lower 2 meters, is overlain by less shaly and medium-bedded Defiance Member. Massive beds of the Matson Dolomite Member form the ledge at the top of the exposure.

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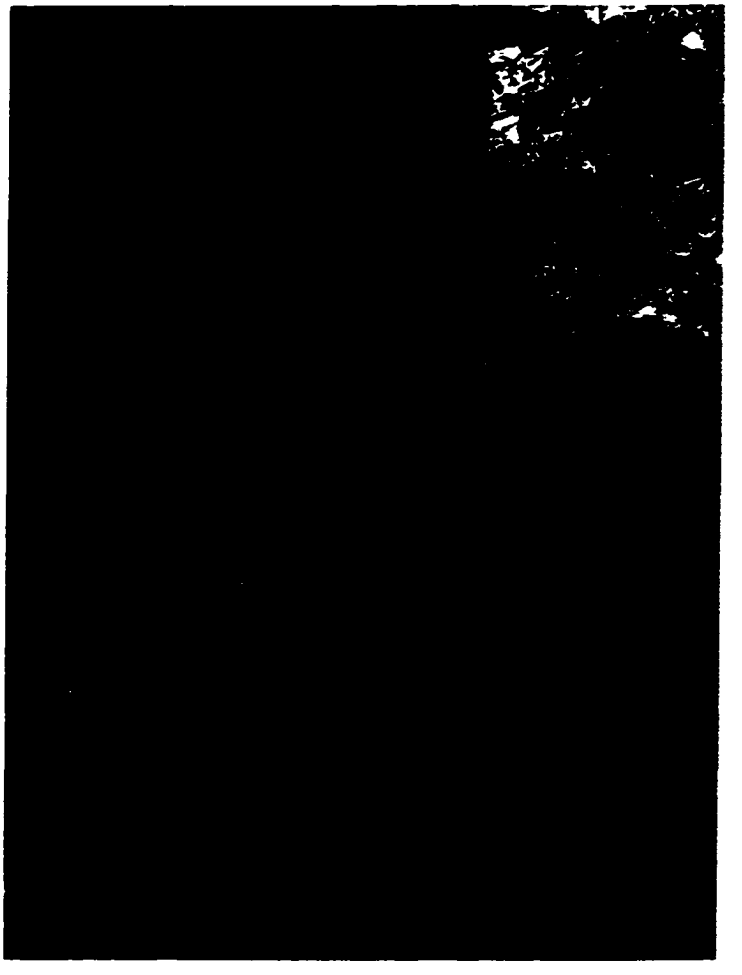

Figure 21: Matson Dolomite Member of Joachim Dolomite conformably overlying massive, quartz arenites of the Tonti Sandstone Member of the St. Peter Sandstone. Contact is ferrigenous, burrowed interval marked by arrow. Tonti Sandstone is time-transgressive from east to west in central Missouri and the Abernathy, Defiance and Boles members of the Joachim Dolomite are lost to lateral lithofacies changes.

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character, but the "Pecatonica" is mostly a massive, burrowed calcimudstone. Thompson (1991) considered it probable that the lower "Pecatonica" should be included in the upper Joachim. The Matson contains the only macrofauna, ostracods and the brachiopod *Lingula*, studied from the Joachim (Templeton and Willman, 1963; Okharvi and Carozzi, 1983).

Although conformable with the underlying Defiance Member, the Matson Dolomite Member locally overlies the St. Peter Sandstone in central Missouri where the lower Joachim carbonates are progressively replaced by quartz arenite dominated depositional environments.

Most of the conodont fauna studied from the Joachim Dolomite by Andrews (1967) was recovered from "limestone with an abundant ostracode fauna"; if his samples are not from misidentified carbonates of the Dutchtown Formation, they are probably from the Matson Member. The conodont fauna studied from the Joachim by Branson and Mehl (1933) is from the Matson (Templeton and Willman, 1963). The conodont fauna recovered by Leslie and Bergstrom (1995) near Holstein, Mo., is from the Matson Member.

The **Metz Member** is predominantly thin-bedded, silty argillaceous dolomudstone and/or calcimudstone with mudcracks, scour surfaces, "algal domes", and oolite locally (Templeton and Willman, 1963). Thompson (1991) adds that "birds-eye" fenestrae are abundant in the Metz. Oolitic grainstone from the Metz in southeast Missouri is probably the basal deposit of the overlying Bloomsdale Limestone. The upper contact with the basal Plattin Group is a sharp, disconformable, solution-marked,

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ferrigenous, undulatory surface with up to 6-inches (15 cm) relief. This contact is the upper contact of the Ancell Group in its type area.

Platteville Group

In northern Illinois the Ancell Group is overlain by the Platteville Group. The unit is named for Platteville, Wisconsin, where micritic dolostones and limestones disconformably overlie the Glenwood Shale and underlie the Galena Group (Figure 22) (Templeton and Willman, 1963; Ostrom, 1969; Willman and Kolata, 1978).

The Platteville Group is subdivided into five formations, of which only the lower two, the Pecatonica and Mifflin Formations, are of interest in this study. The stratigraphic nomenclature of the lower Platteville Group is summarized in Figure 10.

Pecatonica Formation:

Hershey (1894) named the Pecatonica Formation for its relatively pure dark-brown limestones and dolostones at the base of the Platteville Group exposed along the Pecatonica River, southwest Wisconsin (Templeton and Willman, 1963; Willman and Kolata, 1978). The Pecatonica is 20-25 ft. (6.1-7.6 m) thick in its type area and it thickens southward. It is conformably overlain by the Mifflin Formation; however, the contact is commonly marked by a "burrowed corrosion surface", an irregular, ferrigenous bedding surface with abundant vertical burrows penetrating the underlying bed, and overlain by a medium- to coarse-grain clastic lag.

Templeton and Willman (1963) subdivided the Pecatonica Formation into six members, in ascending order they are : Hennepin, Chana, Dane, New Glarus, Medusa

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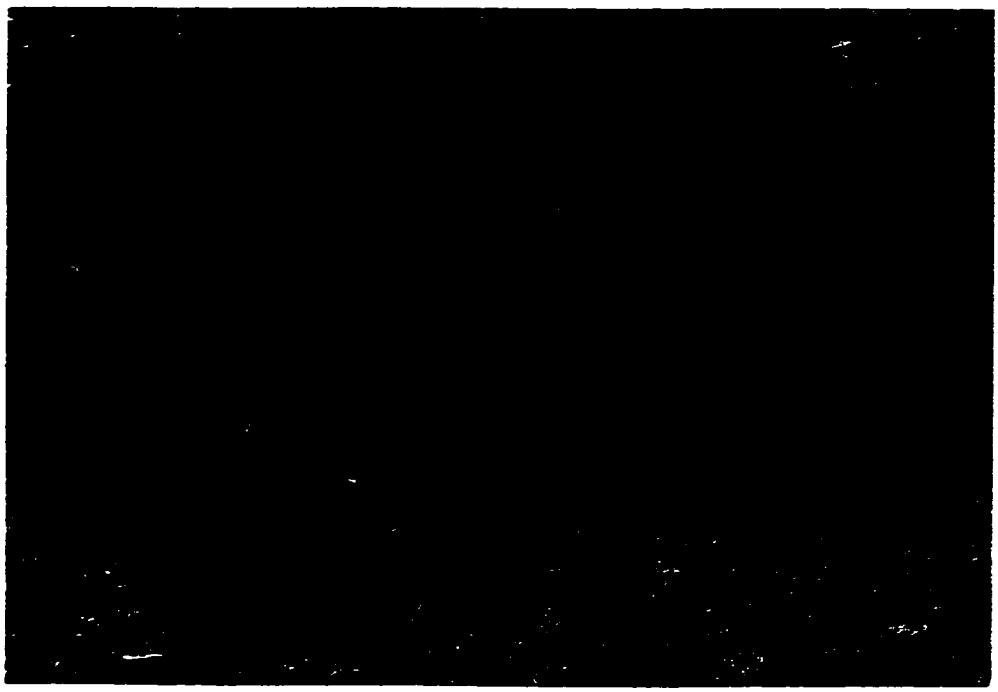

Figure 22: Disconformable, sharp contact of Glenwood Shale, re-entrant, and overlying Platteville Group, Clayton Co., northeast Iowa. Angular to subround, coarse-grain to pebble-size lithoclasts of green mudrock and phosphatized grains, derived from underlying Glenwood, are abundant in lower meter of Platteville carbonates. Locally, the basal Platteville contains a basal quartz arenite.

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and Oglesby. Based on its substantial clastic content, the Hennepin Member has been reassigned to the upper Glenwood Formation (Ostrom, 1969). Templeton and Willman (1963) extended these subdivisions to southeastern Missouri; however, only the Medusa and Oglesby are currently recognized to have a regional distribution (Thompson, 1991).

The **Medusa Member** is a thick-bedded, mottled dolostone or lime-mudstone with argillaceous laminae; the mottling is due to selective dolomitization of burrow-infills (Willman and Kolata, 1978). Dark-gray chert and fucoidal mudstone are locally abundant (Templeton and Willman, 1963). The **Oglesby Member** is a gray, thin- to thick-bedded, medium-grain grainstone that is cross-bedded locally (Willman and Kolata, 1978). The contact of the Oglesby with the overlying Plattin is a well-developed corrosion surface (Templeton and Willman, 1963).

Mifflin Formation:

The Pecatonica Formation is conformably overlain by the argillaceous carbonates of the Mifflin Formation (Bays, 1938); however, the contact is a corrosion surface with local scour relief of 2-12 in. (5-30 cm) and vertical burrows infilled with dolomite (Templeton and Willman, 1963). Although Templeton and Willman (1963) subdivided the Mifflin into three members in northern Illinois, subsequent investigations have shown that the lithic characteristics used to define these units are difficult to identify (Willman and Kolata, 1978).

In southeast Missouri, Mifflin strata are assigned to the Bloomsdale Limestone, the basal formation of the Plattin Group (Thompson, 1991).

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Plattin Limestone Group

Larson (1951) reclassified the Plattin Limestone of Ulrich (1904) as a group and subdivided it into the Bloomsdale, Beckett, Hager and Macy limestones; only the Bloomsdale is of importance to this study. The Plattin Group is equivalent to the Platteville Group of Illinois (Thompson, 1991). The stratigraphic relationships of the lower Plattin Group stratigraphic units are illustrated in Figure 10.

Bloomsdale Limestone:

The Bloomsdale Limestone (Larson, 1951) is a brown calcimudstone, with interbeds of oolitic grainstone, dolomitic shale and dolostone, that is though to be equivalent to the Mifflin Formation of the Wisconsin Arch. The formation is subdivided into three members: a basal Blomeyer Member, a middle Brickeys Member, and an upper Establishment Shale Member.

The **Blomeyer Member** (Figure 23) is an argillaceous dolostone that underlies the Brickeys Member in southern Cape Girardeau Co., Missouri, but is known as far north as St. Genevieve Co., Missouri (Thompson, 1991). In most areas it is indistinguishable from the Brickeys Member (Thompson, 1991).

The **Brickeys Member** (Figures 23 and 24) contains interbedded oolitic grainstone, green shale and breccia; bedding planes are commonly scour surfaces with a few inches (cm's) of relief (Thompson, 1991). Although the Blomeyer Member is the basal unit of the Plattin Group, these distinctive oolitic grainstones are used as markers to identify the base of the Plattin in the subsurface (Templeton and Willman, 1963; Thompson, 1991).

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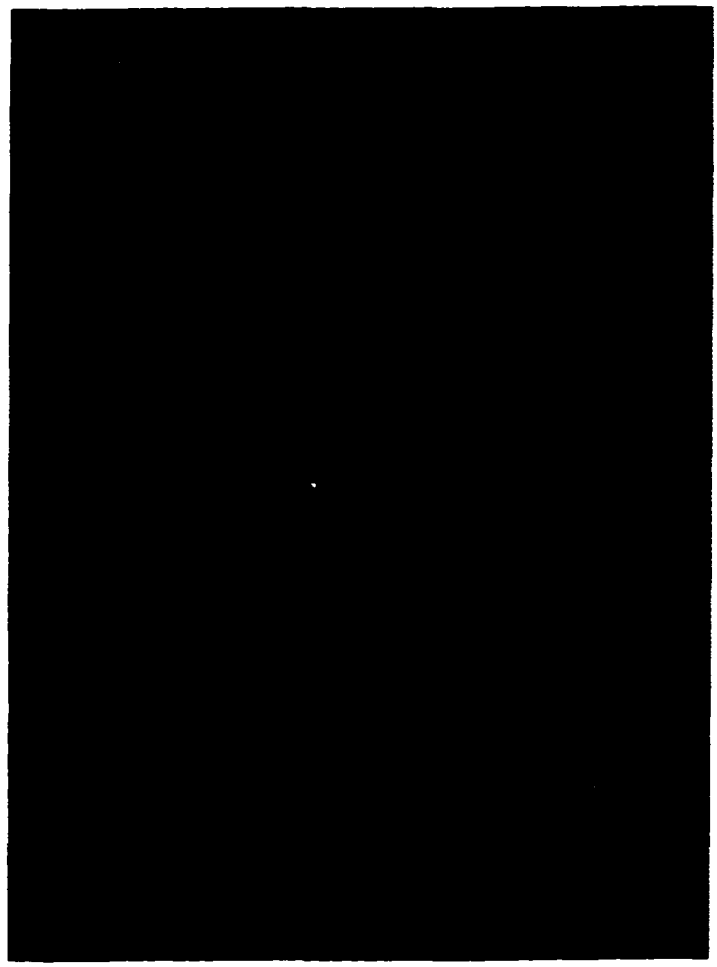

Figure 23: Erosive contact of Blomeyer Member and overlying Brickeys Member of the Bloomsdale Limestone exposed at Joachim Creek North section, southeast Missouri. Green mudrocks of Blomeyer are disconformably overlain by oolite grainstone of Brickeys Member; contact has up to 20 cm of relief locally. Relief is believed to be penecontemparaneous and the hiatus represented by erosive surface is geologically insignificant; however, overlying mudrocks and carbonates are a condensed section representing a significant period of slow deposition.

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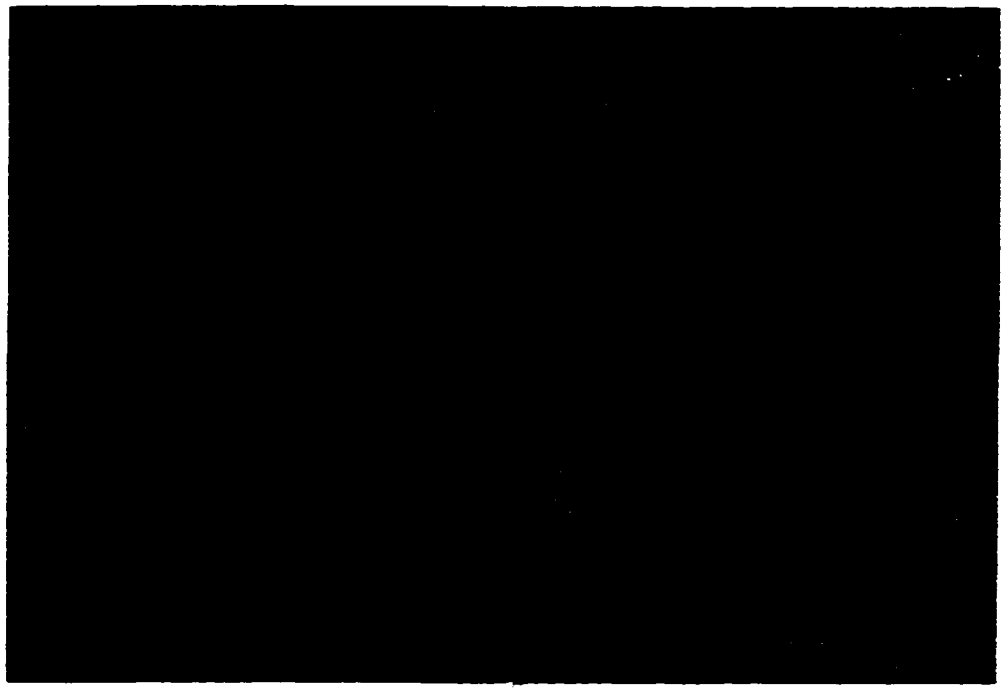

Figure 24: Thin- to medium-bedded, ostracodal grainstones of the upper Brickeys Member grading up-section to interbedded ostracodal wackestone and green mudrocks of Establishment Shale Member, Joachim Creek North section, southeast Missouri.

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The **Establishment Shale Member** (Figure 24) is a blue-gray claystone with minor interbeds of gray bioclastic packstone. Although it has an average thickness of 3 ft. (1 m), it forms a distinctive re-entrant in outcrop and the blue-gray claystone is readily recognizable in drill cuttings and on gamma-ray geophysical logs.

The contact of the Bloomsdale Limestone with the underlying Joachim Dolomite is disconformable (Thompson, 1991) and marked by a corrosion surface that may be correlative with similar corrosion surfaces at the contact between the Murfreesboro and Pierce limestones of the Stones River Group, Tennessee.

Stones River Limestone Group

The Stones River Group includes the carbonates overlying the Knox Group (Lower Ordovician) and underlying the siliceous Hermitage Formation (Wilson, 1949). The Stones River Group is subdivided into six formations, in ascending order they are: Wells Creek Dolostone, Murfreesboro Limestone, Pierce Limestone, Ridley Limestone, Lebanon Limestone and Carters Limestone (Figure 25); only the Wells Creek Dolostone, Murfreesboro Limestone and Pierce Limestone are of interest in this study. Templeton and Willman (1963) considered the Stones River to be equivalent to the Ancell and Platteville groups of the Illinois Basin.

Wells Creek Dolomite:

The Wells Creek Dolostone is the basal unit of the Stones River Group (Middle Ordovician) in central and western Tennessee. It disconformably overlies the carbonates

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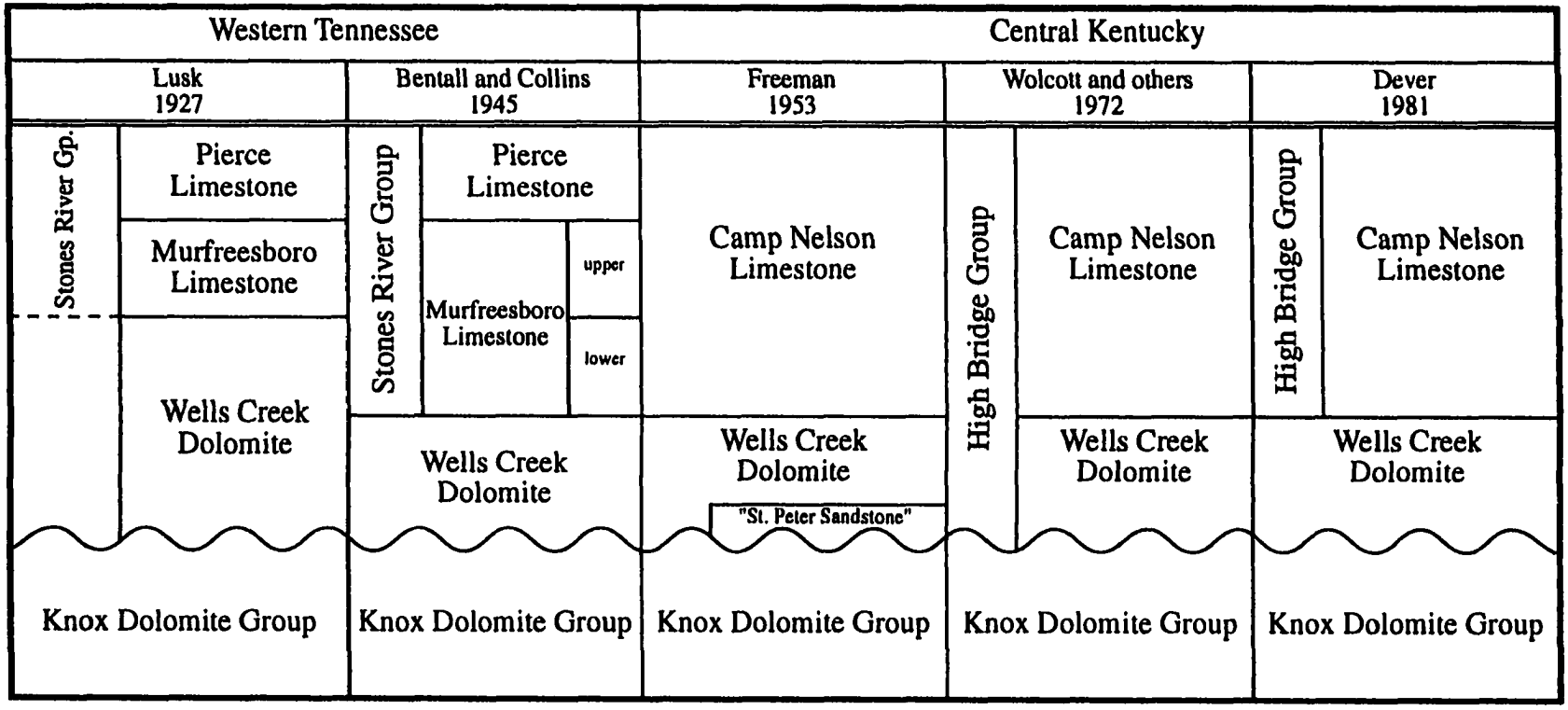
Figure 25: Lithostratigraphic units of the lower Black River Group, Ohio and eastern Indiana.



of the Knox Group (Lower Ordovician), and it is conformably overlain by the Murfreesboro Limestone.

The Wells Creek Dolostone was named by Lusk (1927) for the green-gray dolomitic limestones that underlie the Murfreesboro Limestone within the central portion of the Wells Creek cryptovolcanic structure (see p. 10 for discussion of the Wells Creek structure). The Wells Creek is differentiated from the Murfreesboro Limestone by the presence of sandstone, green shale and argillaceous dolomudstone. The Murfreesboro is a relatively pure, gray limestone with brown, wavy organic laminae. In its type area, the thickness of the Wells Creek is estimated to be 350 ft. (106 m)(Lusk, 1927). The sections used by Lusk to define the Wells Creek are either no longer exposed or do not include the strata currently assigned to the Wells Creek (Wilson and others, 1968; Dr. R. G. Stearns, Vanderbilt University, personal comm., 1991).

Jewel (1969) assigned the Wells Creek lithologies in central Tennessee and northwestern Alabama to an unnamed member of the Murfreesboro Limestone. Kidd and Copeland (1971) reported that the name Wells Creek Dolostone was abandoned by the Tennessee Division of Geology in favor of the name Pond Springs Formation of Milici and Smith (1969). However, use of the term Wells Creek persists (Ross and others, 1982; COSUNA Project, 1985) and is retained for the purpose of this study.

Retention of the name Wells Creek is supported by the lithic differences between the Pond Spring Formation. In its type area, the Pond Springs is mostly greenish-gray argillaceous limestone, interbedded with red limestone, overlying a basal conglomerate (Milici and Smith, 1969). The Wells Creek Dolomite in western Kentucky is mostly green-gray argillaceous dolostone with green-gray claystone and fine-grain quartz arenite

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interbeds, overlain by mottled green-gray calcimudstone. The absence of conglomerate and "red beds", and abundance of shale and sandstone in the Wells Creek provide a basis for differentiating these two units.

Bentall and Collins (1945) determined the distribution of the Wells Creek Dolostone in western and central Tennessee on the basis of well-cuttings; however, their concept of the Wells Creek is unclear. They described the Wells Creek as green, argillaceous dolostone that is 150-200 ft. (45-60 m) thick in its type area; this is about one-half the thickness of the Wells Creek as reported by Lusk (1927). Gooding (1992) proposed that the top of the Wells Creek be placed at the first occurrence upsection of medium- to dark-gray interbedded shale and limestone. This definition is consistent with that used by the Tennessee Division of Geology (R. Gilbert, Tennessee Division of Geology, personal comm., 1991).

This concept was used in identifying the top of the Wells Creek in a 6-inch diameter core and geophysical well-logs from the Dupont, Geohydrological Test (GHS) #1, at Waverly, Tennessee (Craig and Bradley, 1991). This well is located just south of the Wells Creek structure and provides a continuously cored section of the Stones River and Knox Groups. This core is recommended as the principal reference section for the Wells Creek Dolomite.

The lower, more argillaceous portion of the Wells Creek in the GHS 1 core is consistent with the lithic description and thickness of the Wells Creek of Bentall and Collins (1945). The upper Wells Creek in the core appears to be consistent with their concept of the lower member of the Murfreesboro Limestone.

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This interpretation is supported by thickness and structure maps of the Stones River Group prepared by Bentall and Collins (1945). The top of the Stones River was identified by the presence of the Pencil Cave Bentonite, which commonly occurs 1-6 ft. (0.31-2.2 m) below the top of the Stones River Group (Bentall and Collins, 1945). Bentall and Collin's thickness map of the Stones River Group (excluding Wells Creek) indicates its thickness at the GHS drill-site should be 775-825 ft. (235-250 m). This is comparable to the total thickness (749 ft. or 227 m) of the limestones between the T-3 (Pencil Cave) bentonite (1,125 ft. or 341.7 m. below surface) and the top of the lower Wells Creek in this study (1,874 ft. or 569.3 m. below surface).

Murfreesboro Limestone:

The Murfreesboro Limestone is a dark-gray to brown-gray, massive, micritic limestone with minor interbeds of packstone, grainstone and fenestral calcimudstone. Dolomitized burrows are common, and the upper portion of the formation contains dark blue-gray chert that weathers white in outcrop (Wilson, 1948).

Only the upper 70 ft. (21.3 m) of Murfreesboro Limestone is exposed in the type area where its total thickness is known to exceed 400 ft. (122 m) (Wilson, 1948). As a result, the stratigraphic relationship of the Murfreesboro Limestone and the underlying Wells Creek Dolostone is poorly understood.

Fossils are uncommon, but silicified gastropod-nautoloid faunas are known from the cherty limestones in the upper Murfreesboro (Wilson, 1948). Votaw (1971) and Votaw and Repetski (1982) have reported on its conodont fauna.

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Pierce Limestone:

The Pierce Limestone is made up of dark-colored, thin-bedded, bioclastic packstone interbedded with gray, calcareous claystone and siltstone. At its type section (Figure 26) the Pierce is 23-28 ft. (7-8.5 m) thick (Wilson, 1948). Local variations in thickness are due to relief on a corrosion surface developed on top of the Murfreesboro Limestone. The Pierce Limestone is very fossiliferous and contains a diverse brachiopod-bryzoan assemblage (Wilson, 1948). Votaw (1972) reported on a conodont fauna from the Pierce at its type section.

High Bridge Group

In Kentucky, carbonates equivalent to the Ancell and Platteville groups of Illinois, the Stones River Group of Tennessee, and the Plattin Group of Missouri are assigned to the High Bridge Group (McFarlan and White, 1948; Templeton and Willman, 1963). The High Bridge Group conformably overlies the Wells Creek Dolomite (Dever, 1980), and disconformably overlain by the Lexington Limestone (Cressman and Noger, 1976). In its type area at the crest of the Jessamine Dome, the High Bridge Group is 572 ft. (174.5 m) thick and is subdivided into the Camp Nelson Limestone, Oregon Formation and Tyrone Limestone (Figure 25)(Cressman and Noger, 1976; Dever, 1974, 1980).

Wolcott and others (1972), observing that contact of the Wells Creek Dolomite and Camp Nelson Limestone is gradational, included the Wells Creek as the basal formation of the High Bridge Group. Subsequent workers have excluded the Wells Creek from the High Bridge Group (Dever, 1974, 1980; Kuhnhenn and others, 1981; Noger and

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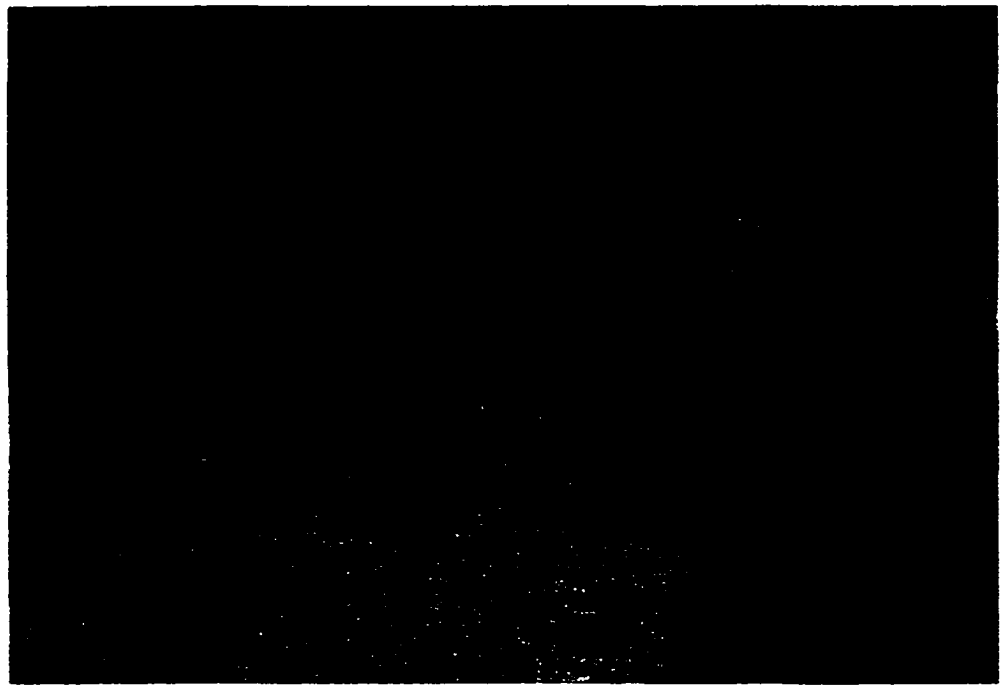

Figure 26: Type section of Pierce Limestone type section, Pierce Mill, Tennessee. The top of the medium-bedded Pierece Limestone is the base of the thin-bedded limestones, where vegatation is developed, and is marked by a ferrigenous corrosion surface. The age of the uppermost Pierce Limestone closely approximates the top of the Matson Member and the two units may be coeval.

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others, COSUNA chart, 1985). This study follows the recommendation of Wolcott and others (1972), and includes the Wells Creek Dolomite in the High Bridge Group as its basal transgressive unit.

In this study the Wells Creek Dolomite and Camp Nelson Limestone are of primary interest; however, because the lower 115 ft. (37 m) of the High Bridge Group is not exposed in Kentucky, knowledge of the lower Camp Nelson and Wells Creek is based upon subsurface studies (Dever, 1974, 1980; Gooding, 1992; Gorman, 1981; Kuhnhenn and others, 1981; Lazarsky, 1983; Milici, 1983) and correlation of the High Bridge Group is based upon the conodont fauna studied by Votaw (1971).

Wells Creek Dolomite:

The lithic criteria for identifying the Wells Creek in the subsurface of Kentucky has not clearly defined until recently (Dever, 1980; Gooding, 1992). Dever (1980) noted that the Wells Creek is silty and dolomitic, and recognized the Wells Creek based on the last occurrence downsection of "micro-grained limestone", a lithology consider by Dever to be characteristic of the High Bridge Group. This is inconsistent with Freeman (1953) who included some very light-gray limestones in the upper Wells Creek.

As previously discussed, Gooding (1992) proposed that the top of the Wells Creek Dolomite be placed at the first occurrence upsection of medium- to dark-gray interbedded shale and limestone. He showed that the Wells Creek Dolomite is mostly medium-dark-gray dolostone, gray-green argillaceous dolostone, and medium- to dark-gray limestone with thin interbeds of gray- to green-gray shale and siltstone. A rubble breccia is typically present at the disconformable contact with the underlying Knox Group.

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Typically, the Wells Creek has a higher silica and alumina content than the overlying Camp Nelson Limestones due to the presence of detrital siliciclastics (Dever, 1974; 1980; Kuhnhenn and others, 1981).

In south-central Kentucky the Wells Creek Dolomite varies in thickness from 10-95 ft. (3.1-29 m)(Gooding, 1992). Wolcott and others (1972) and Gooding (1992) reported that the variable thickness of the Wells Creek is caused by relief developed on the post-Knox paleo-surface.

"St. Peter Sandstone":

In eastern Kentucky, on the margin of the Appalachian Basin, quartz arenites disconformably overlying the Knox Group and conformably underlying the Wells Creek Dolomite have been assigned to the St. Peter Sandstone (Freeman, 1956; McGuire and Howell, 1964; Price, 1981). The distribution of these quartz arenites closely approximates the distribution of the Lower Ordovician Rose Run Sandstone, and it is thought that these arenites have been derived from the Rose Run exposed on the proto-Cincinnati Arch during the development of the post-Knox paleoerosional surface (McGuire and Howell, 1964; Price, 1981).

Price (1981) observed that the "St. Peter Sandstone" of eastern Kentucky texturally differs from the St. Peter Sandstone of the Illinois Basin, and that it lacks depositional continuity with the St. Peter sand sheet of the upper Mississippi Valley. As a consequence, it is recommended that the use of the name "St. Peter Sandstone" be abandoned in eastern Kentucky and a new unit, named for a suitable reference section, be proposed for these sandstones; however, proposing a suitable unit, and identifying a principal reference section for it, is beyond the scope of this study.

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Camp Nelson Limestone:

The upper Camp Nelson Limestone was named by Miller (1906) for a succession of shallow marine and peritidal limestones exposed in the cutbanks of the Kentucky River near Camp Nelson, Kentucky. Micritic and biomicritic limestones (with dolomitized burrows, hard grounds, thin-beds of pack/grainstone and a moderately diverse fauna) dominate the shallow marine lithologies (Kuhnhenn and others, 1981). Massive, fenestral and laminated calcimudstones with mudcracks characterize the peritidal carbonates. Chert occurs in the upper Camp Nelson, but its character is unstudied (Kuhnhenn and others, 1981, Figure 3).

The lower Camp Nelson Limestone is unexposed, but its character in the type area is known from the subsurface (Lazarsky, 1976). The lower 155 ft. (37 m) of the Camp Nelson in the subsurface is olive- to medium-gray calcimudstone that is locally dolomitic and contains mudcracks, organic laminae and a gastropod-ostracode fauna.

Black River Group

The Black River Group of Ohio is based upon the lithic similarity of rocks in the subsurface of south-central Ohio to those assigned to the Middle Ordovician Black River Limestone of New York. The stratigraphy of the Black River Group in its type area has been reviewed by Wilmarth (1938), Young (1943) and Walker (1973), and is presented in Figure 27.

Calvert (1962) used geophysical logs to correlate the Middle Ordovician of central Ohio with the Black River Group of western Virginia. Based on his correlations, the

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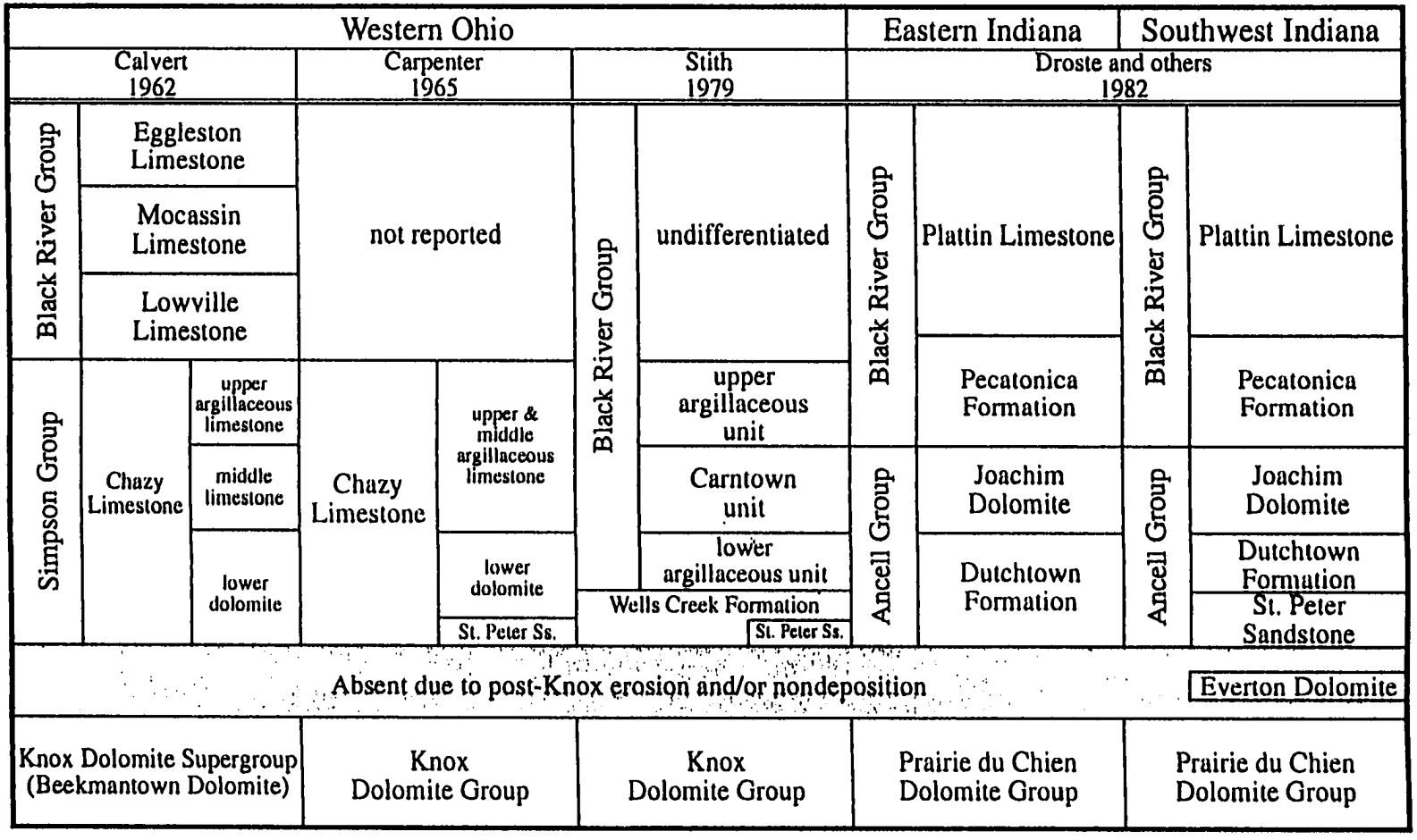
Figure 27: Lithostratigraphy of the Black River Group, Indiana and Ohio



Middle Ordovician was subdivided into the Simpson and Black River Groups. The Chazy Limestone was the only formation assigned to Calvert's Simpson Group, and the Black River Group was considered equivalent to the Black River Limestone of New York. In addition, he subdivided the Chazy Limestone into a "lower dolomite", a "middle limestone", and an "upper argillaceous limestone".

Calvert (1962, Plate 2) correlated the Chazy Limestone to the Dutchtown Formation and Joachim Dolomite of the Illinois Basin. However, there appears to be an inconsistency in his correlation of the "Chazy Limestone" between central Ohio and central Kentucky. The middle and upper argillaceous limestones in central Ohio are correlated with an argillaceous carbonate in central Kentucky that possesses geophysical characteristics and occupies a stratigraphic position consistent with his lower dolomite unit.

Although the use of the term Black River Group is accepted in Ohio, the use of Simpson Group for the lower carbonate section, and the use of the name Chazy Limestone have been abandoned by subsequent workers (Carpenter, 1965; Stith, 1979).

Carpenter (1965) demonstrated the lower dolomite member of Calvert's (1962) Chazy Limestone in southwestern Ohio and north-central Kentucky. In addition to the lower dolomite member, Carpenter recognized "middle" and "upper" limestone members. Carpenter's lower dolomite member is equivalent to the Wells Creek Formation of Stith (1979). Based on the gamma-ray and neutron geophysical log responses (Carpenter, 1965, Figure 2), the middle and upper limestone members are equivalent to the upper "lower dolomite" of Calvert (1962), and the lower argillaceous unit of Stith (1979).

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Carpenter (1965) used the name "St. Peter Sandstone" for a northwest trending, lenticular sandstone body at the base of the lower dolomite developed in north-central Kentucky. The sandstone body has a maximum width of 16 miles (25.75 km) and a length of 53.3 miles (85.8 km); it's maximum thickness is 60 ft. (18.3 m) in northern Boone Co., Kentucky (Carpenter, 1964, Figure 4). As noted by Janssens (1973), the distribution of the sandstone is vary similar to the subcrop of the "Knox Sandstone" of Patton and Dawson (1969).

Carpenter (1965) reported that this sandstone is not contiguous with St. Peter Sandstone of the upper Mississippi Valley, nor with the "St. Peter Sandstone" of southeast Kentucky. As in the case of the "St. Peter Sandstone" of eastern Kentucky, it is recommended that the name "St. Peter" be abandoned for the these sandstones and that they should be assigned to the Wells Creek Formation.

Dolly and Busch (1972) adopted Calvert's (1962) threefold subdivision of the "Chazy" limestones.

Stith (1979) included Middle Ordovician micritic carbonates overlying either the Wells Creek Formation or the post-Knox unconformity, and underlying the bioclastic grainstone of the Trenton Limestone, in the Black River Group (Stith, 1979). The contact of the Black River and Trenton is 1-7 ft. (0.3-2 m) above the Millbrig K-bentonite; the Millbrig is identified as the alpha bentonite by Stith (Potter, 1991). Stith rejected the use of "Chazy" for the lower carbonates and assigned the lower dolomite of Calvert (1962) to the Wells Creek Formation.

Stith (1979) studied the contact of the Wells Creek Formation and lower Black River Group as conformable, and subdivided the lower Black River into three units: a

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"lower argillaceous", a middle "Carntown", and an "upper argillaceous" unit. The "lower argillaceous" and "Carntown" units are equivalent to Calvert's "middle limestone".

Locally, one or more of these units may be absent due to nondeposition related to the paleotopography of the post-Knox surface (Stith, 1969). Dolly and Busch (1972) observed a similar relationship in central Ohio, and noted that the carbonates overlying the post-Knox disconformity are "deformed" into syn- and antiforms due to differential compaction of post-Knox sediments over paleotopographic features.

Wells Creek Formation:

The Wells Creek Formation in western Ohio is green argillaceous dolostone with interbeds of argillaceous, fine-grain quartz arenite, siltstone and shale (Stith, 1969). The Wells Creek and "lower argillaceous unit" are differentiated on the basis of the dolomitic composition of the former, and by the predominance of limestone in the latter. The Wells Creek thins northward, varying in thickness from 54 ft. (16.5 m) in southwest Ohio to less than 10 ft. (3.05 m) in the northwest Ohio (Wickstrom and others, 1985; Shrake and others, 1990).

Stout and Lamey (1940) studied that a blue-green shale interval common in the lower Wells Creek Formation is commonly referred to as "St. Peter" shale in older studies, and Stith (1969), following Carpenter (1965) identified the basal Wells Creek sandstones as "St. Peter Sandstone". As in the previous discussions of the Wells Creek, it is recommended that the use of the term "St. Peter" be abandoned in this area.

Lower argillaceous and Carntown units:

The "**lower argillaceous unit**" is dominated by brown, laminated calcimudstone with interbeds of mottled, green-gray argillaceous lime-mudstone. The overlying

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"**Carntown**" unit is medium-gray, burrowed lime-mudstone and ostracodal packstone with sparse to abundant *Tetradium*; the burrows are commonly dolomitized.

The contact of the Carntown and "upper argillaceous" unit is characteristically a vertically-burrowed, bioclastic wacke/packstone hardground overlain by interbedded gray-green shale and brown to medium-gray, burrowed lime-mudstone with organic laminae.

In Indiana, Droste and others (1982) elevated the stratigraphic rank of the Black River Limestone to group, and subdivided it into the Pecatonica Formation and Plattin Limestone. The Pecatonica of Indiana is made up of medium- to grayish-brown limestones and dolostones. A thin, argillaceous limestone, calcareous shale and/or sandstone marks the base of the Pecatonica in much of northern Indiana, but elsewhere this interval is 10-30 ft. (3-9.1 m) above the base of the Pecatonica (Droste and others, 1982). This horizon is thought to be equivalent to Stith's marker II bed which occurs stratigraphically well above the "upper argillaceous unit".

K-Bentonites

Based on trace element composition, lithic characteristics and geophysical log responses, Kolata and others (1986, 1987), Huff and Kolata (1990), and Haynes (1994) have demonstrated the regional correlation and distribution of the Millbrig and Deicke potassic bentonite ("K-bentonites") beds of the lower Galena Group (upper Middle Ordovician) throughout eastern North America. The Deicke and Millbrig are correlative with the T-3 and T-4 ash beds of the southern Appalachians, and the Pencil Cave and Mud Cave bentonites of Kentucky, respectively (Huff and Kolata, 1990; Haynes, 1994).

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These two bentonites represent upper-Middle Ordovician ash-falls from Taconic island arc volcanism and serve as chronostratigraphic and lithostratigraphic markers for the upper-Middle Ordovician of eastern North America. Ar^{40}/Ar^{39} dating of biotite in the Deicke has yielded an absolute age of 453.7 +/-3 Ma (Kunk and Sutter, 1984). The Millbrig K-Bentonite, just above the Deicke, has been radiometrically dated to be 454.6 Ma (+/- 1.8) in southeast Missouri (Tucker and others, 1990), and 454.1 Ma (+/-2.1) in northern Kentucky (Kunk and others, 1985). Huff and others (1992) correlated the Millbrig geochemically and biostratigraphically with the Big Bentonite of Baltoscandia.

Although these bentonites are present higher in the section than the Ancell Group, they have been utilized in this study as stratigraphic markers. Typically, the Deicke is a single graded bed, suggesting it may be the product of single, depositional volcanic event, and therefore, it has utility as a chronostratigraphic datum for graphic correlation.

Because of the unique geophysical response of bentonites within the mostly carbonate upper-Middle Ordovician succession, the Deicke K-bentonite can be readily identified in the subsurface using an assortment of wireline logs (Huff and Kolata, 1990). In the course of this study, recognition of the Deicke in the subsurface based on wireline logs was confirmed by geochemical analysis of core material from the Superior Oil Co., H. C. Ford et al C-17, well in White Co., Ill. (Huff and Kolata, written comm., 1991).

Several other Middle and Lower Ordovician bentonite layers have been identified locally, but their geographic distribution within the basin has not been demonstrated.

Templeton and Willman (1963) identified green, waxy shales in the Everton Dolomite as possible bentonites. During this study only one possible bentonite was identified within the Everton. A laterally persistent 1-2-inch (2.5-5 cm) green shale is

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present in cores of the upper Everton Dolomite in western south-central Illinois (King #1, 3059.5 ft., and House #1, 3048.75 ft., Montgomery Co.; Carr 1-16, Morgan Co., Ill.). Kolata (ISGS, ps. comm., 1992) confirmed the identification of the shales in Montgomery Co. as bentonites based on their physical character. X-ray diffraction profiles of these shales do not exhibit the mixed-layer composition considered diagnostic of bentonites (Dr. R. Hughes, ISGS, ps. comm., 1992); however, the samples are enriched with authigenic potassium feldspar and are diagenetically altered clay (Dr. R. E. Hughes, ISGS, personal communication, 1992).

K-bentonite on the post-Knox surface has been studied elsewhere in eastern North America. A "brown" K-bentonite in the lowermost Wells Creek Dolomite (1752-1757 ft.) is studied in a sample study of the Jarvis & Marcell, Parrigan #1, Clinton Co., Kentucky (Freeman, 1953). Laurence (1944) studied on a bentonite preserved in a pre-Mohawkian, post-Canadian sinkhole developed on the post-Knox erosional surface in eastern Tennessee.

Drillers have reported a K-bentonite from the Dutchtown Formation in the subsurface of southeastern Missouri. Sample studies on file at the Missouri Geological Survey study a K-bentonite containing biotite 110-120 ft. (33.5-36.5 m) below the top of the Dutchtown in the Arthur Job #1 and Orchard #1 wells in Cape Girardeau Co. (T30N-R13E-Sec.'s 1 and 12). K-bentonites studied as the "Mosheim K-bentonite Complex" by Bergström (1989) from late Whiterockian to early Mohawkian rocks in eastern Tennessee may be coeval with the Dutchtown bentonites. Huff and others (1992) reported the Mosheim bentonites fall within the *Cahabagnathus sweeti* conodont biozone (mid-Late Whiterockian), the same age as the Dutchtown of southeastern Missouri (Repetski, 1972).

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BIOSTRATIGRAPHY AND AGE RELATIONSHIPS

In order to understand the lateral distribution of lower-Middle Ordovician depositional environments in the Illinois Basin, it was necessary to develop a more detailed relative chronostratigraphic framework. As part of this study the Ancell Group, and its equivalents, have been graphically correlated and subdivided into internationally recognized biochronozones based on their conodont faunas. Time-related stratigraphic features, such as bentonites and regional hiatal surfaces, have been identified within biostratigraphically-controlled sections and their presence used to extend the biochronostratigraphic framework to those portions of the Illinois Basin where biostratigraphic control is lacking.

Previous work

In general, detailed biostratigraphic studies of lower-Middle Ordovician rocks in the Illinois Basin are lacking due to poor exposure, the absence of biostratigraphically useful faunas, and the lack of detailed biostratigraphic studies of the few fossils groups that are present.

Exposures of the Ancell Group and correlative units are limited to the Wisconsin Arch and Ozark Dome, or to small structurally controlled exposures along the Kentucky River Fault, or within the central up-thrown blocks of the Kentland and Wells Creek structures. In addition to the limited distribution of exposures, the lack of continuous vertical sections precludes establishing a biostratigraphic succession based on outcrops.

A second factor inhibiting the development of a high-resolution biostratigraphic framework is that the rock types present in this lower-Middle Ordovician succession represent environments in which biostratigraphically useful fossils are absent, or rarely

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preserved. The eolian quartz arenites of the St. Peter Sandstone are a primary example. The sparse macrofauna present within the carbonates tend to be dominated by endemic, and/or biostratigraphically long-ranging species such as the brachiopod *Lingula*. As a result, a biozonation of sufficient resolution cannot be established.

Lastly, macrofauna are uncommon and where found, they have been poorly documented. Sardenson (1892), later redescribed by Sloan (1987a), reported a molluscan-dominated assemblage from the St. Peter Sandstone in Minnesota. Shrock (1937) reported a macrofauna from the St. Peter Sandstone and Glenwood Formation at Kentland Quarry, Indiana. The brachiopod *Lingula* has been reported from the Glenwood Formation (Elder, 1936) and the Joachim Dolomite (Templeton and Willman, 1963). Several workers have observed ostracodes (primarily leperditiids), pelecypods, gastropods and brachiopods in thin-section from the Joachim Dolomite. McQueen (1937) described a moderately diverse, marine fauna containing bryzoans, gastropods, brachiopods, cephalopods and ostracodes from the Dutchtown Formation, southeast Missouri. However, these reports are of local occurrences and macrofossils are rare in the Ancell Group and its equivalents.

Microfossils are more readily recovered and have provided the basis for regional correlation of the lower-Middle Ordovician of the Illinois Basin. At present, a number of published and unpublished conodont studies (Table 1) provide the basis for biostratigraphic correlation of lower-Middle Ordovician strata in the basin (Norby, 1991). Although chitinozoans, acritarchs and ostracodes have demonstrated biostratigraphic utility and have been reported from lower-Middle Ordovician rocks in the basin, current reports are limited to reconnaissance level studies.

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Table 1: Reports of Middle Ordovician conodonts in the Illinois Basin region.

Author	Stratigraphic unit(s)	Location
Stauffer (1935)	Glenwood Formation	Iowa
Cullinson (1938)	Dutchtown Dolomite	Missouri
Youngquist and Cullinson (1946)	Dutchtown Dolomite	Missouri
McLaughlin (1941)	Dutchtown Dolomite	Missouri
Webers (1966)	Glenwood Formation	Iowa
	Platteville Group	Iowa
Andrews (1967)	Joachim Dolomite	Missouri
Golden (1969)	Everton Dolomite	Arkansas
		Missouri
Clark (1971)	Glenwood Formation	Wisconsin
Atkinson (1971)	Platteville Group	Wisconsin
Votaw (1971)	Platteville Group	Illinois
	High Bridge Group	Kentucky
	Stones River Group	Tennessee
Repetski (1973)	Dutchtown Dolomite	Missouri
Rexroad and others (1982)	Everton Dolomite	Indiana
Klapper and Bergstrom (1984)	Dutchtown Dolomite	Missouri
Ethington and others (1986)	Dutchtown Dolomite	Indiana
Craig (1986)	Everton Dolomite	Arkansas
	Joachim Dolomite	Arkansas
Norby and others (1986)	Everton Dolomite	Illinois
Sweet (1987)	Glenwood Fm.	Iowa
	Platteville Group	Iowa
Shaw (1990)	St. Peter Sandstone	Illinois
Witzke (1992)	St. Peter Sandstone	Iowa

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Conodont Biostratigraphy

Conodonts are the microscopic hard-parts of a primitive marine vertebrate that, although now extinct, was a common component of marine faunas from the middle Cambrian through the Triassic. The conodont animal, a conodontophorid, was probably pelagic and/or nektobenthic. Although at a specific level conodontophorids may have been sensitive to water mass salinity/temperature, as a group they were widespread in normal and hypersaline marine environments in both warm and cold waters. Each conodontophorid possessed an apparatus, presumably for feeding, made up of a number of discrete elements. These "elements" are commonly referred to individually as conodonts

Conodont elements are composed of calcium phosphate (apatite) and trace amounts of organic matter. Apatite is insoluble in dilute organic acids that readily dissolve calcite and dolomite. This characteristic provides a basis for recovery of conodonts from carbonate, or carbonate-cemented rocks by simple acid dissolution. Dissolution of carbonate rocks yields an insoluble residue that is then wet sieved to remove the clay-sized and very fine-grain fractions. Conodonts, with a specific gravity of 2.84-3.10 gm/cm^3, are separated from less dense insoluble components by heavy liquid separation and the resultant heavy residue is then examined under a binocular microscope for conodonts. More detailed discussions on the procedures used to recover conodonts can be found in Collinson (1963) and Austin (1987).

Conodonts have greater biostratigraphic utility over other fossil groups in the Early Paleozoic of the Illinois Basin for three reasons. First, faunas can be readily recovered from limited sample material, which increases their utility for subsurface

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investigations. Second, although endemic species are present a sufficient number of cosmopolitan species are present for reliable correlation. Third, where graptolites are unavailable conodonts are the internationally accepted basis for biozonation of the Ordovician (Ross and others, 1981).

Although previous conodont studies have provided a rudimentary biostratigraphic framework for correlation of lower-Middle Ordovician rocks, the focus of many of these studies has been taxonomic and with few exceptions (Votaw, 1971; Sweet, 1987), scaled biostratigraphic data are unavailable. More significantly, most previous studies have presented biostratigraphic data for sections on the marginal uplifts and data for the regional depocenter are lacking. As a result the current biostratigraphic framework is poorly constrained.

In order to establish a more robust biozonation, a collaborative investigation with Dr. W. C. Sweet, The Ohio State University was undertaken to determine the conodont biostratigraphy of the Middle Ordovician succession in the Illinois Basin. In order to do so eight rock-cores from the subsurface and one road-cut were measured, described and sampled for conodonts. The distribution of localities investigated is shown in Figure 28. At each locality, samples were collected at 10 ft. (3.05 m) intervals from the lowest to the highest Middle, or Upper Ordovician carbonate present. At localities 8 and 9 the highest samples are from within +/-1 m of the Deicke K-bentonite Bed; for the remainder of the sections, the highest sample immediately underlies the Maquoketa Shale (Upper Ordovician). Samples were collected at much closer intervals, sometimes every

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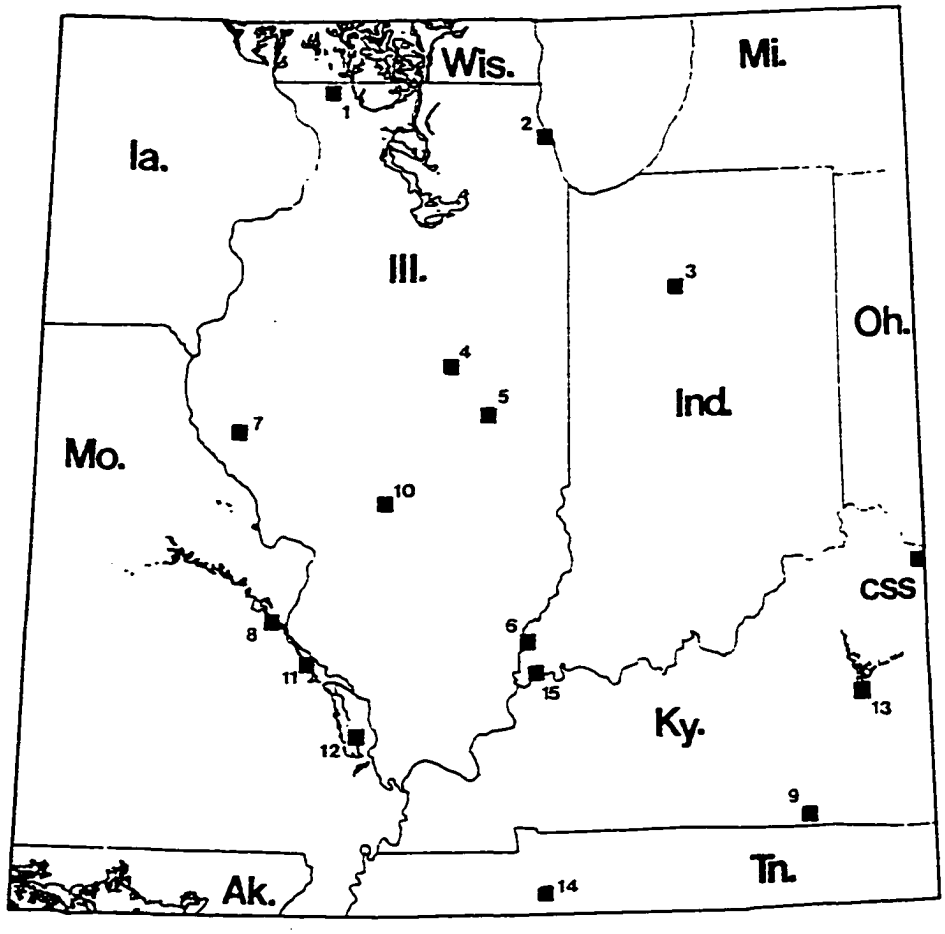
Figure 28: Location of sampled sections, key reference localities and the Middle Ordovician composite standard section (CSS) of Sweet (1984).



Sampled localities

1. Commonwealth Edison UPH-3, Stephenson Co., Illinois.
2. Chicago Metropolitan Sanitary District, DH-71-9(31), Cook Co., Illinois.
3. NIPSCO, Forbes #1, White Co., Indiana (Votaw, 1978).
4. Peoples Gas, Light & Coke Co., J. Lamb #1, De Witt Co., Illinois.
5. Central Illinois Composite, Champaign and Douglas Co.'s, Illinois.
6. Superior Oil, H. C. Ford et al C-17, White Co., Illinois.
7. D & G Drilling, G. Saylor #1, Pike Co., Illinois.
8. Weber Hill, Jefferson Co., Missouri.
9. Cominco American Ca-254, Cumberland Co., Kentucky.

Reference localities

10. Illinois Power Co., L Truitt #1, Montgomery Co., Illinois
11. Ancell Group outcrops, Ste. Genevieve Co., Missouri.
12. Geiser Quarry, Cape Girardeau Co., Missouri (Repetski, 1972).
13. Camp Nelson North, Jessamine Co., Kentucky (Votaw, 1971)
14. Dupont, Inc., Geohydrological Test #1, Humphreys Co., Tennessee.
15. General Electric, WD-2, Posey Co., Indiana (Rexroad and others, 1982)

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foot, from the units under investigation. Of the over 700 samples processed, more than 90% yielded identifiable conodont elements.

Where inadequate data was available for intervals poorly represented in the collections (i.e., Dutchtown and Everton formations), or where sample material was unavailable (i.e., subsurface of Indiana), additional samples were collected from key outcrops and/or previously described faunas from key reference localities aided interpretation (Figure 28). In addition, faunal lists from unpublished U. S. Geological Survey collections, courtesy of Dr. J. E. Repetski, were made available for localities in western Tennessee, southwest Missouri and central Illinois.

Graphic Correlation

A detailed taxonomic discussion of the faunas recovered is beyond the scope of this report; however, a discussion of methodology used for correlation is warranted in that it plays a fundamental role in establishing the chronostratigraphic control for determining the lower-Middle Ordovician lateral depositional relationships. This method has been applied to the Middle and Upper Ordovician rocks of North America to establish a chronostratigraphy based upon the stratigraphic ranges of conodonts from the North American Midcontinent Province (Sweet, 1984; 1988). The methodology will be briefly summarized herein, but the reader is referred to Shaw (1964), Miller (1977), Edwards (1984) and Phillips (1986) for more detailed discussions.

Graphic correlation is a method proposed by Shaw (1964) in which paleontological correlation, utilizing the total stratigraphic range of the fossil species present in two or more lithic successions, can be used to develop time-stratigraphic (i.e., chronostratigraphic) control for sedimentary sequences (Miller, 1977). As Miller (1977)

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observed, Shaw's method diverges from other quantitative correlation methods in that the distance (i.e., thickness) to time relationships are solved graphically, rather than algebraically.

The method is based upon three assumptions. First, each fossil species in the geologic record has a unique, total stratigraphic range determined by its time of biological origination and extinction. Second, the total stratigraphic range can be approximated by interpolating the local stratigraphic ranges determined at multiple stratigraphic sections. And lastly, a species does not originate more than once in the geologic record.

In graphic correlation the stratigraphic ranges for individual species, denoted by first and last appearance datums (LAD and FAD), are determined and recorded for a standard reference section (SRS) in meters above a stratigraphic datum. The SRS serves as standard for comparison of all subsequently correlated sections. Because it serves as the standard for comparison, ideally the SRS is a thick, undisturbed section with few significant sedimentological breaks and contains an abundant, diverse fossil content that is characteristic of the biogeographic province of the study area.

To compare two sections, the SRS is plotted on the x-axis and the second section on the y-axis, using units of thickness (meters) for scale and placing the base of each section at the origin (Figure 29). The biostratigraphic datums for species present in both sections, both LAD and FAD, are then plotted using their stratigraphic position in each section as the x-y coordinates. Stratigraphic datums (SD), the stratigraphic position of unique events (i.e., volcanic ash falls) and non-unique events (i.e., geophysical log patterns), are also plotted if the phenomena have time-significance (Edwards, 1989).

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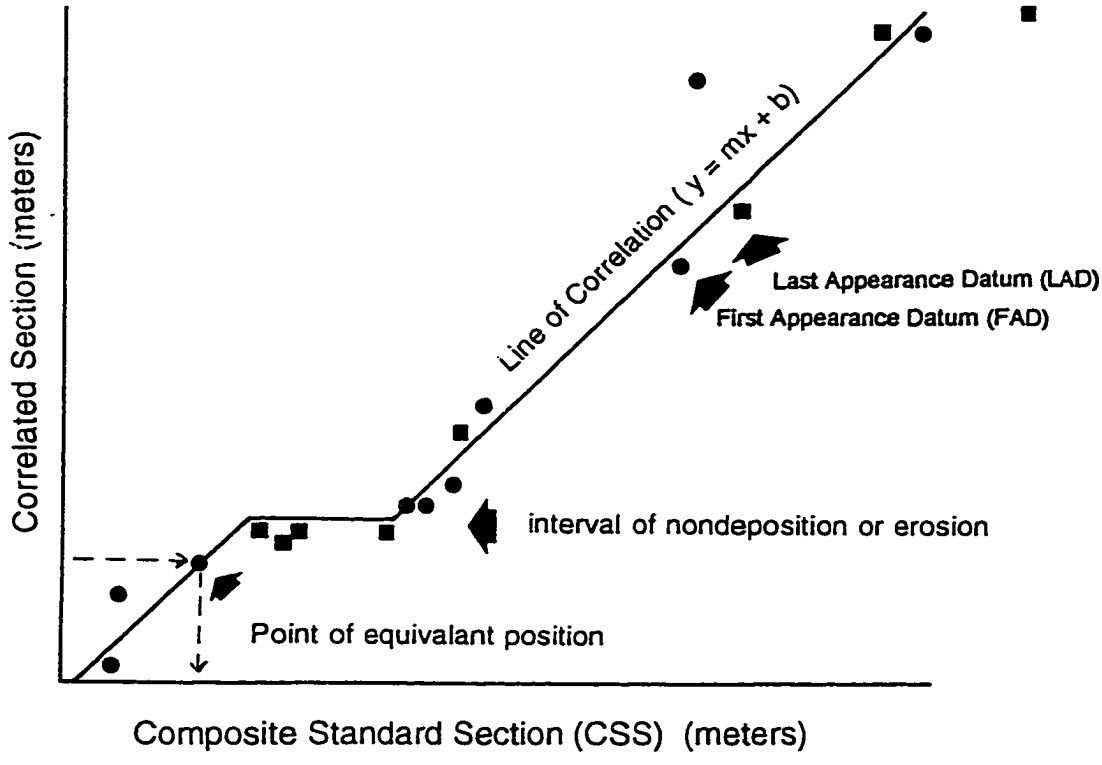

Figure 29: Diagrammatic graphic expression of correlation showing key elements.

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A line of correlation (LOC) is then drawn by the least squares method using datums of species whose ranges in the SRS are considered to accurately reflect their total stratigraphic ranges (Figure 29). The least squares method is preferable in that it minimizes the bias introduced by anomalous sedimentation rates (Hay and Southam, 1978). The position of the LOC may then be modified based on the judgement of the biostratigrapher (Finney and others, 1996).

The equation describing the LOC ($y = mx + b$) can be solved to find the equivalent position (x) in the SRS of a datum (y) in a correlated section. The slope (m) of the line is the relative rate of net rock accumulation. Because it does not take into account diagenetic phenomena, such as compaction, dissolution and cementation, nor the episodic character of deposition, the slope is not the rate of sedimentation and does not directly relate to absolute time (Miller, 1977). The exception is where the correlated sections have similar depositional and burial histories. The y-intercept (b) is the equivalent position of the base of the correlated section in the SRS (Figure 29).

In theory, the LOC should be a continuous series of short straight lines with slopes reflecting the rate of accumulation for depositional events (i.e., a shoaling sequence). In cratonic depositional settings the creation of accommodation space is episodic (Sloss, 1991; Wilkinson and others, 1991; Sloss, 1996) and sedimentation rates grossly exceed the rate of accommodation. Therefore, filling of accommodation space is virtually instantaneous at geologic time-scales. As a result, a meter scale, "step-wise" array would most accurately describe the relationship between two sections where near vertical lines would describe the instantaneous filling of accommodation space, and horizontal lines describe the intervening period of nondeposition (Harper and Crowley, 1985).

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At geologic time scales (Figure 30) the rate at which accommodation space is created in a cratonic setting is essentially linear over short periods of geologic time and therefore, the error introduced by assuming a linear relationship, rather than a step-wise relationship, is negligible (Shaw, 1964; Miller, 1977; Edwards, 1985). However, because the preserved stratigraphic section probably represents only 5-10% of the time over which it was deposited (Wilkinson and others, 1991; Sloss, 1996), the vast majority of time is represented by surfaces of nondeposition and/or erosion. As a result, the graphically derived LOC is a time-averaged, *nonunique*, "best-fit" solution for the data obtained from the *preserved* stratigraphic succession.

It should be apparent that if deposition is interrupted, either by erosion or nondeposition, in the section being compared to the SRS, the LOC should have a terrace at the level of discontinuous deposition (Figure 29). During a period of nondeposition, and/or erosion, in which no rock accumulates in the section plotted on the y-axis, coeval strata continue to accumulate within the SRS. As a consequence, at the level of discontinuity where the rate of net rock accumulation is zero the LOC parallels the x-axis and has no slope. An interval where the LOC has no slope, or terrace, is diagnostic of hiatal surfaces and the relative magnitude of the hiatus can be estimated by the interval not represented in the comparative section (Shaw, 1964; Miller, 1987; Phillips, 1986).

A period of starved sedimentation may also result in the offset of the line of correlation because the slope of the line of correlation is in part reflective of the rate of sedimentation. In intervals associated with marine flooding surfaces, sedimentation is uninterrupted, but the rate of sedimentation is significantly lower (Loutit and others,

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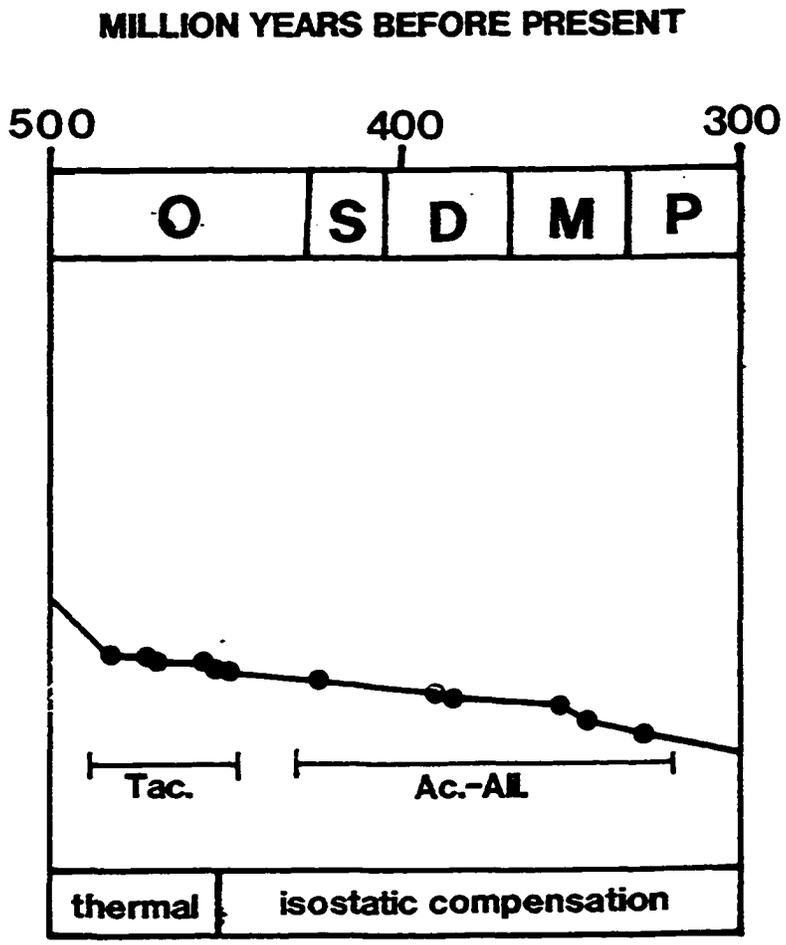

Figure 30: Early Paleozoic tectonic subsidence curve for the Illinois Basin (modified from Kolata and Nelson, 1990).

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1988). Because of the abrupt shift in depositional environments above the flooding surface, species previously excluded from the area due to paleoenvironmental considerations may first appear, while the lower net rock accumulation or other paleoecologic controls may suppress the last appearance of some species. Thus, a diffuse vertical distribution of horizontal datums is typically associated with a condensed interval as a result of a rapid lateral shift in depositional environments.

This is in contrast to an unconformity where the abrupt shift in depositional environments, above and below an unconformity, are represented by a bedding plane and there is no sedimentary record of the intervening hiatus. Consequently, datums for any species with a first or last appearance during the hiatus is horizontally distributed relative to the Line of Correlation within a short vertical distance of the unconformable bedding plane. Horizontal displacement relative to the LOC is indirectly proportional to the relative magnitude of the stratigraphic hiatus, and the vertical displacement is, in part, controlled by the sampling interval. As a result if the sampling interval is small enough, the tight vertical cluster of datums relative to the hiatal surface can provide a basis for differentiating an unconformity from a condensed section.

Because the species ranges in the two sections compared are local stratigraphic ranges, it is desirable to transfer the datums to the SRS for species that either are absent in the SRS, or have ranges which exceed their equivalent range in the SRS. The equivalent position in the SRS of the datum in question is calculated from the LOC and this equivalent position of the datum then recorded in the SRS. The result is that as new species datums can be added or existing ranges may be extended in the SRS and ranges of

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species in the SRS more closely approximate the total stratigraphic ranges of each species.

Because the ranges in the reference section are now composites and the total ranges are no longer determined by the physical presence of taxa in the SRS, the new ideal section is called the Composite Correlation Standard (CSS). An infinite number of additional sections can be added to the composite until the ranges of species do not appreciably change, or "stabilize" within the CSS. The completed composite is referred to as the Composite Standard Reference Section (CSRS). Miller (1977) reported that the ranges of species within the CSS usually stabilize after 6-12 sections have been integrated into the composite.

Biozones defined by graphically determined ranges are more accurately termed biochronozones because the composited species ranges can no longer be defined by the physical presence of a fossil in the Composite Standard Section (Johnson, 1992). As Loutit and others (1988) observed any unit based on the ranges of species within a section that can be determined by the physical presence of a fossil is by definition a chronostratigraphic unit and not a biostratigraphic unit.

In order to establish a more refined chronostratigraphic scale, the thickness of the CSRS is established as a measure of time, and then subdivided into units of equal thickness referred to as standard time units (STU's) (Shaw, 1964; Miller, 1977). The dimensions of the STU's are determined by the confidence component for the least well-controlled section in the composite standard section (CSS). These units can then be projected into other sections using the LOC equation and their relative time position in the CSRS, by the Law of Superposition, has time significance. The interval represented

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by an STU does not have a measurable duration in years and is solely a relative time unit because the true rates of net rock accumulation for any given stratigraphic interval are unknown (Miller, 1977).

Conodont-based Middle Ordovician Graphic Correlation

Sweet (1984) proposed seventeen conodont biochronozones for the Middle and Upper Ordovician defined by the ranges of over 100 key species within the North American Midcontinent composite standard section developed from graphic correlation of over 70 sections. Subsequently, the Composite Standard Section (CSS) has been expanded to include the entire Ordovician and over 100 measured sections including those sections discussed herein (Sweet, 1988; 1995a and 1995b). Because of the extensive biostratigraphic control afforded by this network, Sweet (1988) noted that for all practical purposes these biochronozones also serve as biozones with in the North American Midcontinent faunal province.

Because a single, stratigraphically complete Middle Ordovician section is unavailable in the North America Midcontinent, the SRS for Middle and Upper Ordovician rocks of North America is itself a composite developed from three successions. The lower SRS (Whiterockian-Mohawkian) is based upon exposures in the Arbuckle region (Bauer, 1987; Derby and others, 1991). The middle SRS (Mohawkian-early Cincinnatian) and upper SRS (late Mohawkian-early Silurian) are based upon subsurface cores obtained in the eastern Illinois Basin. The middle SRS is based upon a core cut near Minerva, north-central Kentucky (Votaw, 1971; Sweet and others, 1974), and the upper SRS is based on a core cut near New Point, Indiana (Bergstrom and Sweet, 1966). All three sections are unfaulted, fossiliferous carbonate sequences containing

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conodonts of the North American Midcontinent Province (NAMP). For each section, samples have been collected for conodont recovery at 1-5 ft. (0.3-1.5 m) sample interval. However, because the sections have significant overlap and graphically correlate with great reliability it is generally accepted that the SRS is complete. Conveniently for this study, having two of the three reference sections within the Illinois Basin minimizes the potential for paleoenvironmental, or biogeographic bias.

Sweet (1988) subdivided the Middle and Upper Ordovician CSS into eighty Standard Time Unit's (STU's) with the dimension of 6 meters (19.7 ft.). This implies that the age relationship of events that occur less than 6 meters (19.7 ft.) apart within the CSS cannot be graphically determined. Sloan (1987b) proposed an Ordovician time-scale based assumed time values for the STU's. Using radiometric dates for the Deicke K-bentonite Bed and the Ordovician-Silurian boundary as time constraints, Sloan proposed that each STU have a duration of 330,000 years. Then, assuming that the duration of an STU remained constant throughout the Middle and Upper Ordovician, he then extrapolated absolute ages for the remainder of the Middle Ordovician based on his calculated STU time equivalency. As Fordham (1992) observed, STU's only have absolute time value when all of the sections within the composite have similar net rock accumulation rates, the sections are unaffected to a significant degree by diagenesis or anomalous sedimentation rates, and sampling procedures for all the sections are uniform. Sweet's Composite Standard Section does not meet these requirements, and predictably Sloan's time scale is not in agreement with more rigorously determined Ordovician time-scales proposed by Cowie and Bassett (1989), Harland and others (1989), or Ross and others (1992).

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Graphic correlation of the Illinois Basin Middle Ordovician:

Table 2 summarizes the ranges of the species utilized in correlating the sections analyzed and Figure 31 shows the uninterpreted results of the graphic correlation exercise.

Because the sampled intervals exclude most of the Upper Ordovician and the lowermost Middle Ordovician, only forty of the over one hundred species in the Composite Correlation Standard (CSS) are represented in the collections at hand. Table 3 provides the comparative statistics showing the number of shared events for each section and the Middle Ordovician CSS. On average, about half the events recognized in the CRS are also recognized in any one section studied. The Forbes #1 and Weber Hill sections have the lowest number of shared events with the Composite Standard Section and as a result, they are the most poorly constrained.

As noted previously, the resolution of the Composite Standard Section is limited to +/-6 m (19.7 ft.); therefore, graphic correlation does not offer any insight as to the time equivalency of events separated by less than 6 m (19.7 ft.) in the CSS. Consequently, the objective of the following discussion is to not only document the methodology, but to begin to integrate the biostratigraphic analysis and the observed lithostratigraphy in order to develop a more coherent interpretation. A detailed discussion will be presented for the critical Ford et al C-17 section, but the subsequent discussion of the other sections will be limited to the key observations.

Superior Oil, H. C. Ford et al C-17, White Co., Illinois

The Superior Oil, Ford et al. C-17 well is located in the Fairfield Subbasin of the central Illinois Basin. The well reached a total depth of 7683.5 ft. (2342 m) within the

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Table 2: Middle Ordovician Conodont Ranges (meters above datum), Illinois Basin

Species / Section Name	Composite Standard Section		Ford et al C-17 White Co., Il.		Central Illinois Composite		J. Lamb #1 De Witt Co., Il.		McGregor, Iowa (Sweet, 1987)		SE Minnesota composite (Weber)		RBY St. Paul, Mn.		C9475 Cook Co., Il.		Forbes #1 White Co., Ind.		G. Saylor #1 Pike Co., Il.		UPH-3 Stephenson Co., Il.		CA-254 Cumberland Co., KY		Weber Hill MO.	
	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD	FAD	LAD
Amorphognathus ordovicicus	1136	1244																	92							
Amorphognathus superbus	998	1136					186	201			79	90														
Aphelognathus kimmswickensis	973	998																					242			
Aphelognathus politus	1001	1270																			43					
Appalachignathus delicatulus	832	884	195	210																			84	132		
Belodina compressa	937	1018	291	381	130	184	104	201	1.8	22.8	1	23	0	28	27	70	62	71	23	66	2	34	203	230	48.3	66.1
Belodina confluens	1019	1183									37	90			88	122			69	91	66	98				
*Belodina monitorensis**	773	933	257	282	106	114	84	99									9	41					84	172	27	48.7
Bryantodina typicalis	958	1004							13.9	18.6	0	21	3	28	67											
Chirognathus duactylyta	665		321								0	3					14				2					
Curtognathus spp.	807	994	110	383	62	178			4.6	21.7	0	20	0	20	26	66	7	11	14	60	2	33	0	230	6.6	61.6
Dapsilodus mutatus	823	1248							4.9	13.7	41	89			26	98			36	42	2	71	166		48.3	66.1
Drepanoistodus suberectus	822	1270	181	385	73	210	76	201	2	23	0	90	0	28	36	122	0	71	9	92	2	97	9	242	9	66.1
Histiodella radicans	807	933	110	381	66	178			3	22.1					26	49	0	67	2	60			0	230	0	48.7
Juntodella superba	962	1198	361	385	210		191				82	89							76		64					
*Leptochirognathus quadrata**	727	842	48	53																			18			
Microcornus primus	987	962									0	3							17							
Multioistodus subdentatus	803	803	0	47																						
Oistodus venustus	816	1166							3	20	1	31			119				81		96					
Oneotodus evelus	884	971									0	3									2					
Oulodus serratus	987	994							13.2	22.8	1	21	0	20	70				39		32	33				
Panderodus feutreti	968	1261					163	201			19	90	16	28												
Panderodus gracilis	804	1263	192	385	70	210	84	178		23	0	90	0	28	26	122	7	71	23	92	2	97	77	242	0	66.1
*Parapriniodus n. sp.**	680	796	14	49																						
Periden grandis	833	1134	369				184	201			23	90	28		82	113					71	83				
Phragmodus cognitus	960	986			153	178			1.8	18.3	3	16	2	13												
Phragmodus inflexus	824	962			86	86	92	124			0	3			27		7	11	17	23	2		71	186	9	17.9
Phragmodus undatus	960	1259	382	388	178	210	167	201	13.2	23	8	82	3	28	64	101	66	71	36	92	24	71	230	242		
Plectodina aculeata	807	1009	181	364	66	182	76	178	1.8	22.8	0	21	0	28			0	67	4	60	2	33	7	230	0	27
Plectodina n. sp. Sweet	841	974			86	146			1.8	18.3					26	66			27	36			161	178	31	66.1
Plectodina tenuis	979	1268	376	381	203	210	163	201			26	90	14	28	79	122			61	92	43	97	233	242		
Polyplacognathus ramosus	942	1024	300	366	135	184	110	161	1.8	23	1	21	0	20	40	70	67	71	48	61	2	34			48.7	66.1
Protopanderodus insculptus	1120	1120																	88	92						
Protopanderodus tripicus	984	1196									63	81			110	122					74	92				
Pseudobelodina dispansa	976	1249					161	196							70	110										
Pseudobelodina n. sp.	930	993	291	347	147	182	144	178	18.6	22.8					36	66					33		178	227		
Rhodesognathus elegans	971		381												88											
*Scandodus sinuosus**	473	789	3	46																						
Scandodus superbus	822	926	181	214	66																					
Staufferella falcata	849	1182	266	385	202	206	86	193	3	13.1	0	89	2	28	26	119	9	11	64	78	2	92	161			
Tetraprioniodus breviconus	962	986			182		157				3	6	13		67	70					32					
Yaoxianognathus abruptus	972	1114	382	385	176	178	161	191					19	20	96		66	67	48	61			230	242		
Amorphognathus sp.			364	385	106	210									73	122			66		71	97				
Aseelia sp.																			64							
Culumbodina? n. sp.															101											
"Fibrous" conodonts							69	178																		
Hoernulleistodus sp.			0	3																						
Pseudobelodina sp.																					80	92				
Delta	971		341			178.2		148.7		13		8		0						36				220		67.6
Milbig	976									13.5		10.8		4												

*Revised range reported in Sweet, 1995

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Figure 31: Uninterpreted results of conodont-based graphic correlation of Middle Ordovician lithostratigraphic units in the Illinois Basin region. Locations of columns given below (see Text for detail). References are given if data was obtained from published or unpublished reports.

Biostratigraphic reference sections

Column	Location
1	Upper Mississippi Composite (Weber, 1966, Sweet, 1984).
2	Commonwealth Edison UPH-3, Stephenson Co., Illinois.
3	Chicago Metropolitan Sanitary District, DH-71-9(31), Cook Co., Illinois.
4	NIPSCO, Forbes #1, White Co., Indiana (Votaw, 1971; 1978).
5	Peoples Gas, Light & Coke Co., J. Lamb #1, De Witt Co., Illinois.
6	Central Illinois Composite, Champaign-Douglas Co., Illinois
7	Superior Oil, H. C. Ford et al C-17, White Co., Illinois.
8	PB-KBB, G. Saylor #1, Pike Co., Illinois.
9	Weber Hill, Missouri..
10	Jessamine Dome, SRS (Sweet, 1984) and type section of High Bridge Group, Camp Nelson, Kentucky (Votaw, 1971).
11	Cominco American Ca-254, Cumberland Co., Kentucky.
12	Rutherford County composite, Tennessee (Votaw, 1971; Kim, 1988).
13	Arbuckle Anticline, Oklahoma (Sweet, 1984).

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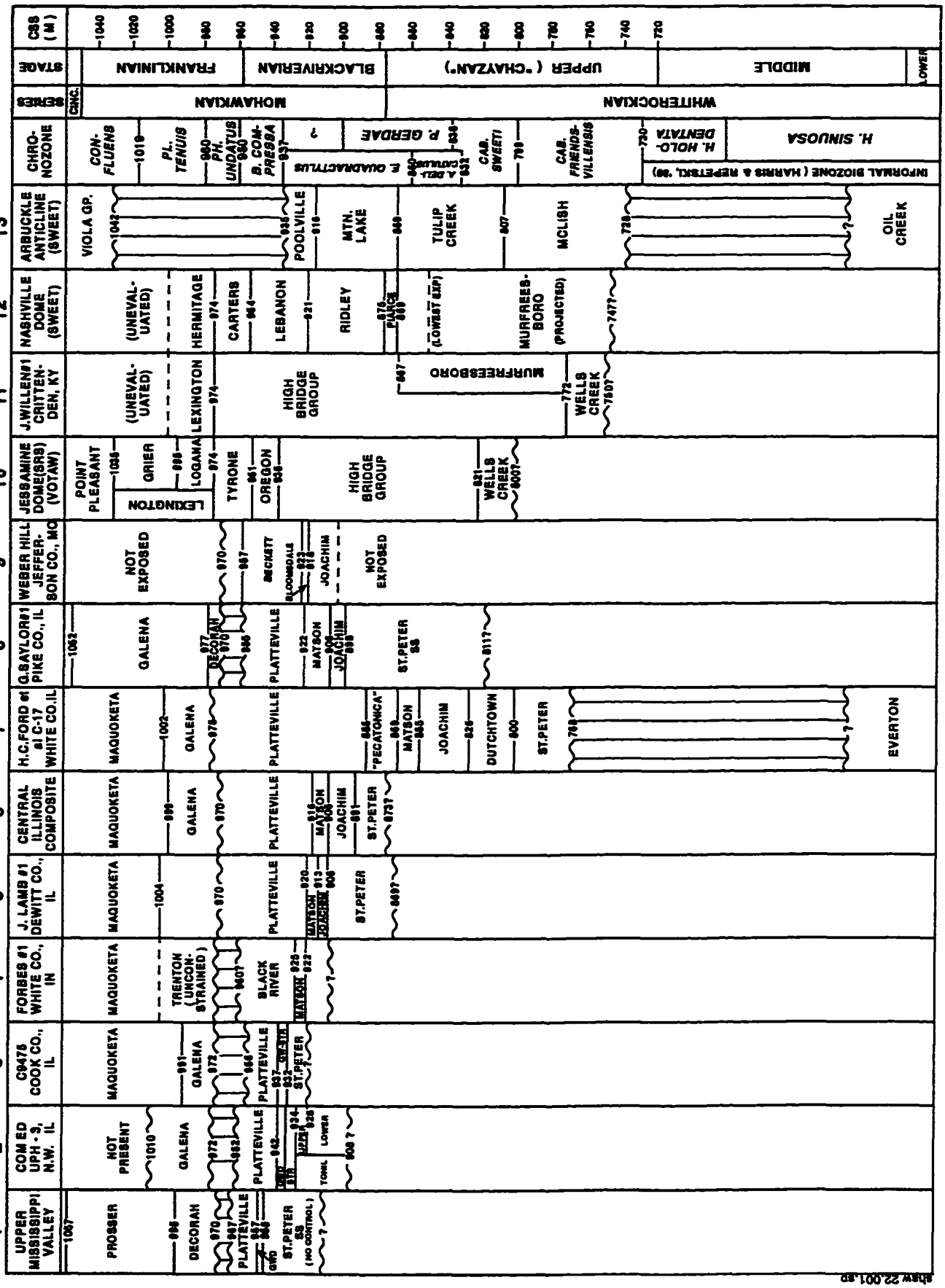

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Table 3: Comparative statistics of occurrence events for the sections biostratigraphically correlated

Section	Location	Deicke SD	Number				Compared to Ordovician CSS			
			Taxa	Bases	Tops	Events	Taxa	Bases	Tops	Events
Metropolitan Sanitary District DH-71-9(31)	Cook Co., Ill.		23	23	17	40	58%	58%	45%	51%
Superior Oil, H. C. Ford et al C-17	White Co., Ill.	X	22	22	18	40	55%	55%	47%	51%
PB-KBB, Inc., G. Saylor #1	Pike Co., Ill.	X	22	22	16	38	55%	55%	42%	49%
Commonwealth Edison UPH-3	Stephenson Co., Ill.		22	22	14	36	55%	55%	37%	46%
Central Illinois Composite Section	Douglas/Champaign Co's, Ill.	X	20	20	16	36	50%	50%	42%	46%
Illinois Power, J. Lamb #1	De Witt Co., Ill.	X	18	18	15	33	45%	45%	39%	42%
Cominco American Ca-254, J. Willen #1	Cumberland Co., KY	X	18	18	15	33	45%	45%	39%	42%
NIPSCO, Forbes #1	White Co., Indiana		13	13	12	25	33%	33%	32%	32%
Weber Hill section, Rte. 30 roadcut	Jefferson Co., Mo.	X	10	10	5	15	25%	25%	13%	19%
Ordovician Composite Standard Section		X	*40*	*40*	*38*	*78*				

Everton Dolomite. A continuous 6-inch diameter core was cut from 3050 ft. to 7650 ft. (930-2332 m). Regional isopach maps of the Everton suggest that its thickness is greater than 300 ft. (91 m) in this area and as a result, it is estimated that less than half of the Everton's total thickness is represented in the core.

In total, the thickness of the sub-Maquoketa Shale, Middle and Upper Ordovician succession in this area is estimated to be slightly over 1400 ft. (427 m) (Collinson and others, 1988), of which 1,264 ft. (385 m) is represented in the core. Although the sub-Maquoketa, Middle to Upper Ordovician succession attains a maximum thickness greater than 1,700 ft. (518 m) in westernmost Kentucky (Collinson and others, 1988), the H. C Ford et al C-17 core is the thickest sub-Maquoketa Shale, Middle to Upper Ordovician section available for study in the Illinois Basin.

One-hundred-seven samples, 1-3 kg, were collected and processed from the available core material. Each sample was made up of a 40% slab of 1 ft. (0.3 m) interval of core. Although twenty-seven samples, generally anhydrite-bearing, failed to yield conodonts, the faunas recovered from the eighty productive samples yielded forty faunal datums identifiable in the Composite Standard Section. The preservation of the Deicke K-bentonite Bed in this core at 6568 ft. (2001.9 m), 26 ft. (8 m.) below the top of the Platteville Group (Kolata and others, 1996), provides a stratigraphic datum that must be honored in the interpretation. Identification of this bed as the Deicke is supported by geochemical data (Kolata and others, 1996, p. 24).

Figure 32 shows the graphic correlation scatter plot for the Ford et al C-17 section versus the Middle Ordovician CSS. The position of the LOC is constrained by the first appearance datums for *Curtognathus* spp., *Pseudobelodina* spp., *Belodina compressa*,

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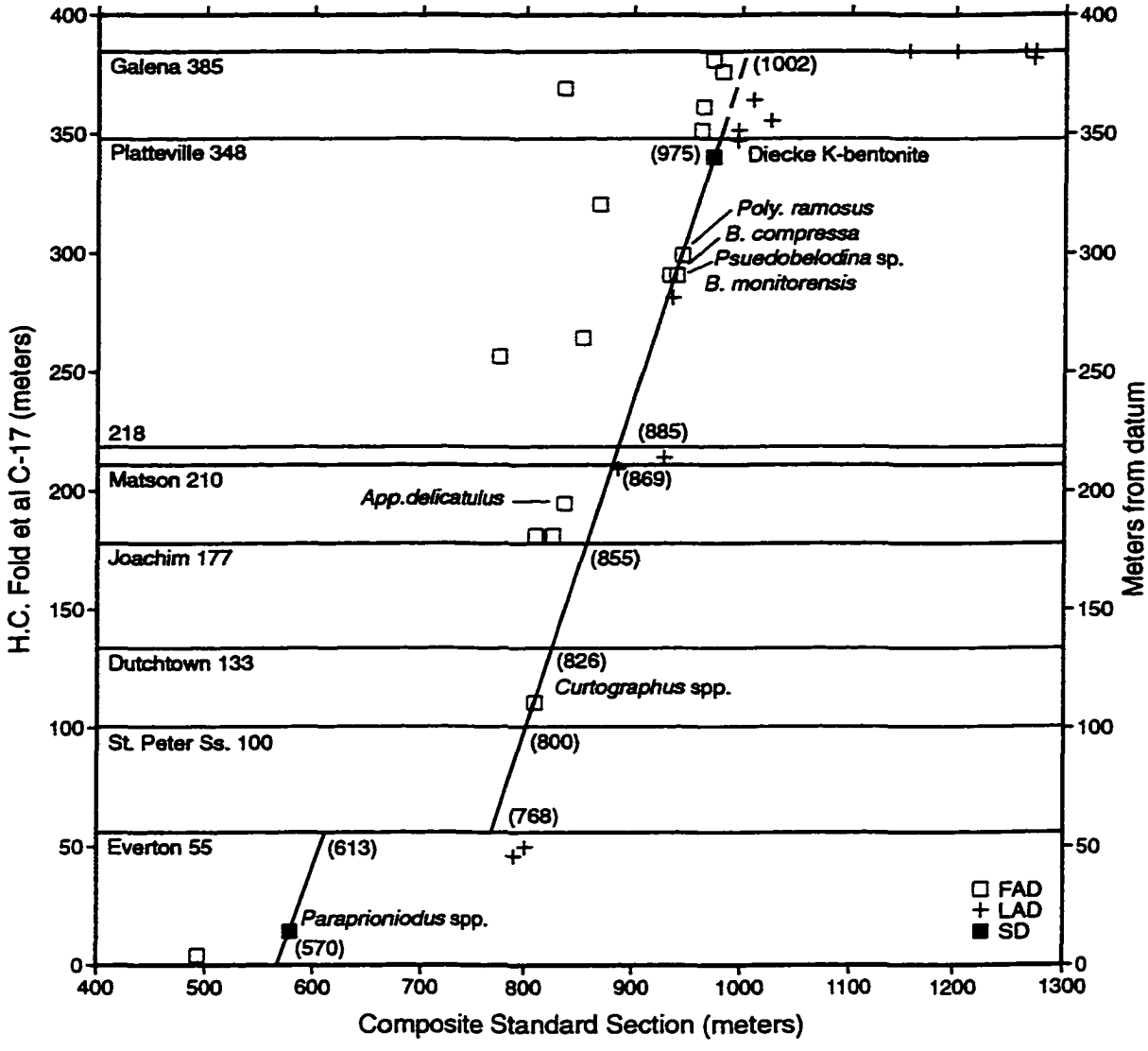

Figure 32: Graphic correlation plot for Superior Oil Co., H. C. Ford et al C-17, White Co., Illinois, locality.

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Polyplacognathus ramosus, the LAD for *Belodina monitorensis*, and the Deicke K-bentonite Bed stratigraphic datum. Note that although there is considerable scatter in the paleontological datums in the lower portion of the section, probably due to paleo-ecological and preservation factors, the abundance of well-constrained datums higher in the section allows the LOC to be established. If the rate net rock accumulation is assumed to be constant, the LOC allows chronostratigraphic control to be extended to those portions of the stratigraphic column lacking biostratigraphically useful fossils.

Although it can be argued that the slope of the LOC may differ for the mixed-lithology Ancell Group, versus the overlying carbonates of the Platteville Group, assumption of a constant slope can be supported statistically and qualitatively. The coefficient of correlation (r) is a statistical measure of the linear relationship described by the LOC equation. The square of (r) yields the coefficient of determination which describes the amount of variation in (y) attributable to the linear relationship described by the LOC (Sincich, 1982). When $r = 1.0$, 100% of the variation in the data set is can be accounted for by the linear relationship defined by the LOC. In this case, $r = 0.99$ which implies a high confidence level for predicting y from x, or x from y, using the LOC equation.

From a qualitative perspective the assumption of a constant net rock accumulation appear to be valid also. As Sloss (1991, 1996) observed, the abundance of sediment supply in the lower and upper portions of the section means that accommodation space is instantaneously filled at geologic time scales. Therefore, the rate of rock accumulation is being controlled by the overall subsidence rate which appears to have remained constant (Figure 29), rather than sedimentation rates of specific stratal units.

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Although the net rock accumulation rate appears to be relatively constant there are four intervals where the horizontal distribution of datums relative to the LOC imply a change in the net rock accumulation rate: 1) Everton-St. Peter Sandstone contact (55 m above datum), 2) top of the Joachim Dolomite (177 m above datum), 3) contact of the Platteville and Galena groups (348 m above datum), and 4) the top of the Galena Group (385 m above datum). The last is an artifact of sampling and has no geologic significance based on the current data set. No samples were collected from the overlying Maquoketa Shale and the stratigraphic ranges of those species that range into Maquoketa time are artificially suppressed.

The terrace developed at the top of the Everton Dolomite implies the presence of a significant discontinuity where the faunal datums are horizontally distributed along the St. Peter Sandstone/Everton Dolomite contact (55 m above the datum). First appearance datums plot to the left of the LOC and last appearance datums plot to the right. These distributions indicate a period of nondeposition and/or erosion at the top of the Everton. Because the Everton was not completely cored, the LOC below the contact is only constrained by the first appearance of *Paraprioniodus* spp. If this datum constrains the LOC, the magnitude of the disconformity is on the order of 18 STU's.

The horizontal distributions of datums relative to the LOC at the top of the Joachim Dolomite and Platteville Group differ from those at the top of the Everton Dolomite and imply a lesser developed discontinuity, or an interval of starved sedimentation. Although first appearance datums (FAD's) are distributed horizontally, they are over a diffuse over a vertical interval. Because the FAD's tend to be to the left of the LOC, it suggests the appearance of these species have been suppressed due to

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unfavorable paleoenvironments rather than lack of preservation due to nondeposition and/or erosion. This is further supported by the observation that although the LAD's are horizontally distributed, their displacement distance from the LOC is relatively small.

There is also good lithic evidence for starved deposition and development of a condensed section at the top of the Joachim Dolomite and Platteville Group. These intervals are lithically characterized by fine-grained siliciclastics, oolitic carbonates, relative abundance of micro- and macrofaunas, thin- to medium-bedded mudrocks, preserved volcanic ash falls, burrowed hard grounds, and abundant coated-grains. These lithic features are the criteria for identifying condensed sections in general (Loutit and others, 1988) and condensed intervals in the Middle Ordovician of the North American Midcontinent (Schutter, 1992).

Upper Mississippi Valley Composite and McGregor Hill sections

Weber (1966) described the Middle Ordovician conodont faunas from six exposures in the Upper Mississippi Valley in southeastern Minnesota, five of which were graphically composited by Sweet (1987) and are presented herein as the Upper Mississippi Valley composite (UMV). In addition, Sweet (1987) reported on the graphic correlation of the conodont fauna recovered by Votaw (1971) from the McGregor Hill section, Sec. 34-T95N-R3W, Clayton County, eastern Iowa. The McGregor Hill section is located on the western extent of the Wisconsin Arch and forty samples, 1-2 kg, were available for review (Sweet, 1987).

Sweet's (1987, p. 170, Figure 14.4) interpretation is somewhat problematic in that the Deicke K-bentonite Bed, which overlies the Blackriver-Trenton Unconformity (B-TR) and falls within a condensed section at these localities, is used in conjunction with the

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FAD of *Phragmodus cognitus* in the Platteville Group, underlying the disconformity, to constrain the LOC. Doing so assumes the unconformity, and the overlying condensed section do not represent a significant hiatus and there is not offset of the LOC. However, the LOC for McGregor, Iowa section has a change in slope at the top of the Decorah/Platteville contact implying the presence of a significant hiatus. In contrast, the lack of LOC offset at this contact in the SE Minnesota Composite (Sweet, 1987, Figure 14.3, p. 170) was interpreted to imply more contiguous deposition in SE Minnesota, or nondeposition/erosion at the B-TR Unconformity is more pronounced at the McGregor locality.

I reexamined the Upper Mississippi Valley data, based on the more refined datums currently in the CSS, provide by Sweet, in order to evaluate the potential of the B-TR Unconformity to influence the Line of Correlation and consequently, the age of the Ancell Group (Figure 33). In this interpretation the LOC is constrained below the B-TR Unconformity by the FAD's for *Bryantodina typicalis*, *Phragmodus cognitus*, and *Oulodus serratus*, and above the unconformity by the Deicke K-bentonite Bed SD, *Belodina confluens* FAD, and the LAD's for *Phragmodus cognitus*, and *Oulodus serratus*. Based on these data, the LOC is slightly off set at the top of the Platteville Group, but the magnitude of the hiatus is less than one STU and cannot be verified graphically with certainty.

Although the Glenwood Formation can yield abundant conodont faunas, the lack of scaled biostratigraphic data from the Ancell Group requires that its age be determined by assuming a constant slope for the LOC and estimating chronostratigraphic datums

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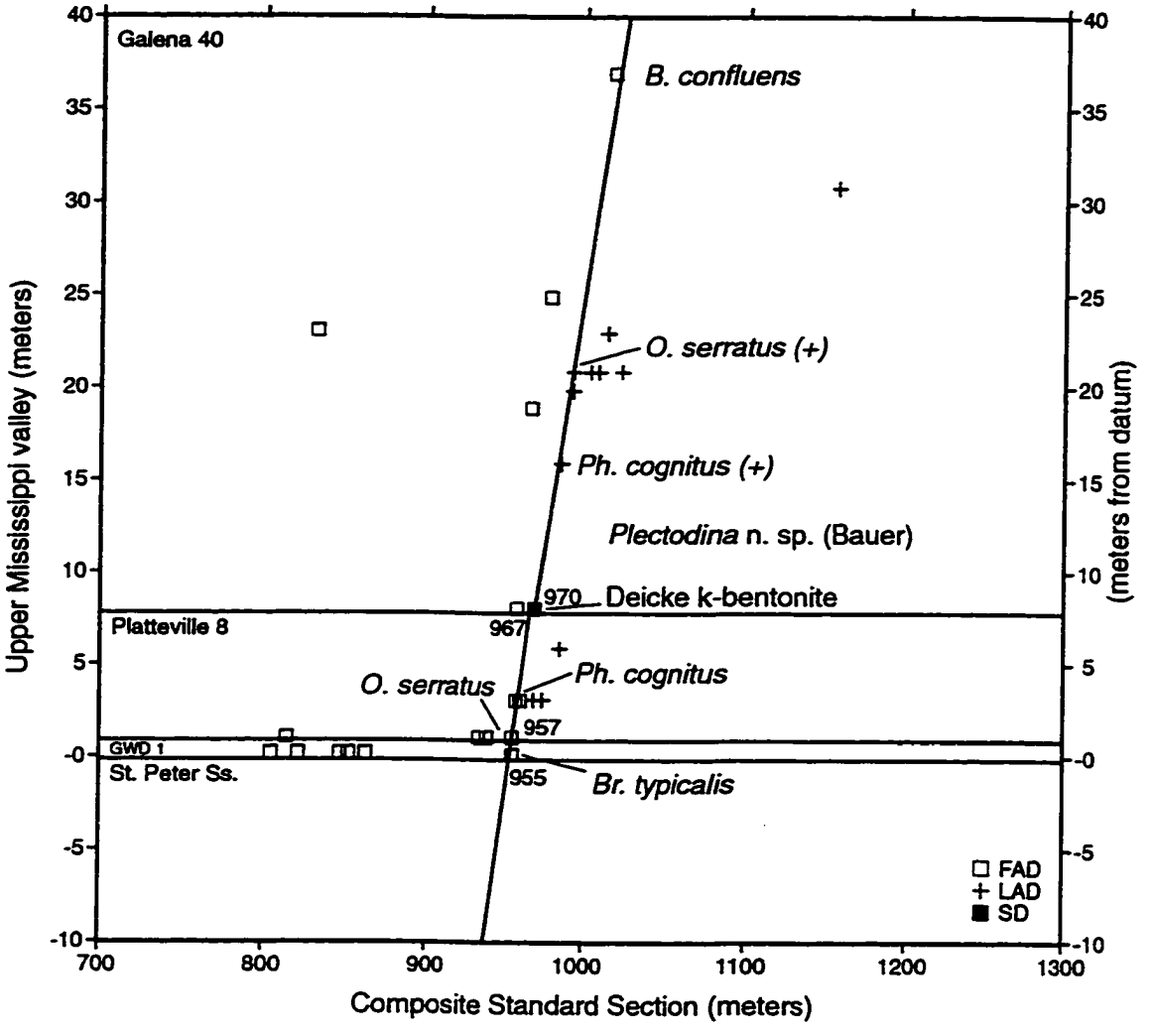

Figure 33: Re-interpreted graphic correlation plot for the Upper Mississippi Composite section of Sweet (1987); data from Sweet (1987, Table 14.1) and personnel communication, 1995.

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based on stratigraphic thickness. The results are not inconsistent with the very limited faunal evidence from the Ancell Group, but the resolution is still much less than is desirable. Sweet (1987) placed the age of the Glenwood within the *Phragmodus undatus* Biochronozone, which conflicted with Weber's (1969) reported of *Phragmodus inflexsus* from the Glenwood Formation is southeast Minnesota. *Phragmodus inflexsus* has a range from the *Cahabagnathus sweeti* to *Belodina compressa* Biochronozone (Late Whiterockian to Medial Mohawkian). The interpretation presented in Figure 33 projects that the age of the Glenwood falls within the *B. compressa* Biochronozone and resolves this inconsistency.

No useful scaled biostratigraphic data were obtained from the St. Peter Sandstone. *Plectodina aculeata* is present in an unpublished collection (this study) from a thin-bed of clayey sandstone in the upper St. Peter Sandstone, Highway X-56 road-cut (described in Sloan and Kolata, 1987), Guttenberg, Iowa. However, the long range of *P. aculeata, Cahabagnathus* sweeti to within the *Plectodina tenuis* Biochronozone, does not allow for refining the age of the St. Peter. In order to estimate the age of the St. Peter, the LOC was projected assuming a constant slope and thickness was used as a proxy for time. The thickness used was assumed to be 92 ft. (30 m) based on the thickness of the St. Peter in Northern Natural Gas Company, Hollandale 67-1A, Sec. 7-R103N-T16W, Freeborn Co., Minnesota. Based on this analysis, the St. Peter is Blackriveran (= Early Mohawkian) in age.

The assumption of a constant slope for the LOC within the Ancell Group is flawed for two reasons and the age of the St. Peter Sandstone remains poorly constrained. First, because the Glenwood Formation of the Upper Mississippi Valley is reflective of

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starved sedimentation (Schutter, 1992), there is a reasonable probability that the LOC should be offset either due to discontinuity, or lower slope through the Glenwood-Starved Rock Sandstone Member interval. Therefore, the estimated age of upper St. Peter Sandstone, assuming a constant LOC slope, yields a younger age than is probable. Second, thickness of the St. Peter is strongly influenced by the paleotopographic relief on the post-Prairie du Chien and therefore, is less time dependent.

Commonwealth Edison UPH-3, northwest Illinois

This section is based upon a 2.5-inch (6 cm) diameter, whole core from Commonwealth Edison UPH-3, Sec. 7-28N-6E, Stephenson Co., Illinois, that contains a complete stratigraphic section from surface to well within basement (Precambrian granite). In addition to core, a full suite of geophysical logs is available for this well. The well is located on a north-south trending anticline, on the southwestern flank of the Wisconsin Arch, and was drilled to determine the feasibility of storing hazardous waste in this structure.

The well was continuously cored from the base of alluvium, at 32 ft. (9.7 m), to total depth of 5272 ft. (1607 m). The Galena Group, 232 ft. (71 m) thick, is truncated by the Recent erosional surface. A complete section of the Platteville Group is present and it's top is at 264.5 ft (81 m). The top of the Ancell Group is the upper contact of the Glenwood Formation at 343.5 ft. (104.7 m). The Glenwood is only 8.5 ft. (2.6 m) thick and is made up of green-gray mudrock, pyritic, stromatolitic dolomudstone and poorly sorted, argillaceous quartz arenite. The underlying St. Peter Sandstone has an aggregate thickness of 123 ft. (37.5 m) the upper 21 ft. (6.3 m) are coarse-grain quartz arenites of the Starved Rock Sandstone Member. The underlying Tonti Sandstone Member, 380 ft.

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(116 m) to 425 ft. (129.5 m), is predominantly light green-gray, fine- to medium-grain, moderately-sorted, massive quartz arenite. The lower Tonti 400-425.5 ft. (122-130 m) is predominantly light green-gray to light yellow-gray, fine-grain, well-sorted, friable cross-stratified quartz arenite locally indurated with pyrite and calcite cement.

The lower 50 ft. (15.2 m) of the Ancell Group composed of brick red and red-orange, fine-grain quartz arenites with interbeds of brick red feldspathic mudrocks of the Kress Member. Shaw (1987) recovered reworked Lower Ordovician conodonts from the basal Kress Member. The Ancell Group disconformably overlies the Shakopee Dolostone of the Prairie du Chien Group, whose age is determined by conodonts to be upper-Lower Ordovician in age (Shaw, 1987).

Forty-eight samples were collected from the Ancell, Platteville and Galena groups at approximately 3-10 ft. (1-3 m) intervals. The sampling interval was reduced to 1-2.5 ft. (<1 m) in the Ancell Group. Each 0.5-1.2 kg sample was composed a 50% cut of the core over a 1.5-2 ft. interval (0.5-0.6 m). All but one sample yielded identifiable conodonts. Graphic correlation of this section is based on presence of 22 conodont species that have 36 shared datums with the Composite Standard Section. The Deicke K-bentonite Bed is absent in this section due to nondeposition and/or post-depositional erosion associated with the development of the B-TR Unconformity (Kolata and others, 1997).

The Line of Correlation (Figure 34) for the Ancell and Platteville groups was established based upon the First Appearance Datums for *Polyplacognathus ramosus*, *Belodina compressa*, and *Phragmodus undatus*. Both *P. ramosus* and *B. compressa* first appear in the upper Glenwood Formation and therefore, their appearance may be delayed

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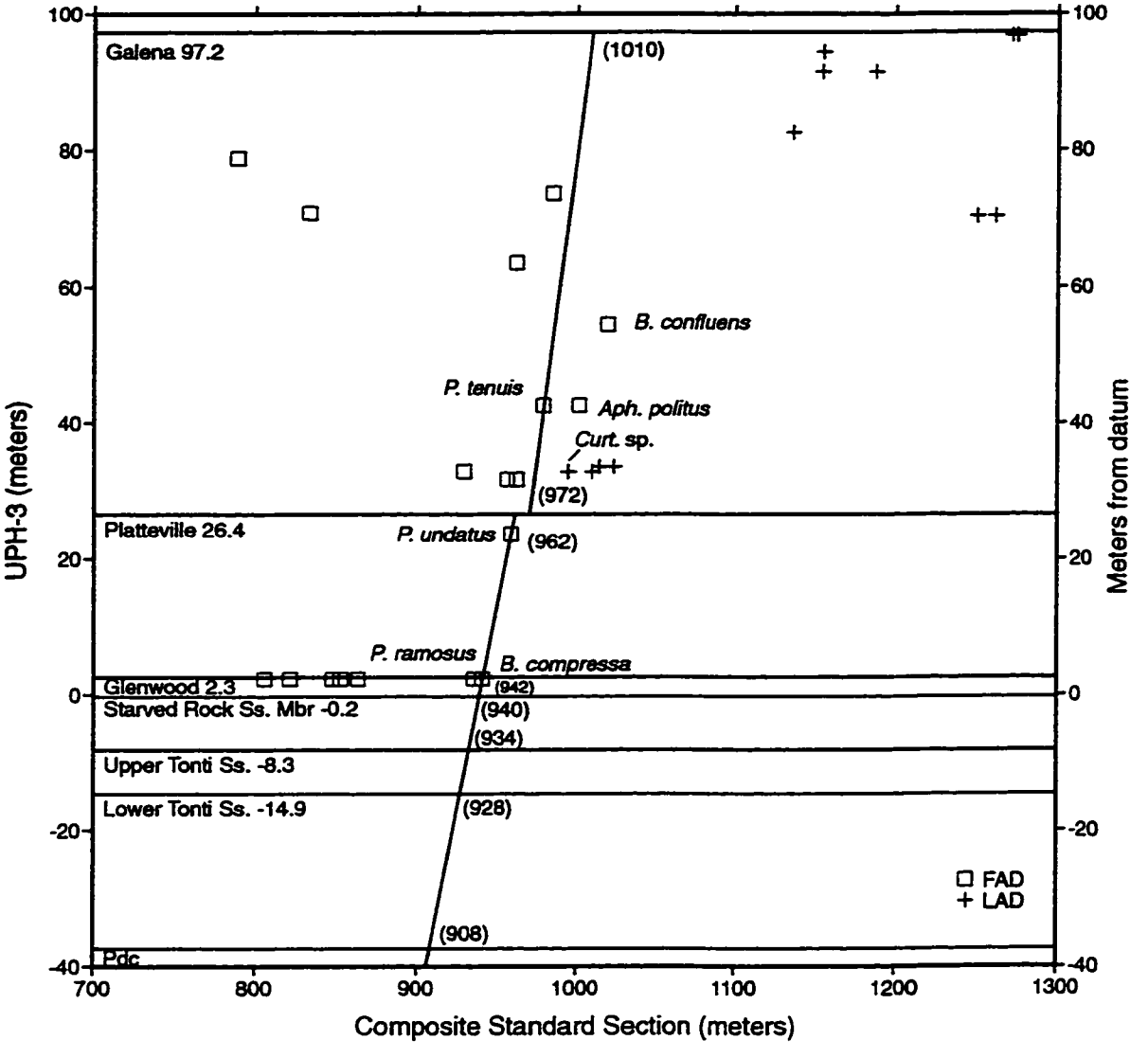

Figure 34: Graphic correlation plot for Commonwealth Edison, UPH-3, Stephenson County, northwest Illinois.

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relative to the CSS by paleoecologic considerations. As a result, the LOC has been drawn through the *P. ramosus* FAD. Based on this interpretation, the Glenwood Formation and Starved Rock Sandstone Member straddle the late *E. quadractylus*-early *B. compressa* Biochronozones and therefore, are early Mohawkian in age.

The Line of Correlation for the post-Platteville section is not of direct concern for this report, but merits some comment. If a constant slope is assumed the LOC above the Platteville-Galena Group contact is only constrained by the *Plectodina tenuis* FAD. However, the absence of the Deicke K-bentonite Bed strongly argues for a hiatus at the contact. If the post-Platteville LOC is assumed to be independent of the slope of the pre-Galena LOC, then the LOC is constrained by the *Aphelognathus politus* and *Belodina confluens* FAD's. This solution has two problems. First, the *B. confluens* and *A. politus* FAD's are anomalous in that unlike elsewhere in the North American Midcontinent they first appears in the UPH-3 section before *Protopanderodus liripipus*, *Peridon grandis* and *Icriodella superba*. Second, it implies a Late Ordovician age for the upper Galena Group, which is in conflict with generally accepted "Trentonian" age (Late Mohawkian) reported by Willman and Kolata (1978). Although possible, this interval should be resampled in order to confirm the first appearance of *B. confluens* and *A. politus* at this level.

In light of this uncertainty, I believe the most geologically reasonable solution requires the LOC to intercept the Platteville-Galena contact above the projected position of the Deicke K-bentonite Bed from the CSS, to account for it's absence, and maintain a positive slope through the FAD for *Plectodina tenuis*. This solution would imply the magnitude of the B-TR Unconformity is between 1-7 STU's and that the age of the upper Galena Group falls within the *Plectodina tenuis* Biochronozone.

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MSD Section, Cook Co., northeast Illinois

Thirty-eight (0.5-0.8 kg) samples were collected from a 2.5-inch (6 cm) diameter continuous core cut in Metropolitan Sanitary District (Chicago) DH-71-9 (31), NE NW Sec. 25–T42N-R13E, Cook Co., Illinois. This well is located structurally on the north flank of the Kankakee Arch and was continuously cored from top of bedrock to a total depth of 1,341 ft. (409 m). The interval sampled is from the top of the Prairie du Chien Group (936 ft. or 285 m) to the top of the Galena Group (422 ft. or 129 m). Formation contacts were identified with the assistance of M. Sargeant, Illinois State Geological Survey.

All of the samples yielded conodonts. The recovered fauna contains twenty-three taxa whose ranges are established within the Composite Standard Section and yield forty shared datums. Although brick-red, feldspathic mudrocks are present in the Decorah Subgroup and the gamma-ray geophysical log has moderately-elevated readings in this interval (722-730 ft. or 220-222.5 m), geochemical analysis did not confirm the presence of either the Deicke or Millbrig K-bentonite Beds and they are assumed to be absent. This is consistent with the observation of Kolata and others (1996) that the Deicke K-bentonite Bed is absent across the crest of the Kankakee Arch.

The Line of Correlation (Figure 35) below the top of the Platteville Group is constrained by the First Appearance Datums for *Belodina compressa* and *Polyplacognathus ramosus*. This interpretation implies the age of the upper Platteville is no younger than late *Belodina compressa* Biochronozone and the top of the Glenwood Formation is coeval with base of the *B. compressa* Biochronozone.

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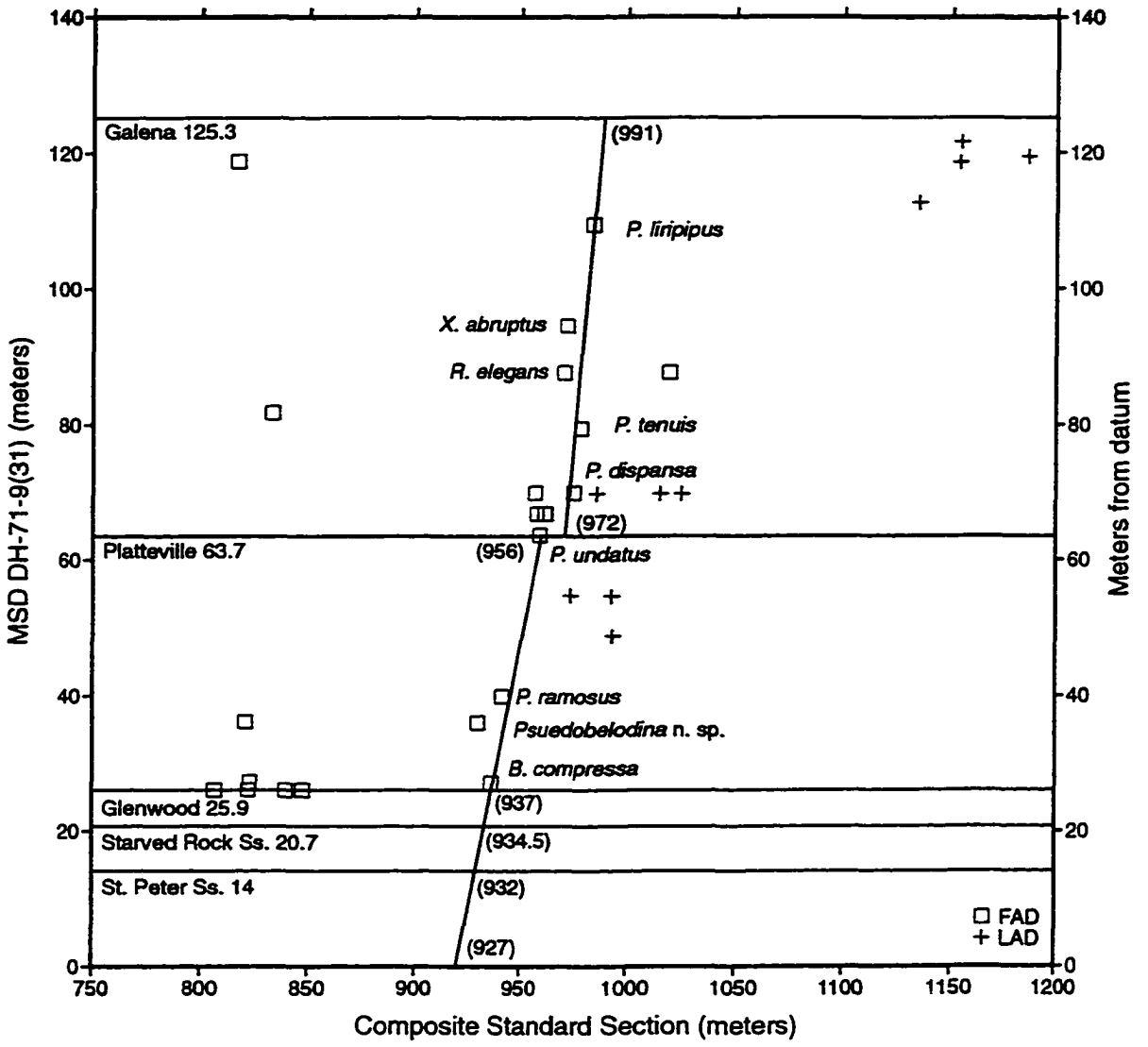

Figure 35: Graphic correlation plot for Metropolitan Sanitary District (Chicago) DH-71-9 (31), Cook Co., northeast Illinois.

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This interpretation is in question because *Phragmodus undatus* has its first appearance 0.3 m (1 ft.) above the top of the Platteville and the B-TR Unconformity. In all other sections examined, *P. undatus* has its first appearance in the upper Platteville Group; however, the uppermost Platteville (731-740 ft. or 223-226 m)) was not sampled in this section. If the position the *P. undatus* FAD is assumed to have an uncertainty of – 3 m, and the LOC is redrawn using the FAD's for *P. undatus*, *Belodina compressa* and *Polyplacognathus ramosus*, the resulting solution places the top of the Platteville Group within the *Phragmodus undatus* Biochronozone. This result, adopted herein, is in better agreement with the regionally observed age for the upper Platteville Group, but additional sampling and recovery of *P. undatus* from the upper Platteville Group will be required to validate this interpretation.

Based on the above interpretation, the top of the Ancell Group falls at the boundary of the *E. quadractylus* and *Belodina compressa* Biochronozones. The tops of the upper and lower Tonti Sandstone Member fall within the late *E. quadractylus* Biochronozone. If a constant LOC slope is assumed, the base of the St. Peter Sandstone is early Mohawkian in age; however, as in the Upper Mississippi Valley paleotopographic relief on the post-Prairie du Chien Unconformity probably exerts greater influence on thickness then time and rate of rock accumulation.

Two solutions are available for the post-Platteville section depending on the assumed magnitude of the B-TR Unconformity. If the Deicke K-bentonite Bed is absent due too post-depositional erosion, then the LOC is required to intersect the Platteville-Galena Group contact at a point higher than 972 m in the CSS. The LOC is then drawn through the FAD's for *Pseudobelodina dispansa*, *Plectodina tenuis* and *Protopanderodus*

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liripipus. Alternatively, if the Deicke K-bentonite Bed is absent due to nondeposition as a result of unfavorable preservation conditions, but deposition was continuous, the LOC can be drawn without change in slope through the FAD's for *Bryantodina typicalis*, *Tetraprioniodus breviconus*, *Xianognathus abruptus* and *Rhodesgnathus elegans*. The current biostratigraphic data set does not provide a compelling case for either solution. Based on the reported regional development of the B-TR Unconformity on the Kankakee Arch by Kolata and others (1996, 1997) the former interpretation is provisionally accepted.

NIPSCO, Forbes #1, northwest Indiana

The fauna utilized for graphic correlation of Forbes #1 is that recovered by Votaw (1971, 1978) from a continuous core from Indiana Gas and Water, J. Forbes #1, White Co., Indiana (Sec. 3-T27N-R6W), located on the Kankakee Arch. Abdulkareem (1982) described the core in detail. Votaw collected 31 samples from the Black River Limestone from 1150-1355 ft. (350.5-413 m) which yielded 2500 identifiable conodonts assigned to 13 taxa. These collections were supplemented by new material collected for this study from 1355-1383 ft. (413-421.5 m)

The Forbes #1 section is one of the most poorly constrained of the sections evaluated. Only thirteen taxa have ranges established in the Composite Standard Section and only twenty-five datums are available for comparison. Furthermore, the Deicke and Millbrig K-bentonite Beds appear to be absent in this area. Although the whole core is no longer available and no geophysical logs were run, neither Abdulkareem (1982), nor Votaw (1971) described lithologies that could be identified as K-bentonites. Geophysical logs of the Black River-Trenton contact in nearby wells, in Sec.32-T27N-5W and Sec.

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11-T26N-6W, do not exhibit characteristics indicating the possible presence of K-bentonites; therefore, the Deicke and Millbrig K-bentonite Beds are assumed to be absent due to nondeposition, or erosion. This is consistent with the observation of Kolata and others (1996) that the Deicke K-bentonite Bed is absent in the subsurface of Lake County, Indiana (Sec. 29-T37N-R8W) and elsewhere on the crest of the Kankakee Arch.

Votaw (1971) placed the post-Knox disconformity at the base of a 3 ft. (1 m) sandstone at 1352-1355 ft. (412-413 m). As concluded by Droste and others (1982), examination of the core indicates that this sandstone is a locally developed equivalent to the Starved Rock Sandstone Member of the St. Peter Sandstone. The silty carbonate interval from 1355-1385 ft. (413-422 m) is the Joachim Dolomite. The post-Knox disconformity is at 1467 ft. (447 m) and is overlain by 82 ft. (25 m) of quartz arenites assigned to the St. Peter Sandstone (1385-1467 ft. or 422-447 m).

The Forbes section has proven to be difficult to correlate graphically for two reasons. First, because the Deicke and Millbrig K-bentonite Beds are absent and the section is biostratigraphically unconstrained above the Black River Group. Second, both *Polyplacognathus ramosus* and *Belodina compressa* first occur in the uppermost Black River Group in this section. Both of the species commonly first appear in the lower Platteville (=lower Black River) in northern and central Illinois. In order to determine if these first occurrences have chronostratigraphic significance, or whether are suppressed due to paleoenvironmental considerations, or inadequate sampling, I graphically correlated the section with the central Illinois composite statistically by the principal axis method (Figure 36). This allows for comparison of datums relative to other datums independent of stratigraphy.

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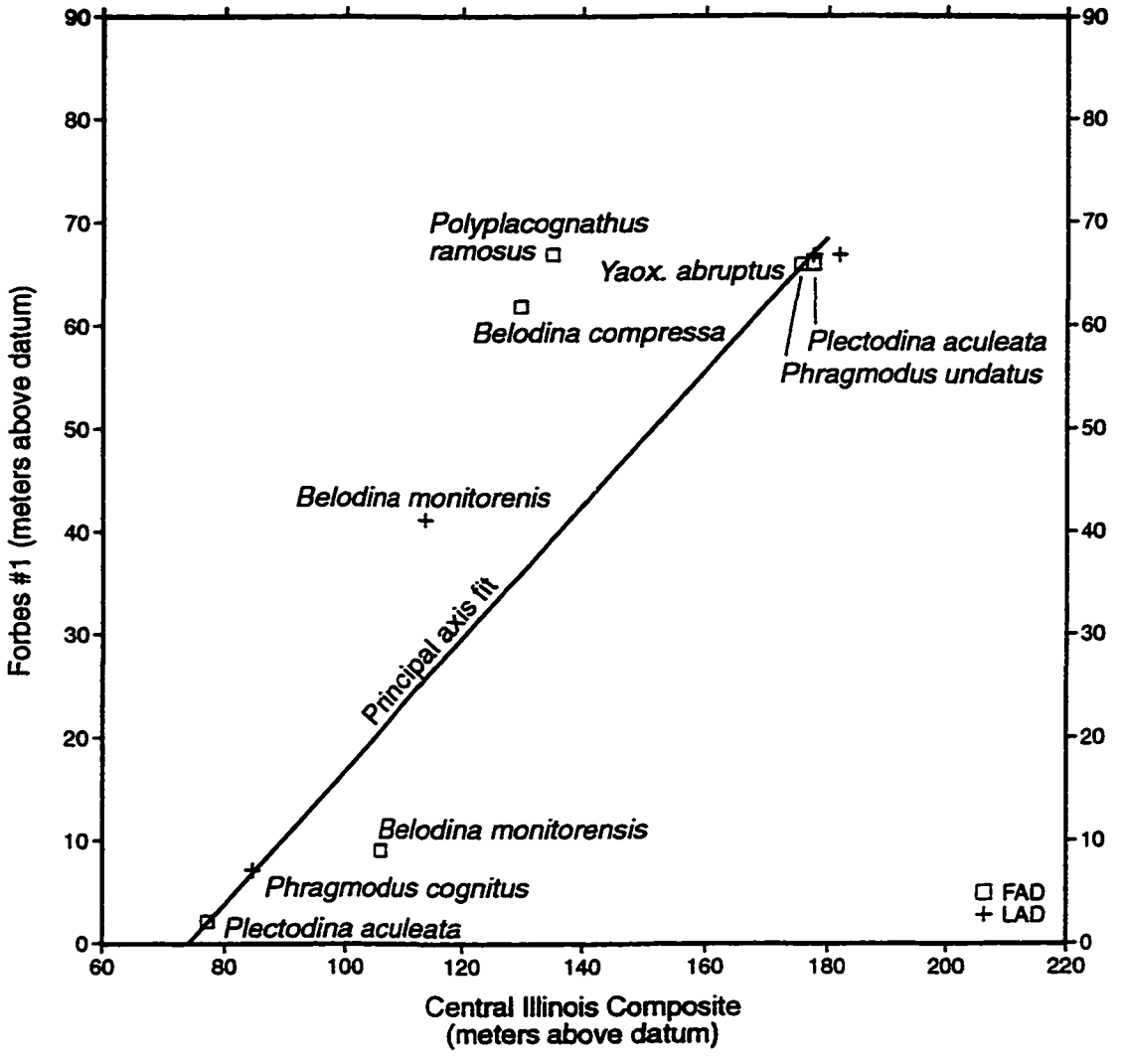

Figure 36: Graphic correlation of NIPSCO, Forbes #1 and the Central Illinois Composite. Note that the FAD's for *Polyplacognathus ramosus* and *Belodina compressa* plot well above the line of correlation, which implies their first appearance in the Forbes #1 is anomalously high in the section.

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Note that the first appearances of *Polyplacoganthus ramosus* and *Belodina compressa* plot well above and the LOC constrained by the FAD's of *Plectodina aculeata*, *Phragmodus cognitus*, *Phragmodus undatus* and *Xianognathus abruptus*. The *Belodina monitorensis* LAD deviates somewhat from the LOC, but appears to be a more reliable datum then *P. ramosus*, or *B. compressa*. This analysis implies that FAD's for *P. ramosus* and *B. compressa* are anomalously high in the Forbes section relative to the Central Illinois Composite.

If first appearance datums for *Polyplacognathus ramosus*, *Belodina compressa*, and *Belodina monitorensis* are graphically projected into the Forbes section from the Central Illinois Composite, the new Line of Correlation for the Forbes and CSS yields a solution more comparable to the nearby northern Illinois sections (Figure 37). This solution offers the greatest consistency with the observed stratigraphy in the area and based on this analysis, the medium- to coarse-grain, poorly-sorted quartz arenite at 1352-1355 ft. (412-413 m) is coeval with the Starved Rock Sandstone.

Peoples Gas, Light & Coke Co., J. Lamb #1, central Illinois

The Peoples Gas, Light & Coke Co., J. Lamb #1, De Witt County, central Illinois (NW, Sec. 1-T20N-R4E) was continuously cored from the lower Maquoketa Formation down-hole to the uppermost Prairie du Chien Group (1790-2495 ft. or 545.6-760.5 m). Tectonically, this well is located in the north-central portion on the Illinois Basin.

Only "representative" whole core "biscuits", 1 to 4-inch (2.5-10 cm) segments of 4-inch (10 cm) diameter core, have been preserved. Forty-seven biscuits were slabbed and 30-50% portions processed for conodonts (sample size = 0.1-0.9 kg). Only four samples did not yield conodonts.

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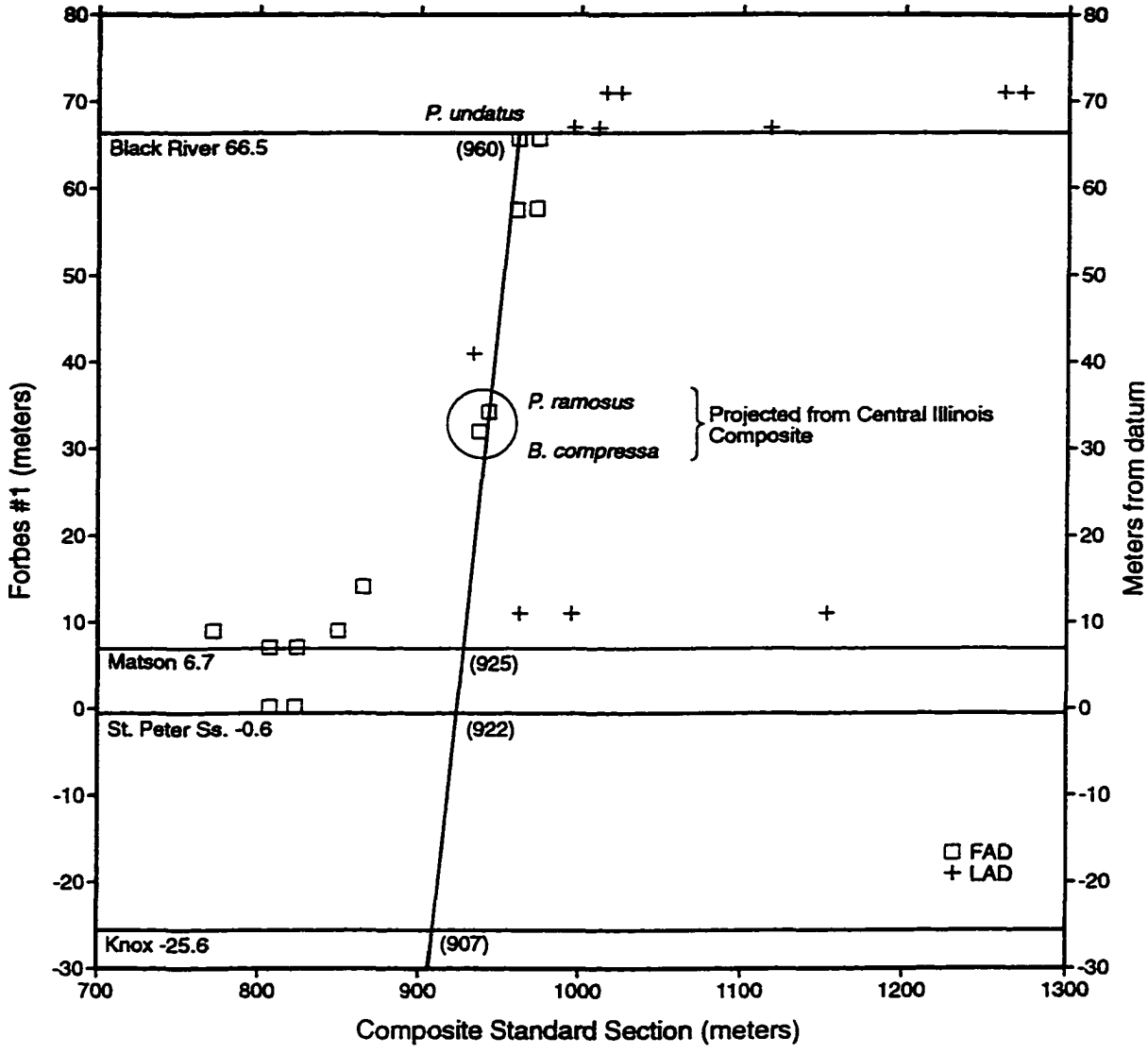

Figure 37: Graphic correlation plot for NIPSCO, Forbes #1, northwest Indiana.

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Although the sample sizes were small, eighteen taxa were recovered that have ranges established in the Composite Standard Section. Thirty-three events are shared between the J. Lamb #1 and Composite Standard Section. The Deicke K-bentonite Bed is not preserved in the available core material, but a 2-inch (5 cm) grayish-green shale, "probable metabentonite" is reported in the core description by T. Buschbach, Illinois State Geological survey (1967), at 1990.3 ft. (606.6 m). On the geophysical logs, this interval ties to a gamma ray "spike" at 1989.5 ft. (606 m). This K-bentonite is interpreted to be the Millbrig K-bentonite Bed and the gamma-ray spike at 2007 ft. (612 m) is the Deicke K-bentonite Bed (Locality 126 of Kolata and others, 1996).

Although sample sizes are small and spacing unequal, the correlation array appears to offer a well constrained solution for the Platteville and Galena Groups; however, it is essentially unconstrained within the Ancell Group (Figure 38). The LOC within the Platteville Group is constrained by the FAD's *Belodina compressa* and *Polyplacognathus ramosus*, and the LAD for *Belodina monitorensis*. Within the Galena Group, the LOC is constrained by the Deicke K-bentonite Bed SD, the FAD's for *Pseudobelodina dispansa*, *Plectodina tenuis* and *Amorphgnathus superbus*. The change in slope and 1 m offset of the LOC at the top of the Platteville Group may reflect development of the Black River-Trenton Unconformity, but the significance of this event is graphically irresolvable. However, the abrupt lithologic change at 1991 ft. (607 m), evident from the core description and on the geophysical logs, supports the presence of a discontinuity.

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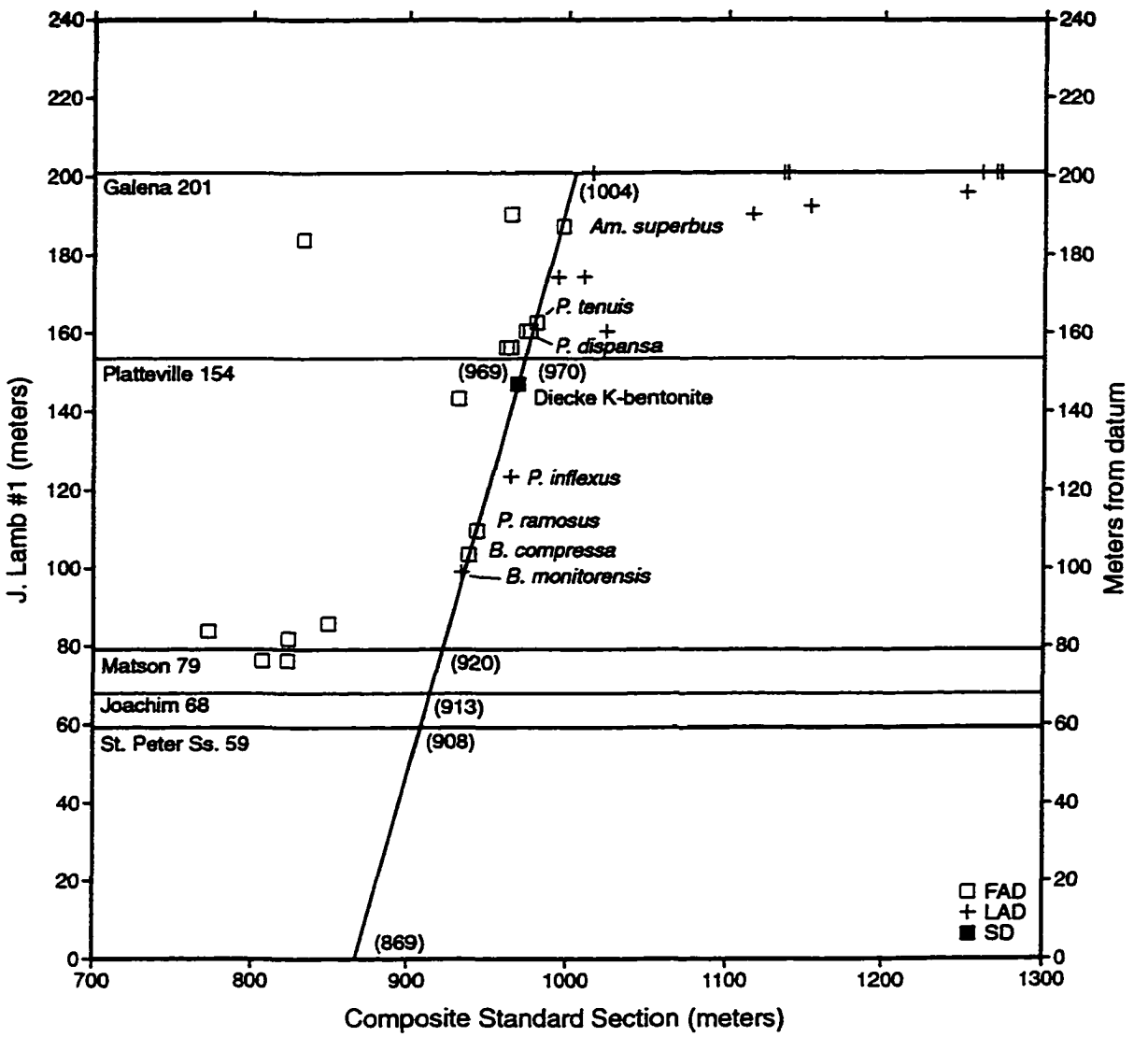

Figure 38: Graphic correlation plot for Illinois Power, J. Lamb #1, De Witt County, central Illinois.

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Central Illinois Composite

Because of concerns about the reliability of the J. Lamb #1 section due to the small sample sizes, it was thought desirable to develop an additional reference section in the north central Illinois Basin area. Although no continuously cored section was available in any one well, continuous whole core was available 30-miles (48 km) east of the J. Lamb #1 location from wells in southern Champaign Co. and northern Douglas Co. All the wells were drilled Illinois Power Co. on the same geologic structure developed for subsurface gas storage.

The samples from three wells, Illinois Power Co., J. Bristow #1 (Sec. 4-T16N-R8E), F. De Bolt #1 (Sec. Ir.4–T16N-R8E), and A. Koss #1 (Sec. 21-17N-8E), were graphically composited, using the techniques previously described, to develop a representative section. The Bristow #1 and Koss #1 cores provide material primarily from the Galena Group, and the De Bolt #1 core material was available from the uppermost Prairie du Chien, Ancell, Platteville and lowermost Galena groups.

The bentonite-bearing Decorah Sub-group was cored in the De Bolt #1 well, but the hard fissile shale described near the base of the unit (1052 ft. or 321 m) in the company core description was not preserved. Geophysical logs demonstrate the possible presence of a K-bentonite in this interval; however, it could not be confirmed geochemically. The bentonite described is probably the Millbrig K-bentonite Bed and based on wire-line logs the Deicke K-bentonite Bed is at 1077 ft. (328 m) (Locality 125 of Kolata and others, 1996).

Ninety-eight samples from two sample sets were processed, of which only twenty-two did not yield conodonts. Sixty-one samples (0.3-0.8 kg) came from composited 4-

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inch (10 cm) core biscuit stratigraphic reference set; each sample is a 40-50% cut of the available material. Thirty-seven samples (2-4 kg) of composited, 2-3 ft (<1 m) intervals of whole core from Bristow #1 (25 samples) and Koss #1 (4 samples). In total the composite contains 20 taxa that have established ranges in the Composite Standard Section and 36 datums are available for graphically comparing the Central Illinois Composite to the CSS.

Figure 39 shows the graphic correlation array for the Central Illinois Composite versus the Composite Standard Section. The LOC was fitted by the least squares method and is controlled below the Galena/Platteville contact by the FAD's for *Phragmodus cognitus*, *Polyplacognathus ramosus* and *Belodina compressa*, and the LAD for *Belodina monitorensis*. Above the contact the LOC is constrained by the FAD for *Plectodina tenuis*, and the Deicke K-bentonite Bed SD. The LOC has a subtle change in slope and is offset by one meter at the B-TR Unconformity. Although there is a change in lithology at this contact, if a hiatus is present it is graphically irresolvable.

Chronostratigraphic control for the Ancell Group is established by assuming a constant slope for the LOC. The scatter of FAD datums within the Ancell Group to the left of the plot are controlled by the intermittent presence of marine lithofacies in the predominantly supratidal succession of the Joachim Dolomite.

PB-KBB, Inc., G. Saylor 1, Pike Co., western central Illinois

Battelle Northwest extensively drilled a the Fishhook Anticline in Pike County, west-central Illinois as part of an feasibility study for subsurface compressed air storage. Although several wells were cored, G. Saylor 1 (Sec. 17-T5S-R4W) has a nearly complete Middle Ordovician section represented in 2.5-inch diameter core. The core

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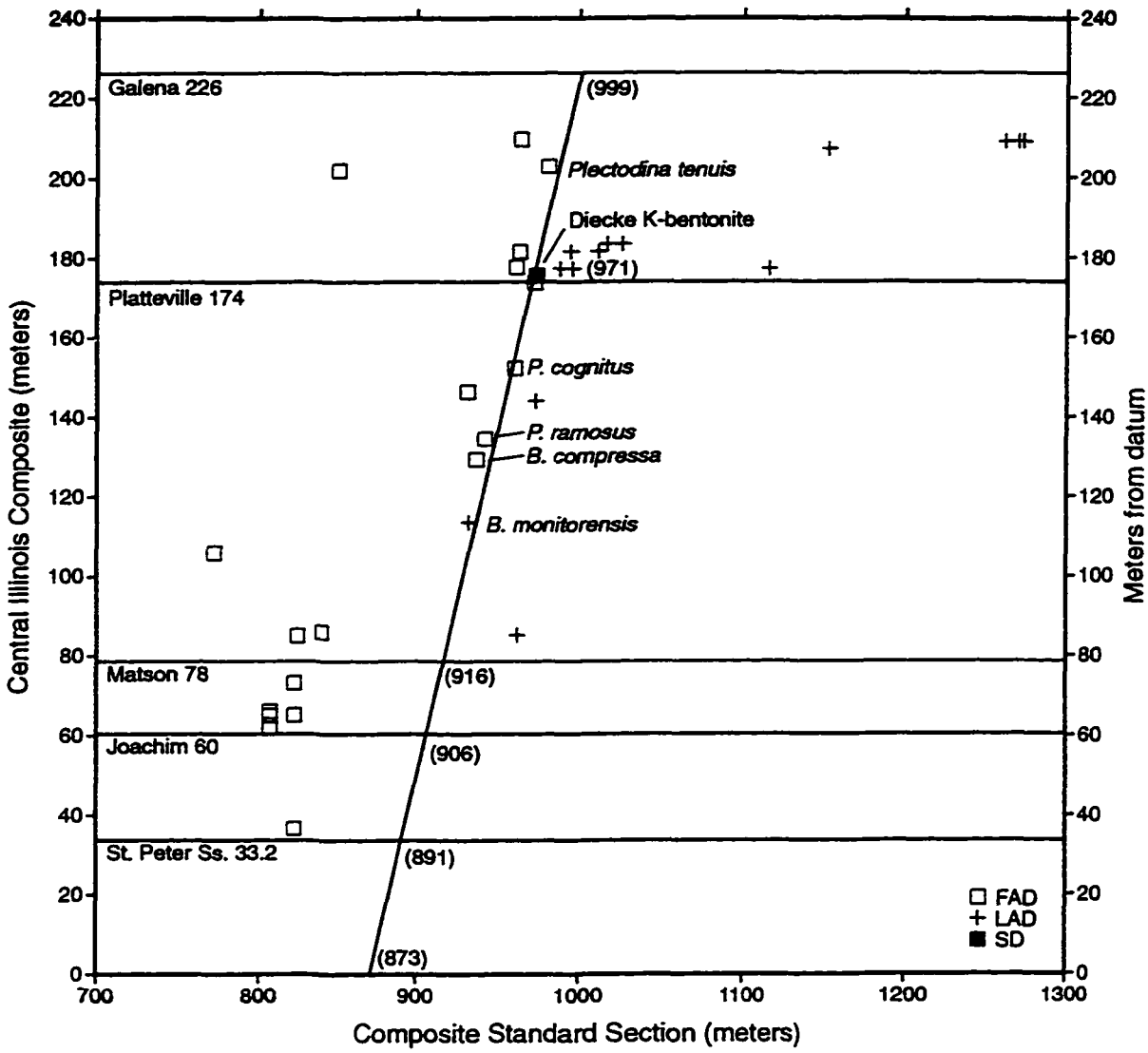

Figure 39: Graphic correlation array for the Central Illinois Composite section.

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was sampled from the base of the Maquoketa Shale (466 ft. or 142 m) down-section to the top of the St. Peter Sandstone (765.5 ft. or 233 m). No core was available for the basal 20 ft. (6 m) of the Platteville Group (689-709.5 ft. or 210-216 m). In addition, core chips were sampled from Pike County Gas Association Conkright 1, Pike Co. (Sec. 4-T4S-R4W) to estimate the age of the uppermost Prairie du Chien Group (1208-1212 ft. or 368-369 m).

Forty-five samples were collected from the Ancell, Platteville and Galena groups at approximately 10 ft. (3.1 m) intervals; sampling interval was reduced to 2-3 ft. (<1 m) in the Ancell Group. Each 0.4-0.5 kg sample was composed of a 50% cut of the core over a 1.5-2 ft. interval (0.5-0.6 m). Thirty-five samples yielded conodonts assigned to twenty-two taxa that have ranges established in the Composite Standard Section. These taxa yield thirty-eight datums for comparing the section with the CSS. Feldspathic mudrocks are present in the Decorah Subgroup (619-650.7 ft. or 189-198.3 m) and the Deicke K-bentonite Bed has been identified at 648 ft. (197.5 m) approximately 0.6 m (2 ft.) above the top of the Platteville Group. The presence of the Deicke at this level is consistent with the observed subsurface occurrences elsewhere in Pike County, Thor Resources Sleight #1 and Drilltron Hanson #2, as reported by Kolata and others (1996).

The Line of Correlation above the Platteville Group is constrained by the Deicke K-bentonite Bed SD, the LAD for *Plectodina aculeata* and the FAD for *Belodina confluens* (Figure 40). The FAD for *Phragmodus undatus* is 0.3 m (2 ft.) above the Platteville Group within the Decorah Subgroup of the Galena Group. As with the MSD section, the uppermost Platteville Group was not sampled and its uncertain if the *P. undatus* FAD is valid.

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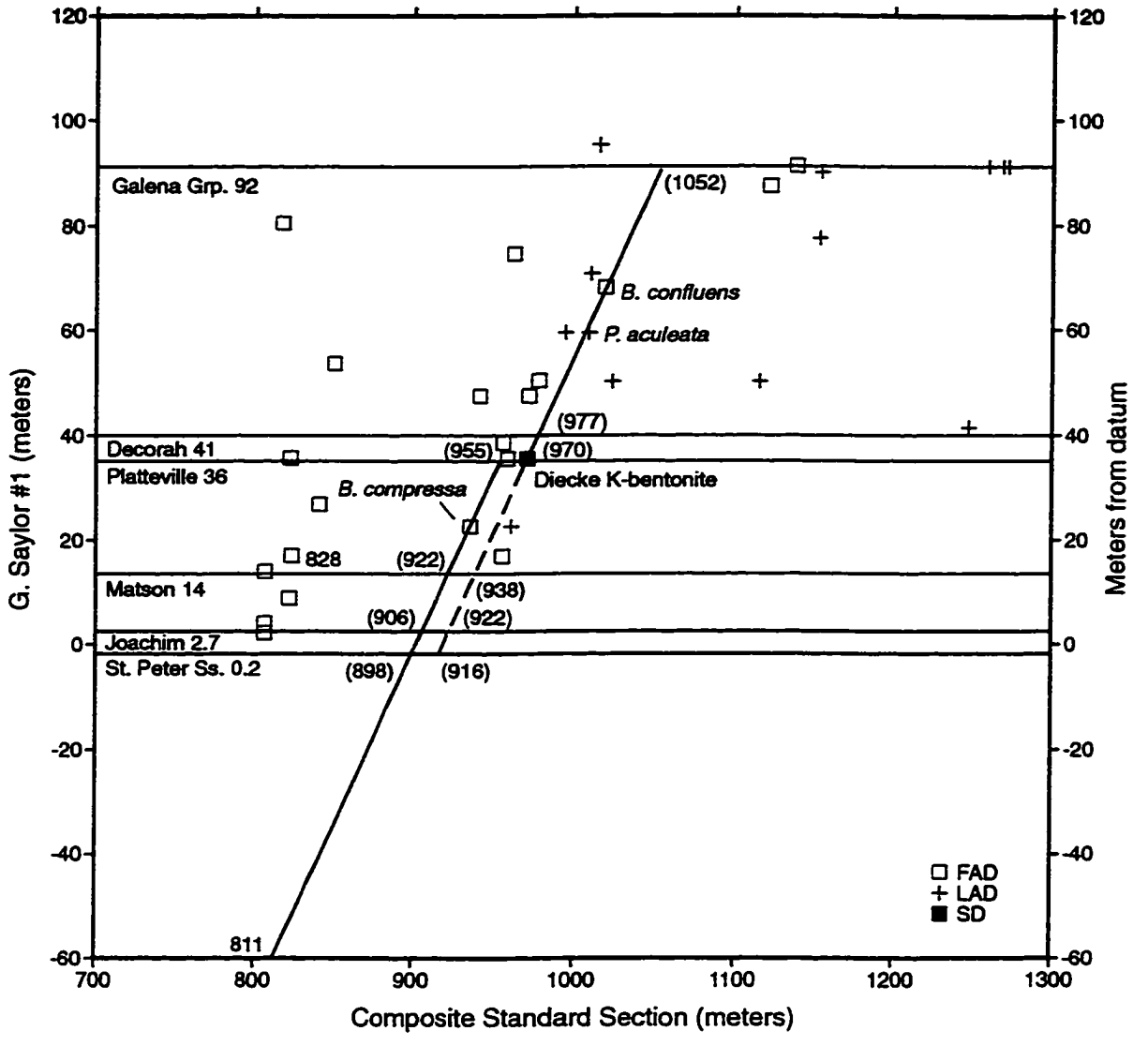

Figure 40: Graphic correlation array for G. Saylor #1, Pike County, western Illinois. Dashed line shows solution assuming constant slope of the LOC and no development of a hiatus at the level of the B-TR Unconformity. The recommended solution (solid line) utilizes the FAD for *Belodina compressa* and assumes that if a positive slope is maintained, the LOC must intercept the B-TR Unconformity at something less than 972 m in the CSS.

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Below the top of the Platteville Group only one datum, FAD for *Belodina compressa*, is available to constrain the LOC, as a consequence the solution is poorly constrained between two alternatives. The first alternative projects the LOC below the top of the Platteville Group down section based on constant rate of net rock accumulation. The second alternative assumes a constant slope for the LOC, but requires that it intercept the FAD for *Belodina compressa*. This alternative requires that the B-TR Unconformity result in a significant offset of the LOC and implies the hiatus has a magnitude of 2.5 STU's. Although this interpretation is supported by the abrupt lithic change at the top of the Platteville Group in this section and is adopted herein, confirmation of this interpretation would require additional sampling from the uppermost Platteville Group (650.5-659.5 ft.) and recovery of *Phragmodus undatus*.

Weber Hill road cut, Jefferson Co., Missouri

Exposure is located along the southbound lane of Missouri Highway 30, Jefferson County, Missouri (NE ¼ of section 27-T34N-R4E), on the eastern flank of the Ozark Dome where a continuous section of the upper Joachim through upper Macy Limestone (uppermost Plattin Limestone Group) is exposed. The lithostratigraphy of the section is described in Thompson and Satterfield (1991, p. 111, figure 68).

Thirty-three samples (2-3 kg) were collected at 1-4 meter intervals from Joachim Dolomite, Bloomsdale Limestone, Beckett Limestone, Hager Limestone and Macy Limestone. Nearly all samples yielded identifiable conodonts, but the fauna is limited to eleven species, of which ten have ranges established in the Composite Standard Section. These ten taxa yield fifteen shared events with the CSS. The uppermost unit exposed is the Zell Member of the Macy Limestone and the contact with the overlying Sprechts

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Ferry (Decorah Group) is unexposed. Based on the stratigraphy of the Middle Ordovician exposed along U. S. Interstate 44 (Thompson and Satterfield, 1991, figures 72 and 104), 10 miles (16 km) to the northwest, the top of the Macy is approximately 2 m (6.6 ft) above the uppermost bed exposed at Weber Hill. Therefore, the Deicke K-bentonite Bed is projected to be 2.5 m (8 m) above the highest conodont sample collected. This section is the most poorly constrained of the sections examined because of the paucity of faunal datums and the lack of precision in the position of the Deicke K-bentonite Bed.

Figure 41 shows the graphic correlation plot and the recommended solution based on the projected FAD for *Belodina compressa* from the G. Saylor #1 section and the Deicke K-bentonite Bed stratigraphic datum. This procedure follows that previously described for the Forbes #1 section. Figure 42 shows the graphic correlation plot for the Weber Hill and G. Saylor 1 section and demonstrates the delayed first appearance of *Belodina compressa* in the Weber Hill section. Solutions based solely on the recovered faunas yield geologically unreasonable solutions that require that the central Illinois Basin is paleotopographically positive relative to the Ozark Dome during Middle Ordovician time.

This proposed solution requires the Bloomsdale Limestone is coeval with Glenwood Formation of northern Illinois and the lower Platteville Group of the central Illinois Basin. Furthermore, the lithic character of the Bloomsdale, oolitic/bioclastic grainstone, abundant mudrock partings, burrowed bedding planes, ferruginous hard grounds, is consistent with a regionally developed condensed section. Lastly, this correlation implies time transgressive, on-lapping of "Joachim" lithologies from east to

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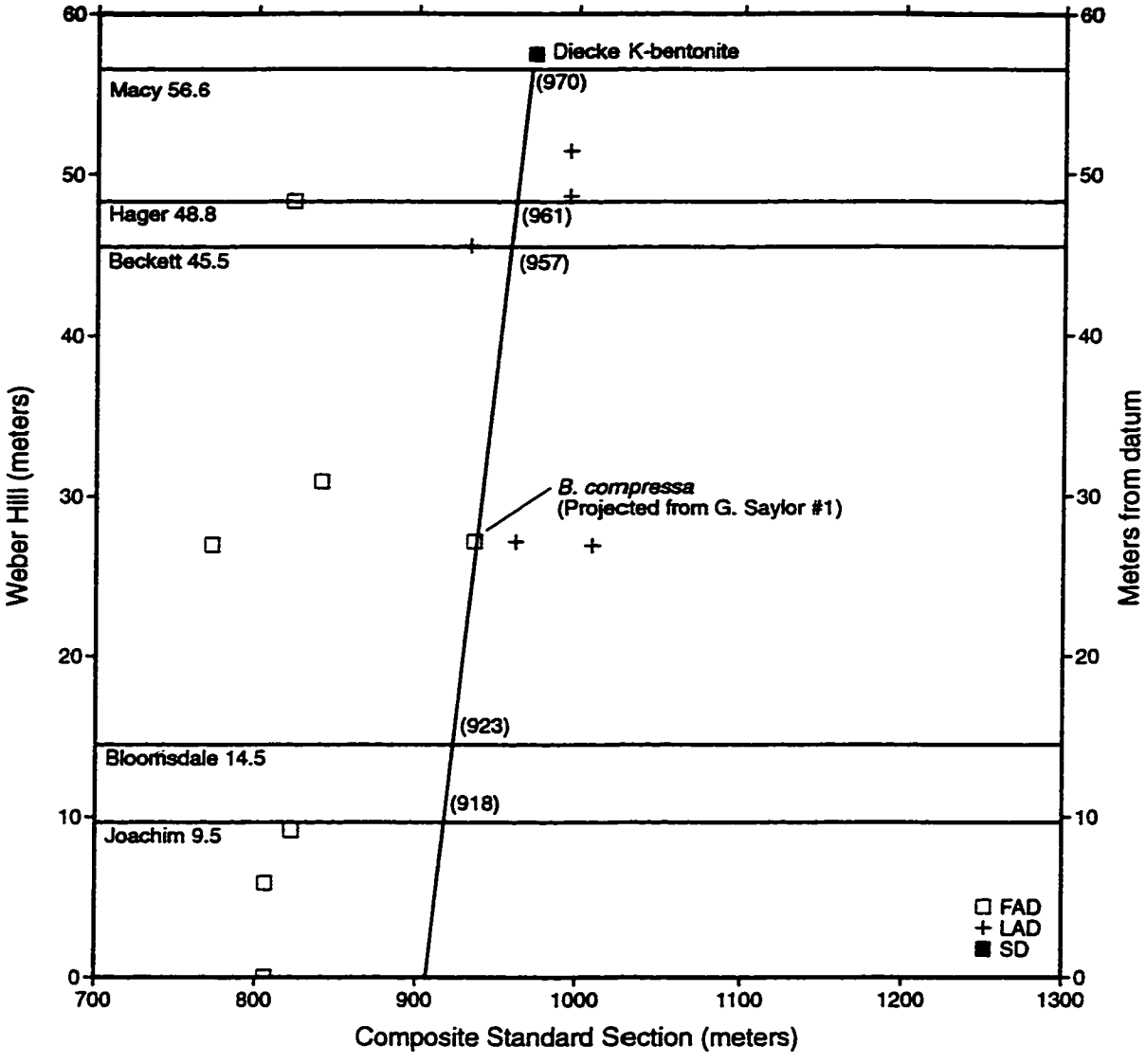

Figure 41: Graphic correlation array for Weber Hill roadcut, northeast Missouri.

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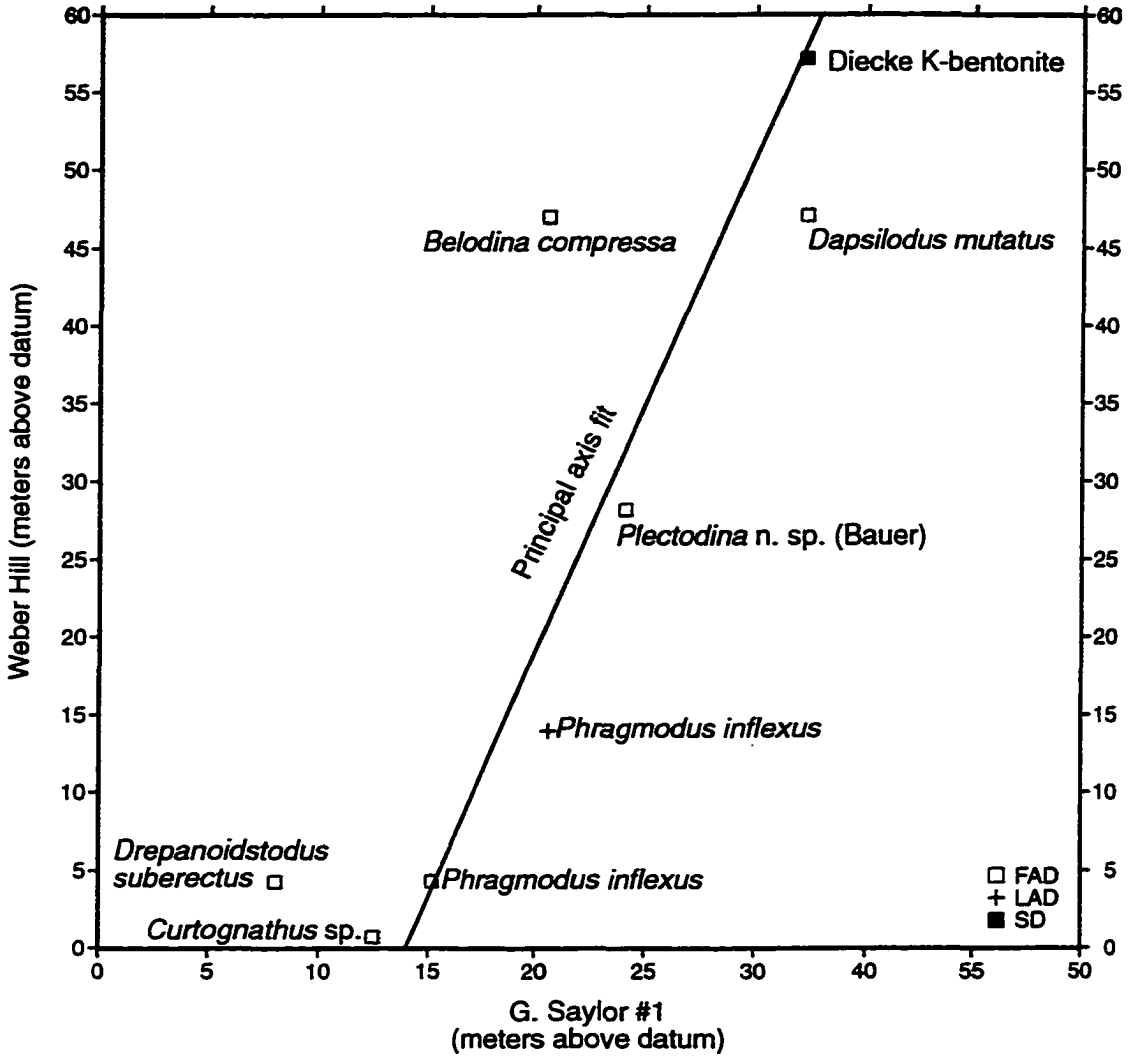

Figure 42: Graphic correlation array for Weber Hill roadcut, northeast Missouri, versus G. Saylor #1, western Illinois. Note that the FAD *Belodina compressa* falls well above the LOC, implying the first appearance is anomalously high in the Weber Hill roadcut.

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west, may provide a better conceptual understanding for recovery of *Phragmodus undatus* from the Matson Member of the Joachim at Holstein, Missouri (Leslie and Bergstrom, 1995b). The Holstein locality is one of the westernmost exposures of the Joachim

Jessamine Dome, northern Kentucky

The Jessamine Dome section is a composite of the Standard Reference Section for the Ordovician Composite and the Camp Nelson Type locality sampled by Votaw, 1971. The Standard Reference Section based on the faunas and stratigraphy represented in the 2.5-inch (6 cm) diameter core from the Cominco American CA-38, Mason Co., north-central Kentucky (Carter coordinate Sec. 15-AA-68), located on the Cincinnati Arch (Sweet, 1995). The stratigraphy and paleontology of the upper Middle Ordovician and Upper Ordovician portions of the core are described in Sweet and others (1974) and Sweet (1979). The conodont fauna from the lower Middle Ordovician portion of the core, 545 ft. (166 m) of carbonate assigned to the High Bridge Group, is described in detail in Votaw (1971). Votaw (1971) collected forty-one samples from the upper High Bridge Group through the basal Lexington Limestone. Total thickness of the High Bridge sampled is 180 ft. (55 m).

Graphic correlation and taxa ranges are reported in Sweet (1984). Having the SRS located within the study area offers a distinct advantage in that faunal ranges are less likely to be influenced by barriers to faunal dispersal (Shaw, 1964).

Cominco American Ca-254, south-central Kentucky

This section is based upon the sampling of a 2.5-inch (6 cm) diameter core obtained by Cominco American on the Ellen farm, Cumberland Co., Kentucky (Carter coordinate system Sec. 16-D-52). Structurally, this locality is in the saddle between the

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Nashville and Jessamine Domes. Although a core description is given in Appendix III, Milici (1983) and Gooding (1992) provide detailed discussions of Middle Ordovician lithostratigraphy in this area. Because the core was obtained for mineral exploration purposes, no geophysical logs were obtained. For purposes of subsurface correlation, the nearby Barrett Oil, Neal #5, (Sec. 15-D-52) can be readily correlated with the core and serves as a proxy for the cored stratigraphic section.

One-hundred-twelve samples were collected from the upper Knox Group to the top of the High Bridge Group as locally defined (=Stones River Group of central Tennessee) at a sampling interval of one sample every 10 ft. (3 m). Within the Wells Creek Dolomite sampling interval was reduced to 3-6 ft. (1-2 m). Each 0.25-0.5 kg sample was composed a 50% cut of the core over a 1.5-2 ft. interval (0.5-0.6 m). Eighty-nine samples yielded conodonts. Eighteen taxa present have ranges established in the Composite Standard Section and yield thirty-three graphically correlative events. The Deicke K-bentonite Bed, locally named the Pencil Cave (T-3) Bentonite, is several centimeters thick and readily identifiable based on the presence of biotite-bearing mudrock at 993 ft. (302.6 m). The overlying Millbrig K-bentonite, locally known as the Mud Cave (T-4) Bentonite, is present at 989 ft. (301.5 m).

The coarse sampling interval and sparse faunas, resulting in uncertain taxanomic assignments, has yielded substantial scatter in the graphic correlation plot (Figure 43). The Line of Correlation solution is constrained by the FAD's for *Phragmodus inflexus*, *Applachignathus delicatulus*, *Pseudobelodina* n. sp. and *Plectodina tenuis*, the LAD for *Applachignathus delicatulus*, and the Deicke K-bentonite Bed stratigraphic datum. This

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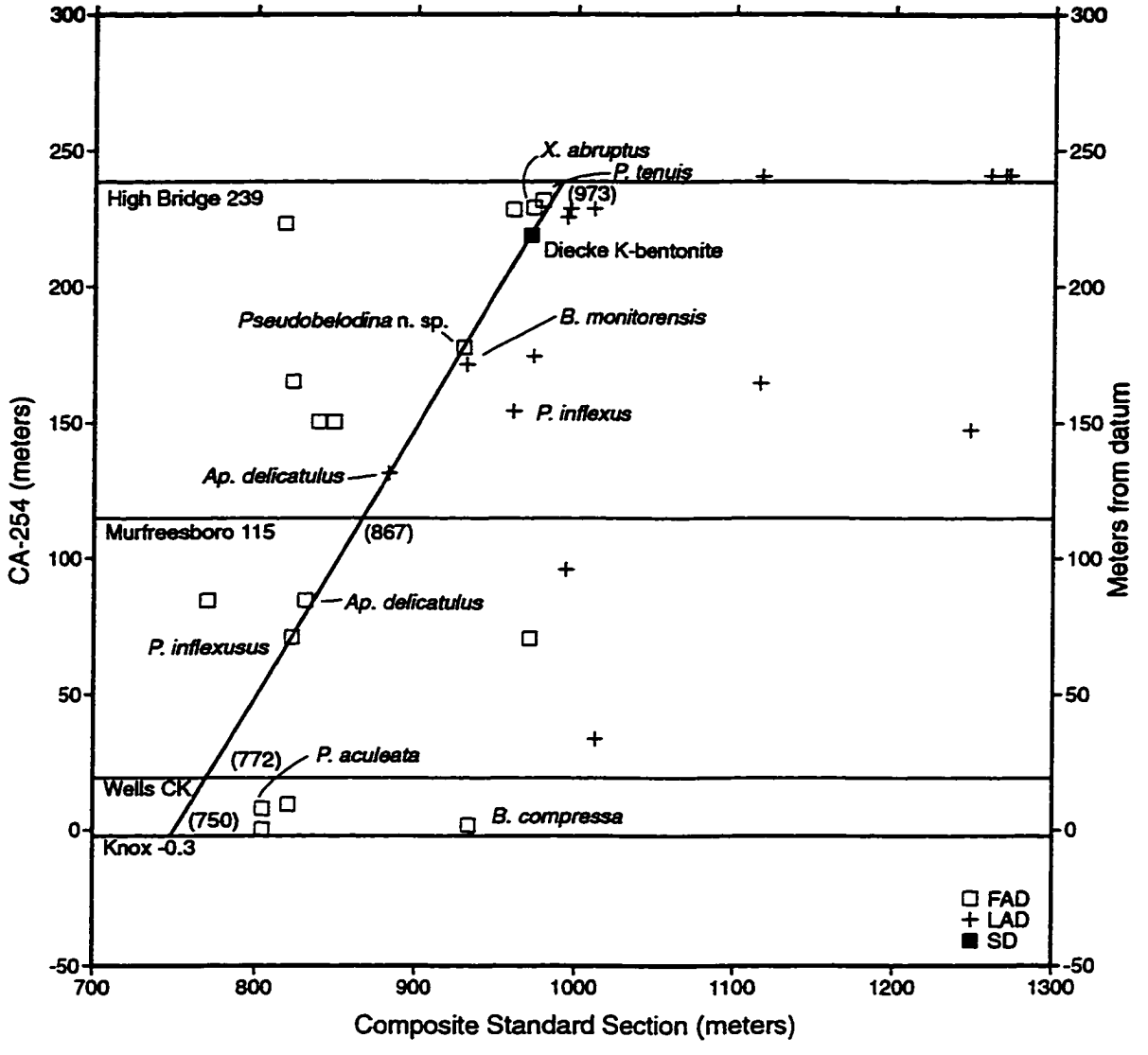

Figure 43: Graphic correlation array for Cominco American Ca-254, Cumberland County, south-central Kentucky.

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solution projects the top of the High Bridge Group within the late *Phragmodus undatus* Biochronozone and the top of the Murfreesboro Limestone within the early *E. quadractylus* Biochronozone (latest Whiterockian). The Wells Creek Dolomite falls within the *Cahabagnathus friendsvillensis* Biochronozone (late Whiterockian).

Nashville Dome, central Tennessee

This section has been included because of its more shelfal position, relative to the peritidal Middle Ordovician succession of the Illinois Basin and because marine deposition appears have been contiguous, so it is better biostratigraphically constrained then the Illinois Basin sections. The Nashville Dome section in a composite section developed, and sampled, by Votaw (1971). Votaw's collections were reviewed and subsequently graphically correlated by Sweet (1984, revised 1986, and 1994 personal communication). Kim (1988) reported on the conodont faunas of the overlying Middle and Upper Ordovician units.

The development of the Nashville Dome composite section is adequately described elsewhere (Votaw, 1971; Sweet, 1994 and 1998), but because the upper Murfreesboro Limestone was the lowest unit sampled by Votaw the projection of the lower Murfreesboro Limestone and Wells Creek dolomite warrants an explanation. The projected top and base of the Wells Creek Dolomite are determined by using the subsurface thickness of the Murfreesboro Limestone (536 ft. or 163 m) and Wells Creek Dolomite (248 ft. or 76 m) in the nearby State of Tennessee SSC F-9-C (Sec. 4-9S-36E), and then graphically correlated assuming a constant slope for the LOC (CSS = 0.981N + 851). Although the lower section is biostratigraphically unconstrained, the projected age

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of late Whiterockian for the lowermost Middle Ordovician succession is consistent with the findings of Votaw and Repetski (1982).

Arbuckle Anticline, Oklahoma

Like the Nashville Dome composite section, the Arbuckle Anticline locality is also provided for comparison. Derby and others (1991) describe the litho- and biostratigraphy of this section, and the conodont faunas have been graphically correlated in Sweet (1984,1995) and Bauer (1987). Because the Arbuckle region was distal to the Taconic Orogen, gross shifts in depositional patterns, and crudely delineated by formation contacts, may reflect true eustatic sea level changes, or far-field tectonic controls on sedimentation.

K-bentonite beds within the Corbin Ranch Member of the Bromide Formation appear to be coeval with the Deicke and Millbrig K-bentonites of the Upper Midcontinent region based on conodont-based age determinations; however, geochemical confirmation is lacking (Kolata and others, 1996). The graphically correlated Arbuckle Anticline section, as reported herein, does not contain a Deicke K-bentonite Bed stratigraphic datum.

Regional correlation

If gross lithic changes, reflected by formation contacts, can be considered indicative of significant changes in depositional conditions, inspection of Figure 31 suggests that these shifts in depositional conditions are coeval across the basin and in some cases regionally. Based on the graphically determined synchroneity, four events are recognizable: 1) post-Everton Dolomite discontinuity, 2) post-Dutchtown Formation event, 3) post-Murfreesboro Limestone, and post-Oregon Limestone. Where examined in

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detail, these "events" can be observed in outcrop and in the subsurface using geophysical logs.

The post-Everton discontinuity is a regionally recognized hiatus and may represent the upper sequence of the Sauk Megasequence of Sloss (1963). The other proximally coeval events are associated with weakly -to strongly-developed condensed sections overlying transgressive flooding surfaces. In addition, significant changes in faunal composition are commonly observed at these horizons. These characteristics are typical of the sequence bounding flooding surfaces proposed by Galloway (1989), and the condensed section developed above the surface of maximum flooding in the transgressive system tract of Vail and others (1977) (Loutit and others, 1988). At this stage of study the sequence bounding surfaces, as they are defined in the Vail sequence stratigraphic concept, are readily recognizable in peritidal carbonate lithofacies of the Ancell Group. However, additional work will be required to define the equivalent bounding surfaces in the St. Peter Sandstone and the subtidal carbonate lithofacies equivalents of the High Bridge and Stone River groups. As a result, although the Middle Ordovician succession can be subdivided into genetically related sequences, the bounding surfaces cannot be rigorously defined yet.

It should also be evident from Figure 39 that the St. Peter Sandstone is a time-transgressive lithotope characterized by its distinctive quartz arenite character, rather than a genetic unit bounded by depositional surfaces. As a consequence, it's desirable to develop an informal nomenclature that relates the current lithostratigrpahic units with the genetic depositional sequences that have chronostratigraphic significance within the Whiterockian to Mohawkian succession of the Illinois Basin. Therefore, for the purpose

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of the following discussion the Ancell Group and it equivalents will be subdivided into four sequences named for the carbonate unit that is most representative of the sequence: 1) Everton Sequence, 2) Dutchtown Sequence, 3) Murfreesboro Sequence and 4) Bloomsdale Sequence. This genetic subdivision is illustrated in Figure 44.

Holland and Potzkowsky (1996) subdivided the Middle Ordovician of the central Appalachians into five sequneces bounded by marine flooding surfaces: Whiterock-a (W-a), Whiterock-b (W-b), Mohwak-1 (M-1), Mohawk-2 (M-2) and Mohawk-3 (M-3). Only W-a, W-b, and M-1 are pertinent to this discussion. Each sequence has basal transgressive unit made up of bioclastic grain- and packstone, overlain within a short interval by mudstone and wackestone with shale. There do not appear to be strata equivalent to the W-b Sequence preserved in the Illinois Basin. The W-a Sequence very closely approximates the combined Dutchtown and Murfreesboro sequences, and the M-1 sequence approximates the Bloomsdale Sequence. The coarse synchroneity of Middle Ordovician sequences in the Taconic foreland to those developed within the Arbuckle region of Oklahoma, and the Illinois Basin (Figures 7 and 44) strongly argues for shared tectonic and/or eustatic controls on creation of accommodation space.

Everton Sequence

The Everton Sequence includes the Everton Dolomite and potentially, lithologies currently assigned to the Wells Creek Dolomite in western Tennessee. Dr. J. E. Repetski (USGS, personal communication, 1992) reported samples from the Dupont Geohydrological Test GHS-1, Humphreys County, Tennessee, contain the conodonts *Tricladiodus clypeus* and *Pteracontiodus* aff. *P. cryptodens*. These species are indicative of an early- to medial Whiterockian age and suggest that the lower Wells Creek in that

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Figure 44: Interpreted graphic correlation chart for the Illinois Basin region showing proposed genetic subdivision of the Middle Ordovician. Refer to Figure 29 and the discussion of graphic correlation for greater detail on the establishment of boundary ages.

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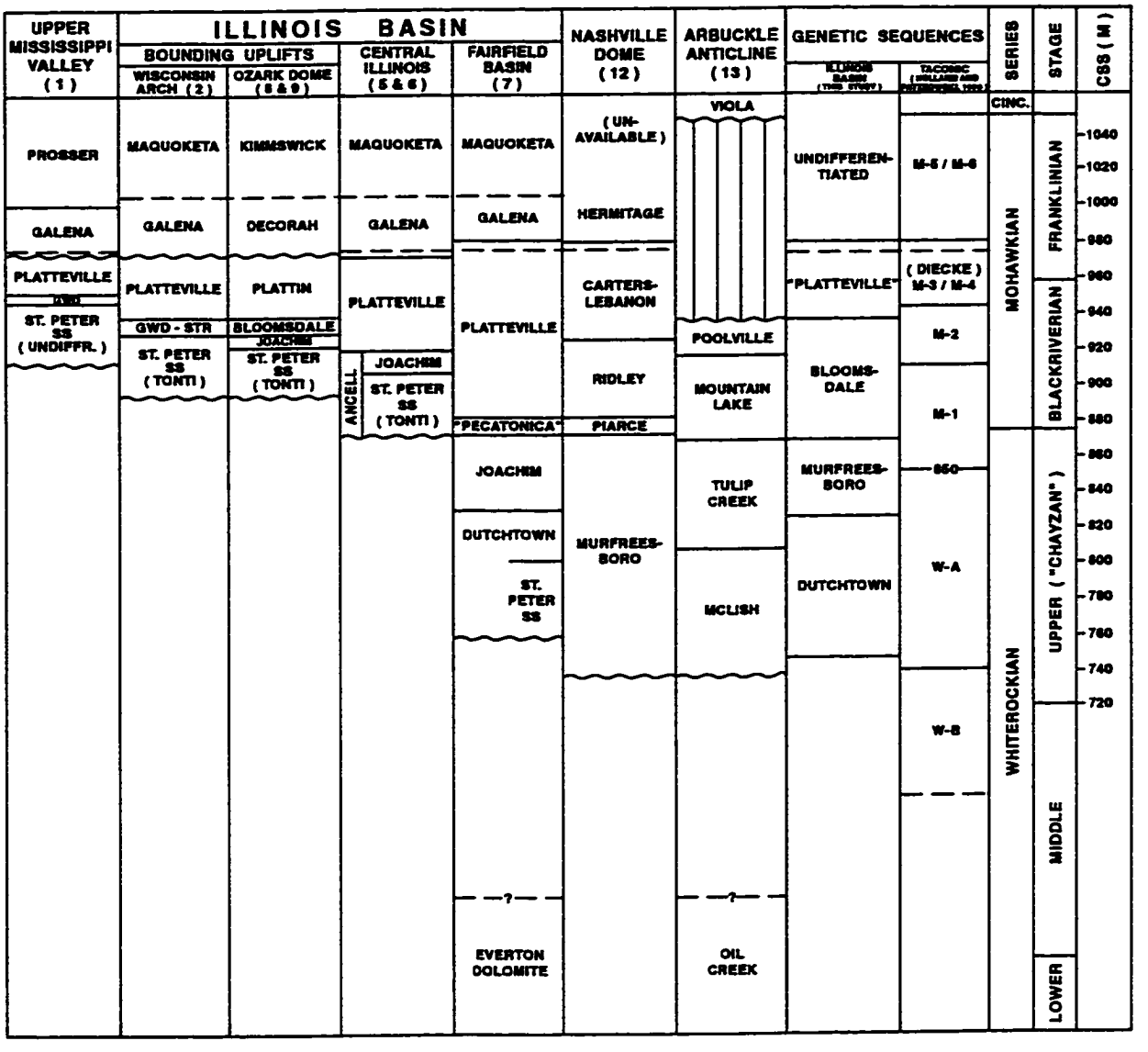

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core may be coeval with the Everton Dolomite of the Illinois Basin. In northern Mississippi, carbonate strata coeval with the Everton are known from the "snow zone" tentatively assigned to the basal Stones River Group, Black Warrior Basin (Alberstadt and Repetski, 1989). Although post-Paleozoic erosion has removed Ordovician strata from the crest of the Pascola Arch, regional isopachs of the Middle Ordovician rocks suggest laterally contiguous deposition from northern Mississippi north into the Illinois Basin.

The age of the Everton Dolomite in the Illinois Basin remains poorly constrained due the small number of localities available for study, limited faunal recovery, and poor taxonomic understanding of the faunas present. The top of the Everton Dolomite has a Composite Standard Section equivalent position of 579 meters, or within the uppermost *H. holodentata* Biochronozone. This position indicates an age of late-medial Whiterockian and correlation of the upper Everton with the uppermost Oil Creek Formation of Oklahoma. As discussed in the previously (p. 56-58), the hiatus between the Oil Creek and overlying McLish Formation has been recognized throughout North America and is recognized by some workers as the Sauk-Tippecanoe Megasequence boundary.

This age evaluation is supported by the conodont fauna reported by Rexroad and others (1982) recovered from the uppermost Everton and lowermost St. Peter Sandstone in a core from the subsurface of Posey Co., Ind. The fauna from the upper Everton is dominated by species of *Multioistodus*, *Paraprioniodus* and *Leptochirognathus*. Biostratigraphically key elements of the fauna include *Scandodus sinuosa*, *Paraprioniodus costatus*, and *Leptochirognathus quadratus*. Although these species

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occur in rocks as young as late Whiterockian, this faunal association is typical of the *H. holodentata* Biochronozone (late-medial Whiterockian). Above the base of the St. Peter Sandstone, species of the genus *Paraprioniodus* and *Leptochirognathus* are absent, and species of the genus *Phragmodus* first appear in association with *Multioistodus* spp. and *Multioistodus subdentatus*. This faunal replacement typically occurs at boundary of the uppermost *H. holodentata* Biochronozone and the base of the *Cahabagnathus friendsvillensis* Biochronozone.

The age of the lower Everton Dolomite remains poorly constrained. Although an equivalent position of 544 m (lower *H. holodentata* Biochronozone) was determined for the lowermost Everton sampled the Superior Oil Co., H. C, Ford et al C-17 well, Norby and others (1986) reported species indicative of fauna 3 (*H. sinuosa* Biochronozone), and possibly uppermost fauna 2 (*H. altifrons* Biochronozone) from the same well. Golden (1969) reported the occurrence of *H. sinuosa* (reported as *H. minutiserratus*) from the lower Everton in southeast Missouri. A moderately abundant fauna dominated by *Multioistodus auritus* was recovered from the lowermost carbonate in the Everton, St. Genevieve Co., Mo. (this study, section at I-55 mile marker 155.9, Thacker and Satterfield, 1977). *Multioistodus auritus* is associated with species assigned to faunas 2-3 (Ethington and Clark, 1981).

These reports imply that the lowest Everton sampled is no younger than the *H. sinuosa* Biochronozone (medial-medial Whiterockian), but it could be old as the *H. altifrons* Biochronozone (late-early Whiterockian). It should be noted that at least an additional 135-200 ft. (41-61 m) of Everton is present in the subsurface of southern

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Illinois and western Kentucky for which paleontological data are unavailable and it's highly likely that early-Early Whiterockian strata are present in the central Illinois Basin.

Dutchtown Sequence

The Dutchtown Sequence is tentatively defined as being bounded by the post-Everton Disconformity and the transgressive surface that define the contact of the Joachim Dolomite and Dutchtown Formation in the subsurface. In the central Illinois Basin the contact is immediately underlain by an anhydrite-bearing supratidal sequence. The Dutchtown-Joachim contact is not exposed in southeast Missouri so the nature of the transition is not well understood in a regional sense.

The ranges of the species recovered from the Dutchtown are poorly understood and as a consequence, the age of this sequence is poorly constrained at present. The graphically coeval contact of the Dutchtown in the central Illinois Basin, the top of the Wells Creek in the Jessamine Dome area suggest the upper boundary of the sequence falls within the late *Cahabagnathus sweeti* Biochronozone. The proximally coeval Tulip-McLish contact in the Arbuckle Anticline area suggest that this sequence boundary may be recognizable beyond the Illinois Basin, but this observation is only speculation until the age of the boundary can be determined with greater confidence.

The fauna recovered from the Dutchtown in the Superior Oil Co., Ford et al C-17 core, White county, Illinois contains elements of *Archeognathus* sp., *Lumidens vitreus*, *Scapulidens primus, Curtognathus sp., Multioistodus* sp. *Erismoduds* sp., and *Plectodina* spp. Currently, only the occurrence of elements assigned to genera *Archeognathus* and *Curtognathus* has biostratigraphic utility. *Archeognathus* is only been reported from post-medial Whiterockian, Middle Ordovician strata (Klapper and Bergstrom, 1984), and

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Curtognathus has its first appearance in the Composite Standard Section in the *Cahabagnathus sweeti* Biochronozone (early-Late Whiterockian). *Lumidens vitreus* and *Scapulidens primus* are known from the Dutchtown Formation, Joachim Dolomite and the basal St. Peter Sandstone of the Illinois Basin, but their total ranges have not been established (Repetski, 1972; Ethington and others, 1986; Shaw, 1990; author's unpublished collections).

Repetski (1972) recovered a more taxonomically diverse and less endemic fauna from the Dutchtown in its type area that included *Plectodina aculeata*, *Curtognathus* sp., *Multioistodus subdentatus*, *Leptochirognathus quadratus*, *Archeognathus* sp., and *Phragmodus flexuosus*. The small vertical section available for study and inability to correlate the outcrops on lithic criteria preclude establishing a firm age for the Dutchtown, but *M. subdentatus* and *Archeognathus* sp. restrict the age of the Dutchtown to late Whiterockian.

The age of the lower boundary of the sequence is even more poorly constrained. The basal portion of the sequence throughout much of the study area is predominantly quartz arenites of the Tonti Sandstone Member of the St. Peter Sandstone. Where conodonts have been recovered from the laterally correlative carbonates, the taxa recovered are from species whose ranges are poorly understood. As a result, the base of the Dutchtown sequence can only be dated by assuming a constant slope for the LOC for the Superior Oil Co., H. C. Ford et al C-17 locality. This approach yields an age of medial *Cahabagnathus friendsvillensis* Biochronozone, which is not unreasonable in light of regional considerations. But, it is likely that this age can be further refined as the faunas recovered in the course of this study from this locality, the lower Dutchtown, and

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the Cominco America Ca-254 core become better understood and incorporated into the Middle Ordovician Composite Standard Section.

Murfressboro Sequence

The Murfreesboro Sequence is defined by the top of the Dutchtown Sequence and the terminal peritidal sequence of the Metz Member of the Joachim Dolomite as developed in the Superior Oil, H. C. Ford et al C-17 core (210 meters above TD). The upper boundary has a Composite Standard Section equivalent position of 869 meters, implying an age assignment of early-*Erismodus quadractylus*, or medial *P. gerdae* Biochronozone (late Whiterockian). The overlying transgressive deposits and condensed intervals are represented by the Bloomsdale Formation of southeast Missouri, the Pierce Limestone of western Tennessee, and the lower Mifflin Formation of southeastern Illinois. These units are coeval with the Post-Chazyan transgressive event that can be recognized throughout the Midcontinent and eastern North America. This horizon also correlates with a break in sedimentation identified within the Camp Nelson Limestone in its type area by Templeton and Willman (unpublished outcrop description, Illinois State Geological Survey) and the top of the "Carntown unit" of the lower Black River Limestone in southwestern Ohio.

The sequence is named for the Murfreesboro Limestone of western Tennessee because of the time-transgressive nature of the Joachim Dolomite lithofacies. The age of the Joachim Dolomite progressively decreases from the basin depocenter on the basin-bounding arches and domes. This in particularly evident when examining the age the Joachim along a south-to-north transect from White County, Illinois, through central Illinois to northeastern Indiana (Figure 31, columns 4, 5, 6 and 7).

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Currently the sequence boundaries cannot be identified within the St. Peter Sandstone lithotope; however, conodonts from the Tonti Sandstone Member of the St. Peter Sandstone suggest that lower Tonti strata may be, in part, coeval with the Murfreesboro Sequence. Shaw (1990) recovered *Archeognathus* sp. (reported as *Appalachignathus* sp.), *Lumidens vitreus*, and *Scapulidens primus* from the basal Tonti Sandstone Member in La Salle County, north-central Illinois. The genus *Archeognathus* has only been reported from late Whiterockian, Middle Ordovician strata (Klapper and Bergstrom, 1984), and *Lumidens vitreus* and *Scapulidens primus* are only known from the Dutchtown Formation and Joachim Dolomite (Repetski, 1972; Ethington and others, 1986; author's unpublished collections). Provisionally, this suggests late Whiterockian strata coeval with the Murfreesboro Limestone Sequence are present in north-central Illinois.

Post-Bloomsdale Limestone Sequence

Although this study was initiated with the expectation that the siliciclastic lithofacies of the Ancell Group would prove to be time-transgressive, the degree to which this prediction was fulfilled was surprising. Study of the post-Joachim succession is beyond the scope of this study, but the development of the Post-Bloomsdale Sequence does have significant genetic stratigraphic implications for the assignment of the Glenwood Formation and Starved Rock Member of the St. Peter Sandstone.

The Glenwood Formation and Starved Rock Sandstone Member of the St. Peter Sandstone were deposited during a period of extended starved sedimentation during the post-Chazyan transgression (Nunn, 1986; Schutter, 1992). The base of this interval, where control is comparatively well established in northwest Illinois (Figure 31,

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column 2), has Composite Standard Section equivalent position of 926 m (late *Erismodus quadractylus* Biochronozone). Within the resolution of the CSS (+/-6 m), the Glenwood-Starved Rock interval is potentially coeval with: 1) the lowermost Black River Group of northeast Indiana, 2) the lowermost Platteville Group of central Illinois, 3) base of the Oregon Limestone of central Kentucky, 4) Bloomsdale Limestone of eastern Missouri, 5) basal Lebanon Limestone of central Tennesssee, and 6) the Poolville Formation of Oklahoma. The widespread synchroneity of the Glenwood –Starved Rock interval with significant lithic changes regionally suggest the development of this condensed section can be recognized regionally.

Although poorly constrained, the age of the Glenwood Formation in the Upper Mississippi Valley is sufficiently diachronous (>6 m) to suggest the Glenwood of southeast Minnesota in not coeval with the Glenwood of northern Illinois.

I believe it is desirable for the Ancell Group to be defined in such a way that it has genetic stratigraphic unit; therefore, the Starved Rock Sandstone Member and the Glenwood Formation should be excluded from its definition. It would be the recommendation of this author that the definition of the Pecatonica Formation of northern Illinois be expanded to incorporate the Glenwood and Starved Rock Sandstone as members, and that the subdivisions of the Glenwood be abandoned. And, that the cored interval 343.5-380 ft. (104.7-115.8 m) in Commonwealth Edison UPH-3 be designated as the principle reference section for the newly constituted Pecatonica Formation.

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LITHOFACIES AND DEPOSITIONAL ENVIRONMENTS

In addition to determining the relative ages of the strata investigated, the lateral extent of sedimentary environments was determined by identifying their characteristic lithologies, mapping the lateral distribution of each lithology, and establishing the lateral depositional relationships by studying the lithic vertical succession. In order to characterize the lithofacies present, ninety-five stratigraphic sections, twenty-two surface exposures and seventy-three rock cores from the subsurface, were measured, described and sampled for petrographic and geochemical analysis. In addition, five unpublished descriptions of Middle Ordovician successions were integrated into the study. The distribution of the sections utilized is shown in Figure 45 and detailed locality descriptions are given in Appendix I; core descriptions are provided in Appendix II.

With minor modifications, rock classification follows Pettijohn and others (1964) for siliciclastic rocks and Dunham (1962) for carbonate rocks. In order to differentiate carbonate "mudrocks" from siliciclastic "mudrocks", Wright (1992) proposed the term "calcimudstone" to identify matrix supported limestone's with <10% grains. I have extend the use "calci" and "dolo" prefixes for use with each of Dunham's rock classes to indicate the predominant carbonate composition. The prefix "dolo" is applied to lithologies greater than 60% dolomite in composition; the prefix "calci" is used for those rocks composed of greater than 40% calcite. To further reduce the confusion sometimes arising from the use of the term "mudstone" for both siliciclastic and carbonate rocks, mudstone is only applied to carbonate rocks and the name

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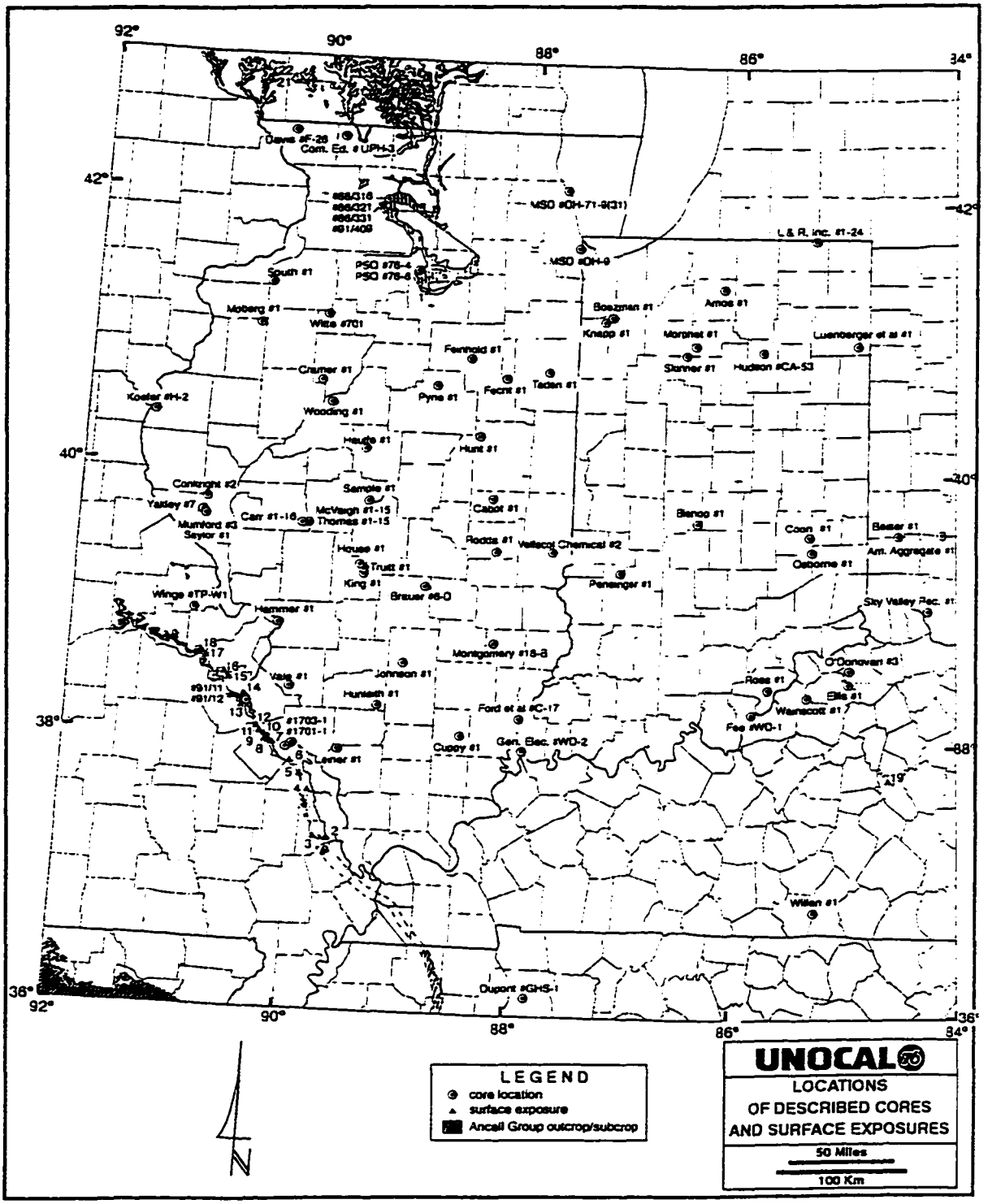

Figure 45: Map of study area showing locations of described sections.

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"mudrock" is used for the siliciclastic rocks containing <10% sand-size, or larger grains. The adjective "quartzose" is used for non-sandstone lithologies with >10% quartz-sand. The lithologic classification utilized in this study is summarized in Table 4.

Types of geochemical analysis included: x-ray diffraction study of clay-size constituents, whole rock pyrolysis (Rock-eval) analysis of organic constituents, and sulfur, carbon and oxygen isotopic analysis of carbonate and sulfate components. Rock colors follow the Geological Society of America, Munsell Color Guide.

As expected, lithofacies of the Ancell Group reoccur both laterally and vertically in the stratigraphic succession. Consequently, description of individual lithofacies for each of the stratigraphic units investigated would be a tedious and repetitive exercise. Instead, lithofacies will be classified initially based on their predominant mineralogical constituents, siliciclastic or carbonate, and then subdivided into lithofacies characterized by textural and compositional characteristics, and sedimentary structures.

The presence of evaporites, although once widespread within the Ancell Group, is now limited due to meteoric dissolution. As a consequence, the distribution of evaporites is discussed separately. For each major lithic group, individual lithofacies are identified, described and their depositional environment interpreted.

Siliciclastics

Siliciclastic lithofacies are present in the Everton Dolomite, St. Peter Sandstone, Glenwood Formation, Wells Creek Dolomite, Abernathy and Augusta members of the lower Joachim Dolomite, and the Bloomsdale Limestone. Based on grain-size, the

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Table 4: Classification of carbonate, siliciclastic and mixed carbonate/siliciclastic sedimentary rocks*

		Framework	Matrix-supported		Grain-supported		Matrix- or Grain-supported		Non-obliterative >10% grains %crystalline cement > matrix			Obliterative (depositional fabric indeterminate)	
			cryptocrystalline, clay- and silt-size		sand-size and greater grains, <30% >2mm nonbiogenic clasts		>30% 2 mm nonbiogenic clasts		cement-supported	grain-supported		crystalline <10% complete grains	
Mineralogy		encrusting/ binding organisms	<10% grains	>10% grains	>10% clay/silt-size (>0.0625 mm)	<10% clay- and silt-size (>0.0625 mm)	rounded to sub-rounded grains	angular to sub-angular grains	cement dominated	<50% sutured grains	>50% sutured grain-contacts	crystalline >10 microns	crystalline <10 microns
>50% carbonate	>40% calcite	Boundstone	Calci-mudstone	Wackestone	Packstone	Grainstone	Conglomerate	Breccia	Cement-stone	Condensed grainstone	Fitted grainstone	Sparstone	Micro-sparstone
				0-5% grains >2mm	<5-30% grains >2mm	<5-30% grains >2mm							
				Floatstone	Rudstone								
<10% quartz	>50% dolomite	Dolo-boundstone	Dolo-mudstone	Dolowackestone	Dolopackstone	Dolograinstone	Dolo-conglomerate	Dolobreccia	Dolo-cementstone	Condensed dolo-grainstone	Fitted dolo-grainstone	Dolo-sparstone	Microdolo-sparstone
				0-5% grains >2mm	<5-30% grains >2mm	<5-30% grains >2mm							
				Dolofloatstone	Dolorudstone								
>50% carbonate	>40% calcite	Quartzose boundstone	Quartzose calci-mudstone	Quartzose wackestone	Quartzose packstone	Quartzose grainstone	Quartzose conglomerate	Quartzose breccia	Quartzose cementstone	Quartzose condensed grainstone	Fitted grainstone	Quartzose sparstone	Quartzose micro-sparstone
				0-5% grains >2mm	<5-30% grains >2mm	<5-30% grains >2mm							
10-50% quartz				Qtzose. floatstone	Quartzose rudstone								
	>50% dolomite	Quartzose dolo-boundstone	Quartzose dolo-mudstone	Quartzose dolowackestone	Quartzose dolopackstone	Quartzose dolograinstone	Quartzose dolo-conglomerate	Quartzose dolobreccia	Quartzose dolo-cementstone	Quartzose condensed dolo-grainstone	Quartzose fitted dolo-grainstone	Quartzose dolo-sparstone	Quartzose microdolo-sparstone
				0-5% grains >2mm	<5-30% grains >2mm	<5-30% grains >2mm							
				Qtzose. Dolofloatstone	Quartzose dolorudstone								
>50% quartz	<25% lithic fragments <25% feldspar	*no proposed terms*	Mudrock	10-25% 0.03-2 mm	10-15% <0.03 mm	Quartz arenite	Quartzose Conglomerate	Quartzose Breccia	Quartz arenite			Quartzite	
				Sandy mudrock	Quartz arenite								
				5-50% >2 mm; 0.03-2 mm <10%									
				Conglomeratic mudrock									
				25-65% 0.03-2 mm; <5% 2mm or greater									
				Quartzwacke									
				25-65% 0.03-2 mm; >5% 2mm or greater									
				Conglomeratic quartzwacke		Conglomeratic quartz arenite							

modified after Folk, 1954; Dunham, 1962; Pettijohn and others, 1973; Wright, 1992

siliciclastic rock types present can be subdivided into mudrocks, predominantly clay- and silt-size grains, and arenites (sandstone) that are fine- to coarse-grain.

Mudrocks

Mudrock and siltstone are minor constituents of the Ancell Group and its correlatives. Five mudrock lithofacies are recognized: conglomeratic mudrock, green mudrock, red mudrock, carbonaceous mudrock and sandy mudrock. One siltstone lithofacies is locally present.

Lithofacies 1: Conglomeratic mudrock

Description: Greenish-gray (5 G 6/1) to grayish-green (10 GY 5/2) to grayish-blue-green (5 BG 5/2), thin- to massively-bedded, noncalcareous mudrock with sparse to abundant, mud-supported, very fine- to coarse-grain quartz, sand-size silicified ooids, and light-colored, sand- to cobble-size, angular chert and/or dolostone (Figure 46). Locally, the matrix is feldspathic. The sand-size and greater constituents are mostly angular clasts of silicified oolite and oncolite, a variety of angular chert fragments, and dolostone. Locally, interbeds of fused chert residuum are present. Typically, the lower contact is sharp, irregular and stylolitic.

Illite is the predominant clay mineral, with subordinate amounts of smectite and mixed-layer clays. Clay- to silt-size feldspar and jarosite, a weathering product of feldspar, are locally abundant (up to 60% of clay-size fraction).

The term "conglomeratic mudrock" was proposed by Folk (1954) for mudstones containing 10%-30% pebbles and less than 50% sand-size particles.

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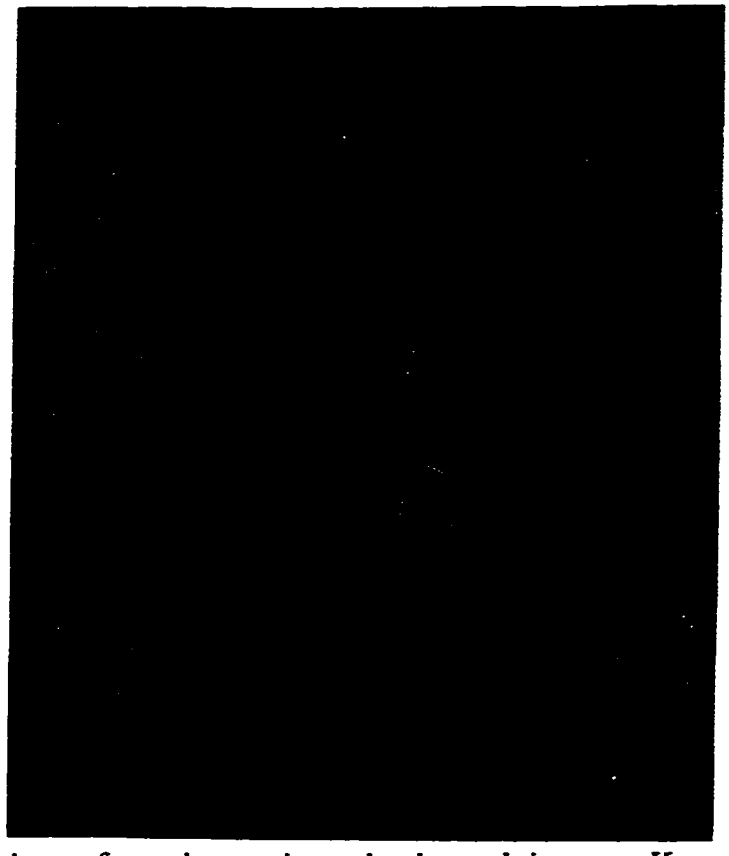

Figure 46: Core photo of conglomeratic mudrock overlying post-Knox disconformity (arrow), Wells Creek Dolomite, Ohio Department of Geological Survey, American Aggregates Quarry 1, Warren Co., Ohio (DGS 2627). Coin for scale is 0.75-inch diameter (18 mm). Sand- to pebble-sized, subrounded to subangular intraclasts of white, microcrystalline chert and argillaceous dolomudstone in green mudrock matrix are present from 1,614 ft. (492 m) to disconformity. Intraclasts are derived from underlying Knox Group carbonates. Although less than one foot (0.3 m) thick in this well, conglomeratic mudrock intervals can be as thick as 22 ft. (7 m).

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Stratigraphic and geographic distribution: This lithofacies is present in the Kress Member of the St. Peter Sandstone in Illinois, northwest Missouri and western Indiana; the lower Wells Creek Dolomite in western Ohio, central Kentucky and western Tennessee; the basal Dutchtown Formation in central and eastern Indiana; and the lower Everton Dolomite in southeast Missouri.

Discussion: Detrital constituents of the conglomeratic mudrock lithofacies appear to be derived from dissolution residuum developed on the post-Knox paleoerosional surface. This interpretation is supported by the sharp, stylolitic lower contact, elevated concentrations of insoluble constituents relative to underlying carbonate lithologies, and abundant, angular sand-size to pebble-size chert. Chert is abundant in the Knox Group, and rare in the basal Middle Ordovician succession.

In addition, conodonts recovered from conglomeratic mudrocks in the Kress Member in northern Illinois and Wisconsin (Grether and Clark, 1981; Shaw, 1987; ISGS, unpublished collections) are characteristic of the upper Knox Group. Their preservation, abraded and chalky white color, indicates they have been chemically weathered.

Lithofacies 2: Green mudrock

Description: Grayish-green (10 G 4/2) to grayish-green (10 GY 5/2) to grayish-blue-green (5 BG 5/2), very thin- to medium-bedded, massive, nonfissle, noncalcareous mudrock with sparse, very-fine- to medium-grain quartz locally (Figure 47). Within specific stratigraphic horizons, lags of phosphate-coated grains are present. Pyrite may be abundant and is typically anhedral to euhedral, with cubic or framboidal habit, and is

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Figure 47: Core photos of massive green mudrock cut by quartz arenite-filled *Skolithos* burrows, Glenwood Formation, 1241 ft. (378 m), Central Illinois Light Co., Witte 701, Stark Co., Illinois (ISGS C9240). (A) Plan-view showing circular cross-section of burrows and "waxy" surface. (B) Sectional view showing linear burrow traces; irregular offsets are due to differential compaction of mudrock. Mudrock does not contain sand-size, or larger, grains. Coin for scale is 0.75-inch (18 mm).

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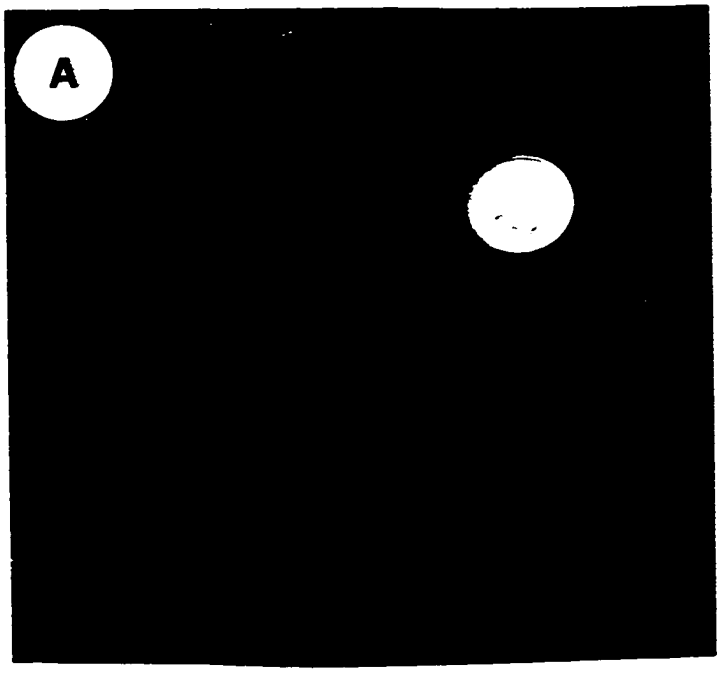

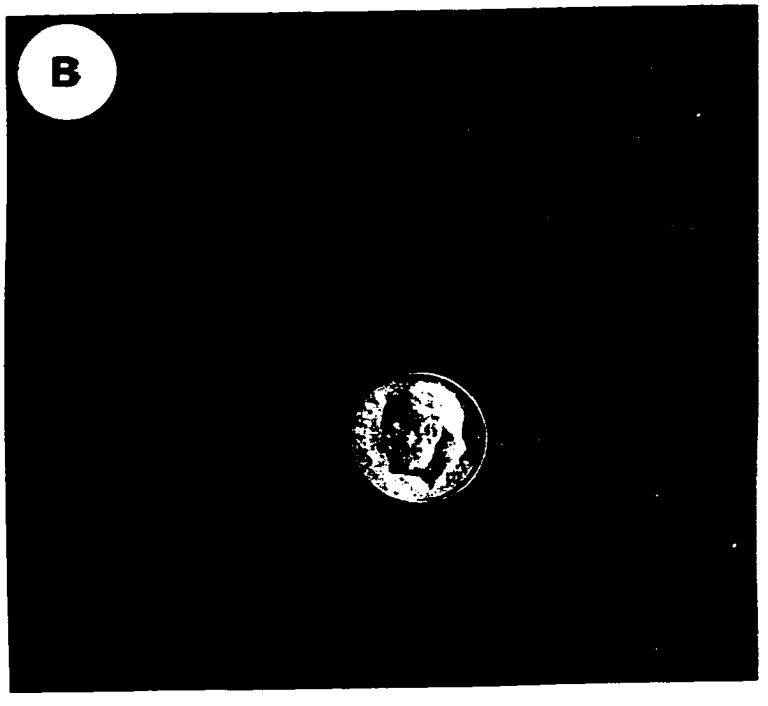

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present as distinct grains and/or aggregate masses. Locally, these units have been reported to be glauconitic (Templeton and Willman, 1963; Fraser, 1976). Quartz is very fine- to medium-grain and well-rounded.

Illite is the predominant clay mineral, with subordinate amounts of smectite and mixed-layer clays. Kaolinite is locally abundant in northern Illinois where freshwater is present; Odom and others (1979) reported that the kaolinite is a diagenetic product of illite. Locally, potassic feldspar make up to 60% of the silt-size and smaller fractions. Total organic carbon rarely exceeds 0.2%, but elevated TOC values (TOC up to 25% by weight) with source potential have been reported from central Iowa (Hatch and others, 1990).

This lithofacies is usually 2-6 cm (1-2.5 in.) thick, but beds up to 60 cm (2 ft.) thick are present in the Glenwood Formation and the Establishment Shale Member of the Bloomsdale Limestone.

Typically, this lithofacies has a high gamma-ray response on geophysical logs due to radionuclides present in the pyrite, clay minerals and feldspathic components. Medium-bedded shale is associated with sand-bearing lithologies. In addition, the impermeable character of this lithology is readily identifiable on porosity logs.

Green mudrocks commonly overlie bedding-planes with abundant mudcracks or ferruginous hard-grounds, and underlie ostracodal pack/wackestones. Locally, large, sand-infilled burrows cross-cut the mudrock beds, but overlying arenites are absent.

Macrofossils are uncommon, but include the phosphatic brachiopod *Lingula* and locally abundant ostracodes. Microfossils, including conodonts, chitinozoans and acritarchs, are locally abundant.

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Stratigraphic and geographic distribution: This lithofacies is wide-spread, but intervals bearing are rarely more than a few feet to 25 ft. (0.3-8 m) thick. Stratigraphically, it is present in the lower Wells Creek Dolomite in western Ohio, central Kentucky and western Tennessee; the Dutchtown Formation in central and eastern Indiana; the Everton Dolomite, lower Joachim Dolomite and Establishment Shale Member of the Bloomsdale Formation in southeast Missouri; the Matson Dolomite Member of the Joachim Dolomite in north-central Missouri; and the Glenwood Formation in northern Illinois.

Discussion: These mudrocks are interpreted as having been deposited under starved sediment conditions as evidenced by phosphatic grain-coats, glauconite content, and abundance and nature of preservations of the microfauna. Starved sediment conditions, or condensed sections, form in carbonate successions at the time of maximum rate of onlap during a relative sea level rise (Loutit and others, 1988). As paleoenvironments rapidly shift shoreward, the indigenous carbonate-producing biota are either stressed, or replaced by new taxa, and carbonate sediment production is inhibited and rates of carbonate sedimentation decrease relative to the rate of clastic input. Although the low relief flooding surface, in this case the adjacent tidal flats and/or post-Knox erosional surface, yielded detrital sediments, coarse-detritus is either trapped at the shoreline, or by-passed on to the margin, and clay and silt-size fractions are deposited at greatly reduced rates by settling from suspension.

Where sampled, this lithology contains a more diverse, and more abundant conodont microfauna then overlying, or underlying carbonates. For instance Weber (1966) and Votaw (1971) recovered up to 1,000 conodont elements per kilogram, in

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contrast to 5-15/kg. for underlying and overlying carbonates. Further more, conodont elements from the Glenwood Formation are typically pyritized, and some elements have anomalously high (4 vs. regional level of 1-1.5) color alteration (CAI) values.

Unusually high conodont abundance and element pyritization are considered to be indicative of lag deposits. Anomalous high CAI values are due to bacterial degradation of organic matter within the conodont element because of the long residence time at the sediment water interface (Repetski, 1989). Although it could be argued that conodont paleoecology might have favored this lithofacies and resulted in larger populations, the magnitude of the difference observed is more likely attributed to significant variation in sedimentation rates.

The local abundance of ostracodes, the absence of other macrofauna, the predominance of fibrous conodonts, and the association with other lithofacies, such as stromatolitic dolomudstones (Fraser, 1976), suggest restricted marine conditions.

Locally, thin-beds (1-2 in., or 2.5-5.0 cm) of a similar lithology are present in the lower Wells Creek and Everton dolomites. These mudrocks differ from the typical occurrences of the green mudrock lithofacies in that they contain abundant insoluble constituents identical in composition to those present in the bounding carbonate units, but in significantly greater concentrations, and that the bounding bedding contacts are sharp, stylolitic and irregular. These mudrocks are appear to be derived from the dissolution of bounding carbonate/evaporite units. Evidence for dissolution include: 1) sharp, stylolitic upper and lower contacts; anomalously high concentrations of insoluble constituents relative to overlying and underlying lithologies; 2) observed cross-cutting relationships with bedding; 3) non-systematic appearance in section; 4) association of

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thicker-beds with bounding, porous, sand-bearing lithologies; and/or 5) association with evaporite pseudomorphs.

Lithofacies 3: Red mudrock:

Description: Dusky-red (5 R 3/4) mudrock that weathers white (N 9) in outcrop. The red color contrasts strikingly with the grayish-green (10 G 4/2) or dark-yellowish-brown (10 YR 2/2) color of other mudrock lithofacies (Figure 48). Typically, rocks of this lithofacies are composed of up to 90% sanidine, a potassic feldspar, and minor amounts of illite, jarosite and kaolinite. Jarosite is a weathering product of potassic minerals. The red color is the result of oxidation of iron during meteoric diagenesis.

Stratigraphic and geographic distribution: This lithofacies is for the most part restricted to the Kress Member of the St. Peter Sandstone in northern Illinois and southern Wisconsin. It is also locally present in southeastern Missouri either at the base, or at the top of the St. Peter Sandstone.

Discussion: A variety of proposals have been made concerning the origin of this lithofacies. Woodard (1972, 1974) proposed that this lithofacies was deposited in a nearshore environment where marine waters saturated with amorphous silica precipitated a gel precursor, that was later altered to sanidine.

Odom (1974) rejected Woodard's interpretation, noting that much of the feldspar studied by Woodard appears to be epigenetic overgrowths on detrital feldspar cores. Odom suggested that the potassic feldspar originated as eolian silt derived from the adjacent, exposed granitic shield area on the Wisconsin Arch. After burial, low temperature fluids migrating through the St. Peter Sandstone precipitated potassic feldspar overgrowths on the detrital cores.

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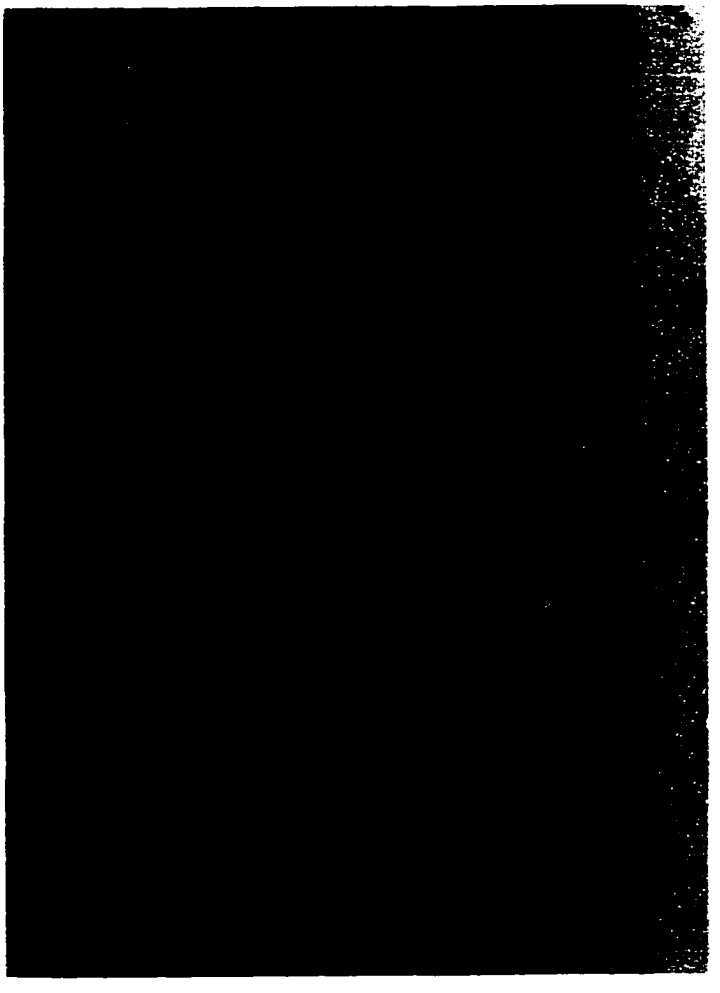

Figure 48: Core photo of red mudrock in upper Kress Member, St. Peter Sandstone, 472.5 ft. (144 m), Commonwealth Edison, UPH-3, Stephenson Co., northwest Illinois (ISGS C12996). Internal laminations vary from planar to highly disturbed. Red color is due to oxidation of iron-bearing potassic feldspar. Contact with overlying quartz arenite is base of Tonti Sandstone Member. Slabbed core is 2.5 inches (6.3 cm) in diameter.

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Odom's (1974) hypothesis is supported by the reported post-Ordovician radiometric dates obtained from these beds. Krueger and Woodard (1972) reported a K-Ar age date of 382 Ma (Devonian) for a sanidine bed in the Kress Member at Waukau, Wisconsin. Hay and others (1988) obtained a Devonian K-Ar date of 390.5 Ma (+/- 6.8) for potassic feldspar from the same interval. Hay and Junhze (1991) reported a range of K-Ar dates for correlative beds of 377-402 Ma (Devonian) for various locations in northern Illinois and southern Wisconsin.

Woodard (1974) argued that these ages are too young and are the result of the diagenetic loss of argon. Odom (1974) suggested the authigenic overgrowths are in fact younger (Penn.-Permian) then the reported ages (Devonian), and that the ages reflect the radiogenic contribution of the older detrital cores. A possible younger diagenetic event has been identified by Lee and Aronson (1991) who reported a K-Ar date of 340 Ma (L. Carboniferous) for authigenic clays in the upper St. Peter Sandstone within the upper Mississippi Valley. Hay and others (1988) concurred with Odom's (1974) proposal of a diagenetic component observing that oxygen isotope values and the K-Ar age dates for the Kress Member are in agreement with other feldspathized units, depositionally unrelated to the Kress, in the upper Mississippi Valley and Ozark Dome region.

An additional possibility is that the sanidine beds are altered K-bentonites. Kolata (personal communication, 1992) considers the lower "white shale unit" studied by Woodard (1972) in the Waukau Quarry, Wisconsin, to be possible altered K-bentonite preserved in a paleotopographic low on the post-Knox surface. Feldspathization of Ordovician K-bentonites is widespread in the upper Mississippi Valley (Hay and others, 1988).

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The red mudrock lithofacies is only present in two of the cores examined in the course of this study. However, it has been noted in the course of this study that potassic feldspar and jarosite commonly make up over 60% of the composition of conglomeratic mudrock from the Kress Member in the subsurface of central and southern Illinois. In addition, it can be observed within outcrops in southeast Missouri that the red mudrock lithofacies laterally grades into the green mudrock lithofacies near the St. Peter Sandstone-Joachim Dolomite contact, and that the occurrence of red mudrock is associated with permeable joints where groundwater seepage occurs. As a consequence, the red mudrock lithofacies is considered a product of feldspathization of the green and conglomeratic mudrock lithofacies, and its characteristic color is a product of meteoric diagenesis of feldspathic constituents.

Lithofacies 4: Sandy mudrock

Description: Similar to the green mudrock lithofacies in that it is grayish-green (10 G 4/2) to grayish-blue-green (5 BG 5/2), thin-bedded to massive, and pyritic (Figures 49 and 50). It differs in the abundance of medium- to coarse- to very-coarse- grain, well-rounded quartz that gives the lithology a bimodal grain-size distribution. This bimodal character is commonly referred to as a "Glenwood texture" (Willman and Templeton, 1963), named for the Glenwood Formation in which this lithofacies is common.

Stratigraphic and geographic distribution: This lithofacies is known from the Glenwood Formation, northern Illinois and southern Wisconsin.

Discussion: I share the view of Fraser (1976) who reported that this lithofacies was deposited in a lagoonal environment and has a lateral depositional relationship with a more shoreward, quartz arenite lithofacies.

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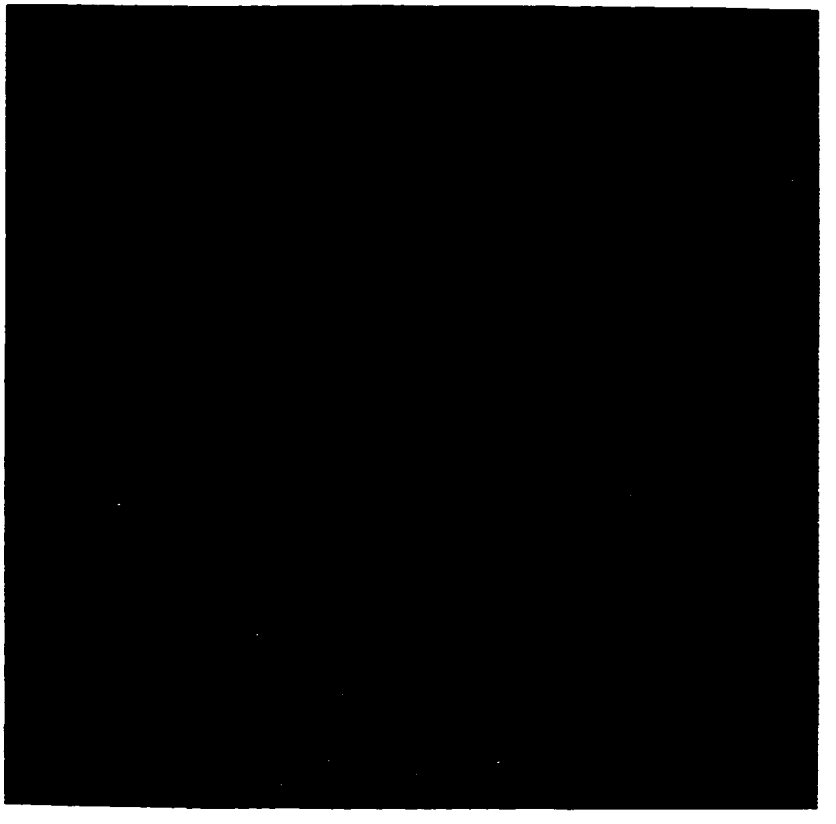

Figure 49: Bedding plane core photo of sandy mudrock, Glenwood Formation, 1248.5 ft. (380.5 m), Central Illinois Light Co., Witte #701, Stark Co, Illinois, (ISGS core C9240, 4-inch diameter). Quartz sand is present as discrete grains and "patches" (light-gray). The later are probably remnants of quartz arenite infilled burrows.

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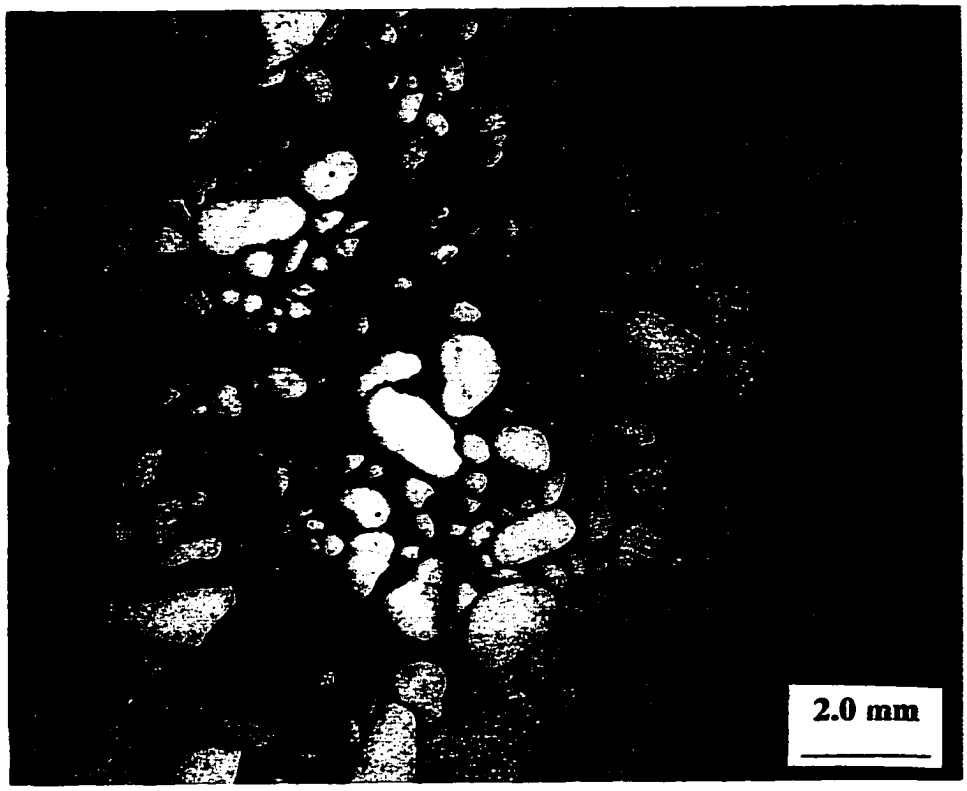

Figure 50: Thin-section photomicrograph (plane light) of sandy mudrock at contact between Tonti and Starved Rock sandstone members, St. Peter Sandstone, Airport Road section, southwest Missouri (see Figure 17). Mud-supported fine- and coarse-grain, bimodal, moderately- to well-rounded quartz. Quartz overgrowths are more common and better developed than in underlying nonargillaceous, low-angle cross-stratified quartz arenite (compare with Figure 64).

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The grain-size distribution is interpreted to originate from the biogenic reworking of clay- to silt-size sediments containing sand-infilled burrows. Figure 49 shows a sand-infilled vertical burrows, probably the ichnofossil *Skolithos*, penetrating mudrock. It is readily envisioned that additional bioturbation would homogenize these sediments and yield the bimodal grain-size apparent in this lithofacies. The absence of macrofauna and lamination implies variable, or elevated water salinity/temperature.

Lithofacies 5: Carbonaceous mudrock

Description: Brown to dusky-yellowish-brown (10 YR 2/2), fissile, finely-laminated mudrock with sparse pyrite (Figure 51). Total organic carbon ranges from 0.001% to 3.5%, and commonly 1.25% when associated with limestones. Beds are rarely more than a few centimeters thick; however, in some outcrops of the Joachim Dolomite it may be up to 10 cm thick. It commonly overlies bedding planes with abundant mudcracks. Bedding contacts are sharp, anastomosing and stylolitic. No macrofossils have been observed. When associated with laminated dolomudstone, the organic-bearing mudrock contains intralaminae of quartz (Figure 52). These sand laminae are silt-size to fine-grain, well- rounded, and well-sorted, and exhibit graded bedding locally. Void-filling quartz cements are present locally in overlying and underlying carbonates.

Stratigraphic and geographic distribution: This lithofacies is most abundant in the Joachim Dolomite, southern Illinois and southeastern Missouri, but it also occurs in the basal Dutchtown Formation, Indiana, and lower Murfreesboro Limestone, western Tennessee.

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Figure 51: Core photos of laminated carbonaceous mudrock, basal Joachim Dolomite, Illinois Power Co., Truitt 1, Montgomery Co., west-central Illinois (ISGS C13443). Slabbed core diameter is 4-inches. (A) planar laminated bed at 3147 ft. (959 m), and (B) concave-up bed at 3087.8 ft. (941 m). Both planar and concave-up geometry's have been illustrated from modern algal mats in the Abu Dhabi peritidal complex (Kendell and Skipwith, 1968, Figure 8; Friedman, 1995, Figures 11 and 12). Concave-up geometry results from partial desiccation of mat.

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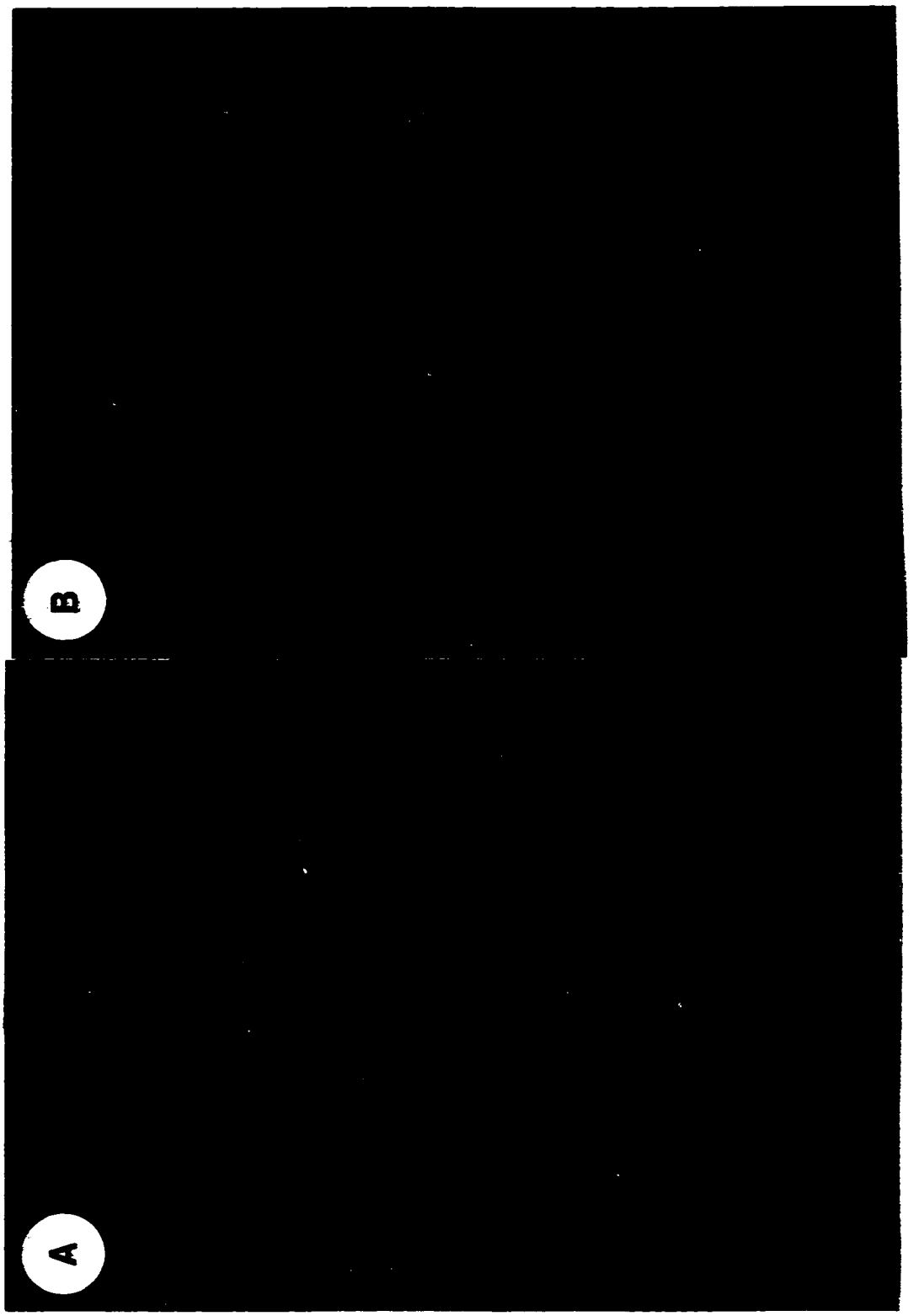

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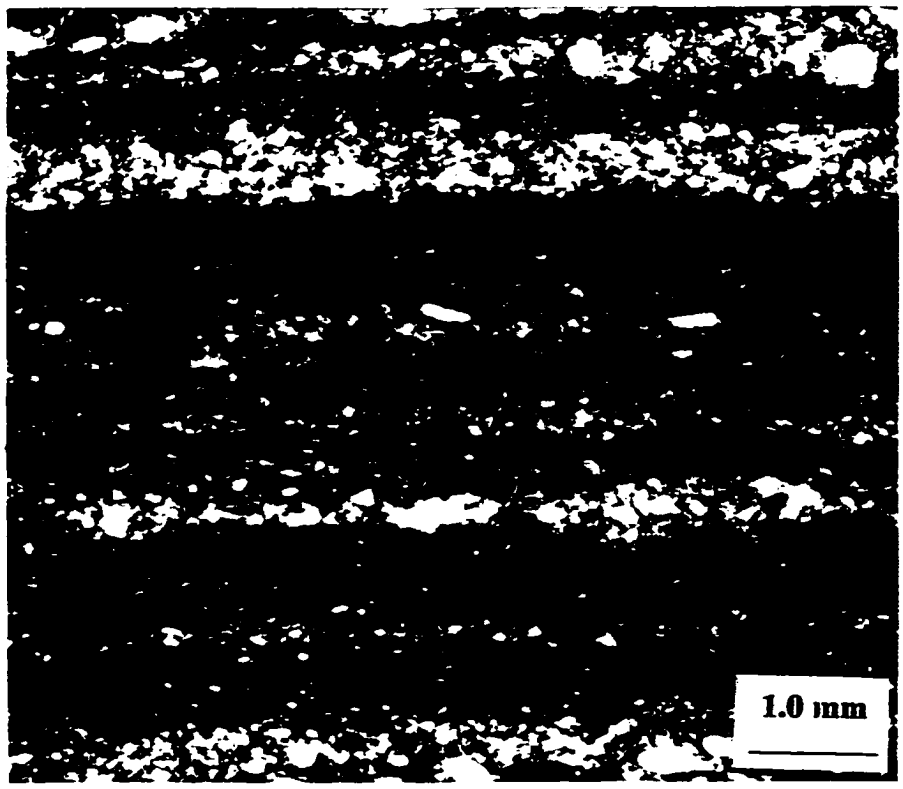

Figure 52: Photomicrograph (cross-polars) showing interlaminated carbonaceous mudrock and fine-grain, very well-sorted quartz arenite in basal Joachim Dolomite, 3161.5 ft. (964 m), Illinois Power Co., Truitt 1, Montgomery Co., west-central Illinois (ISGS C13443). Although underlying quartz arenites are only moderately- to weakly-indurated, quartz arenite laminae are pervasively cemented by quartz overgrowths.

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Discussion: This lithofacies differs from the other mudrock lithofacies in its color, fissility and organic content. Based on whole-rock pyrolysis data for the carbonaceous mudrocks in the basal Joachim and lower Murfreesboro Limestone, and based on palynomorph studies (Dr. M. Miller, AMOCO, unpublished report, 1989), this lithofacies has three notable organic characteristics: (1) relatively high total organic carbon content (1-3% TOC); (2) comparatively high hydrogen-index values (>300) indicative of algally-derived organic matter, and (3) an acritarch flora and dispersed organic matter commonly associated with marine environments.

Dark-brown mudrocks in the basal Joachim Dolomite and Dutchtown Formation in eastern Illinois and Indiana generally have low hydrogen-indices (<85), low total organic carbon (<0.06%), and high oxygen-indices (>150). Organic extracts were prepared from a sample in south-central Illinois and analyzed for biomarkers, and carbon, oxygen and sulfur isotopic compositions determined for each of the organic fractions (Table 5). Uniform carbon and oxygen isotopic values for each of the fractions suggest the sample has been chemically flushed (Dr. M. Helman, Imperial College, unpublished report, 1989).

Organic-rich mudrocks at the base of the Joachim in the Truitt #1 core have a remarkable similarity to the sediment cores from the Khusaifa algal mats described, and illustrated, by Kendall and Skipwith (1968, Figure 8) from the tidal flats of the Khor al Bazam lagoon, Abu Dhabi. During storm events, the tidal- and supratidal flats are flooded by normal marine waters and thick algal/bacterial mats grow. As the mat dewaters through drainage and/or evaporation, desiccation produces shrinkage cracks. Wind intermittently transports quartz-sand onto the mat producing laminae. Where

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Table 5:

Carbon and oxygen isotopic values for organic fraction of laminated carbonaceous mudrock, Joachim Dolomite (3061.5 ft./933.1 m), Illinois Power Co., Truitt 1, Montgomery Co., Illinois (ISGS C13443).

Organic Fraction	δC^{13} (PDB)
Saturate	-29.90
Aromatic	-29.89
Bitumen	-29.42
Asphaltine	-29.88
Whole rock extract	-28.82

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ponds remain undesiccated for extend periods of time, algal mat growth can produce algal "peats". Based on the assocaition with mudcracks and the morphologic similarity with modern algal mats, the organic mudrocks of the Ancell Group are interpreted to form by analogous processed in a similar depositional environment.

Lithofacies 6: Argillaceous siltstone

Description: Grayish-green (10 G 4/2) to pale-green (5 G 7/2) to greenish-gray (5 g 6/1), locally grayish-red (5 R 4/2), clay- to silt-size to fine-grain, moderately- to well-sorted, subangular to well-rounded, well-indurated quartzose siltstone with dolomitic and/or silica cements (Figure 53). Quartz (60-95%) is present as monocrystalline grains, and as intergranular, syntaxial overgrowth cement. Detrital, finely-disseminated clay minerals(1-5%) are present in green-colored lithologies. Dolomite (10-30%) is present as finely- to cryptocrystalline, and anhedral to subhedral, mud-size (<0.0625 mm) matrix and as crystalline intergranular cement. Crystalline dolomite cements are commonly ankeritic (iron-enriched), fine- to medium-crystalline, and anhedral to subhedral.

The dolomitic siltstones lithofacies is only known from well cuttings and a few poorly-consolidated cores cut in northern Illinois; as a consequence, little is known of grain-size trends, sedimentary structures or bedding characteristics. Based on geophysical log characteristics, this lithofacies is thin- to medium-bedded. A carbonaceous variant of this lithofacies is present from a depth of 3972-3974 ft. (1210.5-1211 m) in a core from the Cabot Corp., Cabot #1, Douglas Co., Ill. (Figure 54). In this interval dark-gray to black, laminated mudstone with quartz-silt laminae and weakly-developed burrow mottles is bounded by fine- to medium-grain, burrowed

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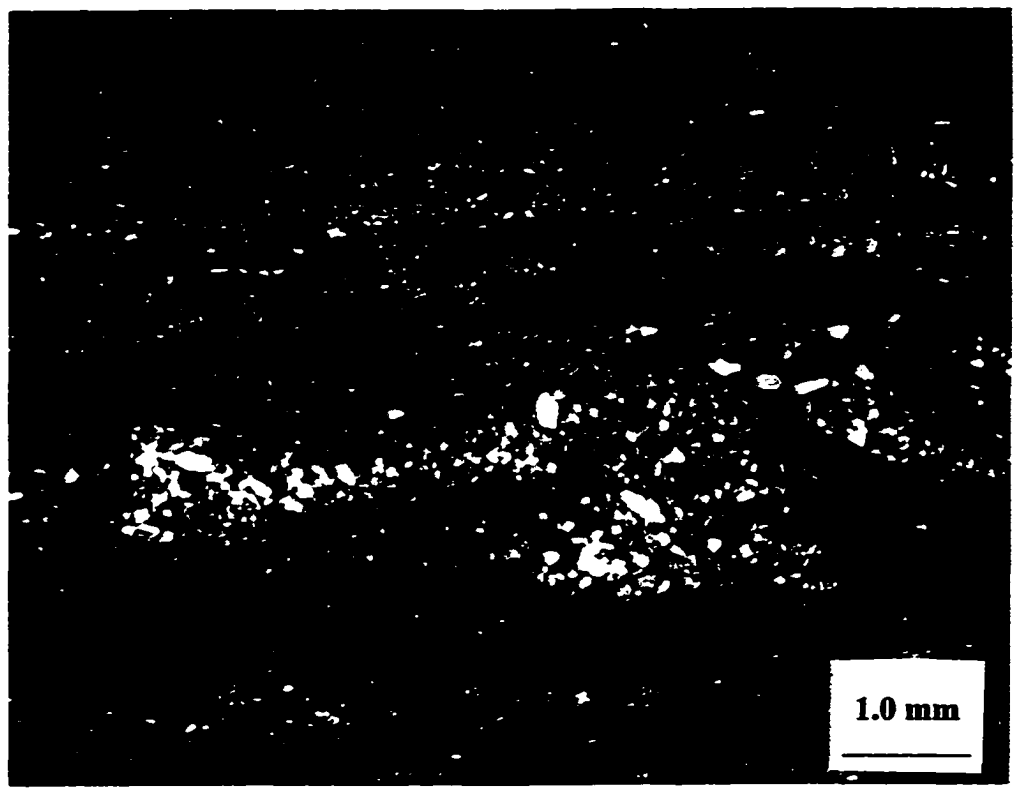

Figure 53: Photomicrograph (cross-polars) of quartz silt in green-gray mudrock matrix, Joachim Dolomite, Gulf Oil, George L. Coon 1, 1523.1 ft. (464 m), Rush Co., Indiana (IGS C325). Silt is locally concentrated in burrow traces. Core diameter is 4-inches (10 cm).

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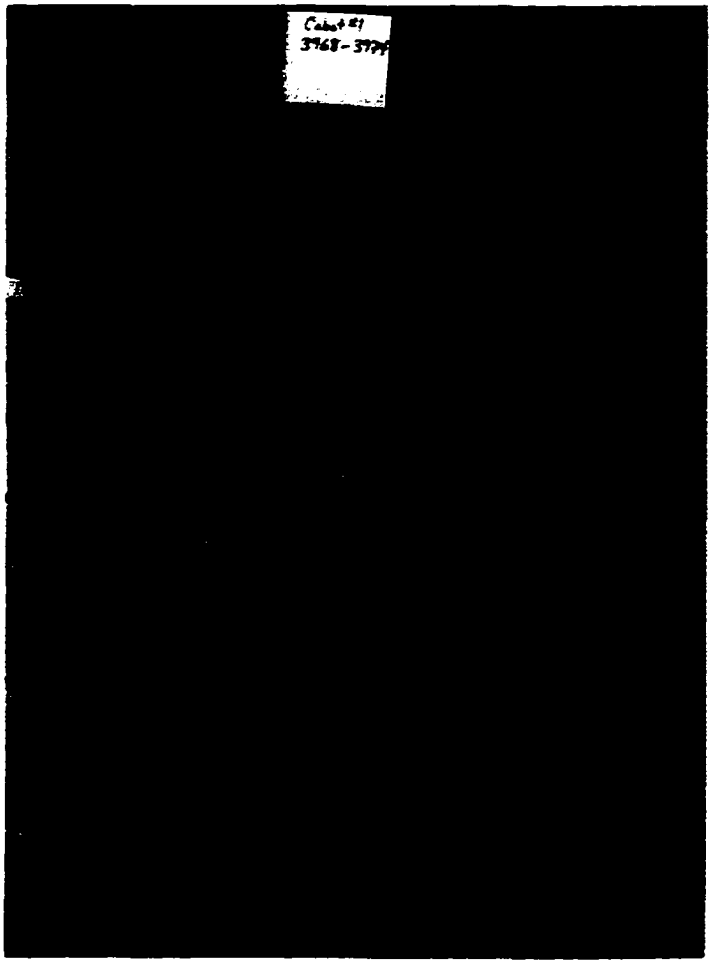

Figure 54: Core photo of interbedded carbonaceous siltstone and mudrock, uppermost St. Peter Sandstone, Cabot Corp., Cabot 1, 3968-3974 ft. (1209.4-1211.3 m), Douglas Co., Illinois (ISGS C4884). Core is 4-inches (10 cm) in diameter.

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quartz arenites. Total organic content varies from 1.5 to 1.8%. This lithofacies is intergradational with carbonaceous mudrock.

Stratigraphic and geographic distribution: This lithofacies is uncommon and is restricted to the area delineated by the depositional limit of the St. Peter Sandstone, the lowermost Joachim Dolomite, and within the Glenwood Formation, northern Illinois.

Discussion: Subtidally deposited where the arenite lithofacies grades laterally into green mudrock and/or argillaceous carbonate lithofacies. In northern Illinois, where it is present in the Glenwood Formation, this lithofacies is commonly interbedded with the argillaceous quartz arenite and green mudrock lithofacies. The fine-grain character and preservation of organic constituents implies a low-energy environment with relatively rapid sedimentation; both features are characteristic of lagoonal settings.

Arenites

Lower-Middle Ordovician quartz arenites (sandstone with <15% mud-size, <0.625 mm constituents) in the Illinois Basin can be subdivided into fourteen lithofacies: (1) conglomeratic arenite, (2) dolomitic arenite, (3) planar cross-stratified arenite, (4) low-angle crossstratified arenite, (5) ripple cross-stratified arenite, (6) trough cross-stratified arenite, (7) laminated arenite, (8) *Skolithos*-bearing arenite, (9) mottled arenite, (10) massive arenite, (11) argillaceous quartz arenite, (12) nodule-bearing arenite, (13) feldspathic arenite and (14) calcilithic arenite.

Lithofacies 7: Conglomeratic quartz arenite lithofacies

Description: Angular to subrounded, pebble- to cobble-size clasts of yellowish-gray (5 Y 7/2) to medium-light-gray (N 6) dolomudstone in a fine- to medium-grain, yellowish-

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gray (5 Y 8/1) quartz arenite matrix. The conglomeratic arenites are poorly-sorted, lack mud-size (<0.0625 mm) constituents, and tend to grade upsection to quartz arenite (Figures 55 and 56). Locally, concavo-convex pebbles of dolomudstone are present. The clasts commonly exhibit soft-sediment deformation and are similar in composition and textural character to underlying lithologies.

Stratigraphic and geographic distribution: This lithofacies is present within the basal transgressive deposits overlying the post- Knox and post-Everton disconformities, and characterize intraformational transgressive-lags within the Everton Formation. This lithofacies is limited to the basal Wells Creek Dolomite, the Everton Formation, and basal St. Peter Sandstone.

Depositional Environment: Carbonate clasts were probably penecontemporaneously derived from partially lithified sediments in adjacent tidal flat environments, and/or the residuum on paleoerosional surfaces. Where present, pebbles exhibiting soft sediment deformation imply the former.

Lithofacies 8: Dolomitic quartz arenite

Description: Interbedded fine-grain quartz arenite and quartzose dolomudstone. The contact between the two lithologies is generally sharp and irregular, and may be stylolitic locally (Figures 57 and 58). The arenite interbeds are fine- to medium-grain, well-rounded, yellowish-gray (5 Y 8/1) quartz arenite that tend to fine-upsection. Quartz grains generally have point contacts, but are locally mud-supported. Microcrystalline calcite infills intergranular void-spaces. The interbedded yellowish-gray (5 Y 7/2) dolomudstones are composed of microcrystalline, anhedral dolomite, and

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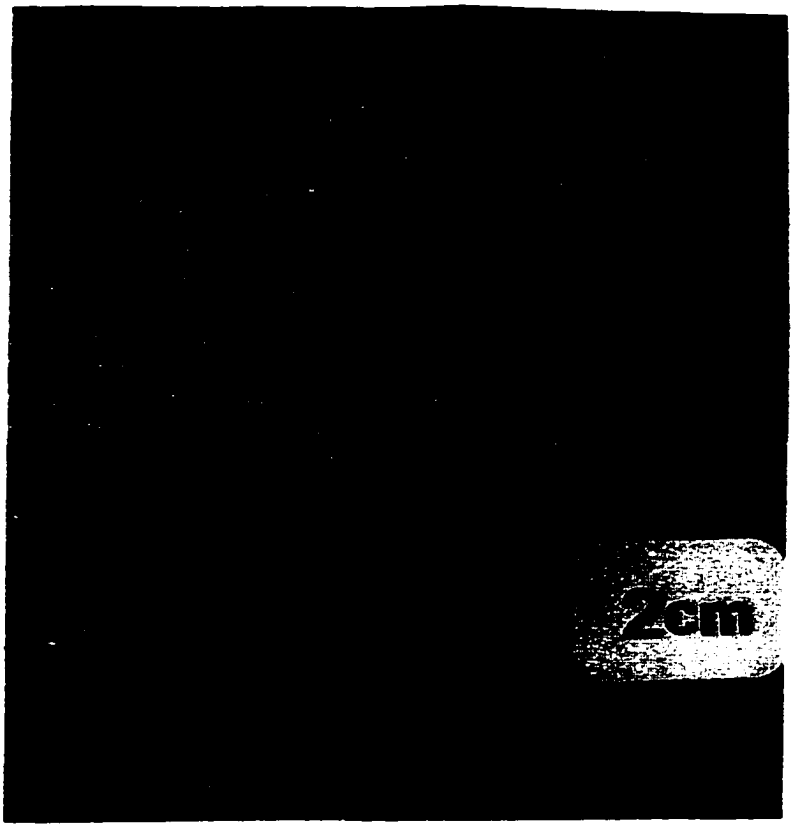

Figure 55: Polished hand sample of conglomeratic quartz arenite overlying stromatolitic dolomudstone, Everton Dolomite, Indian Creek North section, southeast Missouri. Clasts of stromatolitic dolomudstone with very fine-grain quartz arenite matrix.

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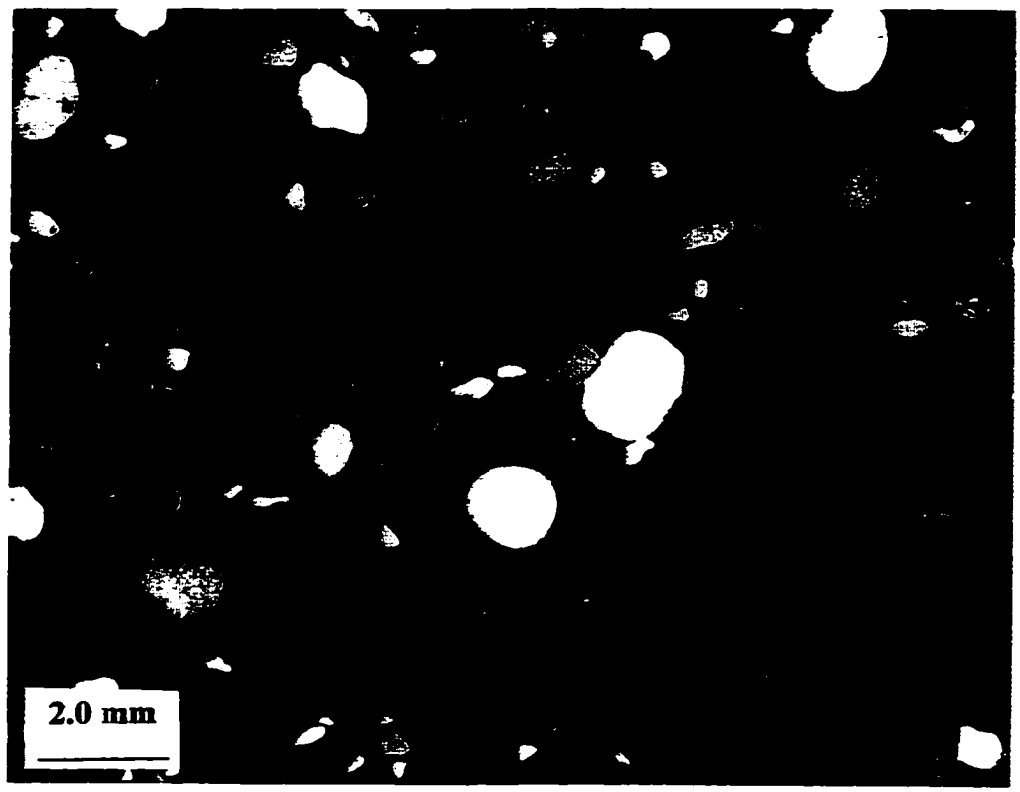

Figure 56: Thin-section photomicrograph (cross-polars) of conglomeratic quartz arenite, basal Wells Creek Dolomite, 720.2 ft. (219.5 m), Cominco American CA-58, Ellis 1, Henry Co., Kentucky (IND C503). Pebble-size silicified ooid grainstone clast (lower right) with admixture of fine- and coarse-grain quartz, sparse dolostone intraclasts, and dolomudstone matrix.

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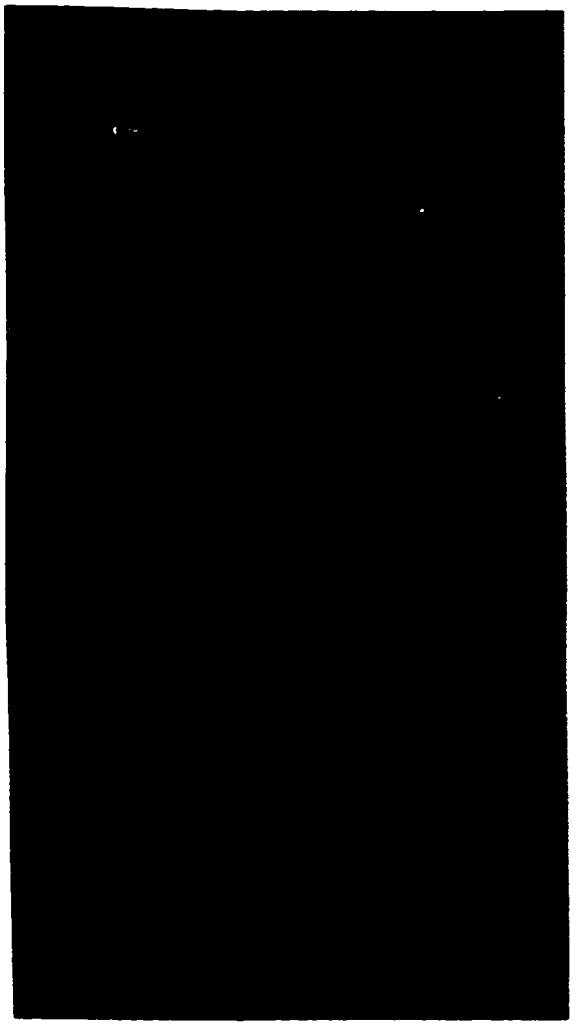

Figure 57: Core photo of interbedded dolomitic quartz arenite and dolomudstone, upper Everton Dolomite, 3274 ft. (997.9 m), Truitt 1, Montgomery Co., Illinois (ISGS C13443). Dolomudstone (medium-gray) enclosed in fine-grain quartz arenite and bounded by stylocontacts. Quartz sand infills brecciated interval at base. Core diameter is 4-inches (10 cm).

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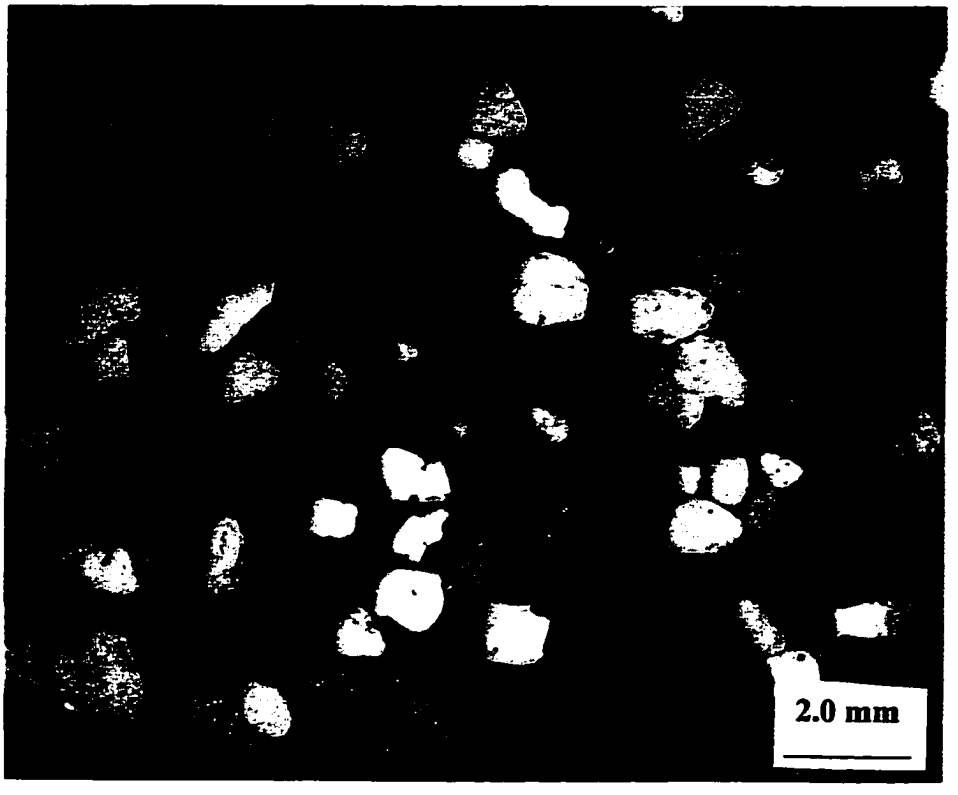

Figure 58: Thin-section photomicrograph (cross polars) of dolomitic quartz arenite, Dutchtown Formation, West Perryville section, Perry Co., Missouri. Moderately well-sorted, subrounded quartz grains with coarsely-crystalline pore-filling dolomite. Gains are locally cement supported and dolomite exhibits twinning.

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dolomicrite, with sparse- to abundant, well- rounded, fine-to medium-grain, monocrystalline quartz present locally.

Stratigraphic and geographic distribution: This lithofacies is limited to the Everton Dolomite, and is associated with the conglomeratic arenite lithofacies.

Discussion: This lithofacies reflects the admixture of storm-washed quartz sand on a bioturbated, carbonate mud-dominated tidal flat.

Lithofacies 9: Planar cross-stratified quartz arenite

Description: The conglomeratic quartz arenite lithofacies is commonly overlain by thin-beds (<5 cm) of planar cross-stratified arenite, and yellowish-gray (5 Y 8/1) to light-gray (N 7), fine-grain, well-sorted, well-rounded quartz arenite with planar-stratified laminae (Figures 59 and 60). Typically, this lithofacies is poorly- to well-indurated with quartz overgrowth cement. Laminae are the product of minor, but uniform variations in grain-size from very fine- to fine-grain; very fine-grain laminae are more extensively cemented than fine-grain laminae.

Stratigraphic and geographic distribution: This lithofacies is known from the Tonti Sandstone Member of the St. Peter Sandstone in the subsurface of central Illinois. It is usually associated with the lower transgressive deposits immediately overlying the post-Knox or post-Everton disconformities.

Discussion: The limited occurrence of this lithofacies in the sections studied hampers the interpretation its depositional environment. The apparent association of this lithofacies with the basal transgressive deposits, and its characteristic thin-bedding, suggest that it does represent a discrete depositional subenvironment. Planar-laminated arenites are commonly associated with peritidal and eolian environments.

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Figure 59: Core photos of planar cross-stratified quartz arenites, Tonti Sandstone Member, St. Peter Sandstone, central Illinois: (A) laminae defined by slight differences in average grain-size (darker lamaine are coarser), 3196 ft. (974 m), Illinois Power Co., Truitt 1, Montgomery Co. (ISGS C13443, core is 4-inch (10 cm) in diameter); and (B) laminae defined by slight differences in average grain-size and abundance of clay-coating on grains (darker lamaine are coarser and have more abundant clay-coated grains), Miller, G. W. Sample #1, Sangamon Co. (ISGS C28, 2.5-inch diameter core).

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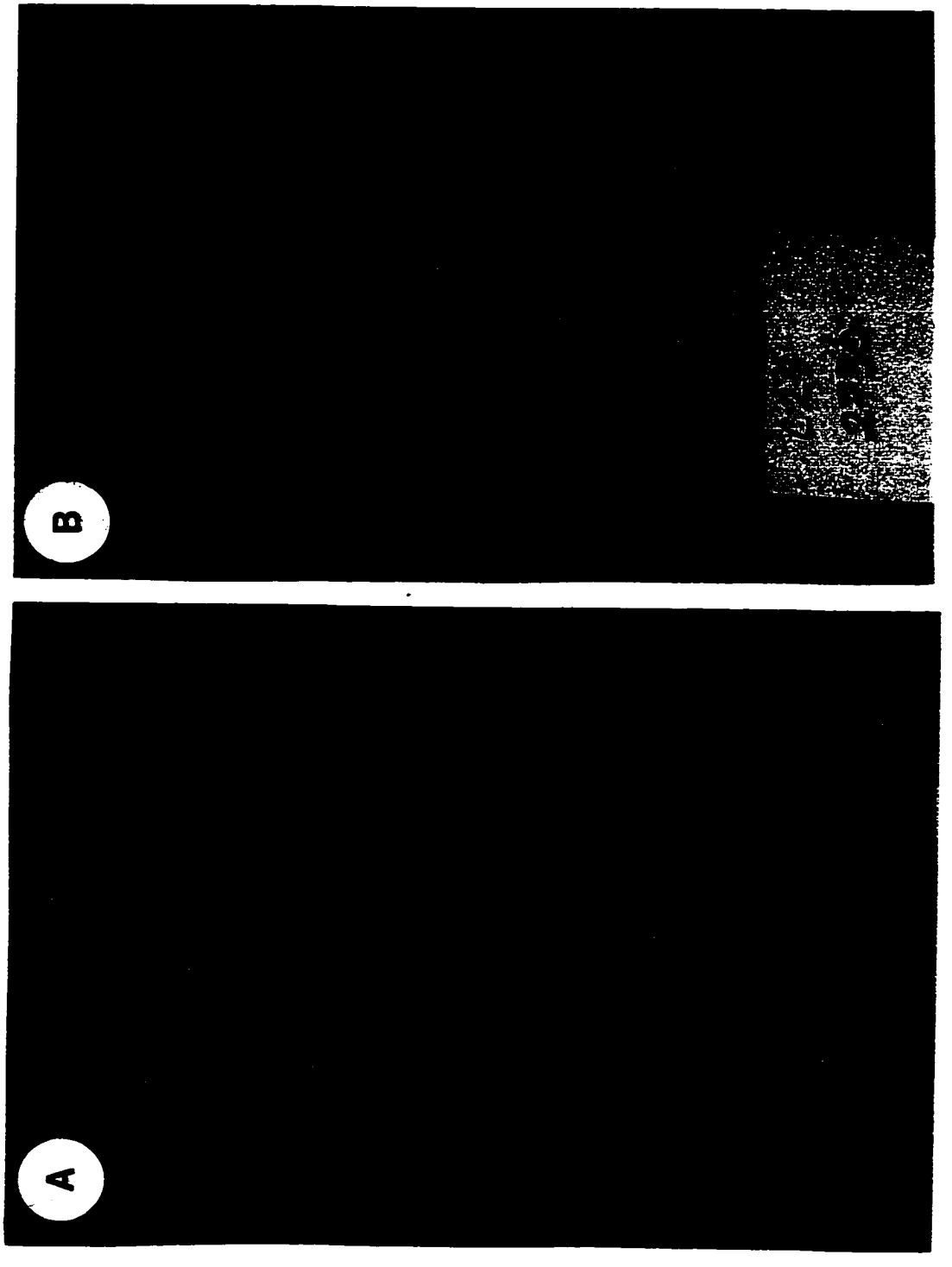

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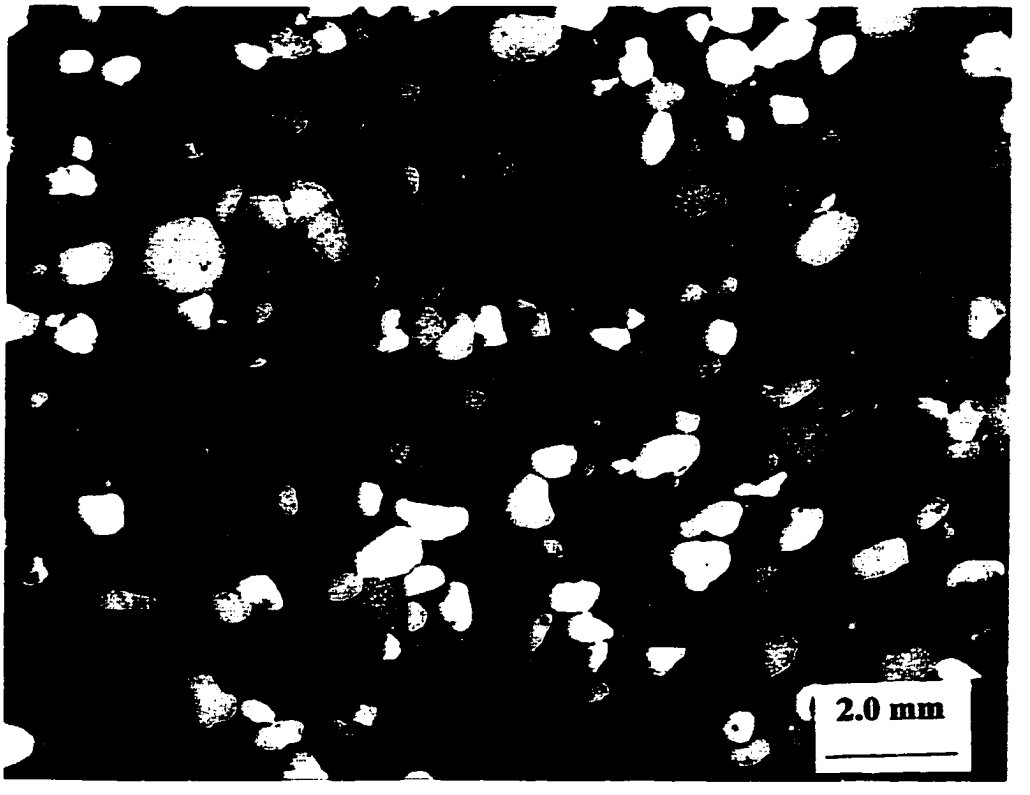

Figure 60: Photomicrograph (cross-polars) of planar cross-stratified quartz arenite, St. Peter Sandstone, 6772 ft. (2064.1 m), Pure Oil Co., C. T. Montgomery 18-B, Richland Co., Illinois (ISGS C3598).

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Lithofacies 10: Low-angle cross-stratified quartz arenite

Description: Yellowish-gray (5 Y 8/1) to light-gray (N 7) cross-stratified, massively-bedded, very-fine to medium- grain, well-rounded quartz arenite that is very well-sorted to bimodal (Figures 61, 62, 63 and 64). Grains surfaces are frosted and may have clay-coats, or ferroan "dust rims". Individual laminae are commonly 1-2 grain-diameters in thickness and well-sorted. Boundaries between laminae mark changes in average grain-size. Thin- beds of slightly coarser-grain arenite with climbing pseudocross-laminae are locally present. These laminae are slightly irregular and may have curvolinear surfaces. In outcrop, adhesion ripples and warts are observable on bedding-planes.

Stratigraphic and geographic distribution: This rock-type is primarily limited to the Tonti Sandstone Member of the St. Peter Sandstone; although thin-beds may be present in the Starved Rock Sandstone Member, basal arenites of the lower Everton Dolomite, and lower Joachim Dolomite.

Discussion: Quartz arenites with low-angle cross-stratification are widely distributed in the subsurface of northern and north-central Illinois, western Illinois and locally, in southeastern Missouri. Where studied in outcrop, workers have interpreted this lithofacies to have been deposited as subaqueous sand-banks (i.e., Dott and Roshardt, 1972; Amaral and Pryor, 1977). However, Dott and others (1986) have provided a convincing argument, based on the presence of adhesion "warts" and ripples, pseudocross-lamination and bedform morphology, that this lithofacies has an eolian origin. However, the characteristic eolian sedimentary features used by Dott and others (1986) are commonly developed on bedding planes, or do not have unique cross-sectional profiles, and as a consequence lose their utility in the subsurface where core is

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Figure 61: Handsample (A) and core (B) photos of low-angle cross-stratified quartz arenite. (A) Hand sample of finely-laminated quartz arenite from Tonti Sandstone Member, St. Peter Sandstone, Clay Hollow section, southern Wisconsin. In situ, laminae are inclined 7-18° relative to bedding planes. (B) Core photo of finely-laminated quartz arenite, Tonti Sandstone Member, St. Peter Sandstone, 1250 ft. (381 m) Central Illinois Light Co., Witte 701, (ISGS C9240, 4-inch diameter core).

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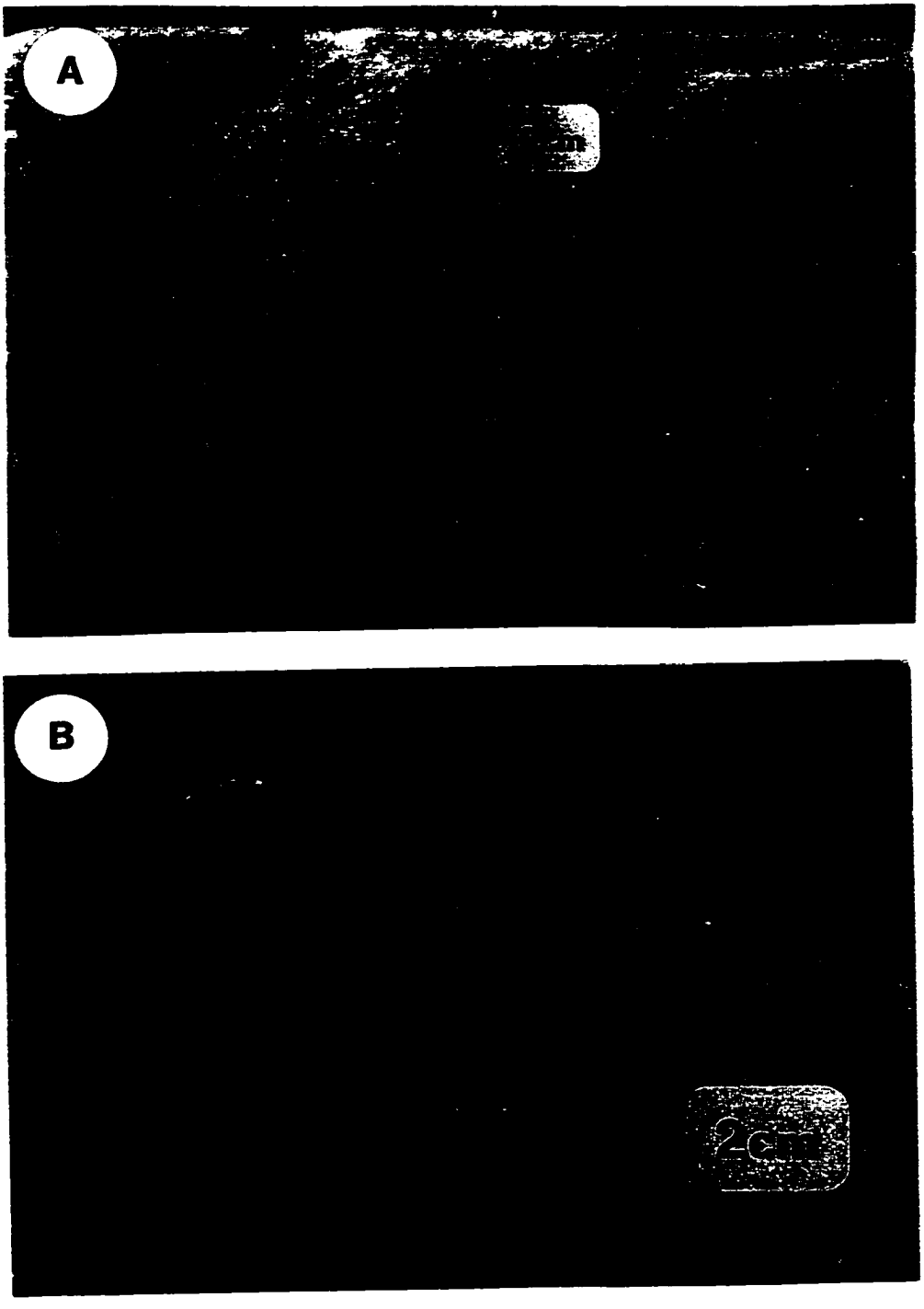

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Figure 62: Eolian cross-stratified quartz arenite (medium-gray, lower left) overlain by massive quartz arenite (white, middle) of the St. Peter Sandstone, which are in-turn overlain by the basal beds of the Joachim Dolomite, Bloomsdale section, southeast Missouri. Note differential weathering of oblique to bedding partings in eolian portion of section.

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Figure 63: Core photos of low-angle cross-stratified quartz arenite, Tonti Sandstone Member of St. Peter Sandstone. (A) cross-stratification delineated by ferroan staining of low-angle cross-stratified quartz arenite, (yellow-orange is limonite and brick-red is hematite), Commonwealth Edsion UPH-3, Stepheson Co., northwest Illinois (ISGS C12996, 2.5-inch core). Note that angular core breaks in orientation of cross-stratification. (B) White, quartz over-growth-cemented, quartz arenite of the St. Peter Sandstone (4097 ft.) just below contact with Dutchtown Formation (black dolomudstone), Stanolind Oil & Gas, Leiner #1, Jackson Co., Illinois (ISGS C58, 4-inch core). Cross-stratification is nearly obliterated by cementation; however, core breaks in preferred, low-angle orientation.

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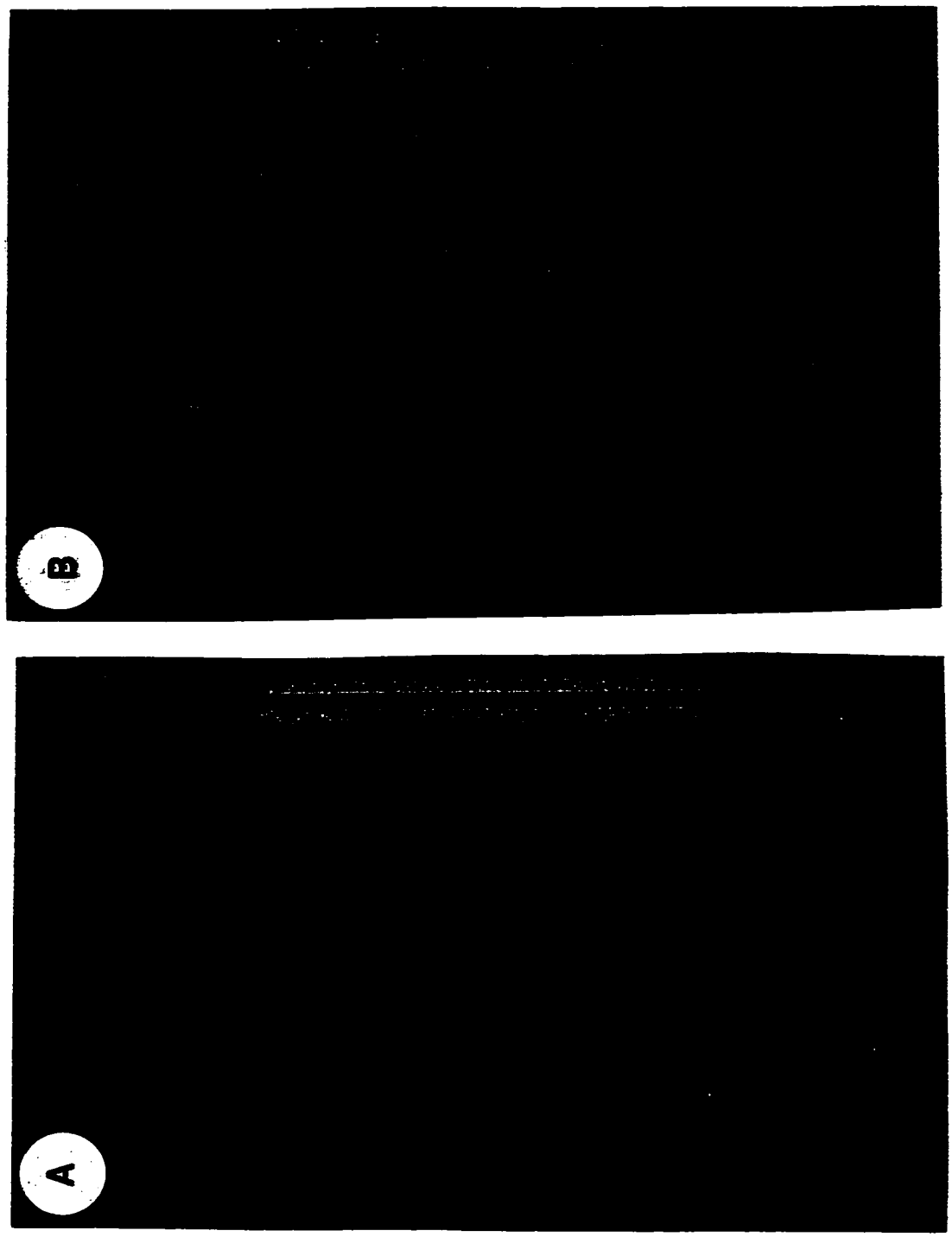

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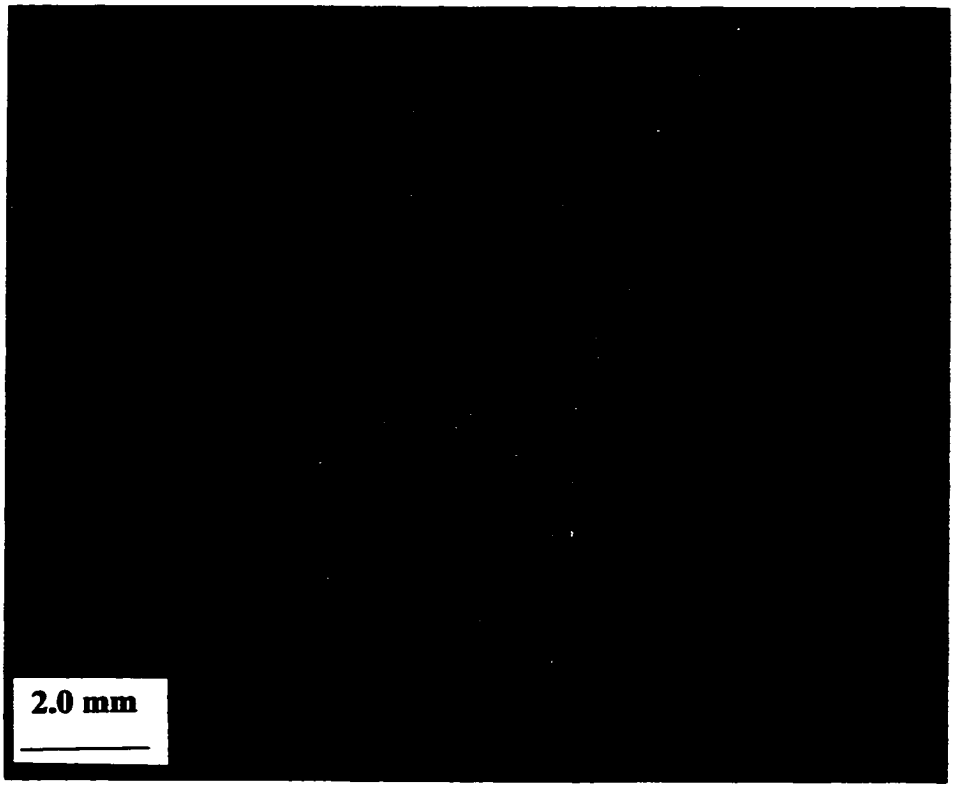

Figure 64: Thin-section photomicrograph (plane light) of low-angle cross-stratified quartz arenite, Tonti Sandstone Member, St. Peter Sandstone, Airport Road section, southwest Wisconsin (see Figure 17). Cross-stratification defined by cosets of interlaminated coarse-grain, moderately- to well-rounded quartz, and very fine- to fine-grain, subrounded quartz. Quartz overgrowths are preferentially developed on fine-grain fraction and give grains an apparent subangular, and angular grain-shape. Blue epoxy shows the distribution of porosity.

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the only available material for study. Potentially useful dip-meter geophysical logs are generally unavailable and the applicability of this log-type for identifying this lithofacies remains untested.

Although frosting of grain surfaces might be a possible discriminating feature in the subsurface, the origin of surface textures on quartz grains in the St. Peter Sandstone remains controversial (Amaral and Pryor, 1977; Odom and others, 1979; Mazzulo and Ehrlich, 1983; Grutzeck, 1986; Johnson and others, 1989; Grutzeck, 1989). Because frosted grain surfaces may be inherited from source lithologies, penecontemporaneously reworked into shallow shelf deposits, or may be diagenetic in origin, this characteristic is of limited utility for discriminating depositional environments.

As a result, although Dott and others (1986) and Lee and Byers (1992) interpreted this lithofacies as eolian in origin and limited its distribution oto southern Wisconsin and northern Illinois in the Wisconsin Arch region, and to west of Pacific, Mo., in the Ozark Dome area. Interpreting the origin of low-angle cross-stratification in subsurface is problematic and at present, this lithofacies cannot be reliably classified as either eolian, or peritidal.

Lithofacies 11: Ripple cross-stratified quartz arenite

Description: Predominated by a yellowish-gray (5 Y 8/1) to light-gray (N 7), thin-bedded, fine- to medium-grain, well-rounded, well-indurated quartz arenite with planar to low-angle cosets (Figures 65 and 66). Typically, development of cross-stratification changes upsection from planar to low-angle cross-stratification. Grain-size also decreases up section. This lithofacies is typically overlain by the massive arenite lithofacies. The lower contact is commonly sharp and planar, the upper contact is

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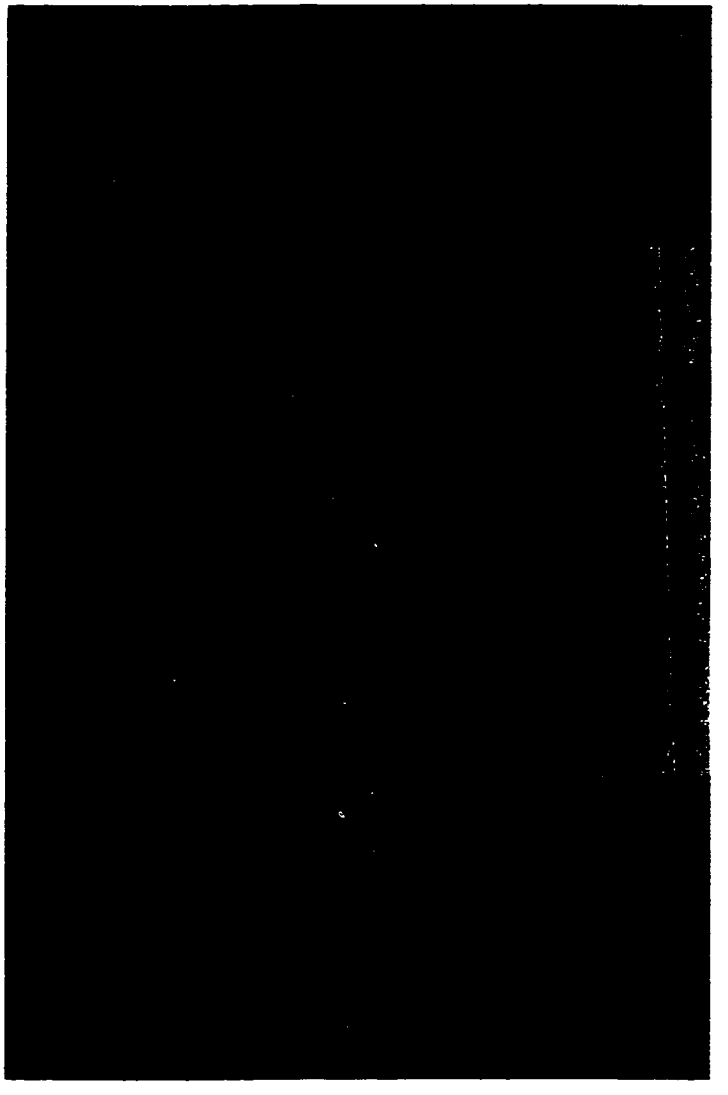

Figure 65: Core photo of ripple cross-stratified quartz arenite, bracketed by arrows (3186-3188.6 ft. or 971.1-971.9 m), overlying trough cross-stratified quartz arenite, 3188.6-3190.0 ft. (971.9- 972.3 m), Tonti Sanstone Member, St. Peter Sandstone, Illinois Power Co., Truitt #1, Montogomery Co., Illinois (ISGS C13443, 4-inch core). Ripple cross-stratification probably formed during waning flow.

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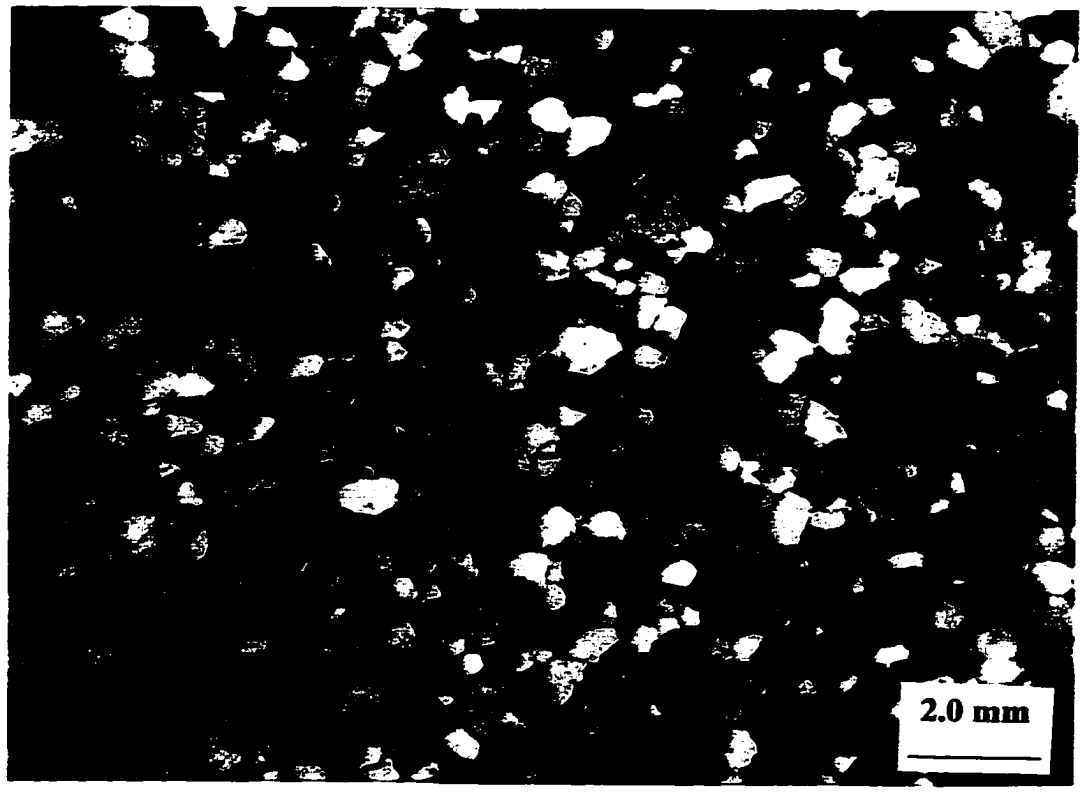

Figure 66: Photomicrograph (cross-polars) of ripple cross-stratified quartz arenite showing typical fine-grain, well-sorted character and development of quartz overgrowth cement, St. Peter Sandstone, 5251 ft. (1605 m), Magnolia Oil Co., M. T. Rodda #1, Coles Co., Illinois (ISGS C3533).

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gradational. This lithofacies can be difficult to differentiate from low-angle cross-stratified lithofacies in small diameter cores where the relationship of the cosets to the bedding planes, the geometry of the cross-stratification and bed thickness are not evident.

Stratigraphic and geographic distribution: This lithofacies is common in the lower Everton Sandstone (Dapples, 1921), rare in the Tonti Sandstone Member of the St. Peter Sandstone (Dapples, 1921; Lamar, 1927), and abundant within the Dutchtown Formation toward its northern limit. Lamar (1927) reported oscillation ripple-marks from the Tonti Sandstone Member in Calhoun, La Salle, Ogle and Winnebago counties in western and northern Illinois.

Discussion: Oscillation ripple-marks are sub-aqueously formed by bi-directional currents generated by standing waves during storm/tidal events. Ripples are preserved by rapid burial beneath storm transported sediments. As a consequence, this lithofacies reflects deposition in the shallow marine environment.

Lithofacies 12: Trough cross-stratified quartz arenite

Description: Yellowish-gray (5 Y 8/1) to light-gray (N 7), coarse- to medium grain, well-to subrounded, well- to moderately-sorted quartz arenite with minor to abundant quartz overgrowths and/or calcite cement (Figures 67, 68 and 69). Induration of this lithofacies varies from friable to well-indurated, and the degree of induration is directly proportional to abundance of quartz overgrowth cement. Beds are commonly thin- to medium-bedded with moderate- to well-developed, trough cross-stratification.

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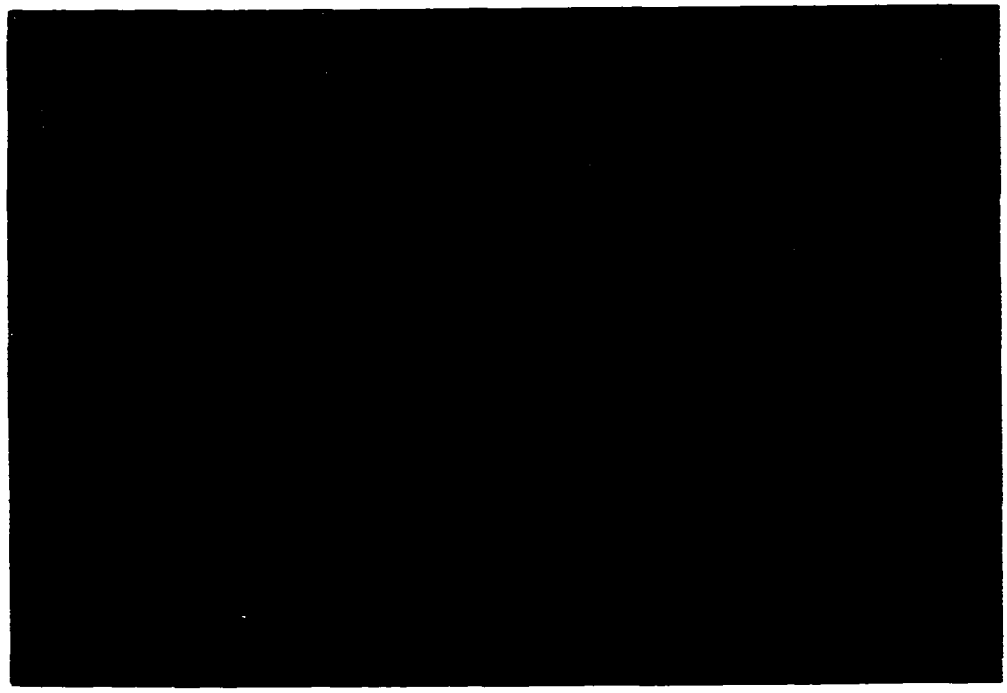

Figure 67: Outcrop photo of (A) trough cross-stratified quartz arenite overlain by (B) *Skolithos*-bearing quartz arenite, Tonti Sandstone Member, St. Peter Sandstone, northbound lane U. S. Interstate 55, Perry Co., southeast Missouri.

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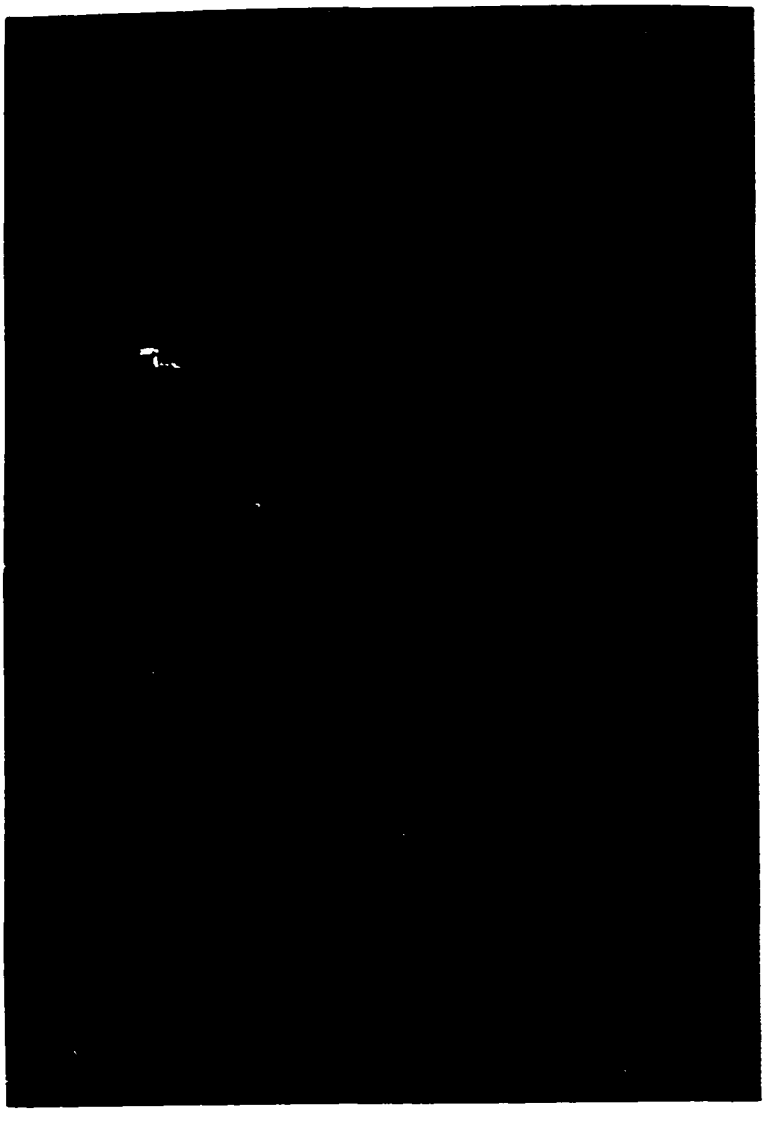

Figure 68: Core photo of trough cross-stratified quartz arenite, Tonti Sandstone Member, St. Peter Sandstone, 3189-3190 ft. (972-972.3 m), Illinois Power Co., Truitt 1, Montogomery Co., Illinois (ISGS C13443, 4-inch core).

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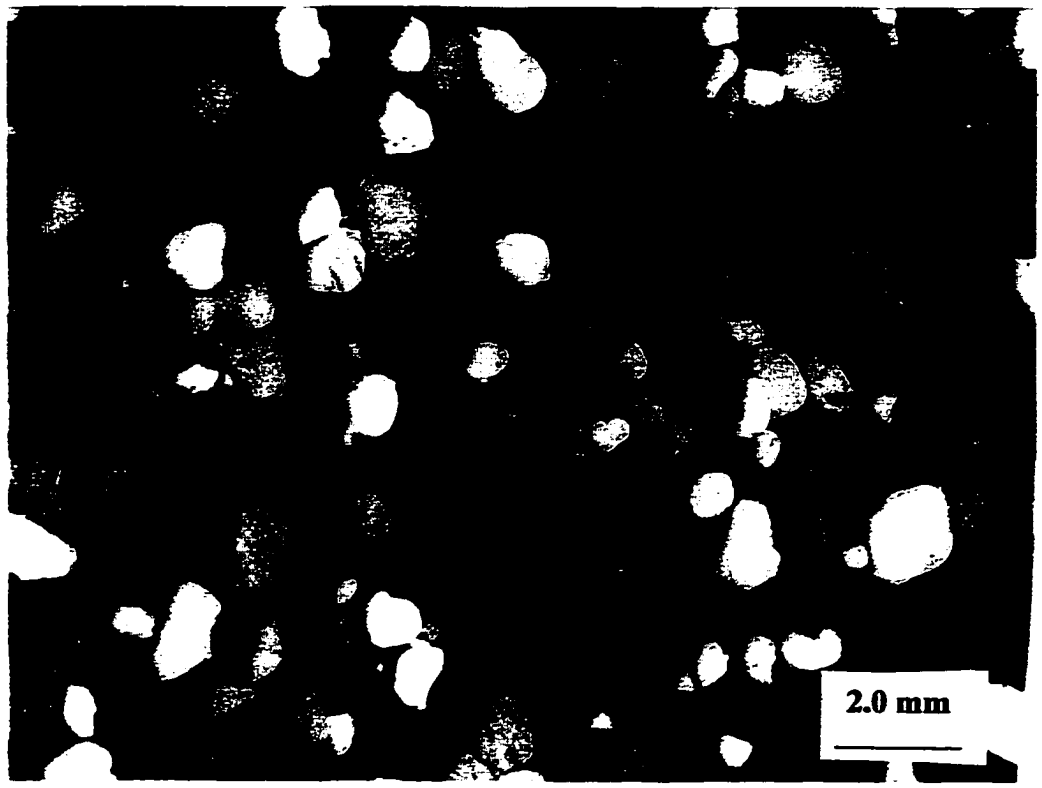

Figure 69: Photomicrograph (cross-polars) of tough cross-stratified quartz arenite showing medium- to coarse grain, well-sorted texture, St. Peter Sandstone, 106 ft. (32.3 m) Unimin Silica 86-816, La Salle Co., Illinois.

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Skolithos burrows are sparse- to moderately-abundant; where present they obscure cross-stratification.

Stratigraphic and geographic distribution: This lithofacies is limited to the St. Peter Sandstone where it is moderately-abundant in the Starved Rock Sandstone Member, and relatively uncommon in the Tonti Sandstone Member.

Discussion: Trough cross-stratification forms from the stacking of bed-sets, bounded by erosive surfaces, due to the migration of bedforms, with curvolinear crests developed at the sediment-water interface, in response to a confined, unidirectional fluid flow. These conditions are develop in peritidal marine environments within tidal channels and in association with longshore currents.

Lithofacies 13: Laminated quartz arenite

Description: Yellowish-gray (5 Y 8/1) to dusky-yellow- green (5 GY 5/2), fine- to medium-grain, well-sorted, well- rounded quartz arenite with moderate to abundant grayish-green (10 GY 5/2) mudrock laminae (Figures 70A and 71), or locally, carbonaceous mudrock lamines (Figures 70B). Laminae morphology ranges from planar to domal. Where sufficiently well defined morphologies are present, beds of domal stromatolites, 0.1 m high and 0.3 m wide, can be observed in outcrop. The sands are commonly well-indurated by quartz overgrowths where grain-supported, and micocrystalline dolomite (dolosparite) cemented where mud-supported. Quartz grains in contact with the clay laminae do not possess overgrowths. The clay laminae, predominantly composed of illite and some authigenic potassium feldspar, contain sparse organic partings.

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Figure 70: Core photographs of laminated quartz arenite. (A) laminated quartz arenite, 3262 ft., basal Tonti Member, St. Peter Sandstone, Illinois Power Co., Truitt #1, Montgomery Co., Illinois (ISGS C13443; 4-inch core diameter). Laminae are defined by green-gray mudrock partings. (B) Core photo of laminated quartz arenite interbedded with mottled quartz arenite, 3163.7-3165.2 ft., and carbonaceous mudrock at 3161.5 ft., uppermost St. Peter Sandstone, Illinois Power Co, Truitt #1, Montgomery Co, Illinois (ISGS C13443, 4-inch diameter core). Note that laminae in quartz arenite go from green-gray mudrock partings (>3165 ft.) to pyritic (3161.8-3163 ft.) to brown carbonaceous-mudrock partings (3160.6-3161 ft.). Conformable contact with overlying Joachim Dolomite is gradational, but is placed at 3158.8 ft. (963 m) where patterned quartzose dolomudstone overlies sharp contact with underlying laminated quartz arenite.

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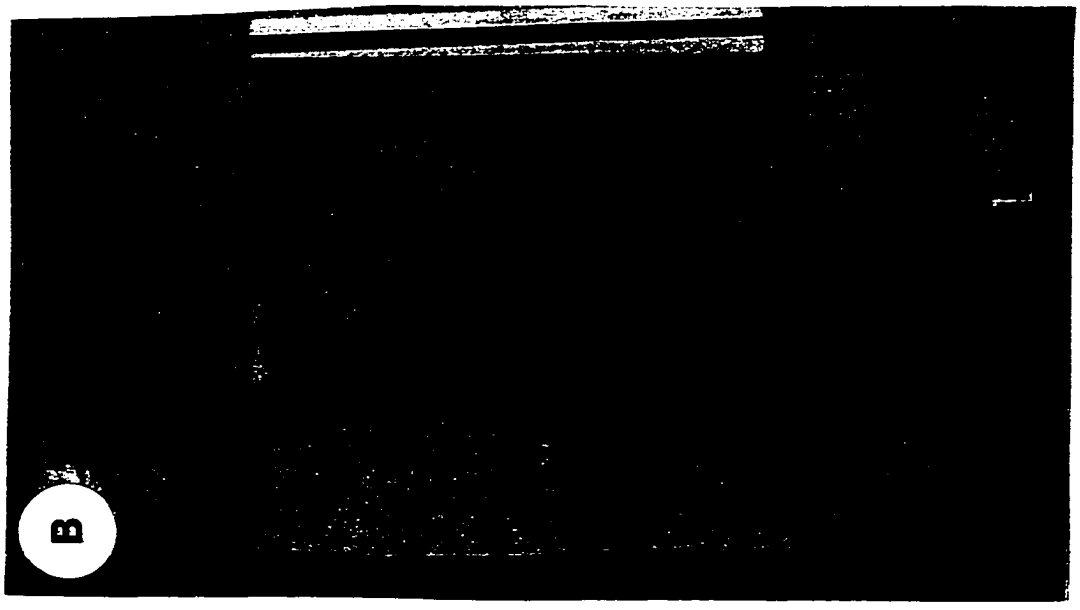

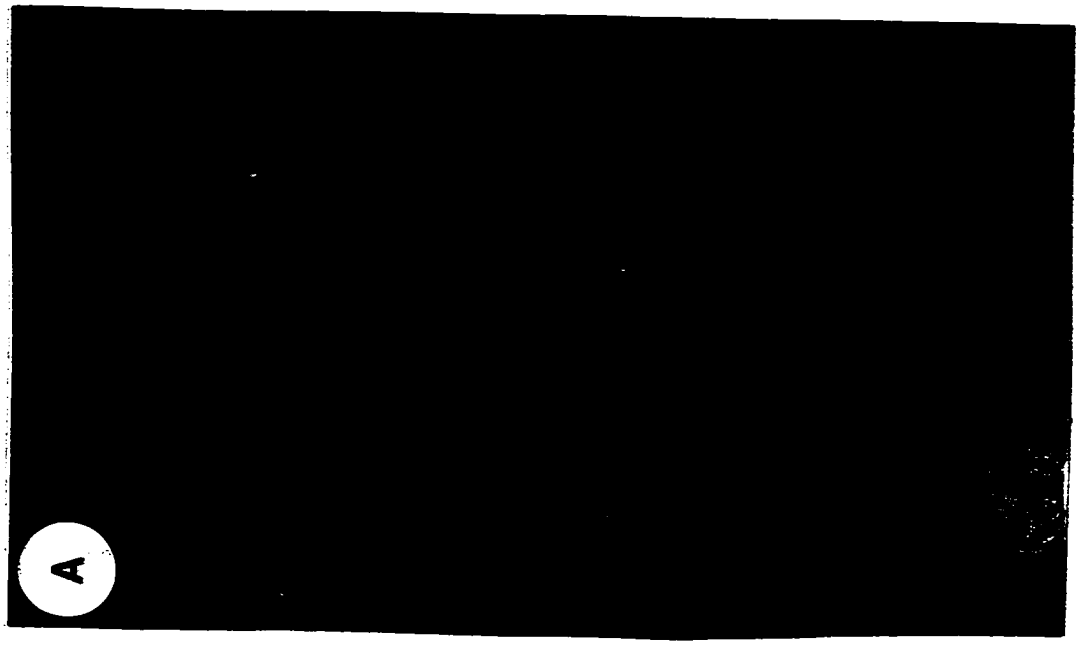

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Figure 71: Thin-section photomicrographs of laminated quartz arenite, Tonti Sandstone Member, St. Peter Sandstone. (A) laminated quartz arenite with green mudrock laminae, Illinois Power Co., Truitt #1, 3166.2 ft. (965 m), Montgomery Co., Illinois (ISGS C13443). Note poor- to moderate-sorting above, and below lamination and development of quartz overgrowths on fine-grain fraction. (B) laminated quartz arenite with thick, feldspathic fine-grain laminae and thin, locally calcite-cemented, coarse-grain laminae, lower Joachim Dolomite, 1554.5 ft. (474 m), Gulf Oil Co., Frank Osborne #1, Decatur Co., Indiana (IGS C317). Both photomicrographs are seen in plane light. Also note the marked distribution of porosity in some layers.

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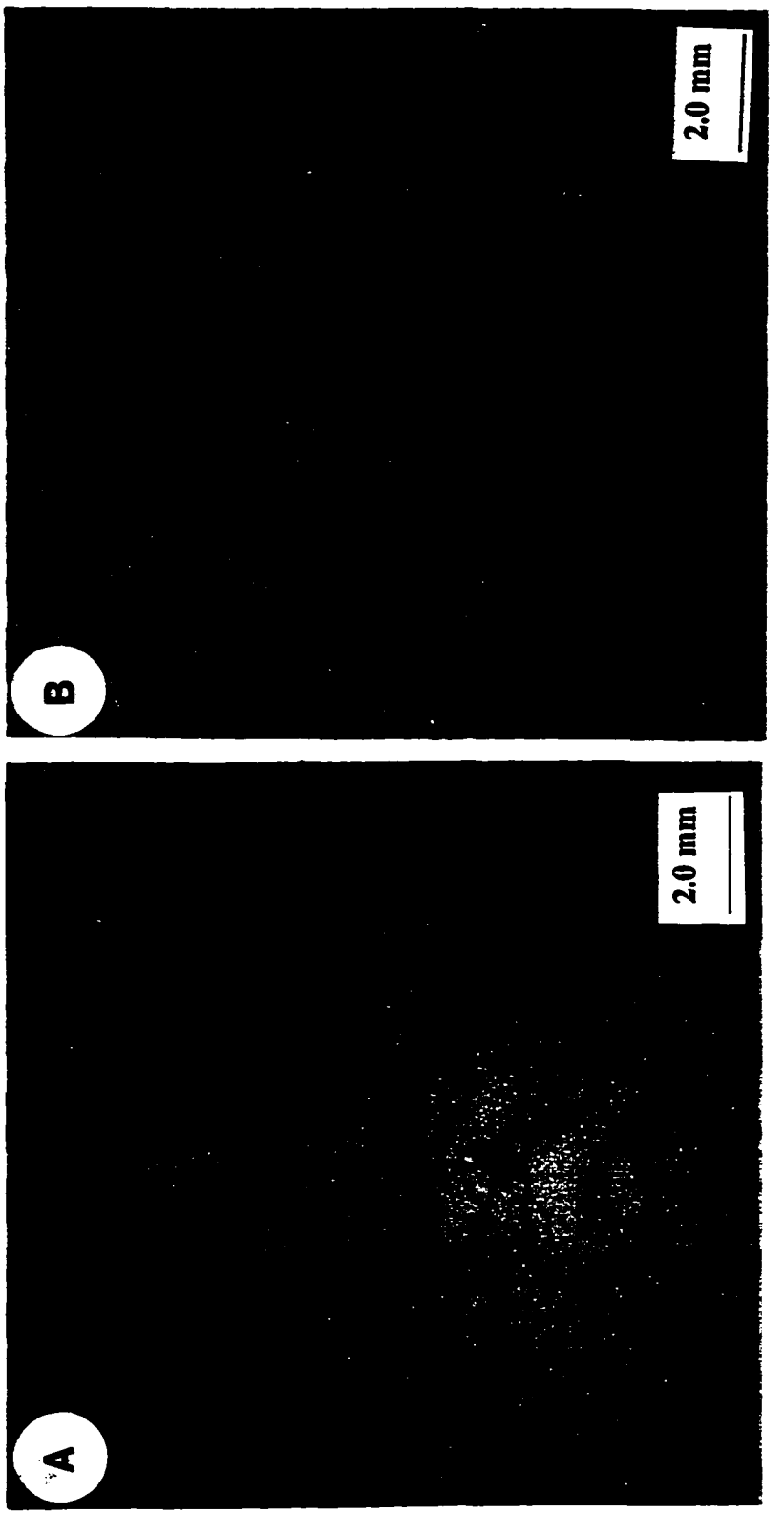

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Where stromatolitic quartz arenite is well developed in the Augusta Member of the Joachim Dolomite (Figure 72), the lithofacies is pervasively cemented by microcrystalline dolomite (10-40% by volume) and the quartz grains are locally mud-supported. This lithofacies is gradational with the stromatolitic dolomudstone lithofacies and following Martin and others (1993), a cutoff of 50% quartz grains is used to differentiate the two.

Stratigraphic and geographic distribution: Laminated arenites are present in the upper Tonti Sandstone member of the St. Peter Sandstone in central Illinois, the upper Everton Dolomite, and the Abernathy and Augusta members of the lower Joachim Dolomite in southeast Missouri.

Discussion: This lithofacies is interpreted as the preserved stromatolitic peritidal sediments associated with a siliciclastic tidal flat. In modern examples (Cameron and others, 1985; Gunatilaka , 1975), the degree of desiccation, strength of current flow and composition of the microbiological population controls the morphology of the mats and therefore, the observed geometry of the preserved laminated sediments. Because organic mats have low preservation potential, early cementation is generally required to preserve the sedimentary structures controlled by mat morphology and distribution (Martin and others, 1993).

For the most part, only planar to low-angle laminae orientations can be identified in core and the possible geometry's of the associated features can not be determined. However, the basal beds exposed at the type section of the Augusta

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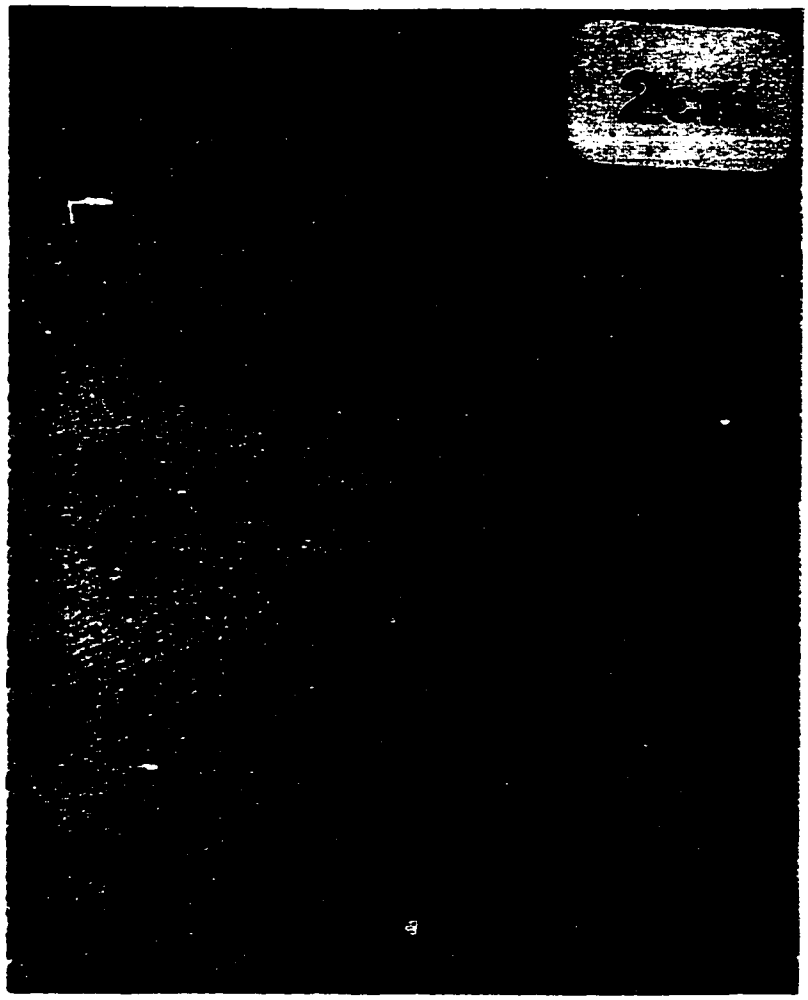

Figure 72: Hand sample photograph of stromatolitic quartz arenite, Augusta Member, Joachim Dolomite, St. Albans section, east-central Missouri. Laminae are well-indurated by dolomicrite and defined by abundance of dolomitic matrix and/or quartz grain-size. Quartz grains are mostly grain-supported, but locally mud-supported.

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Member best illustrate the development of the domal stromatolite aspect of this lithofacies. Gunatilaka (1975) reported that "rounded", or domal mats are restricted to limited areas of the upper intertidal zone of the Mannar Lagoon siliciclastic tidal flats, while the planar, "flat" mats are limited to the lower intertidal zone. At the St. Albans section, well-preserved fibrous conodonts were recovered from a laminated quartz arenite that is pervasively dolomite-cemented. The preservation condition suggests that this fauna has not be reworked and that these sediments were deposited subaqueously.

As mentioned above, other than the quartz content, this lithofacies is nearly identical in character to the stromatolitic dolostone lithofacies.

Lithofacies 14: *Skolithos*-burrowed quartz arenite

Description: Yellowish-gray (5 Y 8/1) to medium-gray (N 7), locally moderate-yellowish-green (10 GY 6/4), coarse- to fine-grain, well- to subrounded quartz arenite with abundant *Skolithos* ichnofossils and that fine-upward (Figures 73, 74 and 75). *Skolithos* are vertical tubiform structures 1-15 cm in length and 0.25-2 cm in diameter that are infilled with medium- to coarse-grain quartz sand. Coarse-grain burrow infills are commonly well-cemented with either calcite and/or poorly-developed quartz overgrowths. The matrix is typically moderate-yellowish-green, clay-cemented, fine-grain quartz sand that is moderately-indurated and lacks cross-stratification. Where the infills are absent, clay coats are observed along the tubiform margins.

The abundance of *Skolithos* varies from sparse, well defined populations, to densely-packed "piperock" (Figure 76). Droser and Bottjer (1990) proposed an index (1 to 5) for classifying *Skolithos* ichnofabrics based on the percentage of original bedding

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Figure 73: Core photos of *Skolithos*-bearing quartz arenite with "large" diameter (1-2 cm) burrow traces, St. Peter Sandstone. (A) Vertical *Skolithos* burrows cutting very fine-grain quartz arenite infilled with coarse-grain quartz arenite, Cabot Corp., Cabot #1, 4082 ft. (1244 m), Douglas Co., Illinois (ISGS C4884). (B) Vertical *Skolithos* burrows cutting argillaceous arenite infilled with coarse-grain quartz arenite, 3251ft. (991 m), Truitt #1, Montgomery Co., Illinois (ISGS C13443). Both cores are 4-inch (10 cm) diameter.

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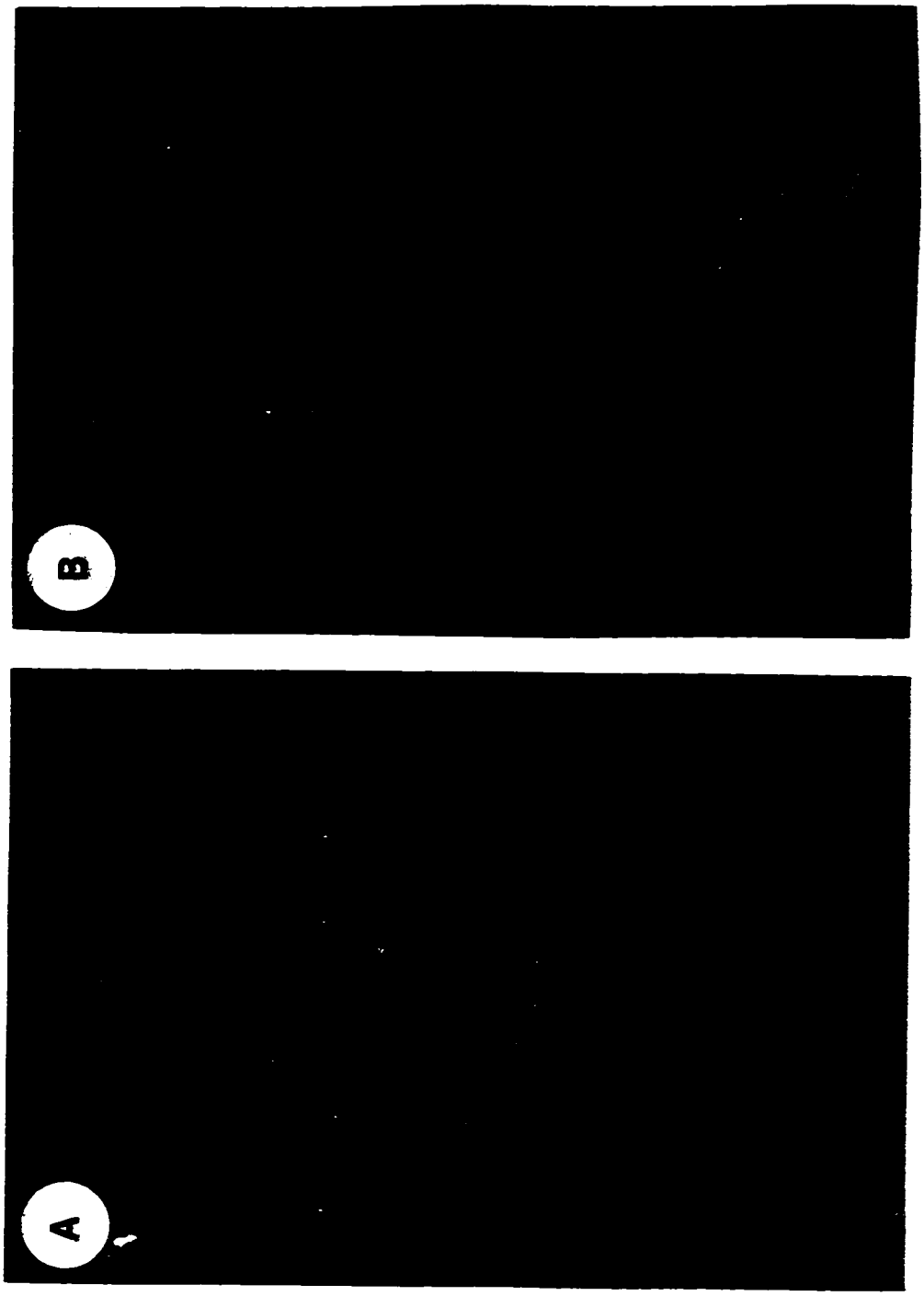

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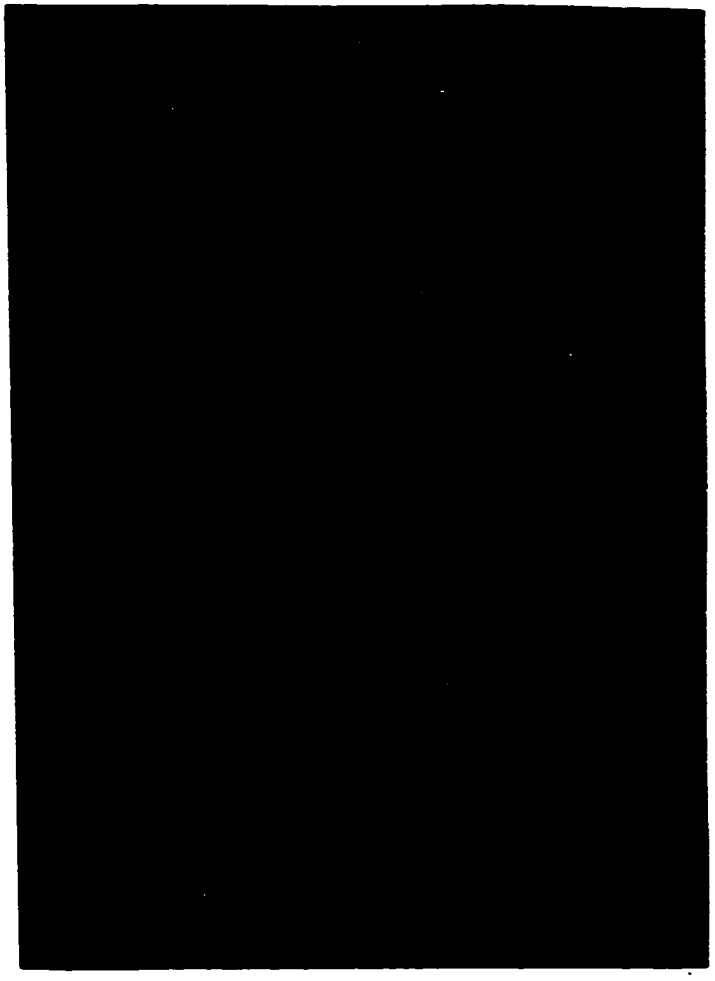

Figure 74: Core photo of *Skolithos*-bearing quartz arenite with "small" (<1 cm) diameter burrows, 3259 ft. (993 m), lower Tonti Sandstone Member, St. Peter Sandstone, Illinois Power Co., Truitt #1, Montgomery Co., central Illinois (ISGS C13443). Core is 4-inches (10 cm) in diameter.

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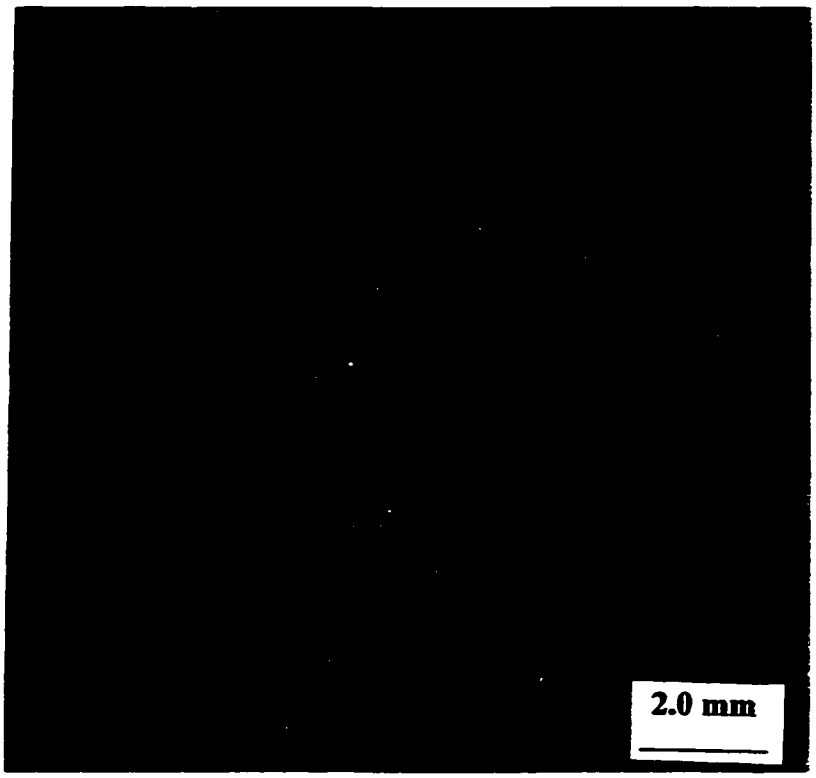

Figure 75: Thin-section photomicrograph of *Skolithos*-bearing quartz arenite, Tonti Sandstone Member, St. Peter Sandstone, Pike County Gas Association, Conkright #2, 1014 ft. (309 m), Pike Co., Illinois (ISGS C3500). Mostly coarse-grain fraction with lower clay content in fills burrow (right side) that cuts finer-grain, clay-cemented matrix (left side).

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Figure 76: Outcrop photo of *Skolithos*-bearing quartz arenite, Tonti Sandstone Member, St. Peter Sandstone. "Piperock", is a weathering expression of *Skolithos*-bearing quartz arenite, Bloomsdale North section, southeast Missouri.

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disturbed by biogenic activity. Generally, the occurrences in the Ancell Group fall within indices 4-5 indicating that greater than 60% of the primary sedimentary fabric is disturbed.

Typically, bedding in this lithofacies is medium- to massive (0.3-2 m). In outcrop, burrows can be traced down- section from a bedding plane and shown to penetrate multiple beds. The beds overlying bedding planes at which *Skolithos* terminate are assignable to the coarser-grain, massive arenite lithofacies. In core, the abundance of burrows and presence of coarser-grain fractions decreases upsection, and this lithofacies appears to grade upsection into the massive arenite lithofacies.

Where clay cemented, authigenic potassic feldspar is common. Due to the presence of radiogenic nuclides in the clays and feldspar, and the presence of molecular water in the clays, these intervals are commonly identifiable using geophysical logs based on their high gamma-ray activity and elevated neutron porosity (Gendron and others, 1988). The potassium feldspar associated with the clay cements of the St. Peter may be related to regional, potassic diagenetic events due to migration of basinal brines (Hay and others, 1988).

Stratigraphic and geographic distribution: This lithofacies is present in the Tonti and Starved Rock members of the St. Peter Sandstone, and within the Kingdom, Loughridge and Nokomis members of the Glenwood Formation.

Discussion: This lithofacies has been widely described by early workers as "pipe-rock" or "burrowed" sandstone, and the burrows interpreted as "worm holes" (Lamar, 1927). Dott and others (1986) assigned these features as the ichnofossil *Skolithos*. *Skolithos* is a trace fossil characterized by the coarse-infilling of vertical tubes though to be the

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dwelling-feeding burrows of infaunal organisms (Pemberton and Frey, 1984; Droser, 1991; Ekdale, 1992). Where early Paleozoic examples have been studied in detail, Bradore Formation (L. Cambrian), Thorold Formation (Silurian) and Eli Springs Dolomite (U. Ordovician), the infaunal organisms are thought to have been suspension-feeders (Pemberton and Frey, 1988). Suspension feeding requires that the sedimentary surface be below the sediment-water contact relatively consistently, and implies a subtidal to intertidal environment.

The interpretation of *Skolithos* as tubular dwelling burrows is favored for the St. Peter Sandstone. The grain-size relationships between the fine-grain matrix and the coarse- grain infill requires that the tube is open at time of deposition of the coarser, burrow-filling sediment. In addition, clay coats of the tubiform margins suggest a precursor cementing agent. In modern environments, soft-bodied worms form *Skolithos*-like burrows in the high-energy intertidal environment proximal to the shoreface by lining their dwelling tubes with organic matter (Ekdale, 1992).

Skolithos has been reported to co-occur with the ichnofossil *Thallasinoides* in the St. Peter Sandstone in southern Wisconsin (Long, 1988), and with *Arenicolites* in southeastern Missouri (Lee and Byers, 1992). Chamberlain (1978) reported *Thallasinoides* and *Arenicolites* are characteristic of lagoon and tidal flat settings.

Unlike most other reports of *Skolithos*, preservation of primary cross-stratification of the host-rock is uncommon. Instead, the *Skolithos* tubes appear to cross-cut a massive quartz arenite matrix, suggesting that the development of *Skolithos* ichnofabric may be subsequent to an earlier homogenization of internal bedding by bioturbation.

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In siliciclastic lithofacies, the *Skolithos* arenite lithofacies is probably the most reliable, proximal indicator of the paleoshoreface.

Lithofacies 15: Mottled quartz arenite

Description: Yellowish-gray (5 Y 8/1) to medium-gray (N 7), fine- to coarse-grain, mostly medium-grain quartz arenite with grayish-green (5 G 5/2) to pale-yellowish-gray (10 GY 7/2) argillaceous mottles (Figures 77 and 78). Locally, the mottles possess an elliptical to circular cross-section. Grains are well- to subrounded and moderately- to poorly-sorted with pitted and frosted surfaces. Locally, thin-interbeds of poorly-sorted, biomoldic quartz arenite are present. This lithology is commonly moderately- to well-indurated by quartz overgrowths and/or crystalline calcite.

Clay-size fraction is mostly illite with some mixed-layer and smectite clay minerals, and minor amounts of authigenic potassic feldspar. The clay-size fraction is present as grain-coats and detrital grains.

Stratigraphic and geographic distribution: Limited to the Tonti Sandstone Member of the St. Peter Sandstone, the lower Dutchtown Formation of central and eastern Indiana, and an unnamed arenite member of the Wells Creek Dolomite in north-central Kentucky.

Discussion: This lithofacies appears to be a transitional lithofacies between the massive arenite lithofacies and the environmentally equivalent, mottled mudstone lithofacies. The mottled appearance is due to the preferential distribution of the clay-size fraction.

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Figure 77: Core photos of mottled quartz arenite, St. Peter Sandstone. (A) Mottled quartz arenite with dolomitic mottles (black) overlain by pyritic quartzose dolomudstone (black), 3995 ft. (1218 m), Cabot Corp., Cabot #1, Douglas Co., Illinois (ISGS C4884). (B) Mottled quartz arenite with mottles defined by green-gray argillaceous content, 1530.4 ft. (466.5 m), Gulf Oil, Osborne #1, Decatur Co., Indiana (IGS C316). Both cores are 4-inches (10 cm) in diameter.

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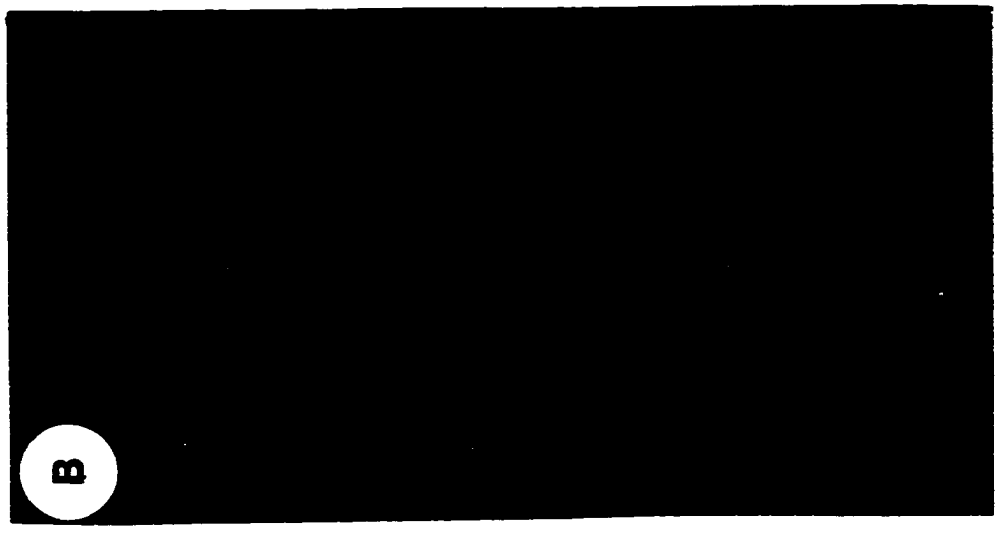

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Figure 78: Thin-section photomicrograph (plane light) of mottled quartz arenite, Tonti Member of St. Peter Sandstone, Pike County Gas Association, Conkright #2, 1013 ft. (309 m) , Pike County, Illinois (ISGS C3500). Note bimodal sorting and abundance of interstitial illite.

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The elliptical to circular cross-sections, delineated by the clay-size fraction, suggest that the mottling is controlled by textural fabrics produced by infaunal bioturbation in a subtidal lagoonal environment.

Lithofacies 16: Massive quartz arenite

Description: Yellowish-gray (5 Y 8/1) to light-gray (N 7), fine- to medium-grain, moderately- to poorly-sorted, well-rounded, moderately- to well-indurated quartz arenite with both calcite and silica cements (Figures 79 and 80). Internal sedimentary structures are absent, with the possible exception of vaguely defined, horizontal burrow traces. Calcite cement is commonly present as circular to elliptical patches within which grains are nonsutured and are either cement supported, or have point contacts. Where calcite cement is absent, euhedral quartz overgrowths are common and grain contacts tend to be sutured or planar. Disseminated pore-filling iron sulfide is common; pyrite nodules (<1 cm) are present where this lithofacies immediately underlies the Joachim Dolomite in the subsurface of central Illinois, and in outcrops in north-central Illinois where the St. Peter disconformably underlies Pennsylvanian coals (Kirchner, 1989).

Although rare, the ichnofossils *Thallasinoides* and *Arenicolites* are locally present. In addition, laterally discontinuous, relict cross-stratification is observed in some intervals.

Stratigraphic and geographic distribution: This lithofacies is limited to the St. Peter Sandstone and an unnamed arenite member of the Wells Creek Dolomite in north-central Kentucky. It is only moderately abundant in the Starved Rock Sandstone

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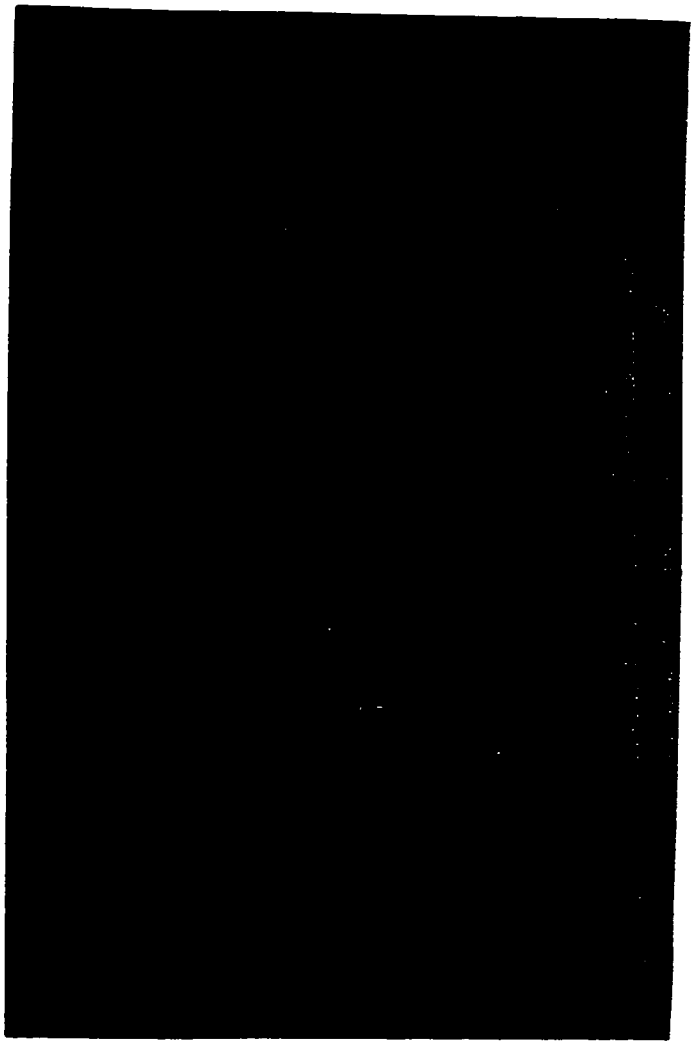

Figure 79: Core photo of 9 ft. (2.75 m) interval of massive quartz arenite, Tonti Sandstone Member, St. Peter Sandstone, 3212-3226.5 ft. (979-983.4 m), Illinois Power Co., Truitt #1, Montgomery Co., Illinois (ISGS C13443) Core is 4-inches (10 cm) in diameter and discoloration is due to differential invasion of drilling fluid.

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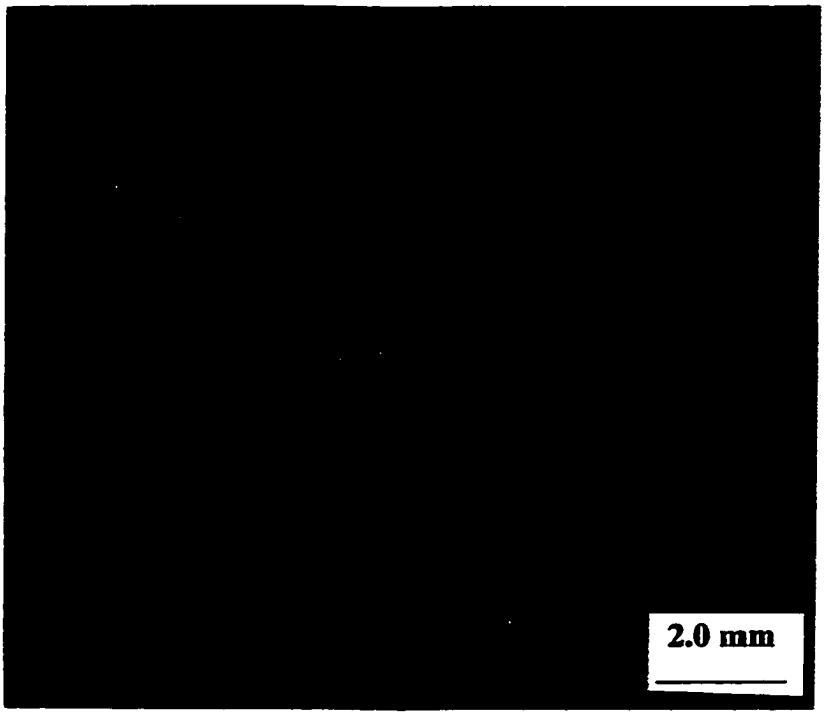

Figure 80: Thin-section photomicrograph (plane light) of massive quartz arenite, Tonti Member of St. Peter Sandstone, Illinois Power Co., Truitt #1, 3167 ft. (965 m), Montgomery Co., Illinois (ISGS C13443). Note poor-sorting, subrounded- to rounded quartz grains, and general absences of pore-filling cement.

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Member, and is locally pervasive in the Tonti Sandstone Member. Its abundance in the later increases from north to south.

Discussion: This lithofacies is interpreted as the byproduct of intense bioturbation by infaunal organisms in a shallow marine environment. The occassional preservation of burrow traces provides direct evidence for the presence of infaunal burrowers. Relict cross-stratification suggests that this lithofacies was initially deposited as medium- to massive bedding, cross-stratified sediments by storms, and then biogenically reworked prior to lithification. The low diversity conodont fauna recovered from this lithofacies by Shaw (1990) probably reflects restricted marine, lagoonal conditions.

Lithofacies 17: Argillaceous quartz arenite

Description: light-green-gray (5 G 8/1) to pale-green (10 G 6/2), fine- to medium-and coarse-grain, bimodal to poorly-sorted, well-rounded, friable to weakly-indurated quartz arenite (Figures 81 and 82). Bimodal texture has been commonly referred to as a "Glenwood" texture (Figure 83). Mostly illite-cemented with sparse calcite and silica cements; illite post-dates quartz over-growths, but predate pore-filling calcite. Internal sedimentary structures are absent, with the possible exception of vaguely defined, horizontal burrow traces. Calcite cement is commonly present as circular to elliptical areas, or laterally persistent bands. Grain contacts tend to be point or sutured; over-sized pore throats are locally present. Disseminated pore-filling iron sulfide is common; irregular sulfide-cemented aggregates (1-4 mm) are locally present.

Lithofacies tends to have high porosity but comparatively low permeability and is generally recognizable on geophysical logs due to high gamma-ray log activity,

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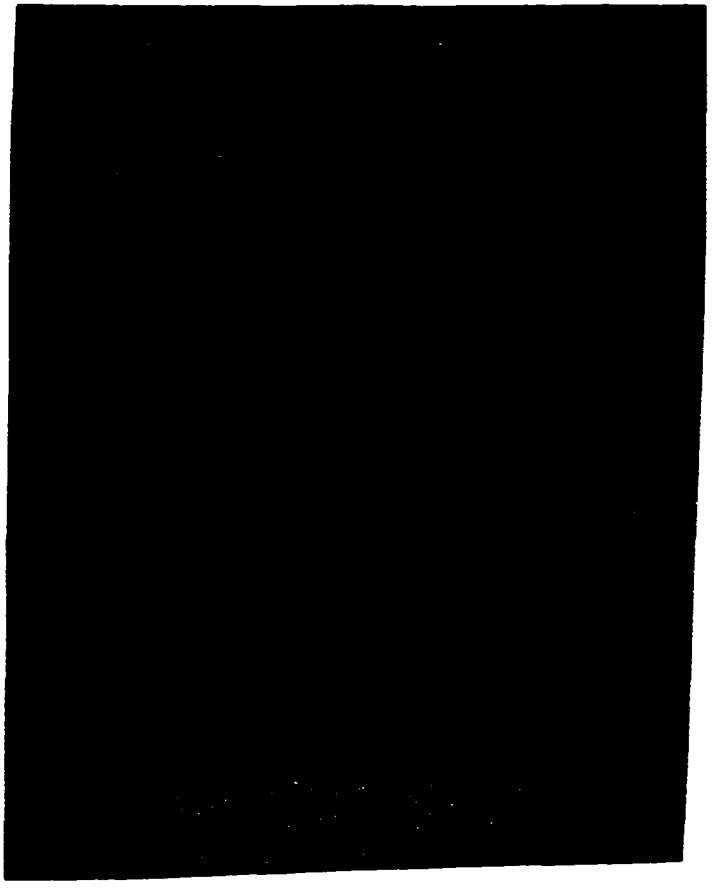

Figure 81: Core photo of argillaceous quartz arenite, Tonti Sandstone Member, St. Peter Sandstone, PBBK, Yakley A-1, 660 ft. (201.2 m), (uncataloged ISGS core, 4-inch diameter). Note characteristic green-gray color and medium- to coarse-grain size.

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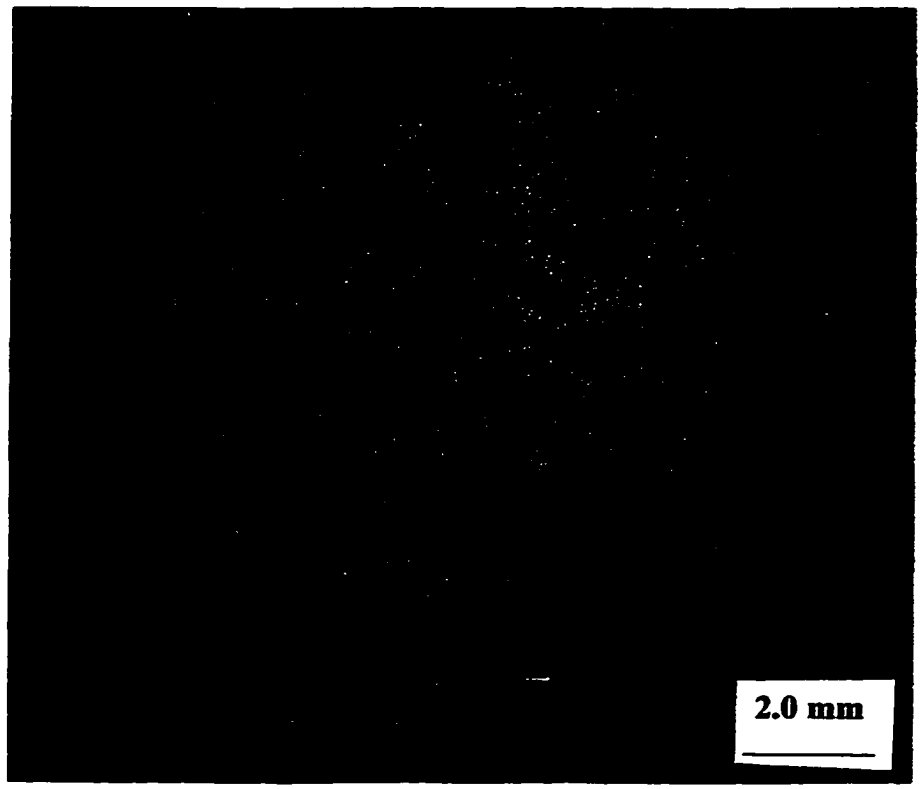

Figure 82: Thin-section photomicrograph (plane light) of argillaceous quartz arenite, Starved Rock Sandstone Member, St. Peter Sandstone, Prairie State Quarry boring 76-4, 73 ft. (22.2 m), La Salle Co., Illinois (ISGS core C12518). Green-brown material is detrital and authigenic illite. Note typical bimodal sorting of very fine- and coarse- to medium-grain quartz. Coarse-grain fraction is sub- to well-rounded; apparent angularity of finer fraction due to preferential development of quartz overgrowths. Core is 2.5-inches (6 cm) in diameter.

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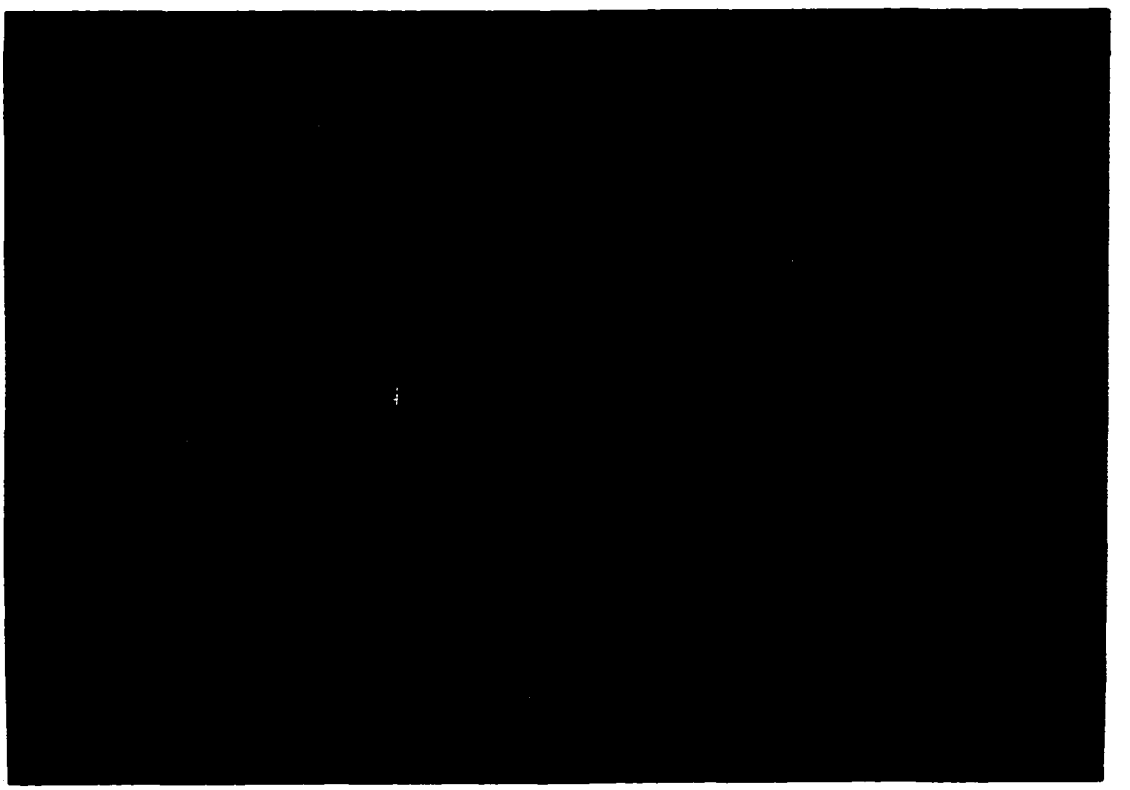

Figure 83: Bimodal sorting ("Glenwood texture") in argillaceous quartz arenite, Glenwood Formation, 343 ft. (104.5 m), Commonwealth Edison UPH-3, Stephenson Co., Illinois (ISGS C12996). Note "small" diameter *Skolithos* burrow. Biomodal texture is probably the result of prelithification, biogenic reworking of coarse-grain storm deposits and fine-grain lagoonal sands. Core is 2.5-inches (6 cm) in diameter.

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caliper log indications of wash-outs, and where neutron log-measured porosity is greater then density-measured porosity.

Stratigraphic and geographic distribution: Most common in Tonti Sandstone Member of St. Peter Sandstone and Glenwood Formation in Indiana and Illinois; locally present in Joachim Dolomite, southern Indiana, central and southern Illinois, and southeast Missouri.

Discussion: Shallow subtidal, most likely lagoonal, environment where biogenic activity extensively reworks sediments. Well-developed bimodal sorting resulted from reworking of coarse-grain, storm-deposits. Although some clay's are clearly detrital, most pore-filling and grain-coating illite is diagenetic.

Lithofacies 18: Nodule-bearing quartz arenite

Description: Light-gray (N 7) to medium-light-gray (N 6), fine- to medium-grain, rounded to subrounded, moderately to well-sorted, grain-supported quartz arenite with nodules of very-light-gray (N 8), carbonate cemented, matrix/cement supported, fine- to medium-grain, rounded to subrounded, moderately- to well-sorted quartz arenite (Figures 84 and 85). Non-nodular arenite matix is moderately-indurated to friable, with calcite and dolomite intergranular cements and sparse quartz overgrowths. Cross-stratification may be present locally.

The nodules are generally greater than 0.5 cm in diameter, and may exceed 10 cm in one dimension. They occur as isolated masses and packed "chicken-wire" fabrics. Within the nodules, grains are cement/matrix supported and lack quartz overgrowths. Cement/matrix is microcrystalline, euhedral dolomite, and less commonly calcite.

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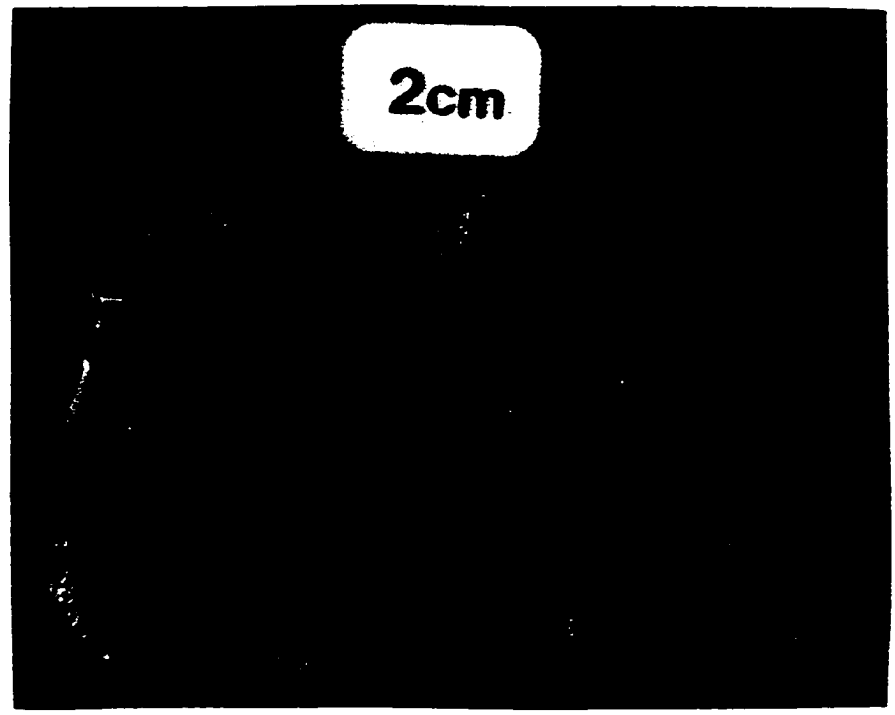

Figure 84: Core photo of well-indurated, dolomite-cemented quartz arenite nodules in weakly-indurated quartz arenite, St. Peter Sandstone, 1168 ft. (356 m) Northern Illinois Gas Co., Feinhold #1, Livingston Co., Illinois (ISGS C4636, 4-inch core impregnated with epoxy).

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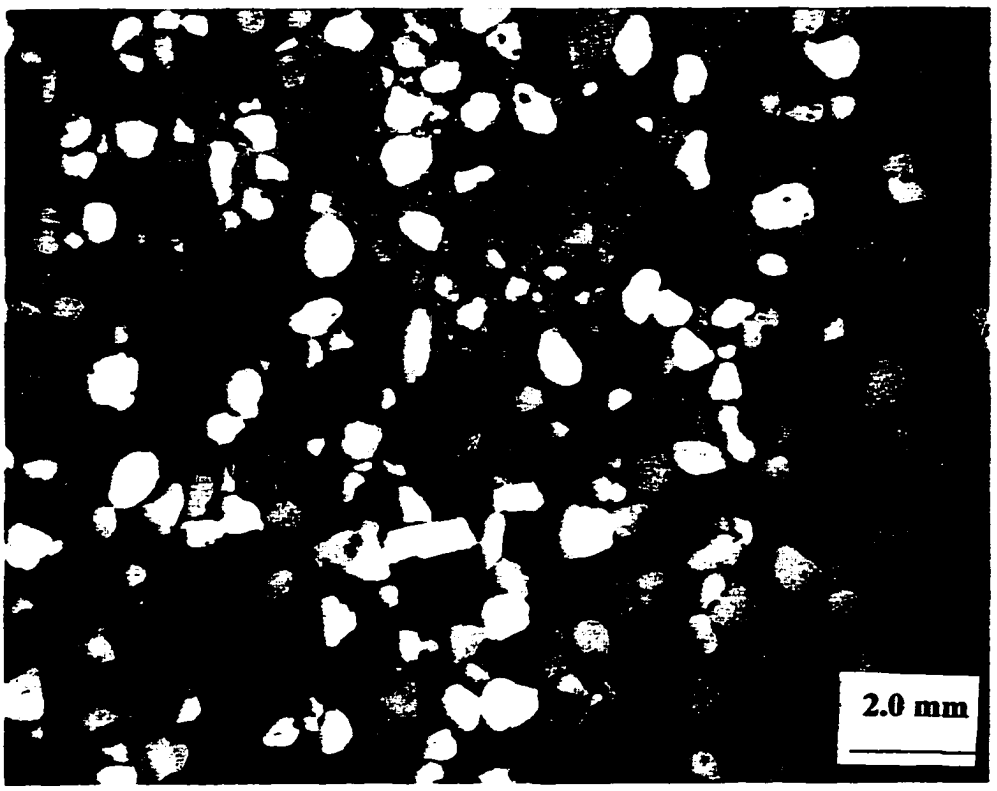

Figure 85: Thin-section photomicrograph (cross-polars) of nodule and matrix, upper Tonti Sandstone Member, St. Peter Sandstone, 1168 ft. (356 m), Northern Illinois Gas Co., Feinhold #1, Livingston Co., Illinois (ISGS C4636). Nodule (upper right quadrant) is made up of well-indurated, dolomite-cemented quartz grains that are locally cement-supported. Matrix is weakly-indurated quartz overgrowth-cemented, grain-supported quartz arenite.

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Locally, nodules appear zoned with a central darker core surrounded by concentric bands that are slightly, and progressively lighter in color. Locally, the nodule margins are bounded by iron sulfide.

Stratigraphic and geographic distribution: This lithofacies is only known from the Tonti Sandstone Member of the St. Peter Sandstone in the subsurface of north-central Illinois. Although its distribution is poorly constrained, its southern limit appears to be northern Champaign County, and it may be present as far north as La Salle County. the nodule-bearing arenite lithofacies occurs consistently within the lower few meters of the upper Tonti Sandstone Member.

Discussion: The geometry of the nodular fabrics suggests the primary composition of the nodules was either anhydrite or gypsum, that was subsequently replaced by carbonate prior to the compaction of the bounding arenite. The disruption of primary sedimentary fabrics (i.e., cross-stratification) implies that the nodules grew displacively. Nodular gypsum/anhydrite are indicative of the development of supratidal soil profiles in a sabkha environment. It is unknown if the paleo-groundwater was marine, nonmarine, or of mixed origin.

Kirchner (1989) reported iron-sulfide nodules with similar morphology from the Tonti Member, St. Peter Sandstone, from outcrops in north-central Illinois and suggested that the sulfide is replacive after carbonate cements. Based on the stratigraphic position of the nodules in the upper Tonti Sandstone Member, it is probably that the pyrite has replaced precursor carbonate nodules observed in the subsurface.

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Because of the apparent association of the nodules with unconformably overlying Pennsylvanian coals, Kirchner (1989) suggested that infiltration of reducing groundwaters from the Pennsylvanian swamp environments, or produced from coalification of the organic matter, provided the appropriate geochemical conditions for pyrite replacement of carbonate. By analogy, Shaw and Schreiber (1988) proposed a similar mechanism for the origin of pyrite nodules in the uppermost St. Peter Sandstone immediately underlying an interval of the lower Joachim Dolomite containing the carbonaceous mudrock lithofacies.

Lithofacies 19: Feldspathic quartz arenite

Description: Moderate-reddish-brown (10 R 4/6) to grayish- pink (5 R 8/2), fine- to coarse-grain, medium- to thick- bedded quartz arenite with 3-15% detrital feldspar grains (Figure 86). Grayish-pink to clear quartz grains are well- to subrounded, moderately to well-sorted, and fine- to coarse-grain. Frosted grain surfaces are generally absent, but ferroan grain coats are common. Detrital feldspar grains are moderate-reddish-brown, fine- to medium-grain, subrounded to subangular, and moderately well-sorted. Angular mudrock pebbles are locally present in some beds. Over-size pores are common. Planar and trough cross-stratification is present locally. Although individual beds fine-upward, the overall succession containing this lithofacies tends to coarsen- upward. It is generally associated with the red mudrock lithofacies.

In silica quarries in northern Illinois, operators (personal communication) report that feldspar content of sand-size fractions locally varies from 2-8%, and may be as great as 12%, by volume in the lowermost Tonti Sandstone Member. As observed by

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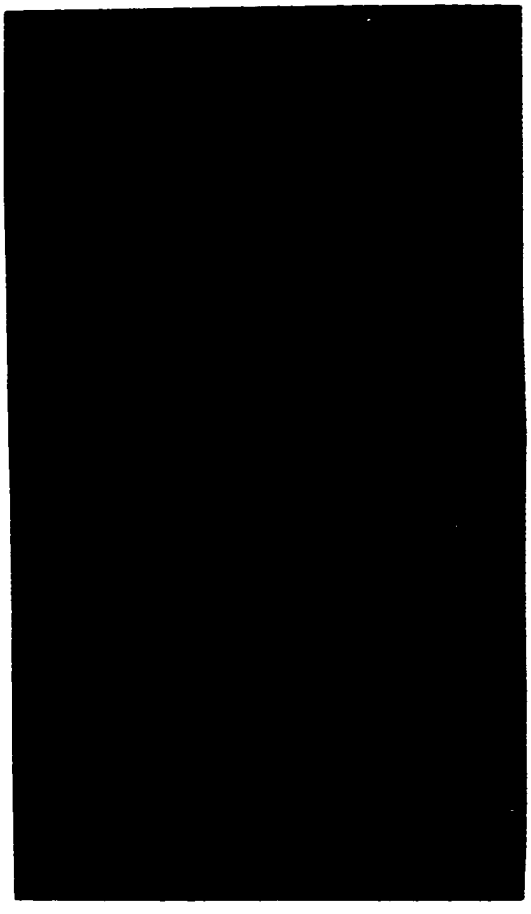

Figure 86: Core photo of interbedded quartz arenite (white to light-gray), ferroan-stained quartz arenite (light to moderate orange-brown), and feldspathic quartz arenite (light red-brown), lower Tonti Sandstone Member, St. Peter Sandstone, 308-318 ft. (93.9-96.9 m), quarry boring, La Salle Co., Illinois. Ferroan staining results from weathering dissolution of feldspar grains. Core is 2.5-inches (6 cm) in diameter.

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Nunn (1986), detrital feldspar content in the upper Tonti and Starved Rock members rarely exceeds 1% by volume. Typically, iron content in these intervals varies from 1-4%. This is in contrast to the 0.3-1.0% iron content for samples from St. Peter reported by Dapples (1921), Lamar (1927), and Thiel (1935). An unpublished study by the Illinois State Geological Survey suggests that the locally elevated iron content is a weathering product of detrital and/or authigenic feldspar.

Thiel (1935) observed that iron content also increases where the St. Peter is overlain by glacial till and that iron may be introduced into the St. Peter by the weathering of glacial tills and groundwater infiltration. Alternatively, stripping of the overburden by glaciation may have accelerated the rate of *in situ* meteoric weathering of feldspathic components.

Stratigraphic and geographic distribution: Feldspathic quartz arenite is only known from northern Illinois where it occurs in the Kress and basal Tonti Sandstone members of the St. Peter Sandstone associated with paleotopographic lows on the post-Knox erosional surface.

Discussion: The detrital feldspathic content of this lithofacies contrasts sharply with the other lithofacies present in the St. Peter Sandstone. However, over-size and grain-shaped pores are observed in the other arenite lithofacies in the subsurface and are interpreted as dissolution of carbonate and potassic feldspar framework grains (Hoholick and others, 1984; Stackelberg, 1987). In addition, in the Michigan Basin, which is more proximal to Middle Ordovician detritial source areas, the St. Peter may contain up to 40% detrital feldspar (Barnes and others, 1992). As a consequence, the restricted areal extent of this lithofacies is probably a function of favorable conditions

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for preservation of detrital feldspar: proximity to paleosource area, shallow burial, isolated stratigraphic position and/or high initial abundance.

Because of the association of this lithofacies with the red mudrock lithofacies, and its restricted distribution controlled by the paleotopographic surface, it is interpreted as having been deposited either within an estuarine and/or laterally associated fluvial environment.

Lithofacies 20: Calcilithic quartz arenite

Description: This rock type is highly variable and is present only at erosive, or nondepositional bedding contacts. The upper bedding-plane of the underlying lithology is commonly bored or burrowed; the borings or burrows are commonly infilled with components of the calcilithic arenite (Figure 87). The upper contact is sharp to gradational and overlain by argillaceous dolomudstone. It is generally thin-bedded (1-4 cm) and composed of rock fragments, typically carbonate and chert, and quartz grains that are either grain or matrix supported (Figure 87).

Grain-size decreases, rounding increases and the abundance of polycrystalline quartz, interpreted as reworked chert, decreases upsection. Rock fragments and intraclasts are fine-grain to pebble-size, angular to subangular, poorly-sorted and are similar in composition to the immediately underlying lithofacies. Some clasts have extensive, infilled microbial borings. Grain contacts may be sutured or point; locally, grains may be cement or matrix supported.

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Figure 87: Core photos of calcillithic quartz arenite. (A) basal Everton Dolomite, 3368 ft. (1026 m), Illinois Power Co., House #1, Montgomery Co., Illinois. Intraclasts, derived from underlying Shakopee Dolomite, include subangular, coarser-grain intraclasts of white, microcrystalline chert, and fine- to medium-grain, argillaceous dolomudstone. (B) Calcithic quartz arenite overlying microcrystalline dolomudstone, Joachim Dolomite, 3132 ft. (955 m), Illinois Power Co., Truitt #1, Montgomery Co., Illinois (ISGS C13443, 4-inch core). Note upward decrease in abundance of dolomudstone intraclasts and quartz arenite-filled burrw in underlying dolomudstone. (C) Black, phosphate-coated grains in argillaceous quartz arenite, lower Glenwood Formation, 343.4 ft. (105 m), Commonwealth Edison, UPH-3, Stephenson Co., Illinois (C12996, 2.5-inch diameter core).

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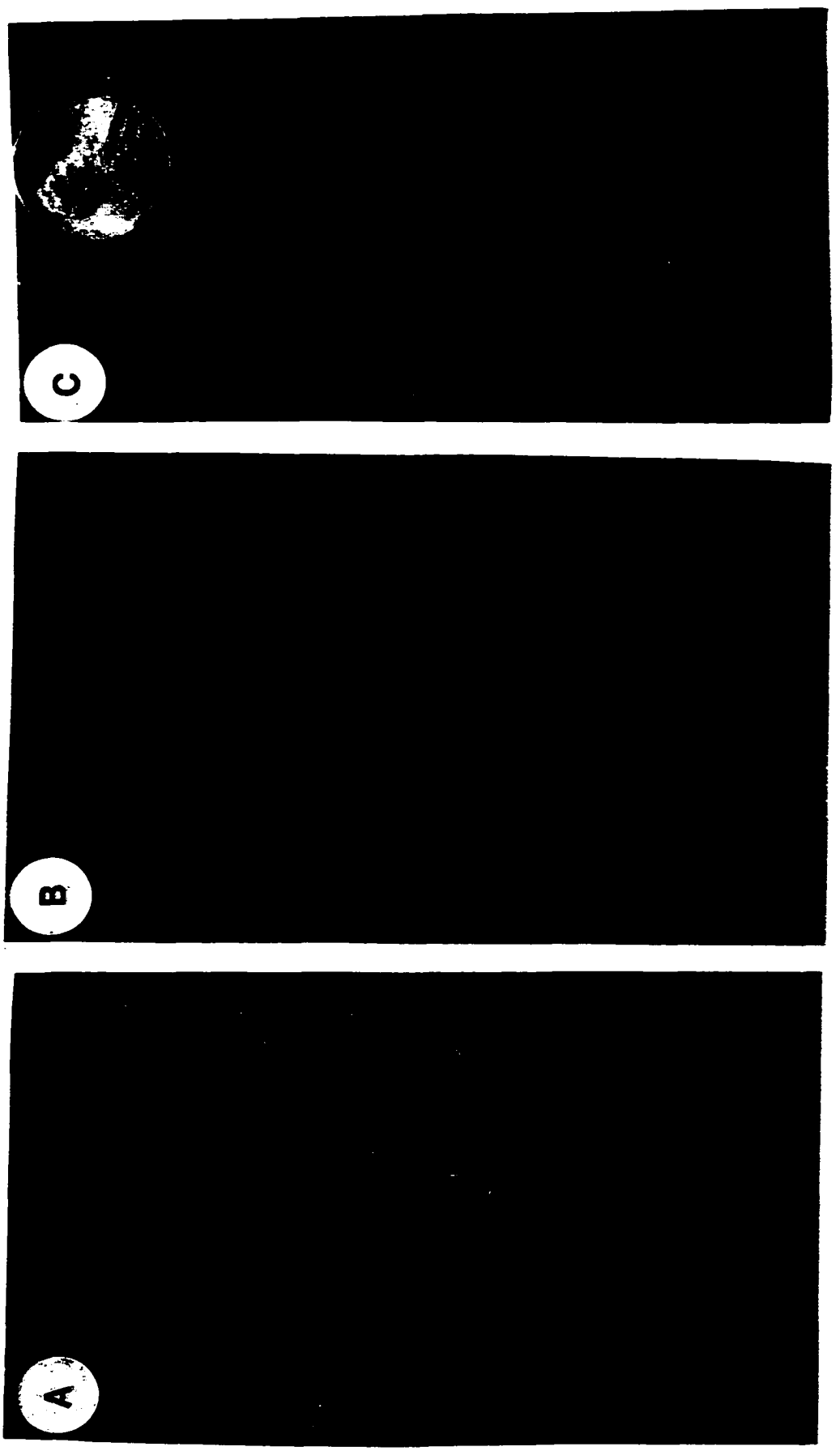

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Figure 88: Photomicrograph (cross-polars) of calcilithic quartz arenite, Joachim Dolomite, 1533.5 ft. (467.4 m), Lacleade Gas Storage Co., Hammer Lease #1, St. Louis Co., Missouri (ISGS C6108).

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The matrix is made up of anhedral, mud-size (<0.0625 mm) dolomite and/or calcite with some clay minerals. Locally, detrital pyrite laminae are present. Clay-size authigenic potassic feldspar is present in some samples from the Wells Creek Dolomite, western Ohio.

Stratigraphic and geographic distribution: This lithofacies occurs basin-wide throughout the lower-Middle Ordovician succession.

Discussion: This lithofacies represents a transgressive lag deposited on a surface of nondeposition or erosion. Detrital material from the underlying lithofacies is reworked. Burrows/borings infilled by detrital sediments, and bored intraclasts are typical of lower intertidal and shallow-subtidal hard grounds.

Carbonates

Carbonate depositional environments dominated much of the early-Middle Ordovician succession in the Illinois Basin, where most carbonate sediments were deposited as lime-muds or sands, in environments ranging from tidal flats to shallow, inner shelf. As noted by Freidman (1964), and recently reviewed by Reid and others (1990), the fine-grain character to the early-Middle Ordovician carbonate lithofacies do not require that they were deposited in low-energy environments. Sedimentary structures, paleontological data and depositional relationships suggest the carbonate lithofacies were deposited in a moderate- to high-energy, storm-dominated embayment. The absence of coarser-grain clasts is attributable to intense biogenic reworking and grain-size reduction, and the absence of macrofauna, a source of coarse-grain to cobble-size biogenic clasts, due to harsh environmental conditions.

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Dolostone is the dominant carbonate rock-type on the flanks of the embayment, with calcite-rich lithologies increasing in abundance toward the depocenter, or toward the marine paleomargin. Geochemical data and depositional relationships suggest that exposure of peritidal sediments during periods of falling relative sea level resulted in penecontemporaneous, and early diagenetic dolomitization of the carbonate sediments.

In addition, the development of restricted marine conditions at various times was favorable for the deposition of evaporative calcium-sulfates and locally, halite. Although anhydrite-bearing carbonates are only present in the subsurface of the central Illinois Basin; the widespread presence of gypsum and halite pseudomorphs in outcrop and in cores on the margin of the basin attest to the widespread distribution of evaporites in the past. The implications of these features will be discussed in greater detail later in this report.

Fifteen carbonate lithofacies are recognized in the Ancell Group and its regional equivalents: (1) quartzose dolomudstone, (2) microcrystalline dolomudstone, (3) laminated dolomudstone, (4) cryptolaminated dolomudstone, (5) mottled dolowackestone, (6) intraclastic dolograinstone, (7) intraformational breccia, (8) laminated mudstone, (9) patterned mudstone, (10) fenestral mudstone, (11) argillaceous mudstone, (12) peloidal mudstone, (13) mottled wacke/mudstone, (14) stylolitic wacke/mudstone, (15) bioclastic wackestone, (16) intraclastic pack/grainstone, and (17) stromatolitic boundstone.

Lithofacies 21: Quartzose dolowacke/packstone

Description: Pale-green (5 G 7/2) to grayish-green (10 GY 5/2) dolomudstone with quartz arenite laminae (Figures 89 and 90). Dolomite (80-95%), clay minerals (2-5%),

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quartz (1-20%) and iron sulfide (<1%) are the primary constituents; sparse calcilithic intracalsts may be present. Dolomite is anhedral to subhedral, and finely- to cryptocrystalline. Clay minerals, mostly illite, are disseminated throughout. Fine- to medium-grain, well-sorted, well-rounded quartz is present as laminae, 1-5 grain-diameters in thickness, and mud-supported grains. Laminae tend to be grain-supported, with point- and planar grain-contacts, and contain sparse to abundant intergranular voids are infilled microcrystalline dolomite or calcite. Iron sulfide, mostly pyrite, is disseminated throughout, or may occur as aggregate masses. The contact with underlying lithologies is sharp to gradational, and the upper contact is commonly gradational.

Stratigraphic and geographic distribution: This lithofacies is present in the Wells Creek Dolomite of western Ohio, central Kentucky, and western Tennessee; the Dutchtown Formation and lower Joachim Dolomite in southwest Indiana, southern Illinois and southeastern Missouri.

Discussion: This facies is most likely to have been deposited under upper-intertidal to shallow-subtidal conditions where eolian processes, or storm currents transported quartz sand from the adjacent eolian environments on to the tidal flat. Subsequent bioturbation admixed the quartz sand grains and lime mud prior to dolomitization.

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Figure 89: Photographs of quartzose dolopackstone with quartzone laminae and rare calcilithic intraclasts. (A) Hand sample from Dutchtown Formation, West Perryville section, southeast Missouri. (B) Core (2.5-inch), lower Joachim Dolomite, Pevely Quarry, Jefferson Co., Missouri.

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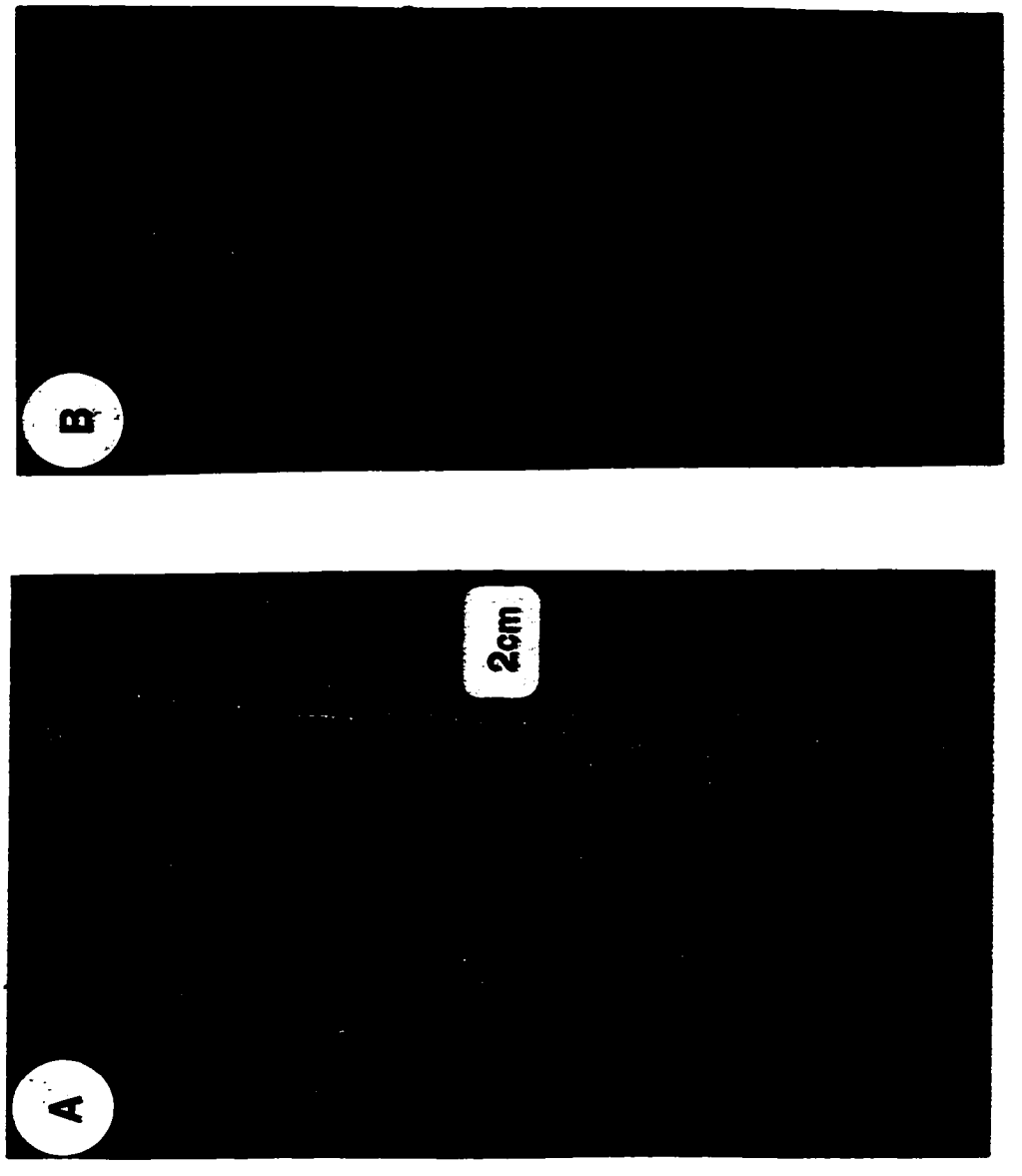

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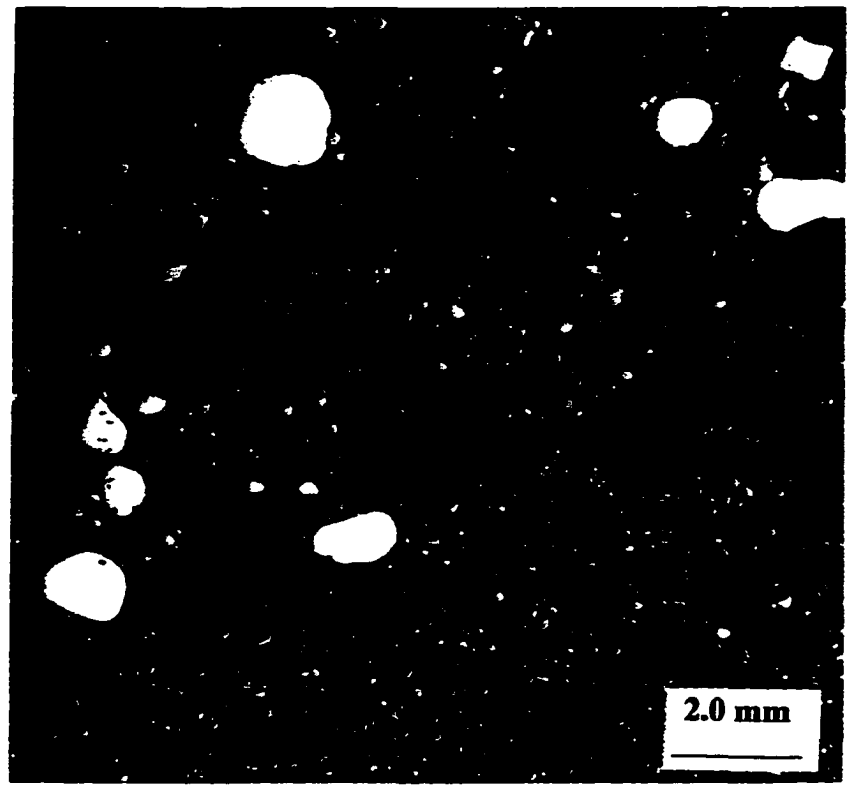

Figure 90: Photomicrograph (plane light) of quartzose intraclastic dolopackstone, Wells Creek Dolomite, 1941.5 ft. (592 m), Dupont, Inc. Geohydrological Survey #1, Humphreys Co., Tennessee. White, subrounded quartz grains and dark, subrounded to well-rounded dolostone intraclasts in very finely-crystalline dolomite matrix. Sparse to abundant, ghosts of grains are common (light-brown-gray); however, grain boundaries have been disrupted, or obliterated by dolomitization of matrix. Where ghost grains are abundant, fabric is grain-supported.

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Lithofacies 22: Microcrystalline dolomudstone

Description: In the subsurface of southern Illinois, this lithofacies is brownish-gray (5 YR 4/1) to dark-gray (N 3) crystalline dolomudstone with up to 50% medium-bluish-gray (5 B 5/1) anhydrite (Figures 91 and 92). Anhydrite is present as distinct pseudomorphs after gypsum and as pervasive, amorphous patches. The abundance of anhydrite dramatically decreases toward the basin margins. As anhydrite content decreases, the character of the lithofacies progressively shifts to a lighter colored, pale-yellowish-brown (10 YR 6/2) to grayish-yellow (5 Y 8/4), chalky-textured, dolomudstone with abundant quartz silt. In most samples, dolomitization has masked the primary sedimentological features and rock it appears, macro- and microscopically, to be featureless. Locally, millimeter scale, lath- and hopper-shaped pseudomorphs may be abundant and infilled with sparry calcite.

So called "clotted fabrics" (Bathurst, 1975, p. 68) are present and may be moderately-abundant in the vertical stratigraphic succession. Clotted fabrics are amorphous, spherical to elliptical textures interpreted to be produced by microbial activity in sabkha paleosols. In outcrop, cobble-size, nodular-voids and chert nodules are present. Where the latter are present, differential compaction around the nodules implies a syndepositional or early diagenetic origin.

Hydrocarbon occurrences are common in this lithofacies. Oil staining of core and cuttings, and gas shows on mud logs have been widely reported in central and southern Illinois, but low permeability has precluded successful testing. Insoluble residues, from conodont processing, commonly contain pink and clear varieties of fluorite, barite and pyrite.

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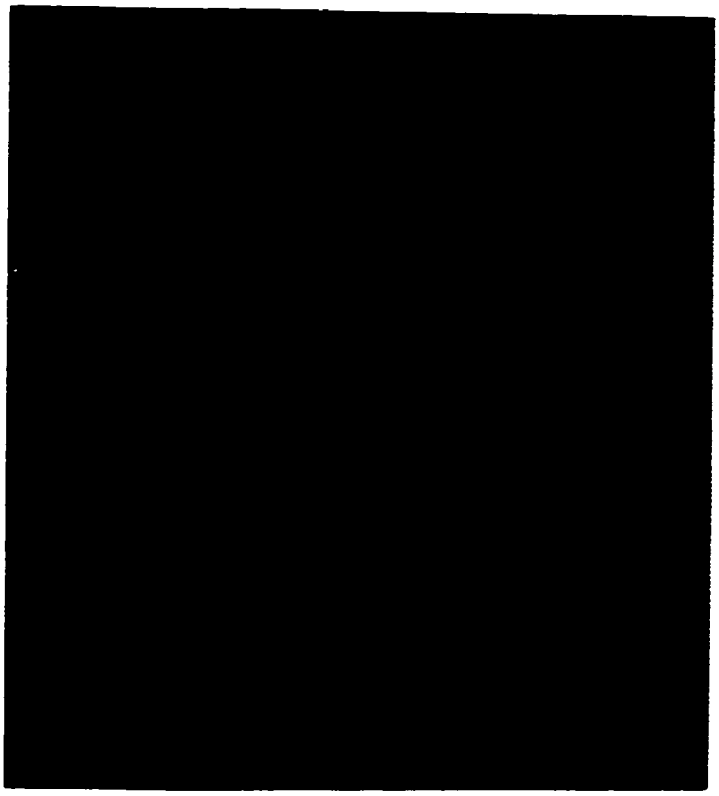

Figure 91: Outcrop photograph of microcrystalline dolomudstone overlying argillaceous dolomudstone (contact at pen), Joachim Dolomite, Weber Hill section, southeast Missouri. Microcrystalline dolomudstone has very high microporosity due to abundance of pseudorhombic voids, probably after halite and/or calcium-sulfate.

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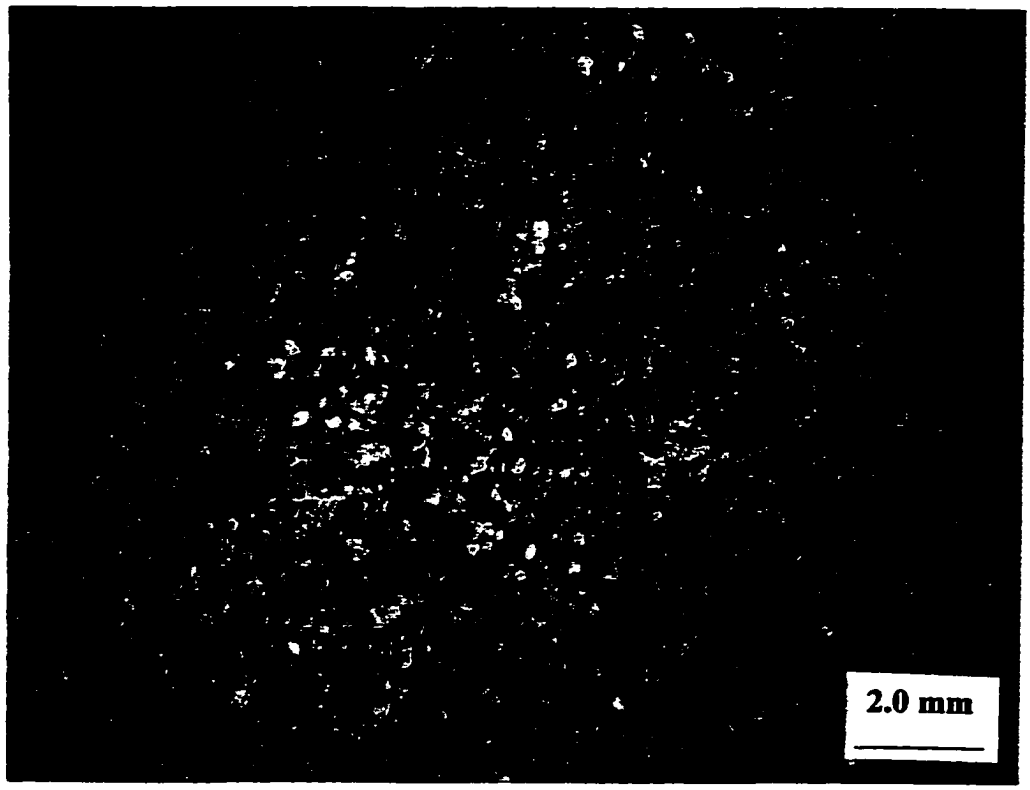

Figure 92: Photomicrograph (cross-polars) of microcrystalline dolomudstone, Wells Creek Dolomite, 1966.5 ft. (600 m), Dupont, Inc., Geohydrological Survey #1, Humphreys County, western Tennessee. Note the fitted fabric of very fine- to finely-crystalline, anhedral dolomite and sparse to abundant, intercrystalline microporosity (blue epoxy). Primary depositional fabric is obliterated.

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Where sulfates are absent, this lithofacies is readily recognized on geophysical logs due to its high intercrystalline porosity, low permeability and low bulk density. In the central Illinois Basin, where anhydrite is present, this lithofacies has negligible porosity, low permeability and high bulk density. Independent of sulfate content, high gamma-ray readings are common due to the presence of radionuclides associated with authigenic minerals and organic matter.

Stratigraphic and geographic distribution: This lithofacies is abundant in the uppermost Dutchtown Formation, the Boles and Defiance Members of the Joachim Dolomite in southeast Missouri, Illinois and Indiana, the Wells Creek Dolomite and lower argillaceous unit of the Black River Limestone in western Ohio, and the Wells Creek in central Kentucky. When present in a stratigraphic interval, anhydrite content increases in abundance up-section and laterally toward the basin depocenter.

Discussion: In the absence of primary sedimentary features, the initial depositional environment is inferred to be intertidal to supratidal based on associations with overlying and underlying lithologies. The abundance of evaporite pseudomorphs, locally developed nodular character of voids and chert, and the abundance of anhydrite in the subsurface suggests that these sediment underwent early diagenesis in a sabkha or salina setting.

Lithofacies 23: Laminated dolomudstone

Description: Differs from the microcrystalline dolomudstone lithofacies primarily in the presence of laterally continuous, dark-yellowish-brown (10 YR 4/2) to brownish-black (5 YR 2/1), carbonaceous laminae, and local abundance of disseminated clay minerals that impart a greenish-gray (5 G 6/1) color to the rock (Figures 93, 94 and 95).

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Thickness of the laminae range from 1-3 mm and vary from planar to highly-"crinkled" morphologies. Bedding varies from laminated to thin-bedded within any one-foot vertical section.

Microcrystalline matrix tends to be darker in well-laminated intervals. Mudcracks are commonly associated with this lithofacies.

Where organic laminae are abundant, the character of this lithofacies becomes transitional with the carbonaceous mudrock lithofacies. However, in contrast to the mudrock lithofacies, total organic content and hydrogen index is low, and the oxygen index is high.

Stratigraphic and geographic distribution: Abundant in the Boles and Defiance Members of the Joachim Dolomite in southeast Missouri, Illinois and Indiana; increasing in abundance up-section and laterally toward the basin margins. It is also common in the Dutchtown Formation of Indiana, and is present in the Wells Creek Dolomite and lower argillaceous unit of the Black River Limestone in western Ohio, and the Wells Creek in central Kentucky.

Discussion: This lithofacies is interpreted as intertidal to shallow subtidal where algal mats may have bound the sediment and sporadic desiccation, or specialized types of microbial populations, controlled mat morphology. Organic matter is generally degraded, probably due to oxidation during dolomitization, but where preserved the organic matter has an elevated hydrogen index and moderately high TOC values (1-3.5%).

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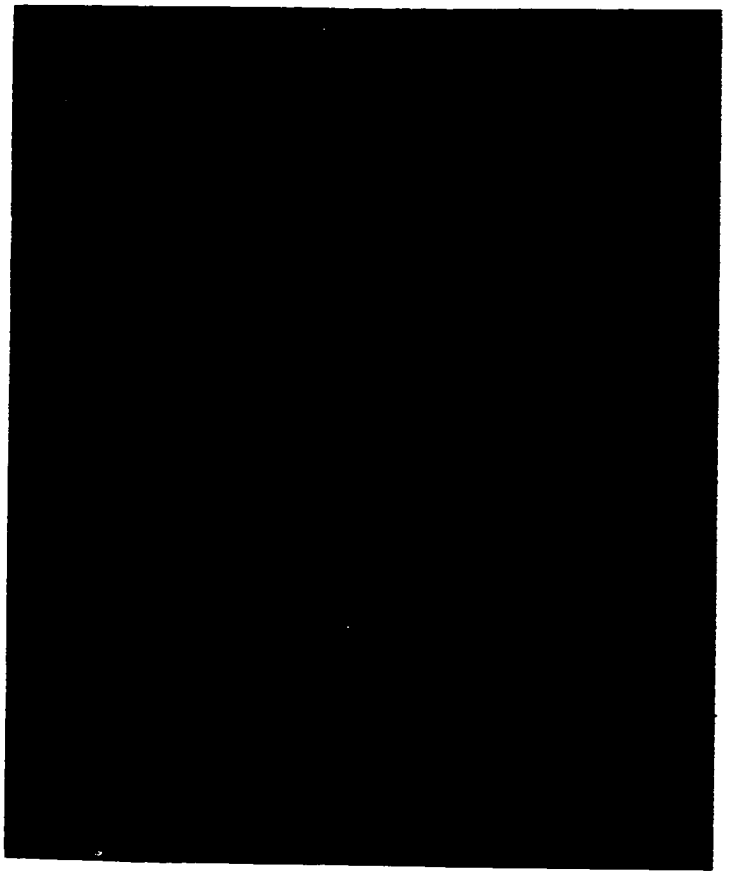

Figure 93: Outcrop photo of laminated dolomudstone overlying microcrystalline dolomudstone, Joachim Dolomite, Zell West section, southeast Missouri.

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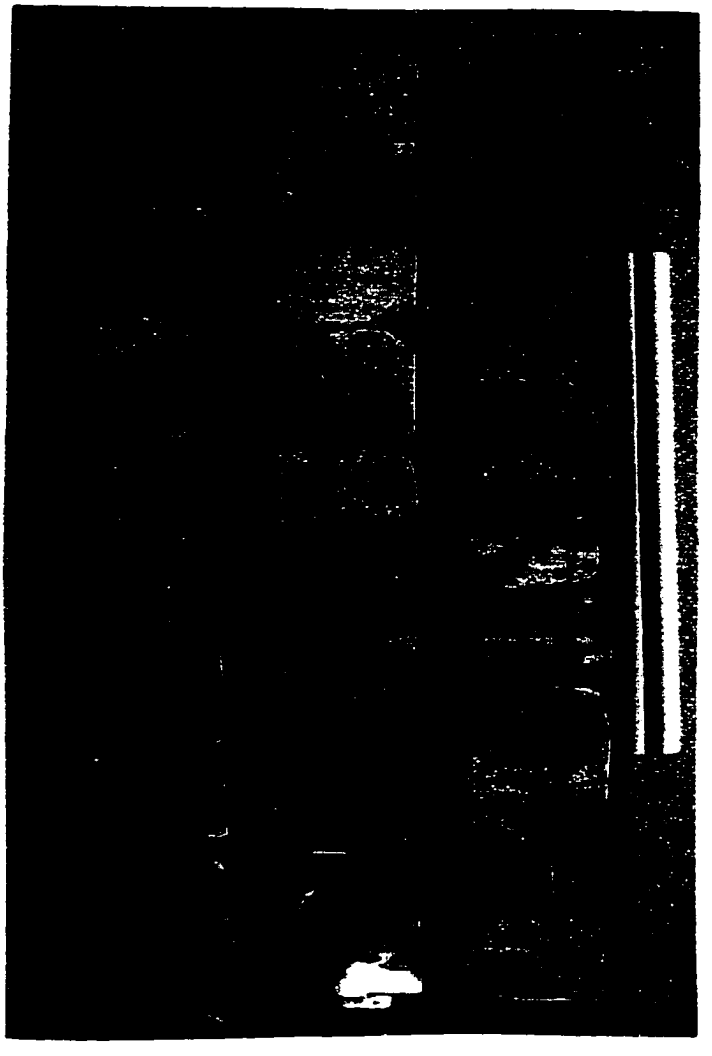

Figure 94: Core photograph of interbedded laminated dolomudstone and microcrystalline dolomudstone, Joachim Dolomite, 3086-3093 ft. (940.5-942.5 m), Illinois Power Co., Truitt #1, Montgomery Co., Illinois (ISGS C13443). Hydrocarbon staining (brown) is observable at 3087 ft. (940.9 m). Core is 4-inches (6 cm) in diameter.

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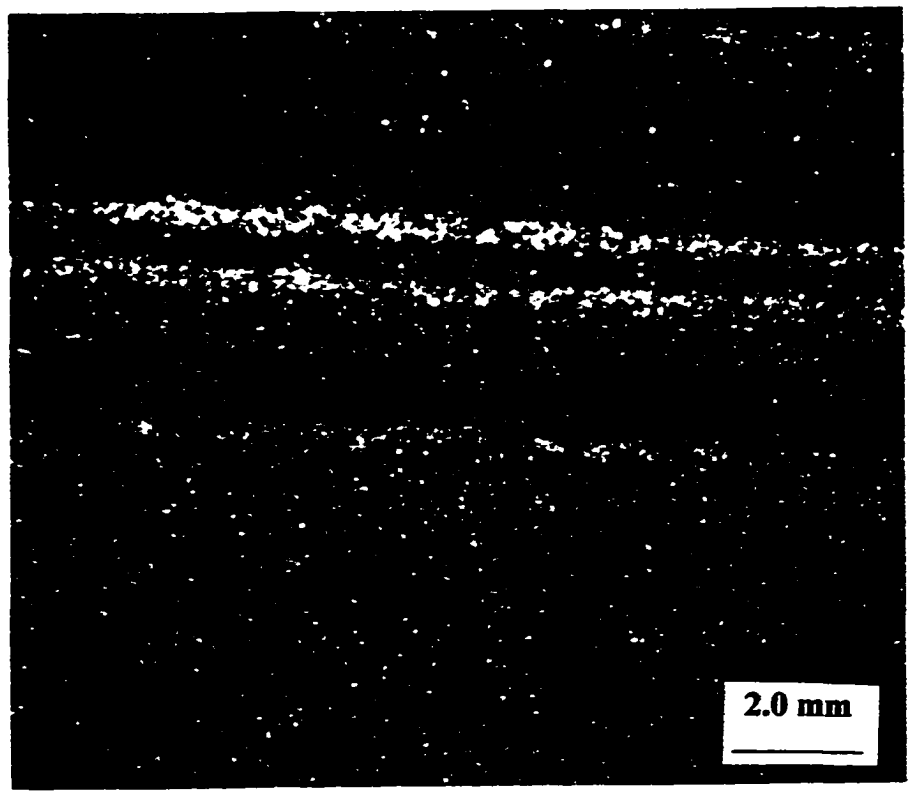

Figure 95: Photomicrograph (cross-polars) of laminated dolomudstone, Joachim Dolomite, Buttercup Energy, R. Pensinger, 3192.5 ft. (973 m), Clay Co., Indiana (IGS C640). Laminae are defined by continuous quartz silt (white) and carbonaceous mudrock partings (dark brown)

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Lithofacies 24: Cryptolaminated dolomudstone

Description: Pale-yellowish-brown (10 YR 6/2) to pale-green (10 G 6/2), thin-bedded microcrystalline dolomudstone characterized by centimeter-scale graded laminae (Figures 96 and 97). The basal contacts of laminae are sharp and overlain by quartz silt that grades upsection into micrite. Disseminated iron sulfide, mostly pyrite, is present locally.

Stratigraphic and geographic distribution: This lithology is locally developed in the Wells Creek Dolomite, and the Boles and Defiance Members of the Joachim Dolomite.

Discussion: This lithofacies was probably deposited offshore, under shallow subtidal conditions where both storm-transported micrite and quartz silt were deposited, and the graded-laminae preserved in the absence of biogenic activity.

Nearly identical fabrics were reported by Rine and Ginsburg (1985; figs. 10a and 10d) from siliciclastic muds deposited as shoreface mudbanks adjacent to the Suriname peritidal coastal plain. The graded laminae in these muds are interpreted as starved ripples formed during storm events.

Lithofacies 25: Mottled dolowackestone

Description: Brownish-gray (5 YR 4/1) lime-micrite (20- 30%) and light-brownish-gray (5 YR 6/1), anhedral to subhedral, microcrystalline dolomite (50-80%), and euhedral, finely- to coarsely-crystalline dolomite (10-20%) with mud-supported, fine- to medium-grain, well-rounded to subrounded, monocrystalline quartz grains (Figures 98 and 99). Crystalline dolomite is present as light-colored mottles, 1-2 cm in diameter, that have sharp, stylolitic or graded boundaries with lime micrite, or microcrystalline dolomite. High intercrystalline porosity is developed within the dolomitic mottles and

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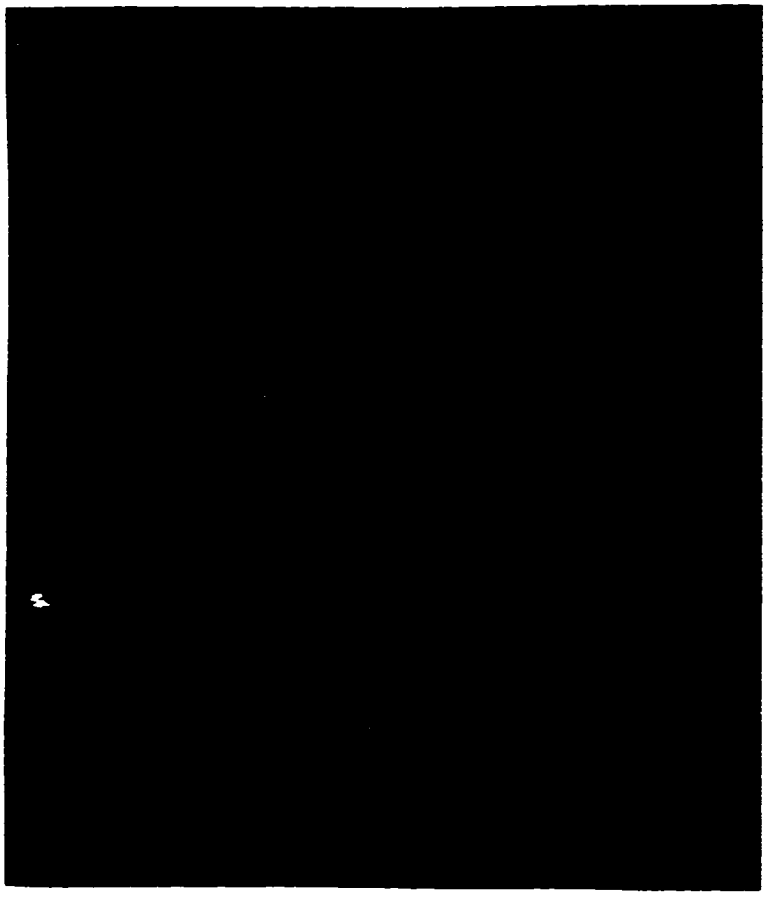

Figure 96: Core photographs of cryptolaminated dolomudstone, Joachim Dolomite, 3023.33 ft. (921.5 m), Illinois Power Co., Truitt #1, Montgomery Co., Illinois (ISGS C13443). In thin-section, laminae appear as small-scale graded intervals and pelletal features have no expression. Core diameter is 4-inches (10 cm).

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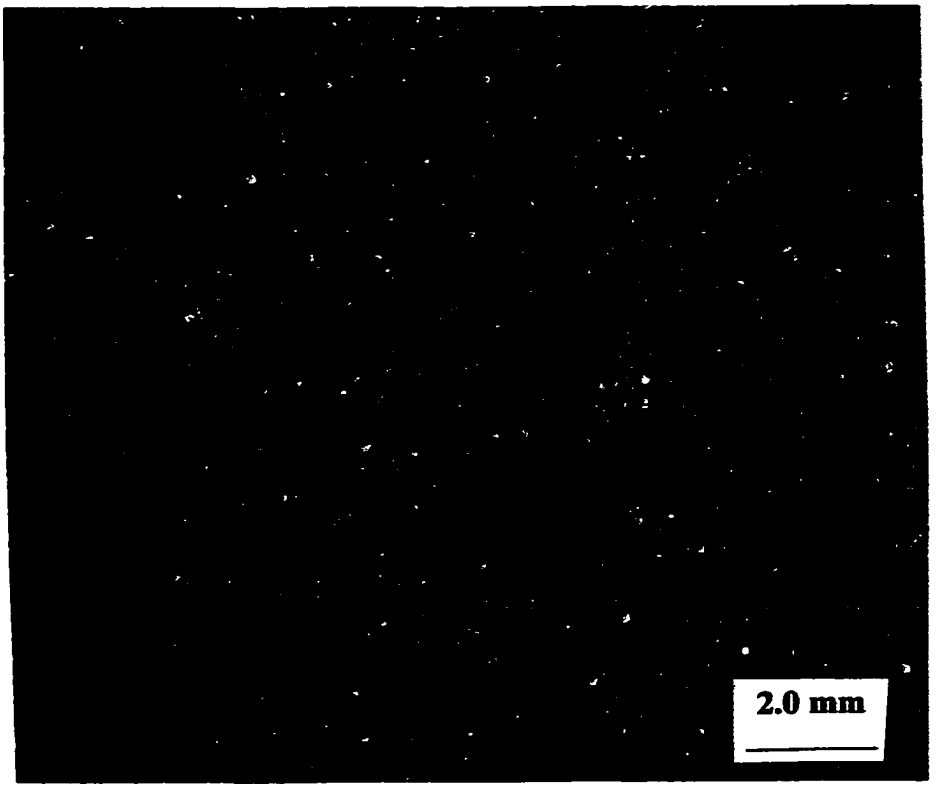

Figure 97: Photomicrograph (cross-polars) of cryptolaminated dolomudstone, Joachim Dolomite, 724.1 ft. (220.7 m), PB-KBB, Inc., G. Saylor 1, Pike Co., Illinois (ISGS C12785).

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Figure 98: Core photos of mottled dolowackestone. Lithofacies differs from the patterned dolomudstone lithofacies in that matrix is commonly calcareous, and mottles are locally quartzose. (A) Joachim Dolomite, 1527.1 ft. (465 m), Gulf Oil Co., Osborne #1, Decatur Co., Indiana (IGS C316); and (B) Everton Dolomite, 3277 ft. (999 m), Illinois Power Co., Truitt #1, Montgomery Co., Illinois (ISGS C13433). Both cores are 4-inches in diameter (10 cm).

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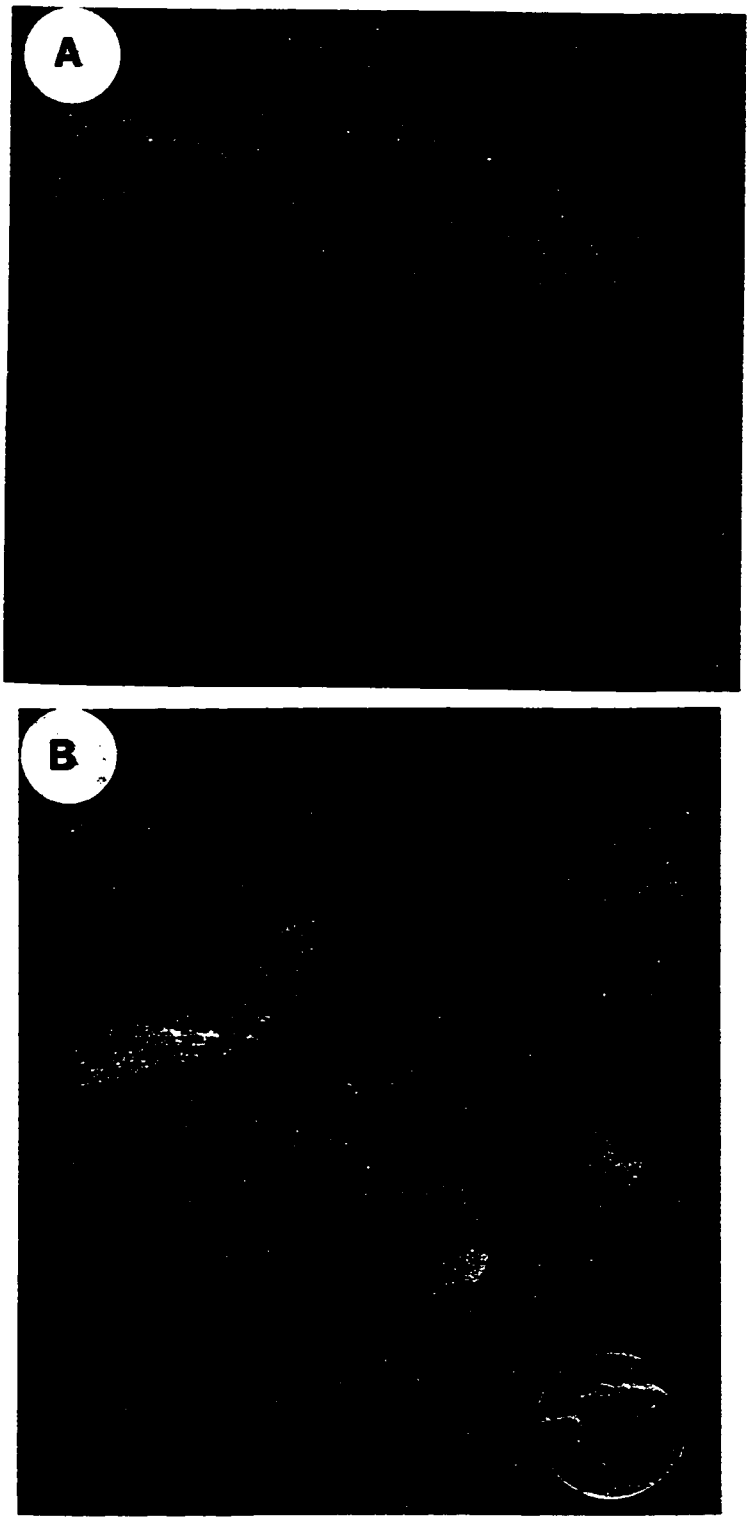

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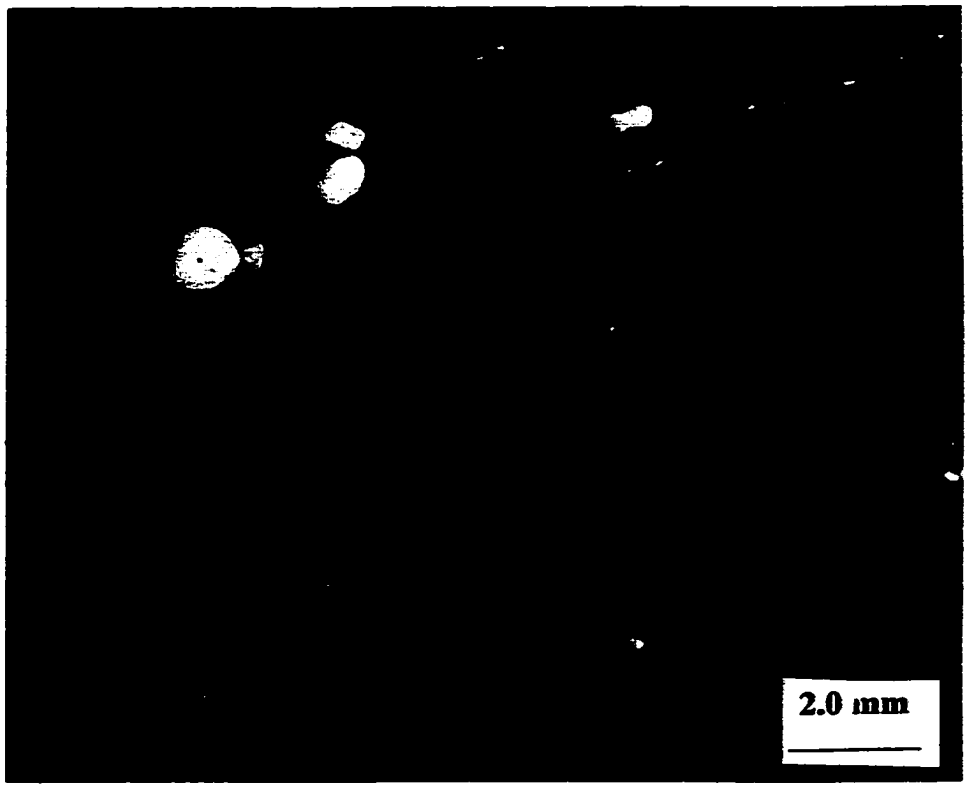

Figure 99: Photomicrograph (plane light) of mottled dolowackestone, Everton Dolomite, 7894 ft. (2406 m), General Electric, Waste Disposal WD-2, Posey Co., Indiana (IGS C495). Mottles defined by slightly more crystalline matrix (lighter area, upper left) associated with fine- medium-grain and silt-sized quartz.

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vuggy porosity may be well developed in the micrite. Quartz-sand grains are sparse, but locally concentrated in mottles.

Stratigraphic and geographic distribution: This lithofacies is restricted to the Everton Dolomite in southern Illinois and Indiana, and lower Wells Creek Formation in western Tennessee.

Discussion: The mottled dolowackestone lithofacies is interpreted as bioturbated lagoonal mud. The quartz grains were transported into the lagoon area by eolian and storm-related processes and locally concentrated by infaunal burrowers. Preferential dolomitization of bioturbated fabrics has produced the mottled appearance.

A subtidal interpretation is supported by the consistent recovery of moderately abundant, well-preserved, complete elements of the conodont *Multioistodus* sp., a fibrous-form with delicate processes. In contrast, conodont recovery from bounding peritidal lithofacies is poor and whole specimens are rarely preserved.

Lithofacies 26: Intraclastic dolograinstone

Description: This rock type is highly variable and is present only at erosive, or nondepositional bedding contacts. The upper bedding-plane of the underlying lithology is commonly bored or burrowed; the borings or burrows are commonly infilled with components of the intraclastic dolograinstone. The upper contact is sharp to gradational and overlain by argillaceous dolomudstone. It is generally thin-bedded (1-4 cm) and composed of rock fragments and quartz grains that are either grain or matrix supported (Figures 100 through 103). Color is highly variable, but generally similar to the underlying lithofacies at the base and gradational upsection to the color of the overlying lithofacies. Grain-size decreases and rounding increases upsection.

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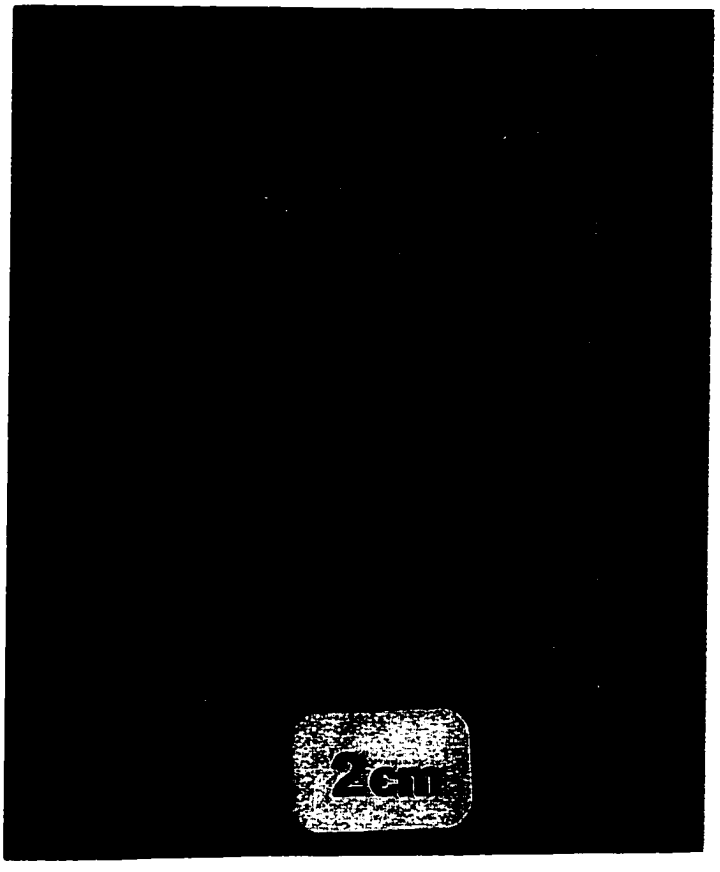

Figure 100: Core photograph of thinly-interbedded intraclastic dolograinstone and dolomudstone, Joachim Dolomite, 722 ft. (220.1 m), PB-KBB, G. Saylor #1, Pike Co., Illinois (ISGS C12785. Intraclasts are subangular to subrounded and poorly-sorted.. Core is 2.5-inches (6 cm) in diameter.

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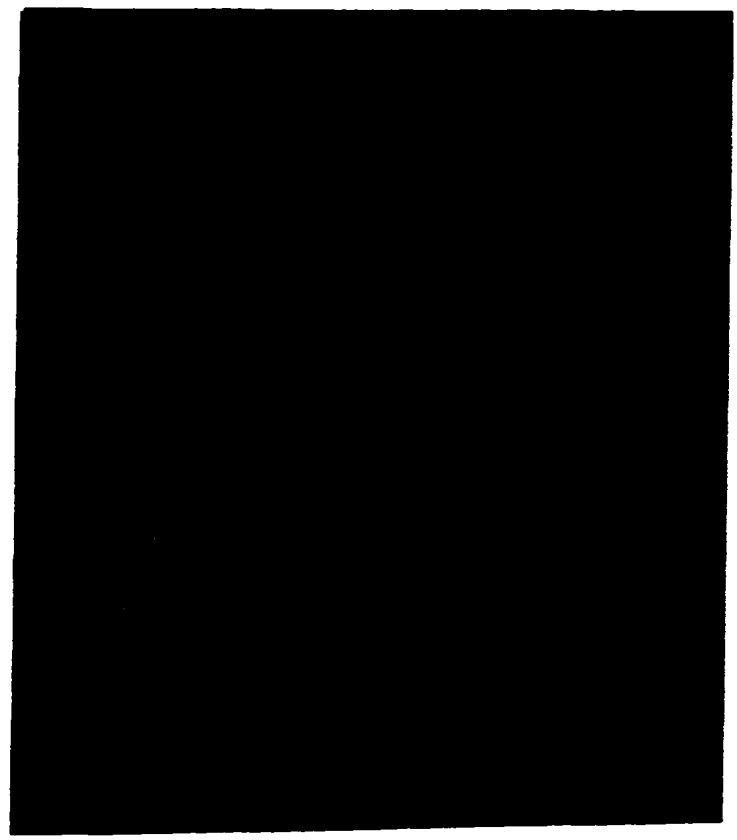

Figure 101: Outcrop photograph showing intraclastic dolograinstone, upper quarter of photo, overlying laminated dolomudstone and argillaceous dolomudstone, Joachim Dolomite, Zell West section, southeast Missouri.

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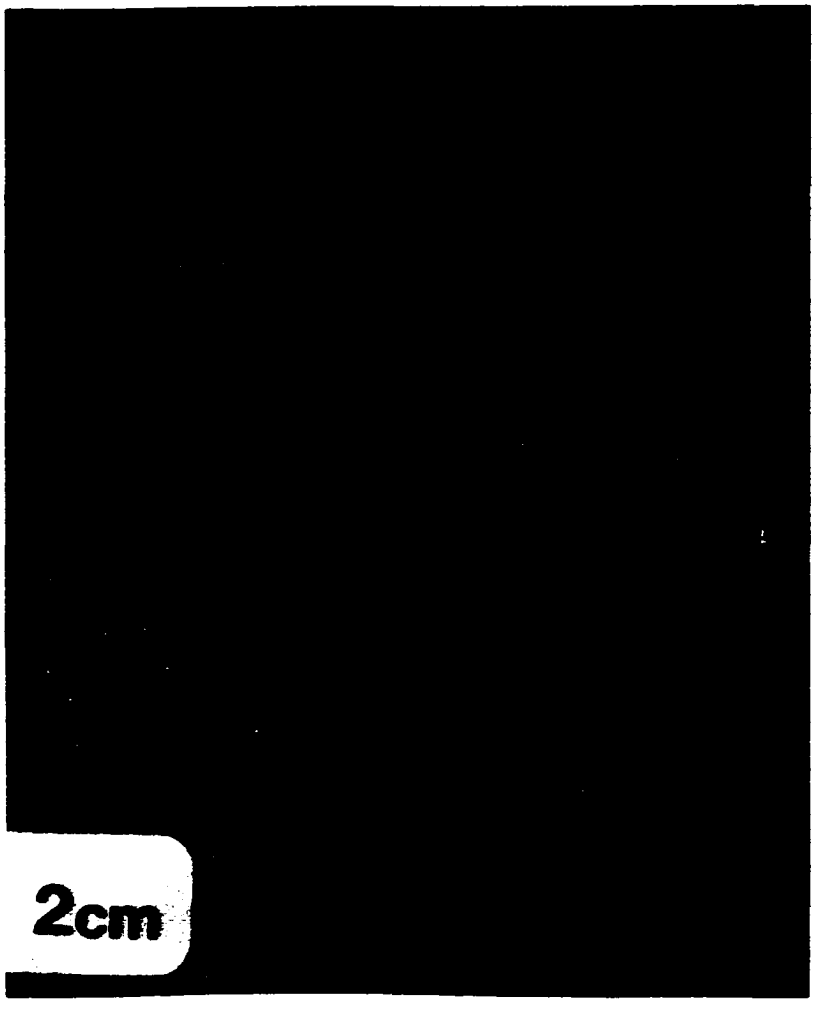

Figure 102: Polished hand sample showing quartzose intraclastic dolograinstone overlying dolomudstone, Joachim Dolomite, Zell West section, southeast Missouri. Note vertical burrow infilled with intraclastic dolograinstone penetrating downward from surface of nondeposition.

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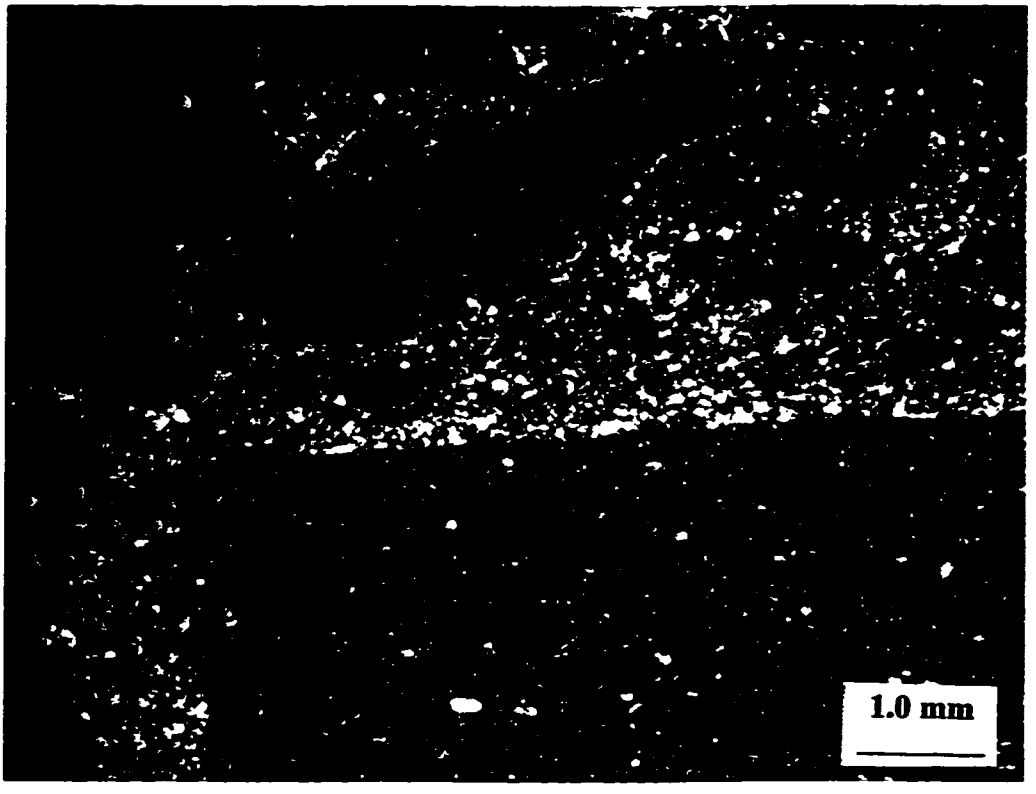

Figure 103: Photomicrograph (plane light) of intraclastic grainstone overlying massive dolomudstone, Wells Creek Dolomite, 1998.8 ft. (609 m), Dupont, Inc. Geohydrological Survey 1, Humphreys Co., Tennessee. Lithology is strongly bimodal with coarse-grain to pebble-size intraclasts of subrounded to subangular, dolomudstone, and silt-sized to very fine-grain, angular, detrital chert. Infilled vertical burrow down-cutting from sharp contact into underlying dolomudstone implies period of nondeposition.

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Intraclasts are fine-grain to pebble-size, angular to subangular, poorly-sorted and are similar in composition to the immediately underlying lithofacies. Some clasts have extensive, infilled microbial borings and may have phosphatic coatings. Grains may be mud- or matrix-supported. Matrix is made up of anhedral, mud-size (<0.0625 mm) dolomite and/or calcite with some clay minerals. Locally, detrital pyrite laminae are present. Clay-size authigenic potassic feldspar is present in some samples from the Wells Creek Dolomite, western Ohio.

This lithofacies is the depositional equivalent of the calcilithic quartz arenite lithofacies.

Stratigraphic and geographic distribution: This lithofacies occurs in the Joachim, Wells Creek and Everton dolomites, and the Dutchtown Formation.

Discussion: This lithofacies represents a transgressive lag deposited on a surface of nondeposition or erosion. Detrital material from the underlying lithofacies is reworked. Burrows/borings infilled by detrital sediments, and bored intraclasts are typical of lower intertidal and shallow-subtidal hard grounds.

Lithofacies 27: Intraformational breccia

Description: Poorly-sorted, angular to subangular, clasts of dolomudstone that range in size from fine-grain sand to cobble-size (Figures 104 and 105). The matrix is locally microcrystalline dolomite, but it is mostly a coarsely-crystalline, sparry calcite. The clasts are mostly grain- or cement-supported, but are locally mud supported. Dolomitization typically obscures the petrographic and sedimentologic character of the clasts.

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Figure 104: Core photographs of intraformational breccia. (A) Locally anhydritic (light-blue-gray) intraformational breccia, Joachim Dolomite, 7192.9 ft. (2192.4 m), Superior Oil, H. C. Ford et al C-17, White Co., Illinois (ISGS C2740, 8-inch core). (B) Intraformational breccia, upper Joachim Doiomite, 1858 ft. (566 m), Panhandle Eastern, Miller 1-16, Morgan Co., Illinois (ISGS C13636; 4-inch core).

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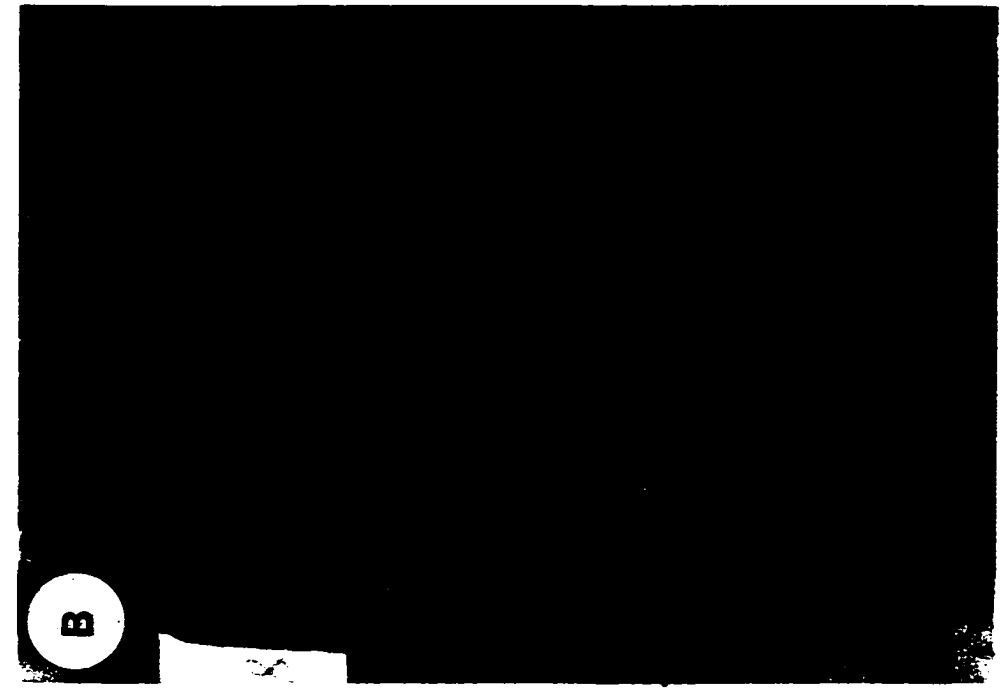

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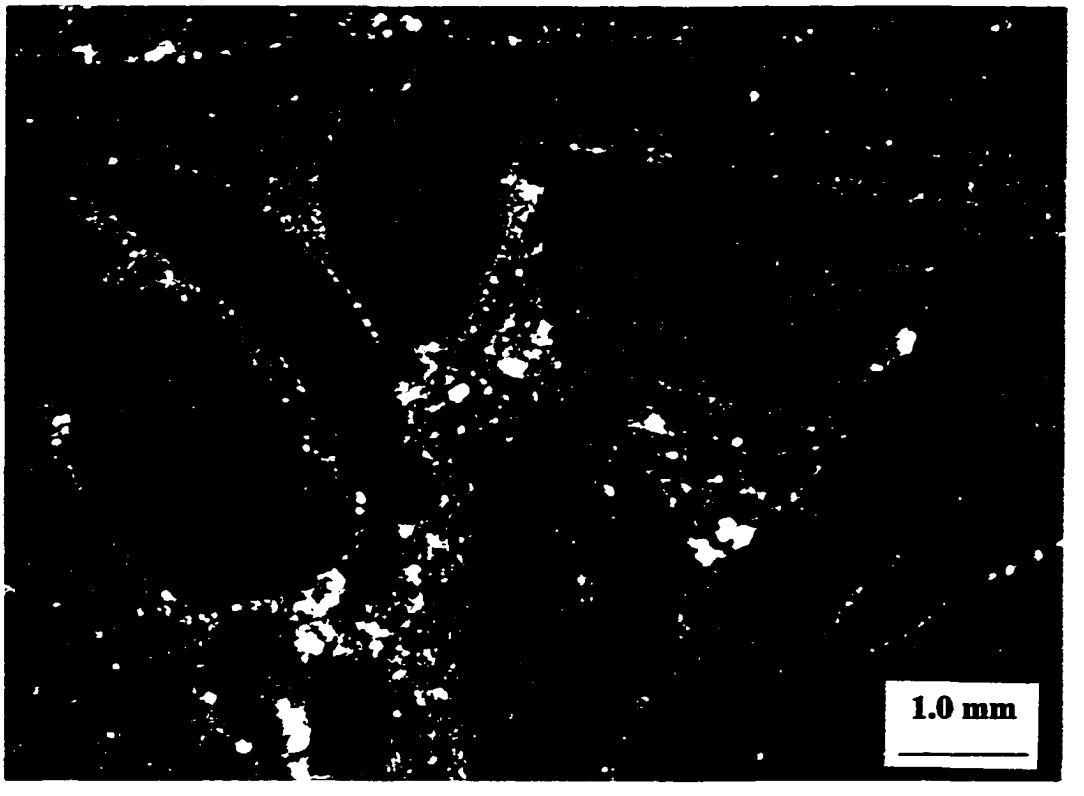

Figure 105: Photomicrograph (cross polars) of intraformational breccia developed in anhydritic dolomudstone, Joachim Dolomite, 4609 ft. (1405 m), Velsicol Chemical, Velsicol Chemical #2, Clark Co., Illinois (ISGS C8737). Continuity of lamination at top across the solution collapse zone and soft sediment deformation of clasts imply syndepositional solution collapse.

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Stratigraphic and geographic distribution: This lithofacies is limited to the Everton and *Joachim dolomites.*

Discussion: This lithofacies is interpreted as collapse breccia formed by the dissolution of evaporites. Breccia in the Everton Dolomite may be penecontemporaneous, or related to post-Everton karstification prior to deposition of the St. Peter Sandstone.

In the Everton dolomite, penecontemporaneous collapse is evidenced by the disturbed lateral continuity of bedding immediately above brecciated intervals that does not extend higher in the section. In addition, beds immediately overlying brecciated beds contain evidence of soft sediment collapse.

Intraformational breccias in the Joachim Dolomite do not effect overlying or underlying beds and are probably the result of post-Ordovician dissolution of evaporites.

Lithofacies 28: Laminated calcimudstone

Description: Pale brown (5 YR 5/2) to grayish-brown (5 YR 3/2), calcimudstone with planar to domal, generally continuous, carbonaceous, dusky-brown (5 YR 2/2) to brownish-black (5 YR 2/1) laminae (Figures 106 and 107). In the subsurface of southern Illinois, anhydrite constitutes up to 50% of the rock by volume. Anhydrite is absent outside of southern Illinois.

Stratigraphic and geographic distribution: This lithofacies is uncommon, but present in the Joachim Dolomite, subsurface of southern Illinois, Dutchtown Formation, southeast Missouri, and the lower Murfreesboro Limestone, western Tennessee.

Discussion: The laminae of this lithofacies are interpreted as buried algal mats of the intertidal zone. Exposure of the mats resulted in the shrinkage and deformation of their planar structure. Storm events, which transported mud-size (<0.0625 mm) sediments

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Figure 106: Core photos of laminated calcimudstone. (A) Dupont, Inc., Geohydrological Surveyt #1, lower Murfreesboro Limestone, Humphreys Co., Tennessee. (B) Anhydrite-bearing dolomitic calcimudstone, Joachim Dolomite, 7214 ft. (2198.8 m), H. C. Ford et al C-17, White Co., Illinois (8-inch core, ISGS C2740). This lithofacies is intergradational with the stromatolitic boundstone lithofacies. Cores are 8-inches 20 cm) in diameter.

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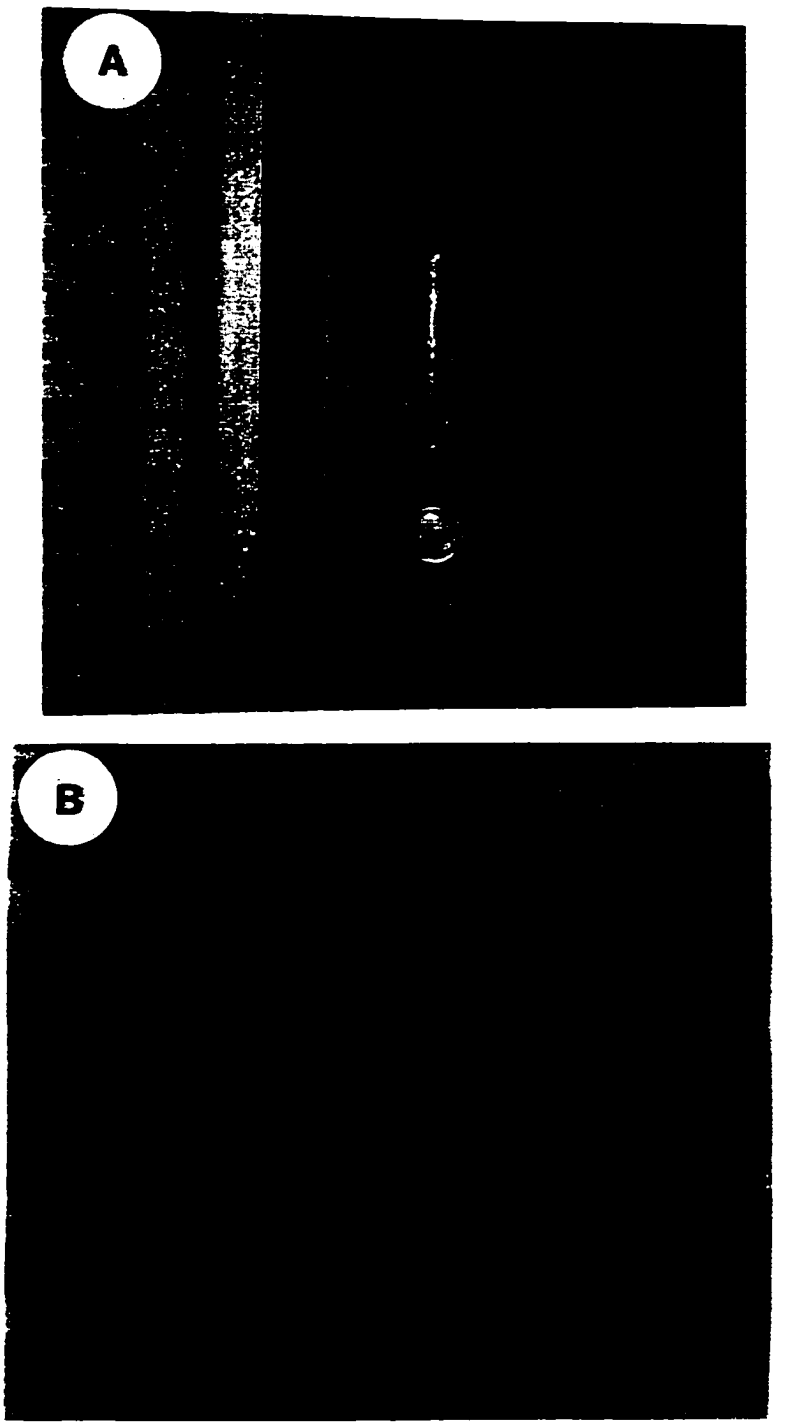

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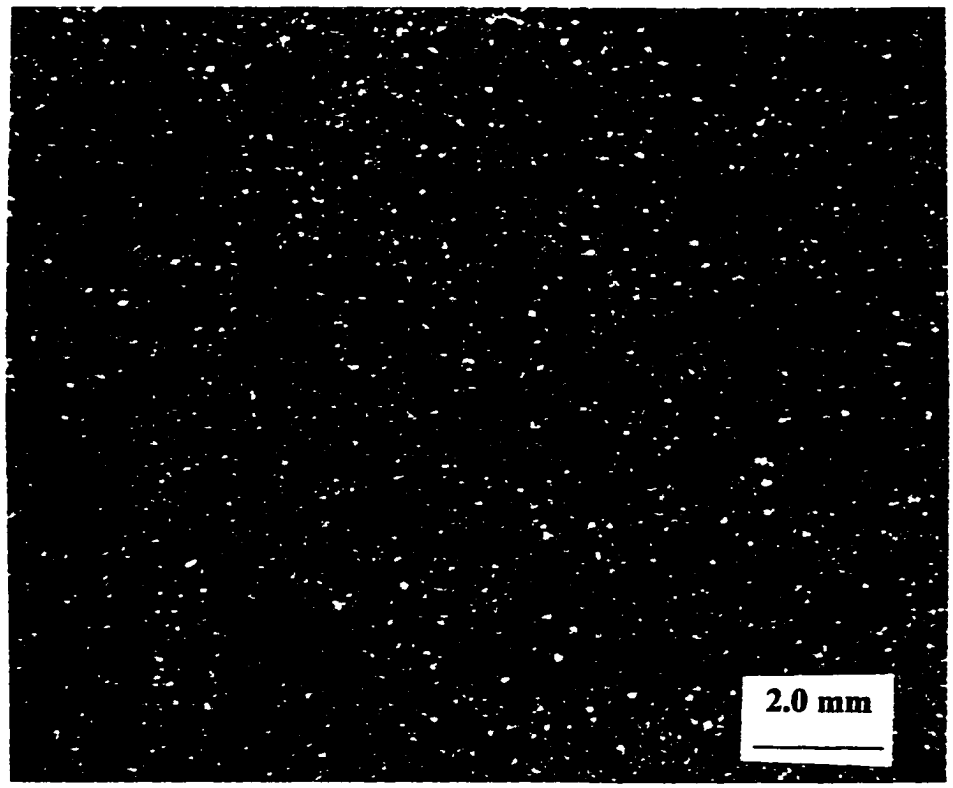

Figure 107: Photomicrograph (cross-polars) of calcimudstone, Pike Co. Gas Association, Joachim Dolomite, 995 ft. (303.3 m), Conkright #2, Pike Co., Illinois (ISGS C3500)

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from the subjacent marine environments, resulted in the episodic burial of the mats and their subsequent preservation as organic laminae.

This lithofacies is a nondolomitized, depositional equivalent to the laminated dolomudstone lithofacies that was deposited basinward where the influx of normal marine waters, and deeper burial have inhibitied the influx of dolomitizing meteoric groundwaters.

Lithofacies 29: Patterned calci/dolomudstone

Description: Distinctive color-mottled calcimudstone and dolomudstone characterized by intercalation's of greenish-gray (5 G 6/1) to light-greenish-gray (5 G 8/1) dolomudstone, and light-brownish-gray (5 YR 6/1) to greenish-gray (5 G 6/1) calcimudstone, or various intermediate compositions (Figures 108 and 109). The "patterned" intercalation's are not reflected in megascopic or microscopic textural features and have various geometry's in vertical profiles, and are apparent liesegang rings when developed on bedding planes (Figure 110). Pyrite is locally associated with the darker intercalation's. Quartz silt is locally abundant. Pseudomorphs after halite and calcium sulfate are common in outcrop and the subsurface on the basin margins; in the central Illinois Basin, rocks of this lithofacies may contain up to 40% anhydrite.

Stratigraphic and geographic distribution: This lithofacies is abundant in the Dutchtown Formation, Indiana; Joachim Dolomite, southeastern Missouri, Illinois and Indiana; the Wells Creek Dolomite, western Ohio, central Kentucky and western Tennessee; the Camp Nelson Limestone, central and western Kentucky; and lower Murfreesboro Limestone, western Tennessee. It is locally developed in carbonate lithofacies of the Glenwood Formation in northern Illinois.

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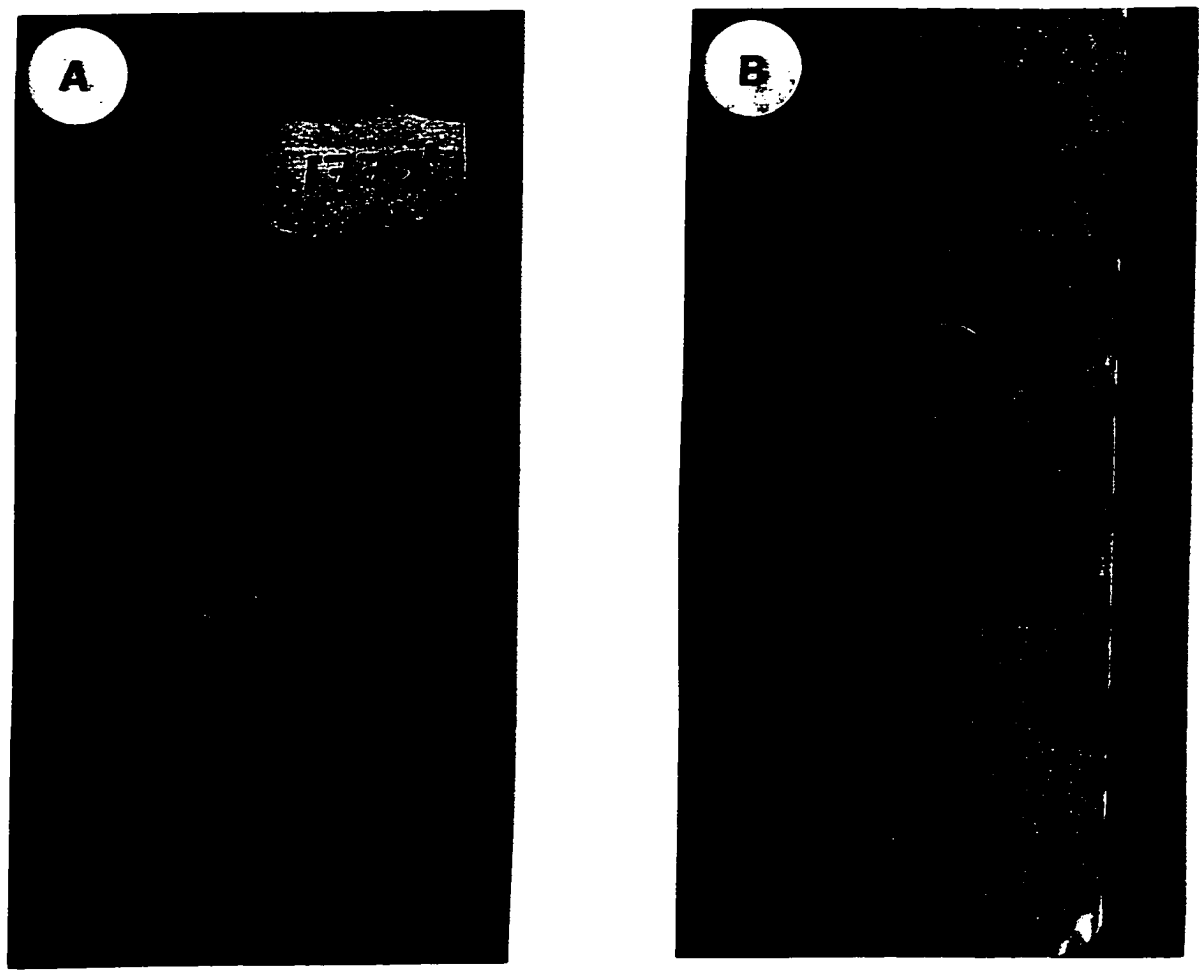

Figure 108: Core photos patterned calcimudstone, Wells Creek Dolomite, (A) 1773 (540.4 m) and (B) 1799 ft. (548.3 m), Du Pont, Inc., Geohydrological Survey #1, Humphreys Co., Tennessee. Core is 8-inches (20 cm) in diameter.

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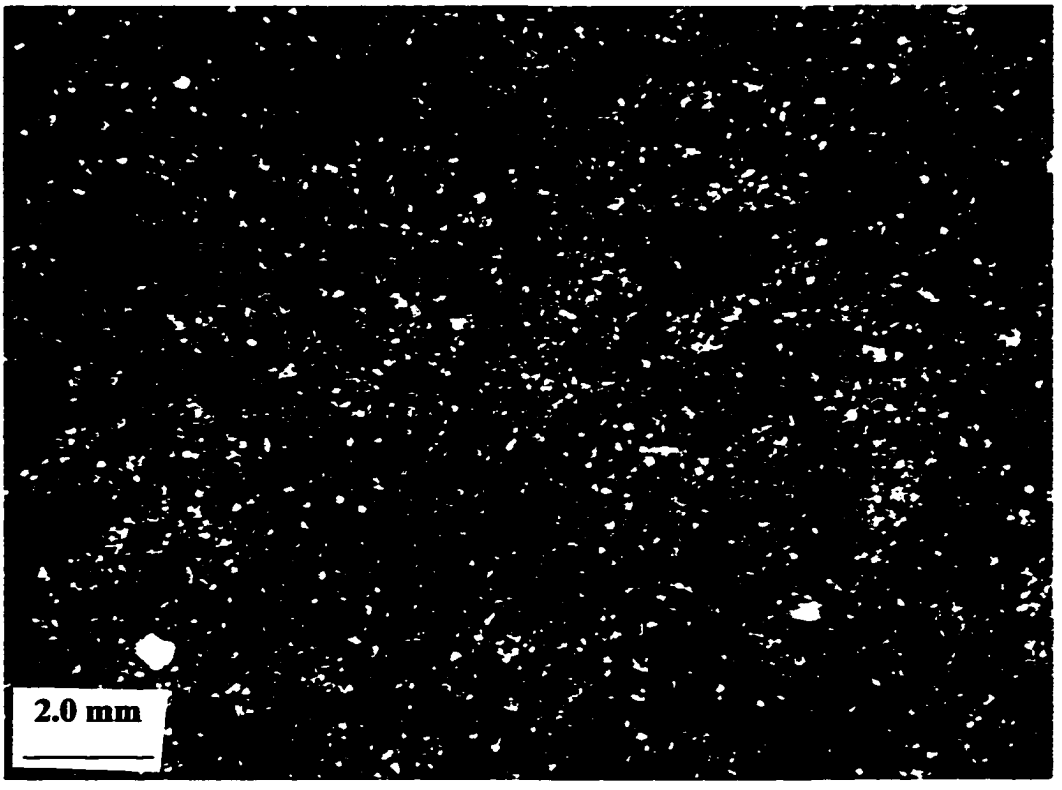

Figure 109: Photomicrograph of patterned dolomudstone with mottling defined by submicroscopic pyrite concentrations (black patches), Joachim Dolomite, 4103 ft. (1250.6 m), Veliscol Chemical Co., Veliscol Chemical #2, Clark Co., Illinois (ISGS C8737).

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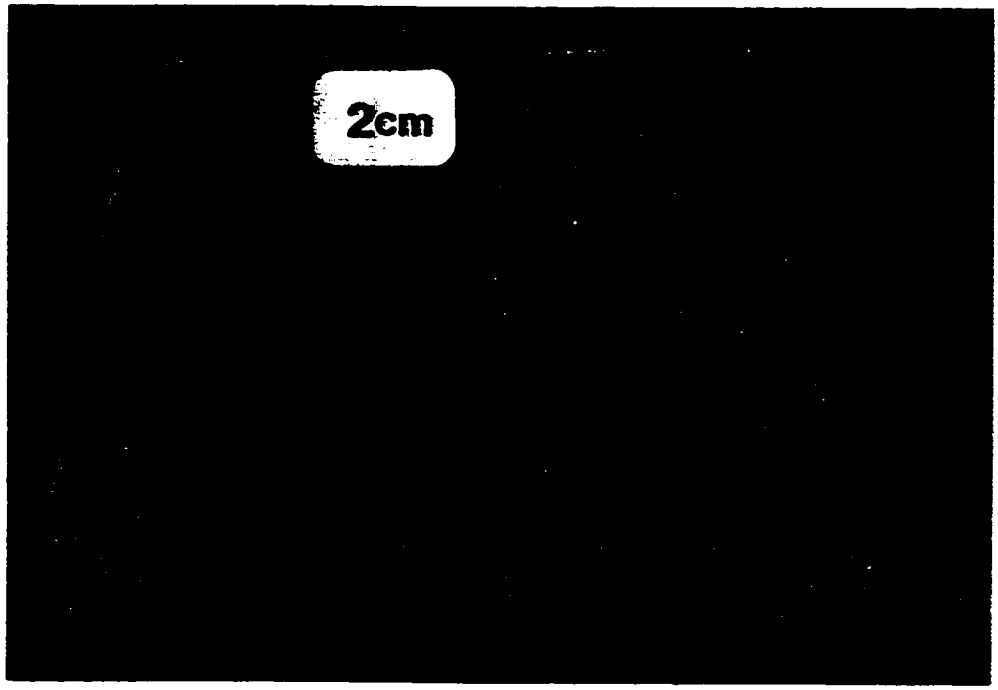

Figure 110: Hand sample photograph of bedding plane on patterned calcimudstone showing well developed liesegang rings, lowermost Camp Nelson Limestone, Camp Nelson North section, central Kentucky.

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Discussion: Dixon (1976) recognized that this lithofacies is widespread in Paleozoic carbonates, and considered it diagnostic of intertidal and supratidal environments. Kendall (1977) suggested that the patterned appearance results from the dissolution of calcium sulfate, and that this lithofacies can be deposited subaqueously.

The origin of this patterned feature remains enigmatic. It is probably related to the composition and distribution of clay minerals and pyrite as controlled by bioturbation and dissolution fabrics. The variable oxidation state of these minerals, producing the light/dark color patterning, may have resulted from mineral interaction with pore-water, the degradation of disseminated organic matter, and/or calcitization of calcium sulfates.

Although the depositional environment is uncertain, the presence of a low diversity, endemic conodont fauna dominated by complete hyaline, fibrous-forms is indicative of a restricted marine, subtidal environment.

Lithofacies 30: Fenestral calci/dolomudstone

Description: Light-brownish-gray (5 YR 6/1) dolomudstones and/or greenish-gray (5 GY 6/1) calcimudstones with abundant spar-filled, vertical, tubular fenestrae (Figures 111 and 112). This lithofacies occurs in thin- to medium-size beds thar have gradational contacts with over- and underlying lithologies. The matrix is microcrystalline dolomite and/or lime-micrite. The tubular fenestrae are 1-2 mm in diameter and 1-8 cm in length. They are commonly infilled with coarsely-crystalline calcite and/or rhombic dolomite. Pyrite and quartz silt are minor constituents. Pseudomorphs after calcium sulfate are common.

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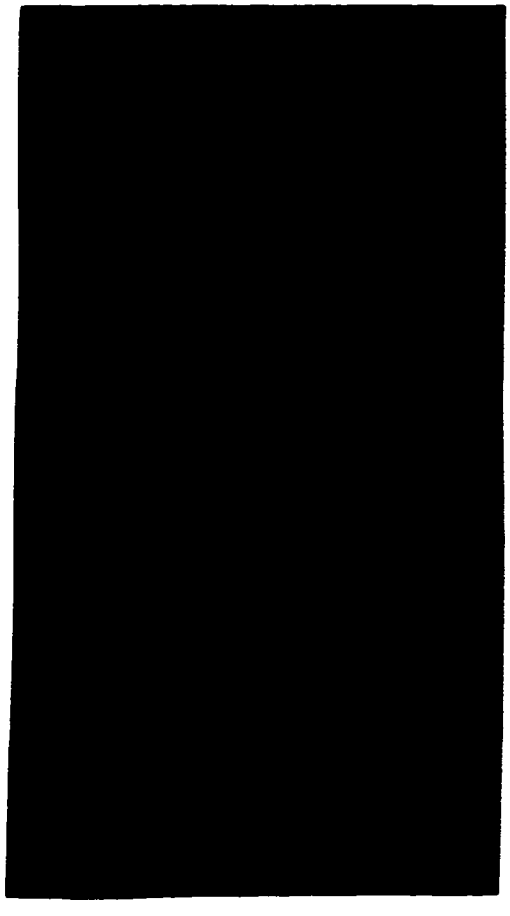

Figure 111: Core photo of fenestral dolomudstone, Matson Dolomite Member, Joachim Dolomite, 732.5 ft. (223.3 m), G. Saylor #1, Pike Co., Illinois (ISGS C12785). Core is 2.5-inches (6 cm) in diameter.

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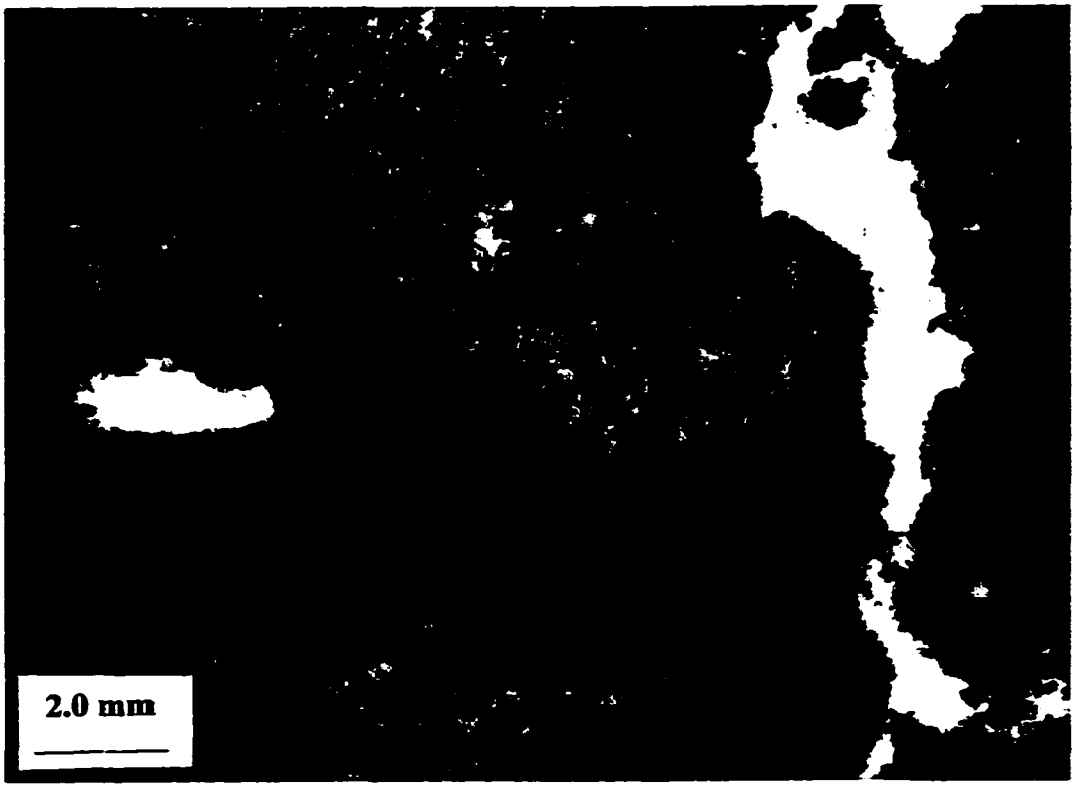

Figure 112: Photomicrograph (plane light) of fenestral dolomudstone, upper Joachim Dolomite, 1400.9 ft. (427 m), Northern Indiana Power Co., E. L. Morphet #1, Fulton Co., Indiana (IGS C437). Vertical and horizontal fenestrae are infilled with coarsely-crystalline calcite, which is locally replaced by silica.

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Stratigraphic and geographic distribution: This lithofacies occurs sporadically in the Joachim Dolomite of Indiana, Illinois and southeast Missouri; the Wells Creek Dolomite in central Kentucky and western Tennessee; the lower Murfreesboro Limestone, western Tennessee.

Discussion: The tubular fenestrae are interpreted as vertical burrows, indicating that the lithologies of this lithofacies were deposited under shallow-subtidal to lower-intertidal conditions. Coarsely-crystalline infills of the burrows are most likely late-diagenetic cements. To preserve the burrows, a precursor cement must have been present and based on the presence of pseudomorphs, it is likely the precursor cement was calcium sulfate.

Lithofacies 31: Argillaceous calci/dolomudstone

Description: This lithofacies is mostly greenish-gray (5 G 6/1) to light-greenish-gray (5 G 8/1) calci/dolomudstone with moderate to high clay-content (Figures 113 and 114). It may be a relatively pure dolomudstone, or calcimudstone with sparse pyrite. Locally, vertical fenestrae may be present at bedding contacts. Fenestrae are 1-6 cm in length, 1-2 mm in diameter, and may be infilled by crystalline carbonate minerals, quartz sand or calcilithic arenite. Clay mineral content, mostly illite, varies from 5-30%. Within limited intervals, disrupted fabrics with yellowish-gray (5 Y 8/1) crusts are present.

Stratigraphic and geographic distribution: This rock type is present in the Dutchtown Formation, Indiana; Joachim Dolomite in Indiana, Illinois and southeast Missouri; Wells Creek Dolomite in western Ohio, central Kentucky, and western Tennessee; and the lower argillaceous unit of the Black River Limestone, western Ohio.

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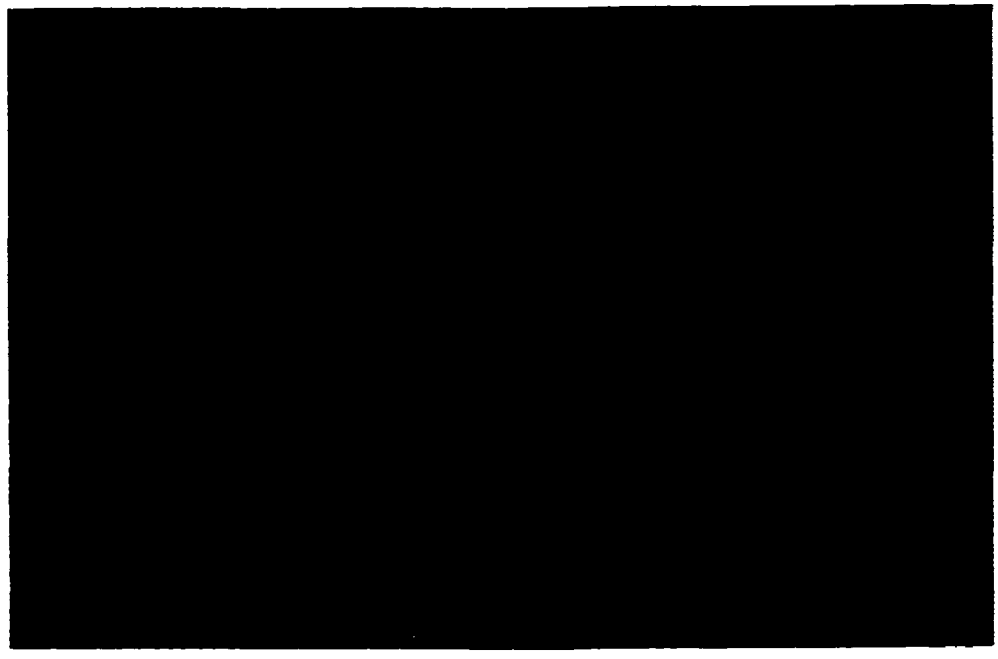

Figure 113: Hand sample photograph of argillaceous dolomudstone, medium-green-gray, with internal light-yellow-gray, fenestral dolomudstone crusts at base, Joachim Dolomite, Zell West section, northbound lane, Interstate 55, southeast Missouri. Dark areas are pyritic mottles. Biogenic activity disrupted contact between argillaceous dolomudstone and weakly-lithified fenestral dolomudstone.

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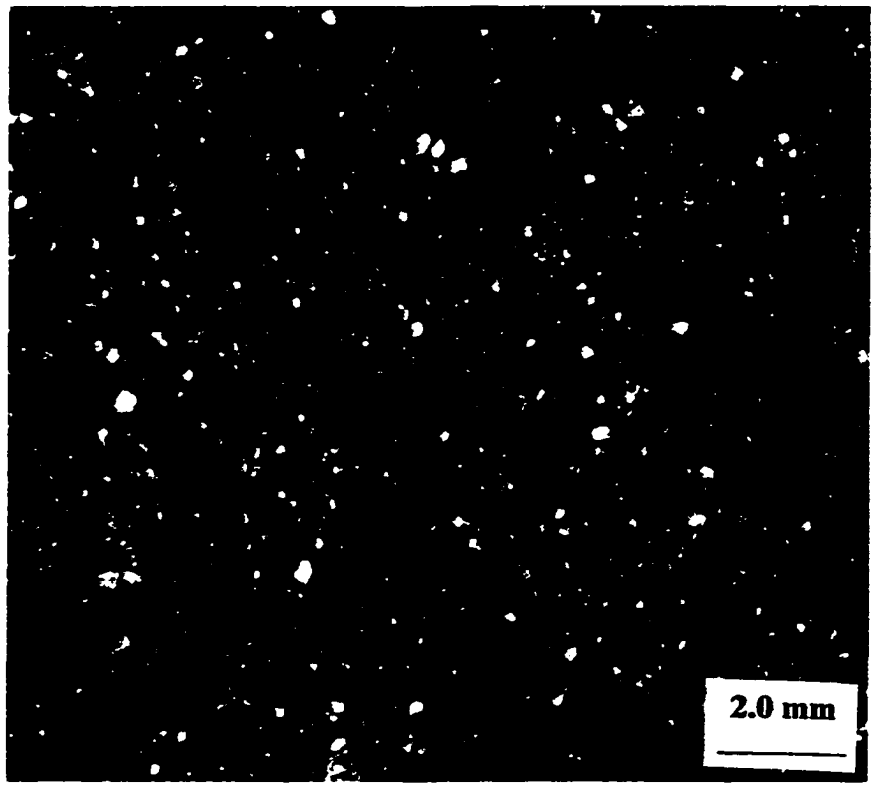

Figure 114: Photomicrograph (cross-polars) of argillaceous dolomudstone, Wells Creek Dolomite, 1402 ft. (427.3 m), Ohio Department of Geological Survey, C. Beiser #1, Butler Co., Ohio (DGS 2537). Green color is imbued by abundance of illite, dolomite crystals are submicroscopic.

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Discussion: This lithofacies is suggestive of shallow-subtidal and lower-intertidal conditions where bioturbation destroys sedimentary structures within the unconsolidated sediment. Vertical burrows are common preserved at nondepositional surfaces in modern subtidal shoreface and channel environments where early lithification of lime-mud occurs.

The disrupted crusts observed locally are similar in character to the outer-ramp, biotextured carbonates, containing a *Thalassinoides* ichnofossil assemblage, reported by Pedley (1992). By analogy, the argillaceous calci/dolomudstone lithofacies was deposited under subtidal conditions on a mud-dominated shelf. When sedimentation rates slowed, or when exposed, early lithification at the sediment-water interface established a hard-ground surface, that in turn was burrowed and yielded the observed burrowed bedding-contacts.

Lithofacies 32: Peloidal calciwacke/packstone

Description: Medium-gray (N 5) to dark-greenish-gray (5 GY 4/1) micrite with regions of diffuse peloidal features (Figures 115 and 116). Contacts between peloids are vague and locally discontinuous; where complete, the peloids are cemented with rims of finely-crystalline, sparry calcite. Typically, thin nodular beds with sparse, carbonaceous mudrock partings.

Stratigraphic and geographic distribution: Sparsely preserved in the Dutchtown Formation, southeast Missouri. More abundant in the Matson Member of the Joachim Dolomite, Indiana, Illinois and southeastern Missouri; Carntown unit of the lower Black River Limestone, western Ohio; the lower Camp Nelson Limestone, central Kentucky; and the lower Murfreesboro Limestone, western Tennessee.

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Figure 115: Core photograph of peloidal calcimudstone. (A) Murfreesboro Limestone, Dupont, Inc., Geohydrological Survey #1, 1764 ft. (537.7 m), Humphreys Co., western Tennessee (8-inch core). Note typical nodular bedding and partings of carbonaceous mudrock (medium-brown). (B) Matson Member of Joachim Dolomite, 3049 ft. (929.3 m), Illinois Power Co.. Truitt #1, Montogomery Co., Illinois (4-inch core, ISGS C13443).

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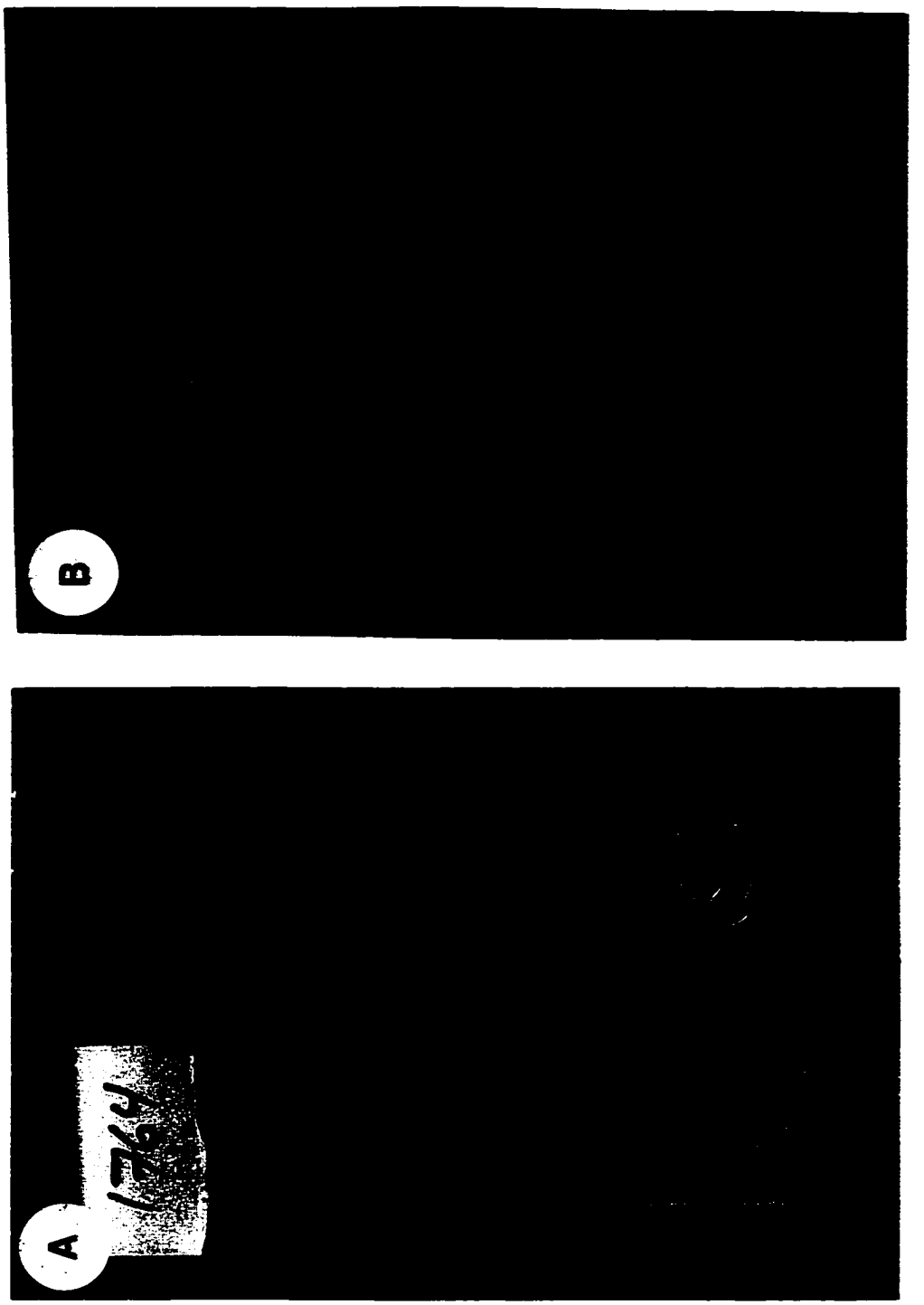

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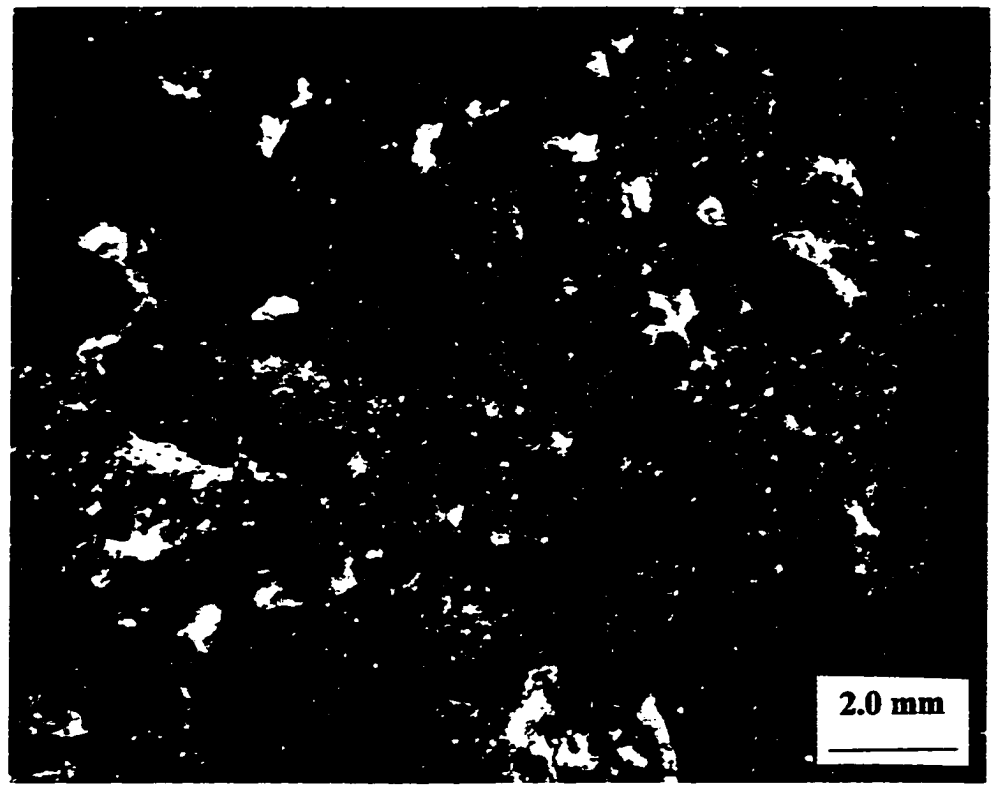

Figure 116: Photomicrograph (plane light) of pelodial calcimudstone, upper Joachim Dolomite, 208.9 ft. (64 m) Getty Oil, Mineral Test 1703-1, St. Genevieve Co., Missouri. Note characteristic amorphous appearance of matrix.

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Discussion: Peloidal wacke/packstone are common components of modern-marine subtidal carbonate environments. Preservation of peloids is thought to be the result of early cementation in the oxygenated phreatic zone.

Lithofacies 33: Mottled calciwackestone

Description: Light-greenish-gray (5 GY 6/1) to medium-gray (N 5), massive, calcimudstone with sparse complete bioclasts that include ostracodes, brachiopods and trilobites (Figures 117 and 118). Disseminated pyrite is common, quartz is absent. Microcrystalline dolomite rarely makes up more than 25% of the rock. Bioclasts are infilled with coarsely-crystalline calcite. Variations in the abundance of irregular, laterally discontinuous organic laminae produce a "mottled" effect. Stylolites are locally present, but are not abundant.

Stratigraphic and geographic distribution: This lithofacies is an abundant component of the Matson Member of the Joachim Dolomite, Indiana, Illinois and southeastern Missouri; the Carntown unit of the lower Black River Limestone, western Ohio; the lower Camp Nelson Limestone, central Kentucky; and the lower Murfreesboro Limestone, western Tennessee.

Discussion: Massive mudstones with sparse megafauna are generally thought to have been deposited under shallow- subtidal conditions in lagoonal environments. Sparse faunas are the result of both restricted marine conditions, high sedimentation rates and microbial degradation. Massive bedding is the result of intense bioturbation.

The observed organic laminae are possibly incipient stylolites developed as thermal maturation of organic matter produced organic acids, which in turn dissolved

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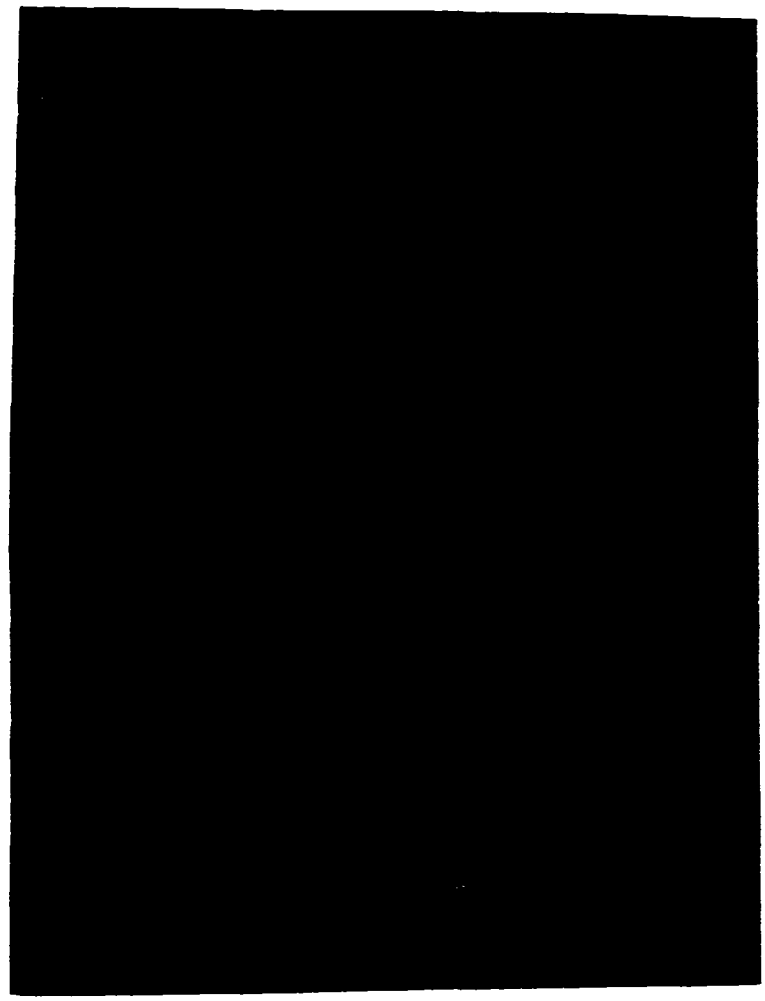

Figure 117: Core photo of mottled calciwackestone, 3061 ft. (933 m), upper Joachim Dolomite, Illinois Power Co., Truitt #1, Montgomery Co., Illinois (ISGS C13433, 4-inch core).

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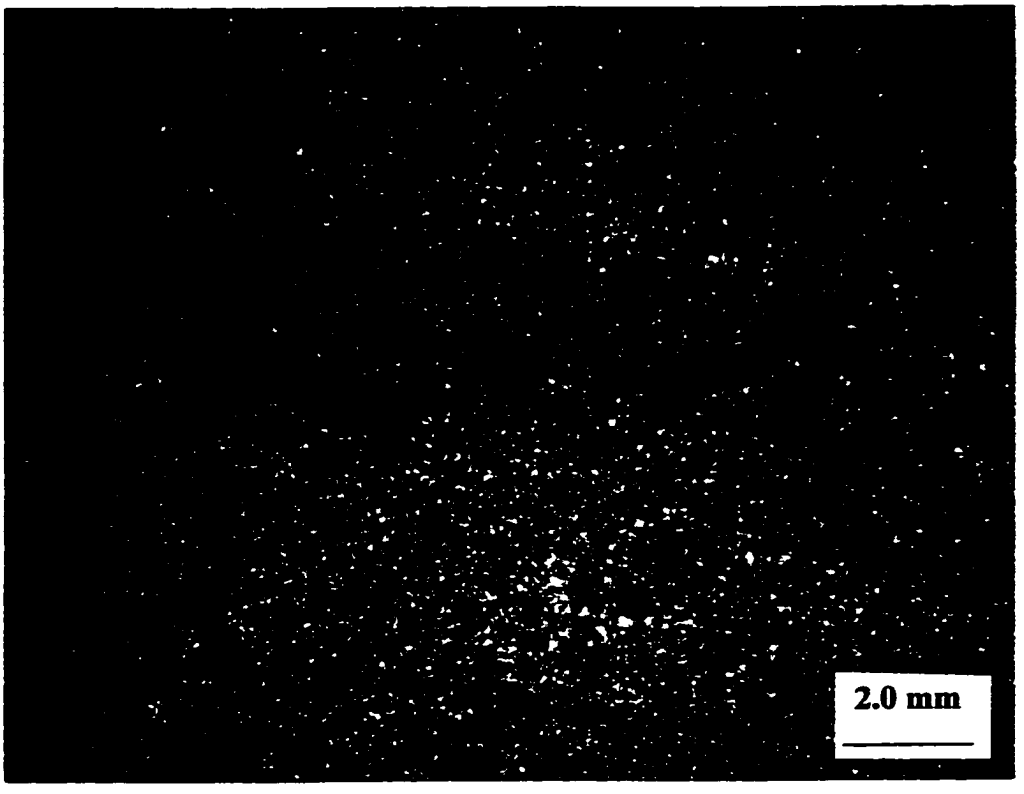

Figure 118: Photomicrograph (plane light) of mottled calcimudstone, upper Joachim Dolomite, 239 ft. (73 m), Getty Oil, Mineral Test 1703-1, St. Genevieve Co., Missouri. Mottling is defined by distribution of disseminated pyrite (dark area in center).

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the adjacent carbonate matrix and concentrated the organic matter subparallel to bedding.

Lithofacies 34: Stylolitic calciwacke/mudstone

Description: Medium-gray (N 5) to brownish-gray (5 YR 4/1) bioclastic wackestone, with sparse complete bioclasts of brachiopods, trilobites, ostracodes and orthocone cephalopods, stylolaminated with bioclastic packstone containing incomplete bioclasts (Figures 119 and 120).

Stratigraphic and geographic distribution: Stylolitic calciwacke/mudstones are abundant in the Matson Member of the Joachim Dolomite, Indiana, Illinois and southeastern Missouri; the Carntown unit of the lower Black River Limestone, western Ohio; the lower Camp Nelson Limestone, central Kentucky; and the lower Murfreesboro Limestone, western Tennessee.

Discussion: The large number of complete bioclasts implies this lithofacies was deposited under subtidal conditions. Abundant organic laminae of variable lateral continuity are present throughout this lithofacies. The preservation of these organic laminae conflicts with the evidence for an oxygenated subtidal environment, as indicated by the presence of complete bioclasts. The occurrence of organic laminae in this lithofacies suggests the generation of organic acids, by diagenetic alteration of organic matter, has resulted in dissolution of carbonate along the boundaries of the differentially cemented lithologies. Continued dissolution yielded the observed fitted stylofabric. Transitional lithologies between nonstylolitized, mottled wackestone and this lithofacies are locally observable.

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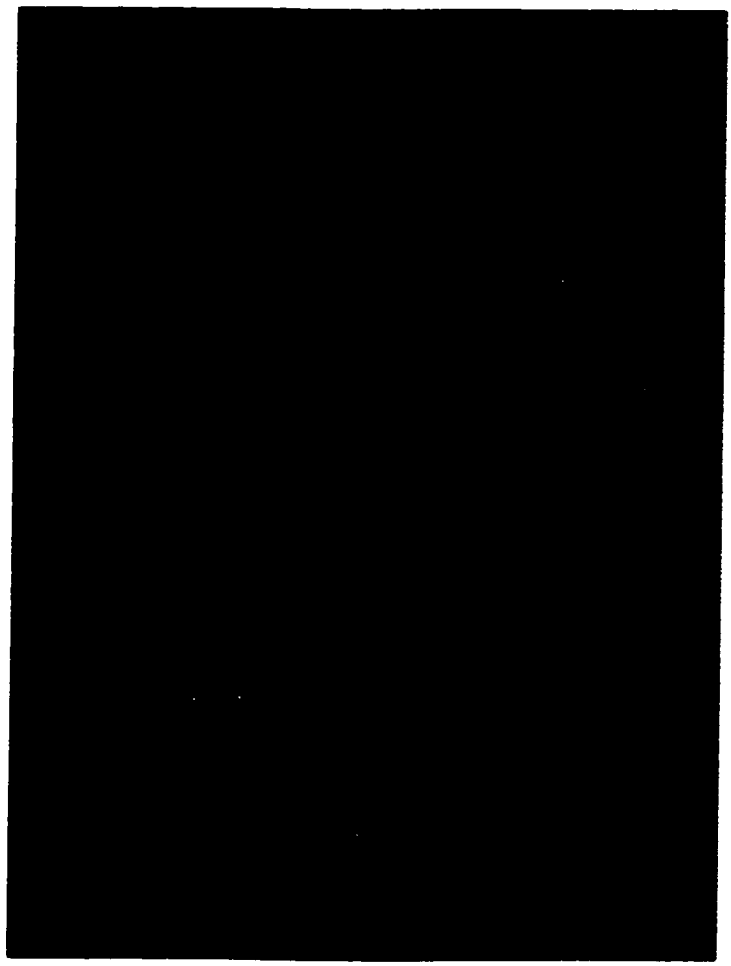

Figure 119: Core photograph of stylolitic calciwacke/mudstone, lower Murfreesboro Limestone, 1602 ft. (488.3 m), Dupont, Inc., Geohydrological Survey #1, Humphreys Co., Tennessee. Core is 8-inches (20 cm) in diameter.

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Figure 120: Photomicrograph (plane light) of stylolitic calciwacke/packstone, Matson Dolomite Member, upper Joachim Dolomite, 3008.5 ft. (917 m), Illinois Power Co., Truitt #1, Montgomery Co., Illinois (ISGS C13443). Abundant ostracode debris and large brachiopod fragments have undergone dissolution and have been infilled by coarsely-crystalline calcite.

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Lithofacies 35: Intraclastic calcipack/grainstone

Description: Medium-gray (N 4) to brownish-gray (5 YR 4/1) pack/grainstone with abundant, moderately-sorted, sand-size and larger, bioclasts, intraclasts, peloids and rare ooids (Figures 121 and 122). Grains are mostly medium- to coarse-grain, subrounded to subangular, with crystalline calcite cement. Identifiable bioclasts include trilobites, brachiopods, ostracodes, and gastropods; complete fossils are uncommon. Intraclasts are micritic and rarely possess internal structure. The intraclastic/bioclastic grainstone lithofacies is commonly gradational with the bioclastic wackestone lithofacies.

Stratigraphic and geographic distribution: This lithofacies is present in the Dutchtown Formation in southeast Missouri and southern Illinois, the Matson Member of the Joachim Dolomite, Indiana, Illinois and southeastern Missouri; the Carntown unit of the lower Black River Limestone, western Ohio; the lower Camp Nelson Limestone, central Kentucky; and the lower Murfreesboro Limestone, western Tennessee.

Discussion: Low mud-content and abundance of fragmentary bioclasts suggests a higher energy environment than the other carbonate lithofacies. This lithofacies yields the most abundant and diverse conodont fauna, although conodont elements are commonly incomplete and indeterminate fragments are abundant. This lithofacies is interpreted to be deposited under shallow subtidal conditions, and to reflect less restricted marine conditions.

Lithofacies 36: Bioclastic dolo/calciwackestone

Description: Similar in character to the intraclastic pack/grainstone lithofacies, but contains fewer intraclasts and micrite is more abundant. Bioclasts are generally complete and grains mud-supported (Figures 123 and 124). Major bioclastic

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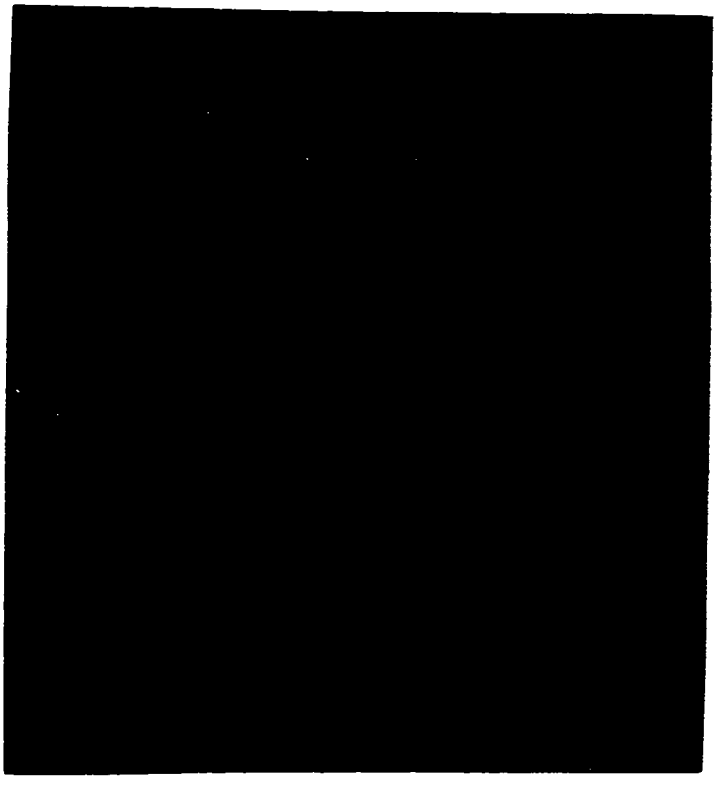

Figure 121: Core photo of intraclastic calcipack/grainstone, upper Joachim Dolomite, 3038 ft. (926 m), Illinois Power Co., Truitt #1, Montogomery Co., Illinois (ISGS C13443. Core is 4-inches (10 cm) in diameter.

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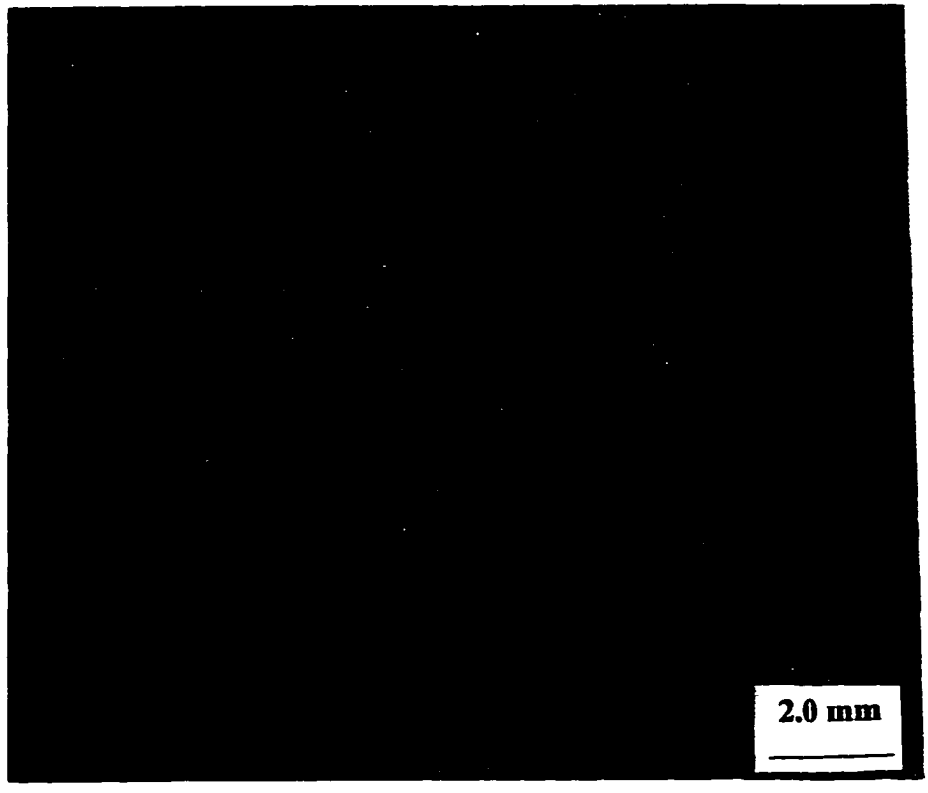

Figure 122: Photomicrograph (plane light) of intraclastic calcigrainstone, Joachim Dolomite, 721.2 ft. (219.8 m), PB-KBB, Inc., G. Saylor #1, Pike Co., Illinois (ISGS C12785). Note that grains are poorly-sorted and cement-supported.

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Figure 123: Photographs of bioclastic dolomudstone. (A) Polished hand sample of bioclastic dolomudstone, Dutchtown Formation, Perryville West section, southeast Missouri. Presence of orthcone cephalopod indicates subtidal deposition. (B) Core photograph of ostracodal dolopackstone, Everton Dolomite, 7541 ft. (2298 m), Superior Oil Co., H. C. Ford et al C-17, White Co. Illinois (ISGS C2740). Core is 8-inches (20 cm) in diameter.

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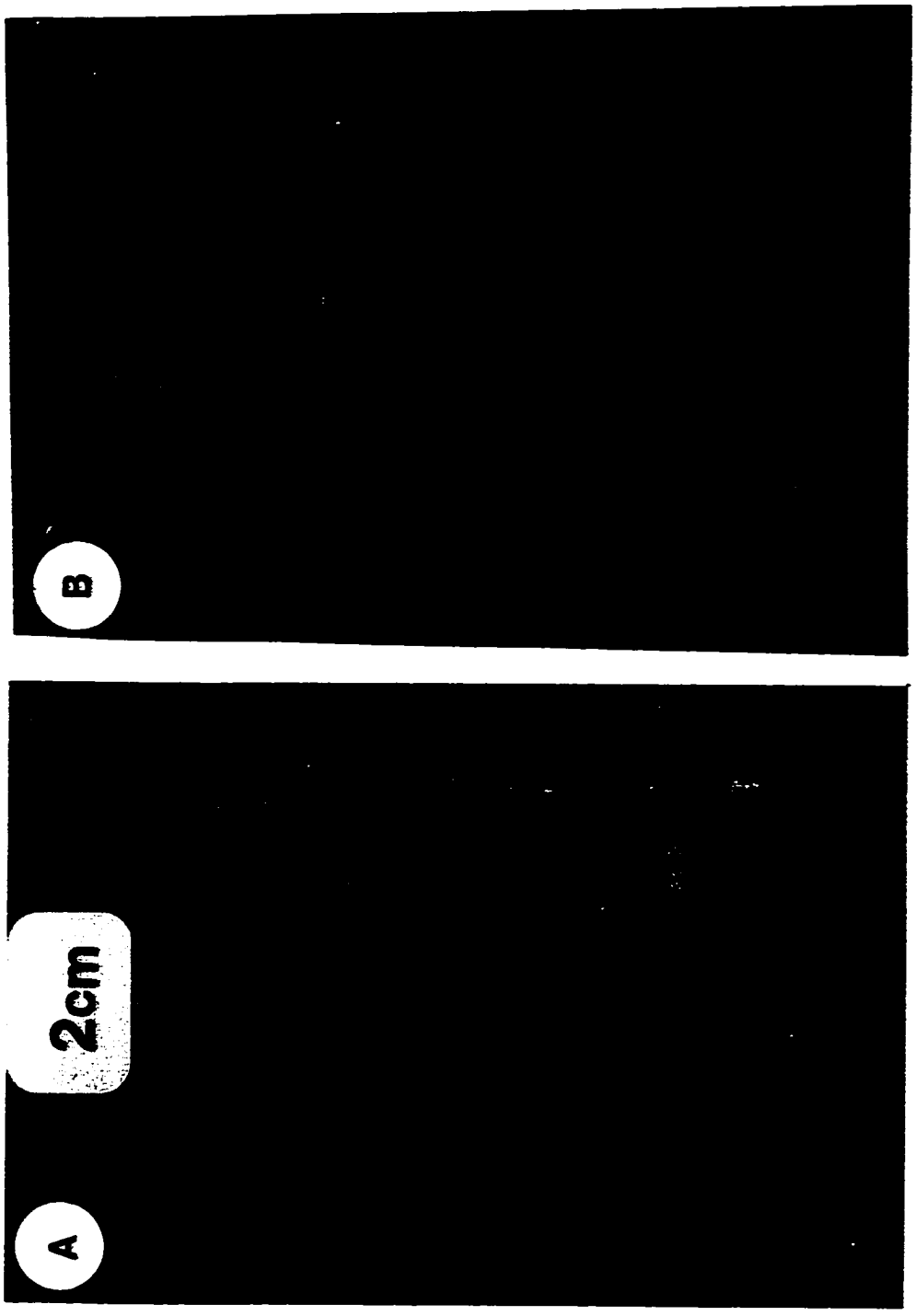

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Figure 124: Photomicrograph (cross-polars) of bioclastic calciwackestone, Joachim Dolomite, 581.5 ft. (177.2 m), D & G Drilling, Elmer Yakley #1, Pike Co., Illinois (ISGS C13068). Note the abundance of trilobite spines and fragmental debris.

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components are ostracodes and sparse trilobites. Centimeter-scale nodular bedding is locally developed,

Stratigraphic and geographic distribution: Common in the Dutchtown Formation, southeast Missouri; Matson Member of the Joachim Dolomite, Indiana, Illinois and southeastern Missouri; the Carntown unit of the lower Black River Limestone, western Ohio; the lower Camp Nelson Limestone, central Kentucky; and the lower Murfreesboro Limestone, western Tennessee.

Discussion: The local abundance of complete ostracodes suggests shallow subtidal, semi-restricted marine conditions. Nodular bedding is developed by early-cementation in the marine phreatic environment.

Lithofacies 37: Stromatolitic boundstone

Description: Brownish-gray (5 YR 4/1) to light-brownish-gray (5 YR 6/1), medium- to thick-bedded, laminated boundstone (Figures 125 and 126). Lower contact is planar; upper contact is domal. Lithofacies is made up of algal/microbial domal structures made up of laminated, micritic carbonate that form domal and digitate morphologies. May be predominantly calcimudstone or dolomudstone. Domes may be up to 2 ft. (0.6 m) in height and 3-6 ft. (1-2 m) in diameter. Bioclastic/intraclastic grainstone, or quartz arenite infill between domal structures.

Stratigraphic and geographic distribution: This lithofacies is restricted to the upper Everton Dolomite, Dutchtown Formation, and Matson Member of the Joachim Dolomite. It may also be present in the lower Murfreesboro Limestone, but its identification is uncertain.

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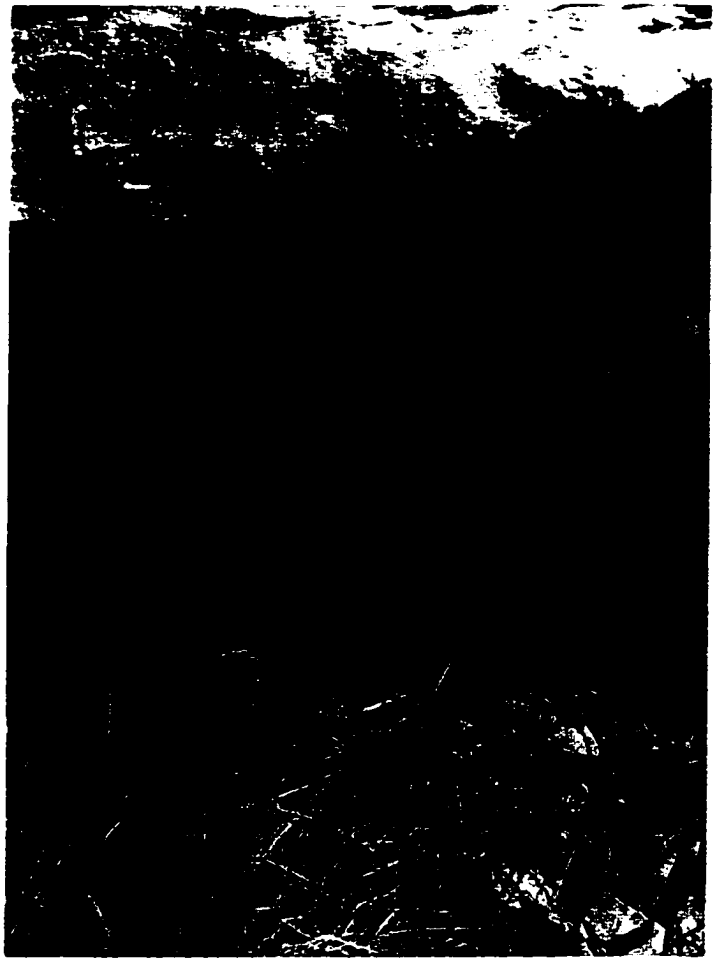

Figure 125: Outcrop photograph of domal stromatolic doloboundstone, Dutchtown Formation, Perryville West section, Perry Co., Missouri. At this locality the lithofacies is dolostone, but further to south, southern Cape Girardeau Co. and northern Scott Co., is mostly limestone (Repetski, 1973, Dutchtown East and Sals Creek localities).

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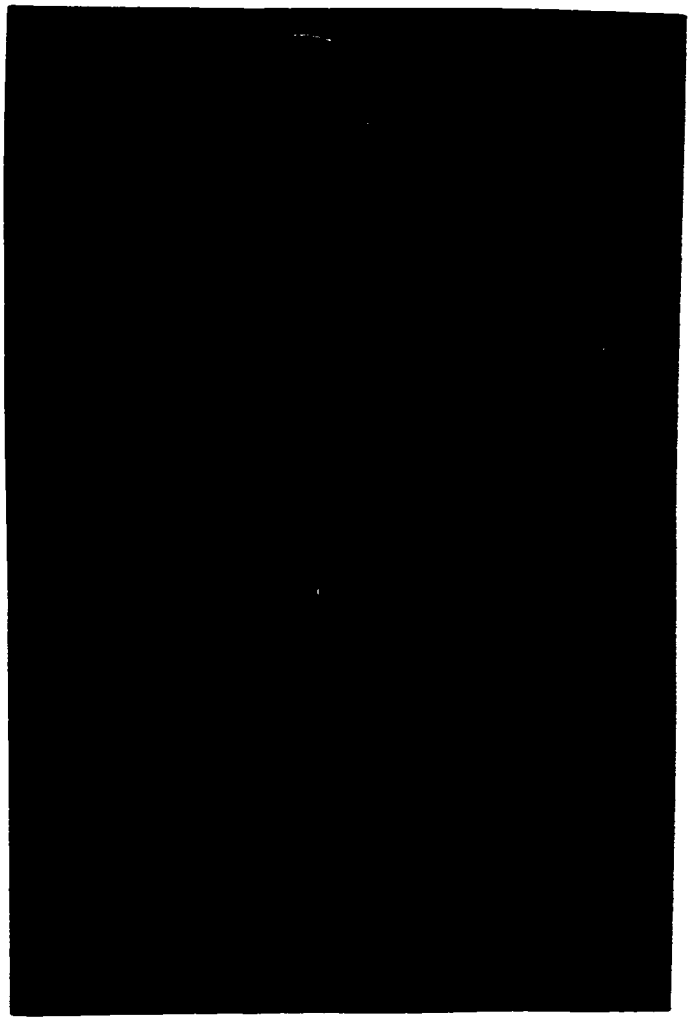

Figure 126: Core photograph of digitate stromatolitic boundstone overlain by intraclastic quartz arenite, Glenwood Formation, 348.25 ft. (106.1 m), Commonwealth Edison, UPH-3, Stephenson Co., Illinois (ISGS C12996). Note truncation of stromatolite just below coin. Core is 2.5-inch core (6 cm) is diameter.

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Discussion: Stromatolitic boundstones are relatively uncommon in modern marine settings, but they were common framework structures in Proterozoic and early Paleozoic nearshore, shallow subtidal environments. Previous workers (McQueen, 1937; Martin and others, 1961; Templeton and Willman, 1963) commonly refer to these structures as "*Cryptozoan* masses".

Lithofacies 38: Oolitic calcigrainstone

Description: Brownish-gray (5 YR 4/1) to medium-dark-gray (N 4), well-sorted, oolitic calicgrainstone containing 40-70% radial, tangential and mixed-character, sand-size ooids; 15-50%, rounded to subrounded bioclasts and intraclasts; and up to 45% mud-size (<0.0625 mm) constituents (Figures 127 and 128). Mud-size constituents included lime-micrite, lime silt, quartz silt, and detrital clay; commonly, content of noncarbonate mud-size fraction increases upsection. Bedding is typically massive, with sharp, erosive, irregular lower contact and gradational or sharp upper contact. Trough cross-stratification is locally well-developed.

Stratigraphic and geographic distribution: Minor amounts of oolitic grainstone are present in the basal Matson Member of the Joachim Dolomite, and associated with stromatolitic boundstone in the Dutchtown Formation. The thickest and most widely distributed Middle Ordovician oolite is the Brickeys Oolite, a member of the Bloomsdale Limestone, that immediately overlies the Matson Dolomite Member in the western half of the Illinois Basin.

Discussion: Oolitic grainstones develop in high energy depositional environments, typically at the margins of carbonate platforms and in the wave surge zone of carbonate ramps. The presence of both radial and tangential ooids implies unstable geochemical

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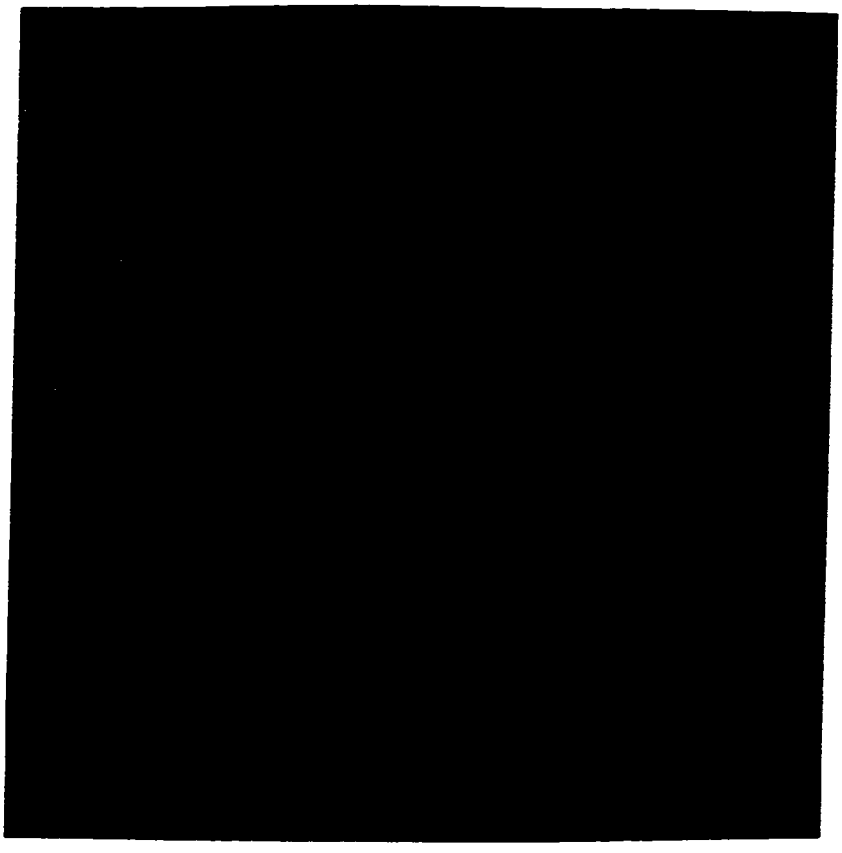

Figure 127: Core photo of fine-grain oolitic calcigrainstone, uppermost Joachim Dolomite, 1858 ft. (566 m), Panhandle Eastern Pipeline Co., Miller 1-16, Morgan Co., Illinois (ISGS C13636). Core is 4-inches in diameter.

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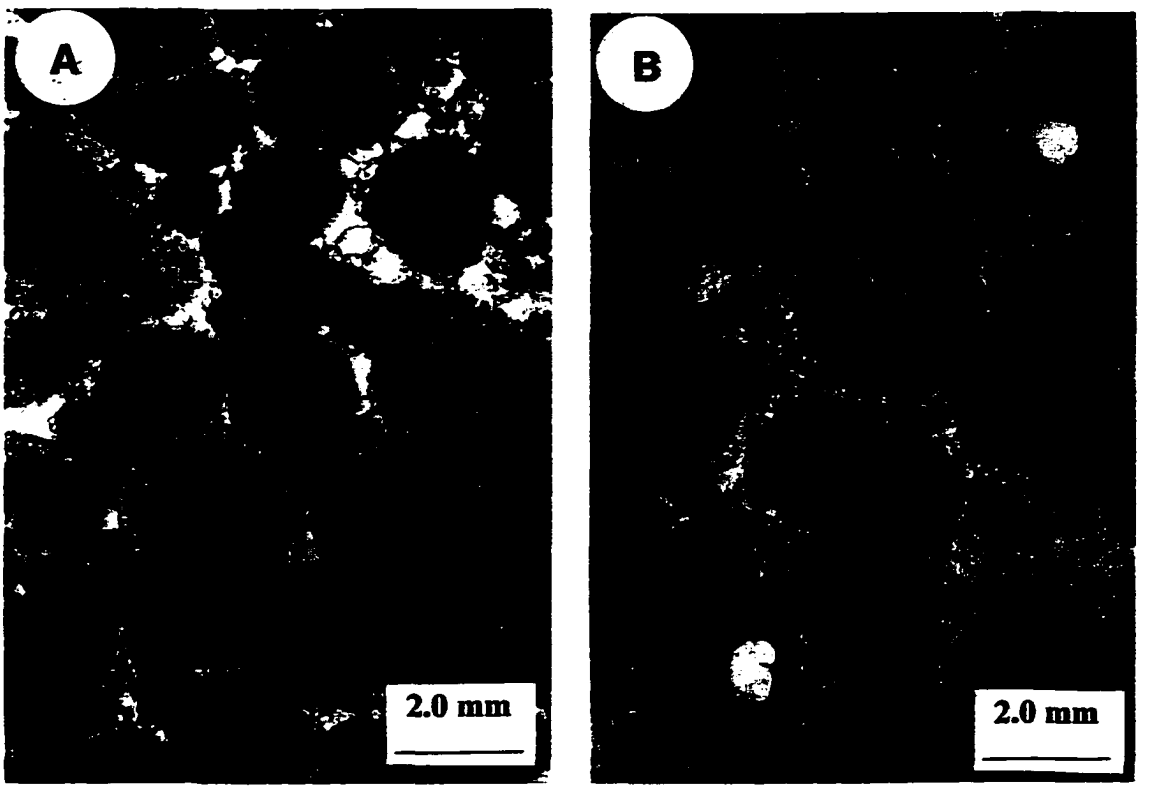

Figure 128: Photomicrograph (cross-polars) of (A) well-sorted oolitic calcigrainstone with tangental-radial ooids, basal Brickeys Oolite, Weber Hill, Jefferson Co., Missouri. Ooids are mostly symmetrical, grain-supported, and lack clastic cores. (B) Oolitic calcigrainstones (plane light) from upper Joachim Dolomite, 20.3 ft. (6.2 m), Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Missouri. Ooids in the Joachim are typically asymmetric, may have clastic cores, and are commonly cement-supported.

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conditions. Schutter (1992) reported that in North American, Ordovician cratonic sediments, ooid grainstones are developed in condensed intervals.

ORGANIC CONSTITUENTS

Sixty-three samples of brown mudrock, or "brown" calci/dolomudstone were submitted for programmed pyrolysis analysis (Rock-Eval) to evaluate the character of the organic constituents. Of the 63 samples analyzed (Table 6), only 18 samples contained sufficient organic matter (TOC > 0.5%) to yield interpretable data. Low total organic content (TOC) of samples may be due to low depositional organic content, or maturation and migration of some organic phases. Peters (1986) discusses the analytical procedure and interpretation of programmed pyrolysis analysis data.

Hydrogen index (HI) is shown plotted versus oxygen index (OI), for samples with sufficiently high TOC to yield reliable results, in Figure 129. Most of the data plot close to the y-axis, indicating the presence of Type I (marine) and Type II (algal/biotic) (Tissot and Welte, 1984; Peters, 1986). Only brown mudrocks within the Joachim Dolomite have *remaining* organic matter of sufficient quantity, and quality to be considered fair- to good-source rocks where thermally mature (Peters, 1986).

Visual inspection of palynological preparations made from several carbonate and laminated carbonaceous mudrock samples indicate organic matter is finely-dispersed and has an amophous character. Complete acritarchs and chitizoan debris are locally present (M. Merrill, Amoco, written communication, 1988). In Tertiary and Recent settings, analogous organic matter is thought to be algal derived (Habib and Miller, 1989; Gregory and Hart, 1992).

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Table 6: Whole rock pyrolysis data for lower-Middle Ordovician rocks, Illinois Basin.

Well Name or Locality	Sample # or Depth (ft.)	Formation	TOC	S_1	S_2	S_3	T_{max}	OI	HI	S_2/S_3	S_2/TOC	PI	Lithology	Source**
Cabot #1	3073'	Dutchtown	1.75	0.59	9.67	0.10	*	6	553	96.70	0.34	0.06	dolomudstone	ISGS
Forbes #1	14610'	St. Peter	[illegible]	0.06	0.03	0.07	*	44	19	0.43	0.38	0.67	brown mudrock	USGS
Ford et al C-17	6844'	Joachim	[illegible]	0.03	0.03	0.13	*	45	10	0.23	0.10	0.50	argillaceous calcimudstone	USGS
Ford et al C-17	70840'	Joachim	[illegible]	0.04	0.01	0.00	*	0	25	n/a	1.00	0.80	oolitic wackestone	USGS
Ford et al C-17	71352'	Joachim	[illegible]	0.17	0.13	0.34	*	189	72	0.38	0.94	0.57	anhydritic calcimudstone	ISGS
Ford et al C-17	71876'	Joachim	0.52	0.44	0.41	0.97	428	187	79	0.42	0.85	0.52	anhydritic calcimudstone	ISGS
Ford et al C-17	71996'	Joachim	[illegible]	0.09	0.07	0.32	*	1067	233	0.22	3.00	0.56	anhydritic dolomudstone	ISGS
Ford et al C-17	72100'	Joachim	[illegible]	0.03	0.02	0.01	*	4	9	2.00	0.13	0.60	anhydritic dolomudstone	ISGS
Ford et al C-17	72179'	Joachim	[illegible]	0.04	0.03	0.07	*	37	16	0.43	0.21	0.57	argillaceous dolomudstone	ISGS
Ford et al C-17	72291'	Joachim	[illegible]	0.18	0.19	0.35	*	875	475	0.54	4.50	0.49	argillaceous dolomudstone	ISGS
Ford et al C-17	72430'	Dutchtown	[illegible]	0.07	0.03	0.36	*	72	6	0.08	0.14	0.70	argillaceous dolomudstone	ISGS
Ford et al C-17	72861'	Dutchtown	[illegible]	0.07	0.08	0.30	*	150	40	0.27	0.35	0.47	argillaceous dolomudstone	ISGS
Ford et al C-17	72977'	Dutchtown	[illegible]	0.11	0.03	0.50	*	111	7	0.06	0.24	0.79	argillaceous dolomudstone	ISGS
Ford et al C-17	73307'	Dutchtown	[illegible]	0.10	0.05	0.23	*	767	167	0.22	3.33	0.67	argillaceous dolomudstone	ISGS
Ford et al C-17	73480'	Dutchtown	[illegible]	0.07	0.40	0.26	*	76	118	1.54	0.21	0.15	anhydritic mudrock	USGS
Ford et al C-17	73680'	Dutchtown	0.51	0.14	0.56	0.21	438	41	110	2.67	0.27	0.20	anhydritic mudrock	ISGS
Ford et al C-17	76080'	Everton	[illegible]	0.04	0.03	0.05	*	28	17	0.60	0.22	0.57	argillaceous dolomudstone	USGS
Ford et al C-17	76760'	Everton	[illegible]	0.02	0.03	0.24	*	800	100	0.13	0.67	0.40	argillaceous dolomudstone	USGS
Geiser Quarry	1	Dutchtown	[illegible]	0.01	0.60	0.38	*	103	162	1.58	0.03	0.02	calcimudstone	ISGS
Geiser Quarry	2	Dutchtown	[illegible]	0.00	0.02	0.19	*	127	13	0.11	0.00	0.00	calcimudstone	ISGS
Gen. Elec. WD-2	7877'	Everton	0.62	0.00	0.17	0.62	*	100	27	0.27	0.00	0.00	dolomudstone	ISGS
GHS #1	17761'	Wells Ck.	1.56	0.54	4.21	0.24	440	15	270	17.54	0.35	0.11	brown mudrock	USGS
GHS #1	18151'	Wells Ck.	[illegible]	0.11	0.18	3.48	*	1740	90	0.05	0.55	0.38	argillaceous dolomudstone	ISGS
GHS #1	18325'	Wells Ck.	[illegible]	0.26	0.18	0.86	*	538	113	0.21	1.63	0.59	brown mudrock	USGS
GHS #1	18456'	Wells Ck.	[illegible]	0.28	0.33	0.61	*	305	165	0.54	1.40	0.46	green mudrock	USGS
GHS #1	18553'	Wells Ck.	[illegible]	0.24	0.29	0.41	*	158	112	0.71	0.92	0.45	green mudrock	USGS
GHS #1	19012'	Wells Ck.	[illegible]	0.06	0.13	0.31	*	282	118	0.42	0.55	0.32	green mudrock	USGS
GHS #1	19095'	Wells Ck.	[illegible]	0.25	0.34	0.29	*	161	189	1.17	1.39	0.42	green mudrock	USGS
GHS #1	19808'	Wells Ck.	[illegible]	0.12	0.12	0.26	*	137	63	0.46	0.63	0.50	green mudrock	USGS
House #1	3360'	Everton	[illegible]	0.05	0.02	0.30	*	1000	67	0.07	1.67	0.71	dolomudstone	ISGS
J. Bell #1	5510'	Dutchtown	[illegible]	0.04	0.03	0.19	*	633	100	0.16	1.33	0.57	argillaceous calcimudstone	KYGS
King #1	32428'	Joachim	1.02	0.36	2.85	0.07	436	7	279	40.71	0.35	0.11	brown mudrock	USGS
King #1	32450'	Joachim	0.87	0.30	1.10	0.14	419	16	126	7.86	0.34	0.21	brown mudrock	USGS
King #1	32518'	Joachim	0.68	0.05	0.35	0.12	418	18	51	2.92	0.07	0.13	brown mudrock	USGS
King #1	3360'	Everton	[illegible]	0.03	0.02	0.23	*	767	67	0.09	1.00	0.60	dolomudstone	ISGS
King #1	33606'	Everton	[illegible]	0.04	0.03	0.24	*	800	100	0.13	1.33	0.57	dolomudstone	ISGS
King #1	33636'	Everton	[illegible]	0.01	0.00	0.22	*	733	0	0.00	0.33	1.00	dolomudstone	USGS
King #1	3364'	Everton	[illegible]	0.04	0.00	0.30	*	1500	0	0.00	2.00	1.00	dolomudstone	USGS
Morell-Lipe #1	3079'	Joachim	1.58	0.36	2.48	0.43	412	27	157	5.77	0.23	0.13	brown mudrock	ISGS
Morell-Lipe #1	3083'	Joachim	[illegible]	0.04	0.26	0.17	*	74	113	1.53	0.17	0.13	brown mudrock	ISGS
Pensinger #1	3169'	Joachim	[illegible]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	dolomudstone	IGS
Pensinger #1	3188'	Joachim	0.90	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	dolomudstone	IGS
Stephans #1	5340'	Dutchtown	[illegible]	0.04	0.02	0.22	*	367	33	0.09	0.67	0.67	mudstone	KYGS
Truitt #1	3067' 6"	Joachim	2.49	1.62	9.95	0.64	426	26	400	15.55	0.65	0.14	stylolitic calcimudstone	ISGS
Truitt #1	3069'	Joachim	4.36	2.02	21.54	0.36	423	8	494	59.83	0.46	0.09	brown mudrock parting	ISGS
Truitt #1	3078' 9"	Joachim	[illegible]	0.29	0.78	0.07	*	17	186	11.14	0.69	0.27	brown mudrock parting	ISGS
Truitt #1	30824'	Joachim	3.10	1.56	11.39	0.23	423	7	367	49.52	0.50	0.12	green mudrock parting	ISGS
Truitt #1	30856'	Joachim	1.79	1.07	5.47	0.35	420	20	306	15.63	0.60	0.16	brown mudrock	ISGS
Truitt #1	30940'	Joachim	1.86	3.87	3.00	0.28	417	15	161	10.71	2.08	0.56	brown mudrock	ISGS
Truitt #1	31468'	Joachim	1.41	0.50	4.32	3.69	432	262	306	1.17	0.35	0.10	brown mudrock	ISGS
Truitt #1	31473'	Joachim	[illegible]	0.08	0.24	0.40	*	91	55	0.60	0.18	0.25	brown mudrock	ISGS
Truitt #1	31481'	Joachim	0.62	0.16	1.05	0.09	427	15	169	11.67	0.26	0.13	brown mudrock	ISGS
Truitt #1	31486'	Joachim	1.32	0.51	3.49	0.18	428	14	264	19.39	0.39	0.13	brown mudrock	USGS
Truitt #1	31500'	Joachim	0.57	0.10	0.48	0.11	420	19	84	4.36	0.18	0.17	brown mudrock	ISGS
Truitt #1	31530'	Joachim	[illegible]	0.02	0.19	0.08	*	17	41	2.38	0.04	0.10	brown mudrock	ISGS
Truitt #1	31533'	Joachim	[illegible]	0.18	0.48	0.15	*	36	114	3.20	0.43	0.27	brown mudrock	ISGS
Truitt #1	31536'	Joachim	0.53	0.25	0.90	0.10	429	19	170	9.00	0.47	0.22	brown mudrock	USGS
Truitt #1	31618'	Joachim	[illegible]	0.08	0.34	0.05	*	24	162	6.80	0.38	0.19	brown mudrock parting	ISGS
Truitt #1	31729'	Joachim	[illegible]	0.03	0.05	0.09	*	150	83	0.56	0.50	0.38	green mudrock parting	ISGS
West Perryville	131.1(92-1)	Dutchtown	0.64	0.00	0.00	0.12	*	19	0	0.00	0.00	n/a	dolomudstone	ISGS
West Perryville	131.3(92-4)	Dutchtown	[illegible]	0.01	0.14	0.07	*	233	467	2.00	0.33	0.07	dolomudstone	ISGS
West Perryville	131.3(92-5)	Dutchtown	[illegible]	0.00	0.00	0.35	*	700	0	0.00	0.00	n/a	dolomudstone	ISGS
West Perryville	131.3(92-8)	Dutchtown	[illegible]	0.00	0.00	0.18	*	1800	0	0.00	0.00	n/a	dolomudstone	ISGS

[illegible] TOC < 0.5, S_2 and HI may be low, T_{max} and OI high.

*S_2 <0.2 or TOC <0.5, T_{max} unreliable

**Sources of data ISGS = Illinois State Geological Survey
IGS = Indiana Geological Survey
KYGS = Kentucky State Geological Survey
USGS = U. S. Geological Survey

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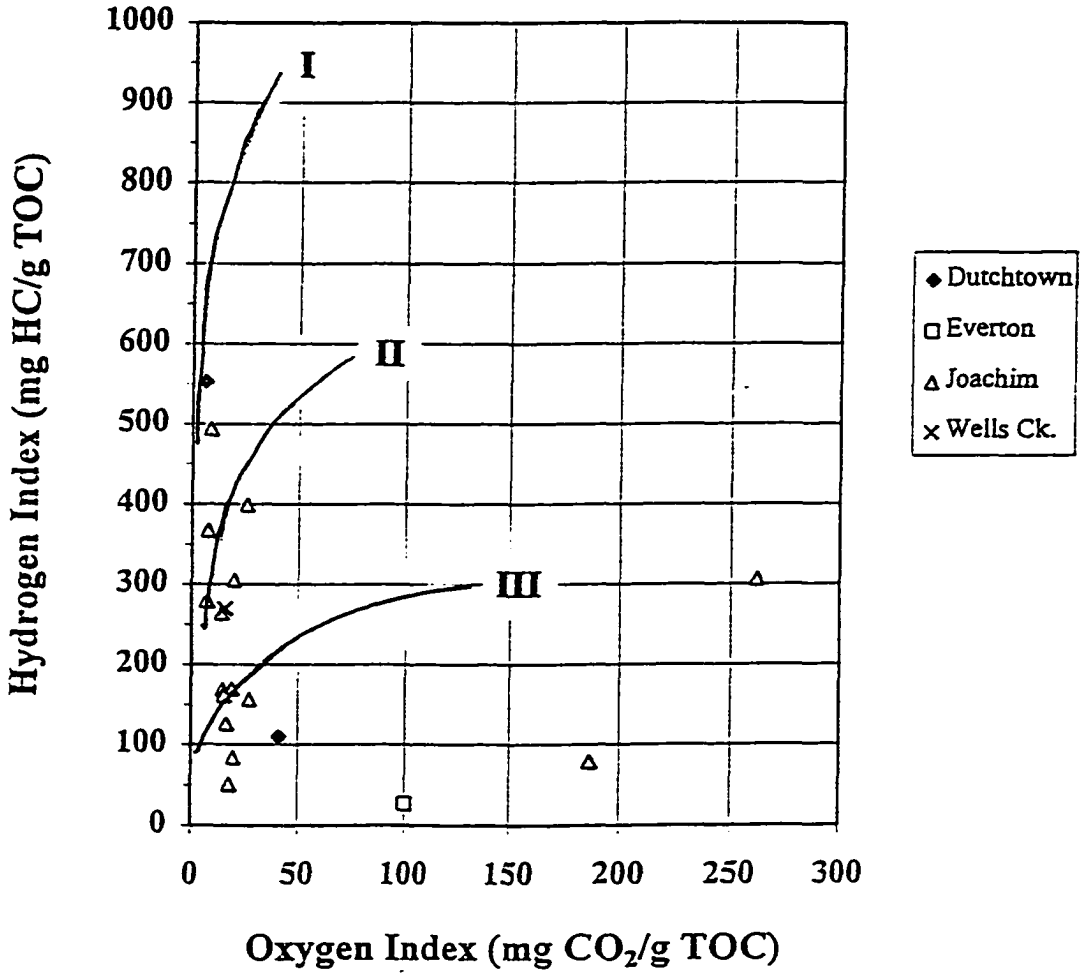
Figure 129

Oxygen versus hydrogen indices, lower-Middle Ordovician rocks, Illinois Basin.



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EVAPORITES

The present day distribution of Middle Ordovician evaporites in the Illinois Basin is geographically restricted due to post-depositional dissolution. Therefore, the interpreted paleodistribution of the evaporites within the Ancell, and correlative strata, is based upon direct observation, where evaporites are preserved, or inferred from: 1) sedimentary structures, 2) geochemical data, 3) faunal constituents and 4) utilizing modern analogs of lithofacies distributions. The initial discussion will focus on the Joachim-Dutchtown interval, and intervals within the St. Peter Sandstone and Everton Dolomite, where preserved evaporites are present and/or relatively unequivocal, evaporite-related sedimentary structures are present, and will be expanded later to include indirect evidence that evaporites were wide-spread in the clastic lithotopes (St. Peter Sandstone and lower Everton Dolomite).

Calcium-sulfate (anhydrite/gypsum)

Anhydrite was, and is, a common to abundant constituent of the Everton Dolomite, upper Dutchtown Formation and Joachim Dolomite, but its present day distribution is limited to the subsurface in a comparatively small area of the central Illinois Basin (Figure 130). Although lenticular and tabular pseudomorphs suggest that gypsum was once present, anhydrite is the only sulfate mineral found in this interval and it is the only known evaporite mineral within lower-Middle Ordovician strata of the Illinois Basin. Given that nearly all the anhydrite-bearing strata in the study area have attained thermal maturities in excess of 95° C (203° F), the temperature at which the dehydration

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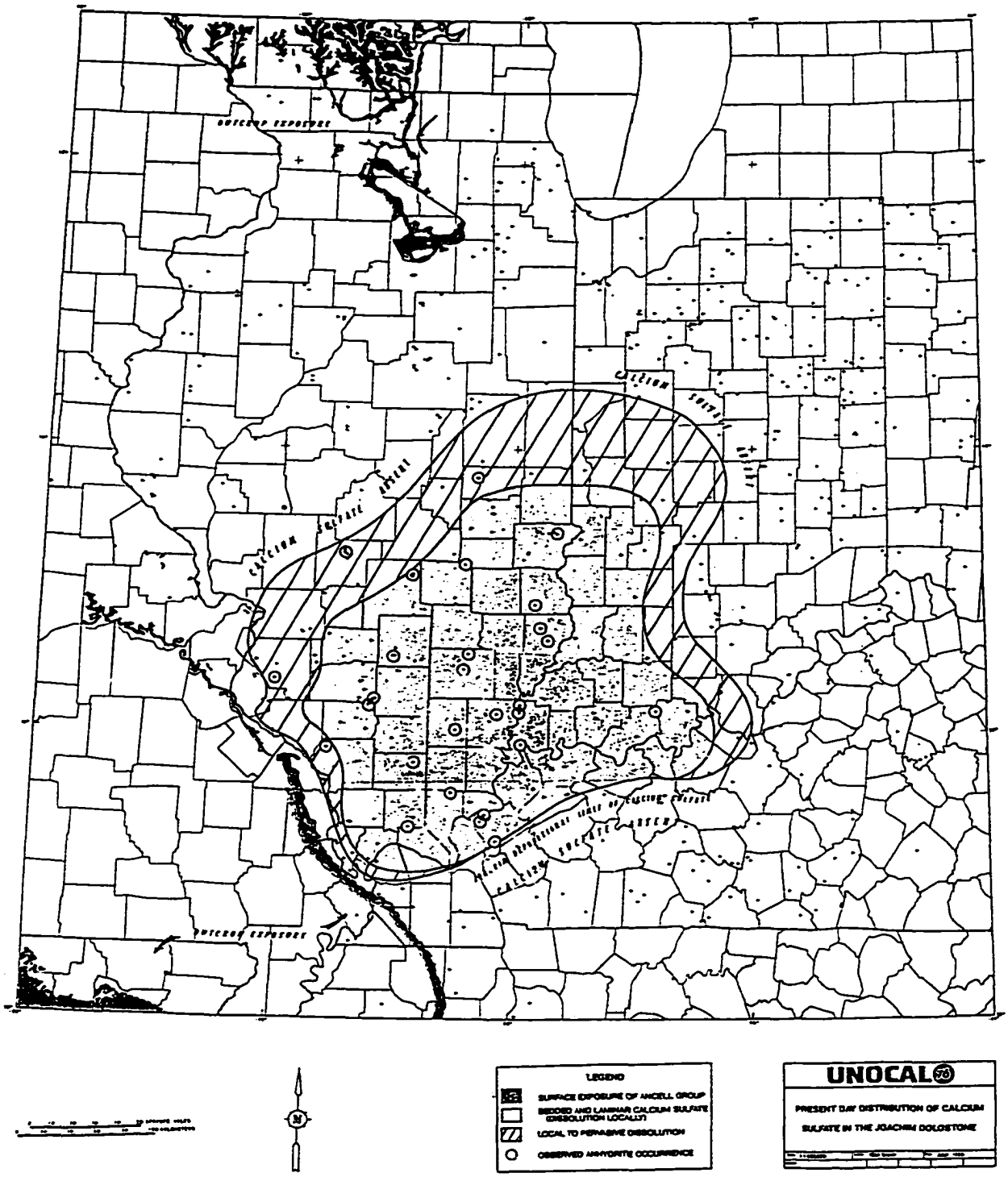

Figure 130: Present day distribution of anhydrite in the Joachim Dolomite. Note that anhydrite occurrences on the margin of the distribution (hatchered) are limited to low permeability lithologies.

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of gypsum to anhydrite is complete (Jowett and others, 1993), the absence of gypsum *per se* is not surprising.

Laminated and thin-bedded anhydrite, nodular anhydrite and anhydrite-bearing dolomudstones locally constitute up to 60% (Saxby, and Lamar, 1957; Okharvi and Carozzi, 1983), by volume, of the Joachim Dolomite cored in the Superior Oil Co., H. C. Ford et al C-17 well, White Co., Illinois (Figure 131). The Ancell Group in this core has been described in exhaustive detail by Dr. T. C. Buschbach (unpublished core description, ISGS well files), and has the Joachim interval has been the subject of a detailed petrographic study by Okharvi and Carrozi (1983).

Anhydrite is present in the subsurface as massive laminae and in thin-beds composed of finely-crystalline lathes, and rare nodular morphologies associated with the dolomudstone and laminated dolomudstone lithofacies. Coarsely-crystalline laths and isolated "patches" locally occur in dolowackestone and dolopackstone lithofacies. Locally, anhydrite infilled fractures are associated with anhydrite-bearing intervals. As noted by Okharvi and Carozzi (1983) the abundance of anhydrite increases upsection within genetically related successions.

Laminated and thin-bedded anhydrite (Figure 132) associated with the laminated and massive dolomudstone lithofacies appear to be analogous to the supratidal and shallow-

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Figure 131: Core photos of (A) Interbedded anhydrite (light gray) and calcimudstone (brown) (7088 ft. or 2160 m), and (B) anhydritic patterned dolomudstone (7180 ft. or 2188 m), Joachim Dolomite, Superior Oil, H. C. Ford et al C-17, White Co., Illinois (ISGS C2740). Both lithologies are 30-40% anhydrite by volume. Core is 8-inches (20 cm) in diameter.

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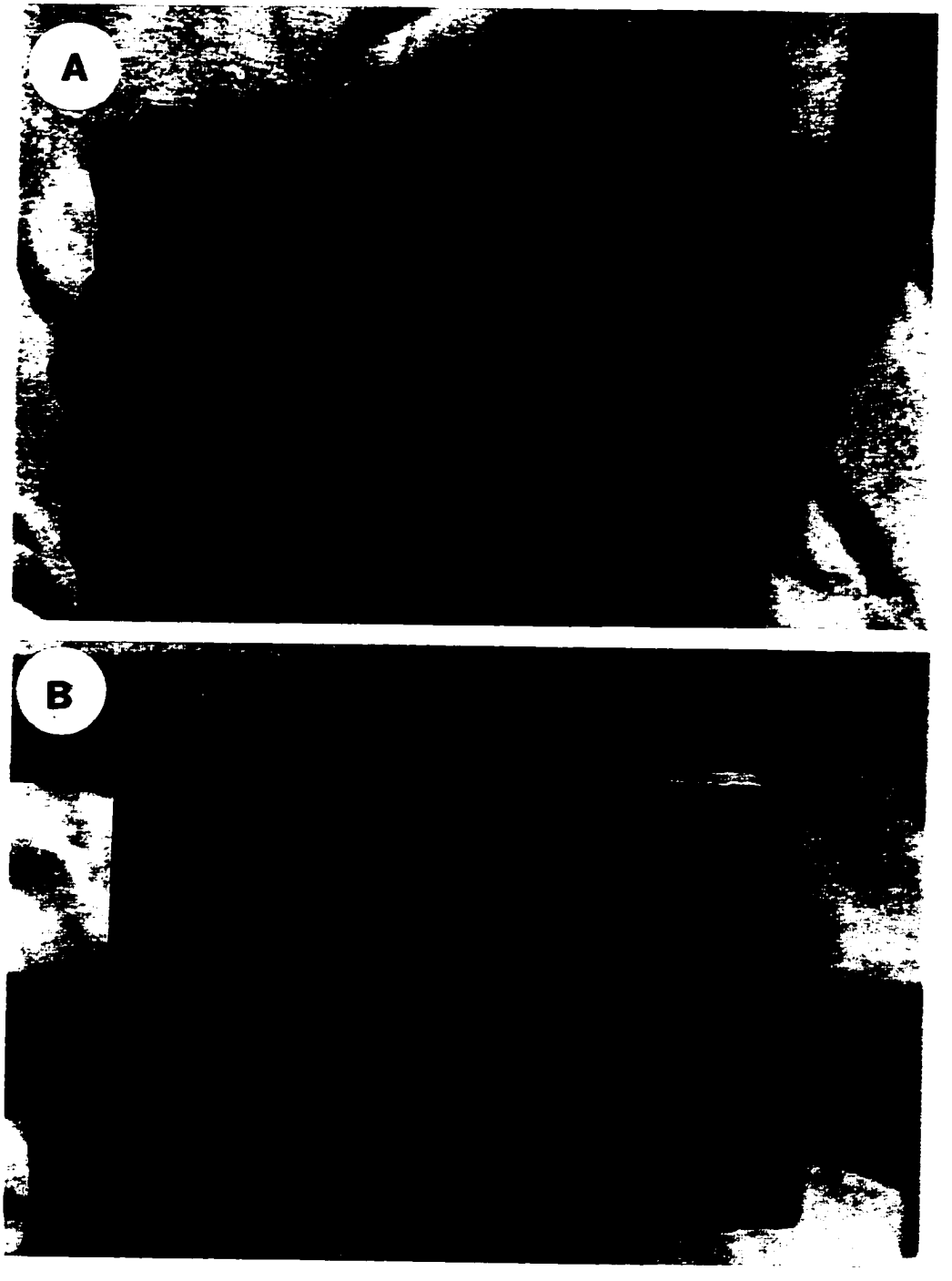

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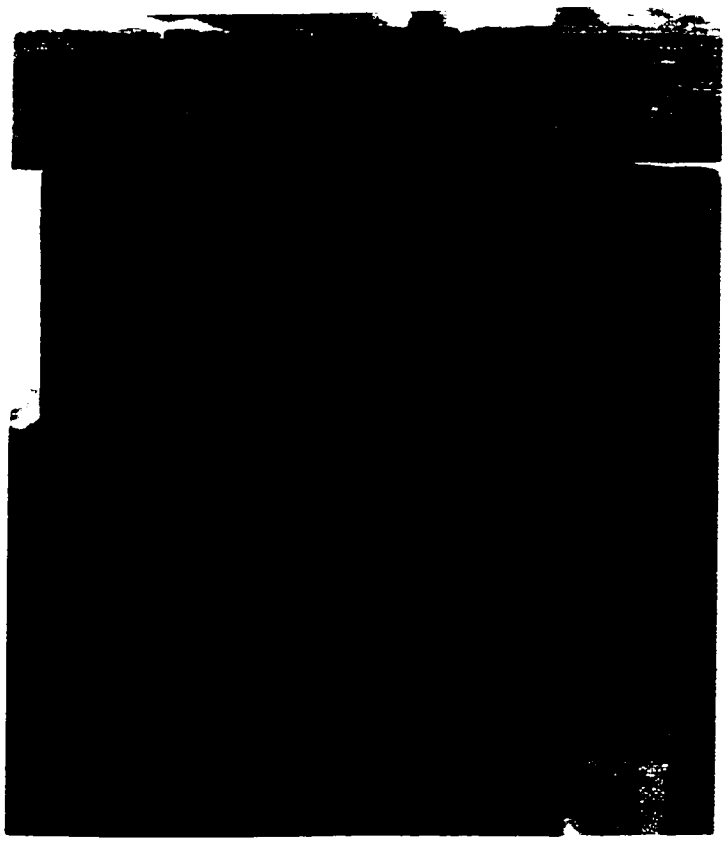

Figure 132: Core photo of laminated anhydritic calcimudstone, Joachim Dolomite, 7195 ft. (2193 m), Superior Oil Co., H. C. Ford et al C-17, White Co., Illinois (ISGS C2740). Core is 8-inches (20 cm) in diameter, scale in inches.

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water laminated sulfates reported from the Messinian of Italy (Schreiber, 1978), Recent salinas in Australia (Warren, 1982), and Recent sabkhas of the Al-Khiran region, Kuwait(Gunatilaka and Shearman, 1988). It is probable, based on lenticular-shaped pseudomorphs preserved in underlying dolomudstones, that the primary mineralogy was gypsum, but pervasive dehydration with burial has destroyed all primary features. Interlaminated dolomudstones and calcimudstones tend to be organic-bearing and contain a locally abundant, low diversity ostracode macrofauna, and an abundant, monospecific conodont fauna dominated made up of fibrous, hyaline forms.

These sediments were probably originally deposited in laterally extensive, shallow ponds that form after the sabkha is flooded by storm surge in areas of negative relief. Locally, ponds may persist where tidal channels provide communication with the adjacent marine basin. The lack of medium- or thick-bedded massive anhydrite, and the general absence of subtidal indicators in interbedded/laminated carbonates suggests that the bulk of the sediments were deposited in peritidal environments.

The isolated "patches" of anhydrite (Figures 133) appear to be the product of neomorphic replacement of calcite and infilling of oomoldic and biomoldic porosity, and suggest sulfate has been locally remobilized. In the H. C. Ford et al C-17 core this type of anhydrite is common in the upper Everton Dolomite and is associated with overlying bedded anhydrite in the Joachim Dolomite. The mobility of sulfate in the subsurface is further demonstrated by fractures infilled by anhydrite observed in core of the Joachim Dolomite in the Illinois Power, Morrell-Lipe #1 and Truitt #1, Montgomery

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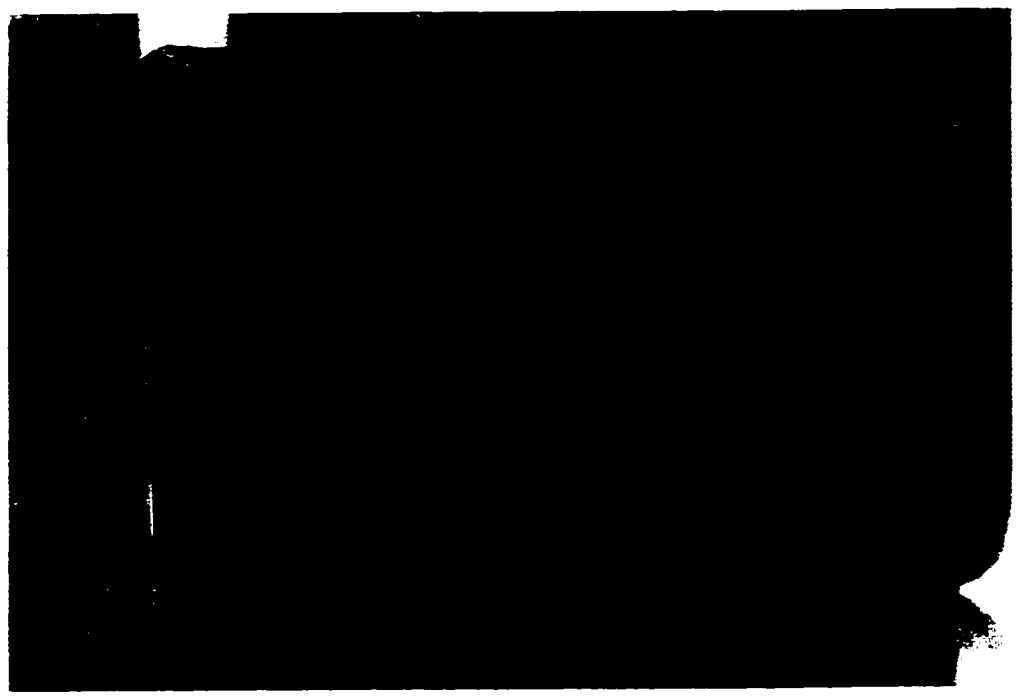

Figure 133: Core photograph of coarsely-crystalline anhydrite laminae (medium-gray) and neomorphic anhydrite "blebs" in anhydritic laminated dolomudstone, Joachim Dolomite, 7145.6 ft. (2178 m), Superior Oil Co., H. C. Ford et al C-17, White Co., Illinois (ISGS C2740). Core is 8-inches (20 cm) in diameter, scale in inches.

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Co., Ill., and of the upper Everton Dolomite and Joachim Dolomites, in the Superior Oil, H. C. Ford et al C-17, White Co., Ill.

Nodular anhydrite (Figure 134) is uncommon in the H. C. Ford et al C-17 core and is limited to the upper Everton and uppermost Joachim Dolomite. Locally, subelliptical chert nodules, probable replacement after nodular sulfate, are preserved in outcrops of the Boles Member, upper Joachim Dolomite, in southeastern Missouri (Figure 135). They are sufficiently common that they were used to designate the base of the Rock Levee Formation; however, they are uncommon elsewhere in the basin and as a result, the use of the term Rock Levee has been abandoned.

The presence of dolomitized "nodular" fabrics (Figures 84 and 85) in stratigraphic the St. Peter Sandstone of central Illinois are interpreted, herein, as replacement after nodular calcium-sulfate cement. Pervasive dolomitization has destroyed the primary sedimentary fabrics; however, the incorporation of quartz grains into the nodules (Figure 85) suggest that the nodular fabric developed quickly and nondisplacively.

The present day stratigraphic occurrence of anhydrite is mainly limited to the Joachim Dolomite and the uppermost Dutchtown Formation. To map the regional occurrence of anhydrite-bearing lithologies, the geophysical log character of anhydrite-bearing rocks was determined by studying the geophysical log character of intervals known to be anhydrite-bearing from core and sample descriptions. In addition to the sample sets examined, sample descriptions by Freeman (1953), Stevenson and others (1975), unpublished ISGS sample descriptions, and company mud logs were used.

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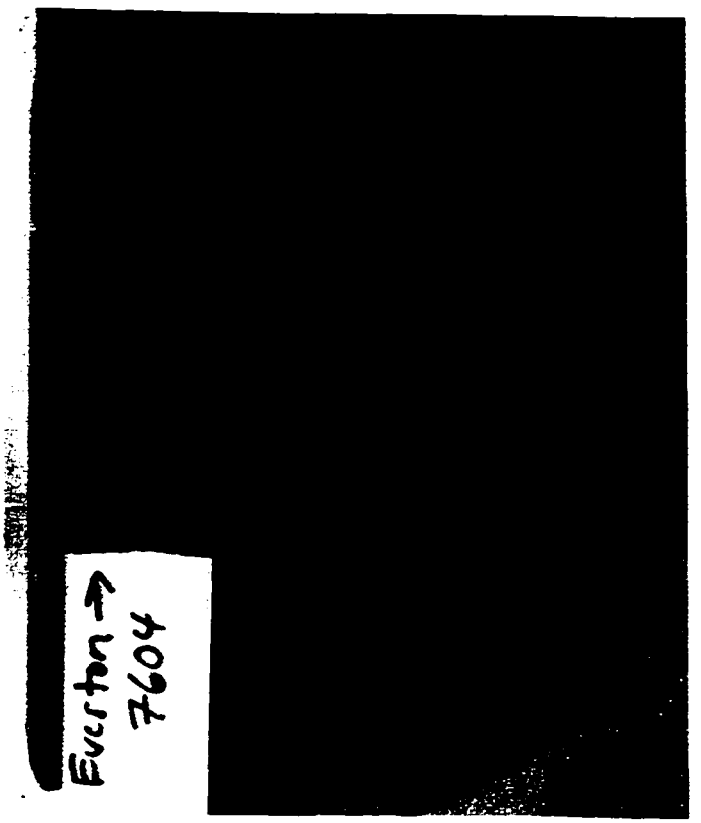

Figure 134: Core photo of nodular anhydrite in upper Everton Dolomite, 7604 ft. (2317.7 m), Superior Oil Co., H. C. Ford et al C-17, White Co., Illinois (ISGS C2740). Nodules are partially calcified and adjacent dolomudstone matrix has "clotted" texture. Core is 8-inches (20 cm) in diameter.

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Figure 135: (A) Silicified calcium-sulfate nodule and (B) subelliptical vugs resulting from dissolution of nodular calcium sulfate, upper Boles Member, Joachim Dolomite, Weber Hill section, Missouri. This chert-bearing horizon defined base of Rock Levee Formation (obsolete term). Associated dolomustones contain abundant (10-15% by volume) halite and gypsum pseudomorphs.

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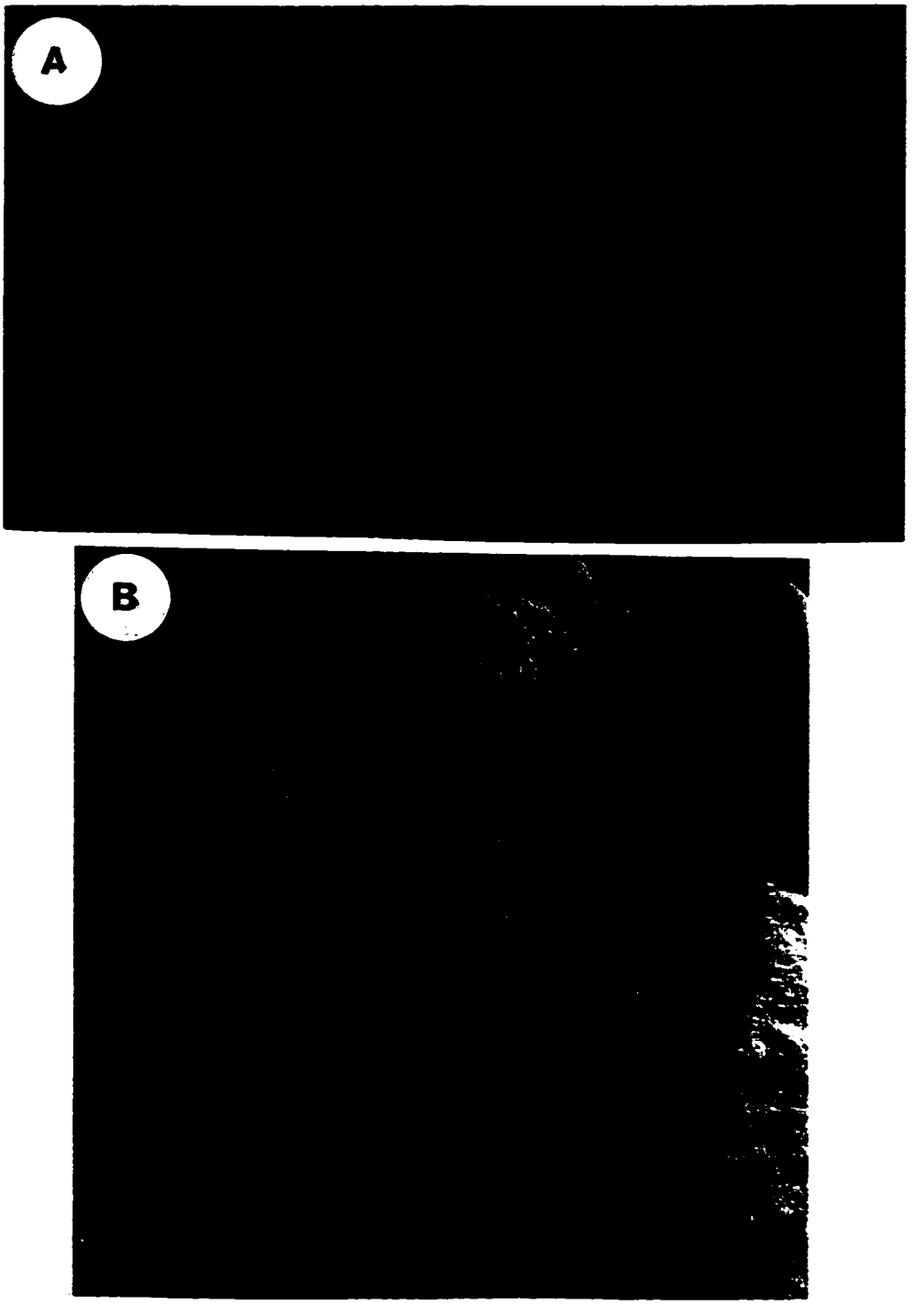

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Massive anhydrites in the Joachim are generally identifiable on geophysical logs using a combination of two, or more of the following geophysical log characteristics: elevated bulk density (generally >2.9 g/cc), low neutron-porosity, low to moderate gamma-ray values, shallow SP deflection, photoelectric absorption coefficient (P_e) of 5.05.

Identification of anhydrite-bearing, Ancell Group lithologies on geophysical logs alone is difficult. Quartz arenites with variable volumes of anhydrite cement are present in core from the St. Peter Sandstone (Texaco, Cuppy 1, Hamilton Co., Ill., Superior Oil, H. C. Ford et al C-17, White Co., Ill.), but the percent of anhydrite by volume (<5%) is insufficient to produce a diagnostic log response. Carbonates containing anhydrite produces a similar geophysical log responses as other mixed lithologies. Dolomite has a bulk density of 2.88 g/cc and a P_e of 3.14, and calcite has a bulk density of 2.71 g/cc and a P_e of 5.08; Dewan, 1983). Therefore, in the absence of a modern suite of logs, anhydrite-bearing lithologies cannot be reliably identified unless cutting descriptions are available. As a result of these factors, the database for mapping of anhydrite-bearing Joachim dolomite strata has been limited to those wells for which core and/or cutting descriptions are available. These occurrences used are summarized in Table 7.

The absence of core and poor quality of cutting samples available for the Everton Dolomite in the central Illinois Basin has greatly hampered the mapping of anhydrite-bearing intervals in this horizon. Sparse, nodular and thin-beds of anhydrite and anhydrite-bearing dolostone are present in core from the middle and upper Everton in the

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Table 7: Occurrence of anhydrite in the Illinois Basin subsurface

Map ID*	Well Name	County	State	Data source			Gross Interval (ft.)	Formation
				log	core	cut.		
24	Velsicol Chemical 1	Clark	Illinois	x	x		4092-4111	Joachim
50	S. Shoulders 21	Crawford	Illinois	x			4950-4994	Joachim
52	L. Willenborg 1-A	Cumberland	Illinois	x		x	5370-5420	Joachim
59	Cabot 1	Douglas	Illinois	x	x		4095-4120	Joachim
70	Weaber Horn Unit 1	Fayette	Illinois	x		x	4306-4375	Joachim
79	Cuppy 1	Hamilton	Illinois	x	x	x	7340-7445	Joachim
89	Leiner 1	Jackson	Illinois			x	3900-3975	Joachim
93	Farley Unit 1	Johnson	Illinois	x		x	5060-5790	Joachim
104	E. Leighty A/C 1-93	Lawerence	Illinois	x		x	5340-5378	Joachim
106	J. B. Lewis #77	Lawerence	Illinois	x		x	5028-5066	Joachim
123	R. S. Johnson 1	Marion	Illinois			x	5090-5160	Joachim
169	Bejma 2	Perry	Illinois	x		x	4810-4835	Joachim
179	Mary Streich 1	Pope	Illinois	x		x	6640-6705	Joachim
188	Vale 1	St. Clair	Illinois	x	x		1940-1951	Joachim
217	Borowiak 1	Washington	Illinois	x		x	5405-5500	Joachim
221	Cisne Community 1	Wayne	Illinois	x		x	6960-7040	Joachim
223	Garrison et al 1	Wayne	Illinois	x		x	6740-6810	Joachim
224	H. C. Ford et al C-17	White	Illinois		x	x	7094-7230	Joachim
225	Winter-Renshaw Comm. 1	White	Illinois	x			7575-7618	Joachim
235	Harris Unit 1	Williamson	Illinois	x		x	7150-7320	Joachim
385	Ford-Corbin Farms Unit 1	Posey	Indiana	x		x	7160-7820	Joachim
386	General Electric WD-2	Posey	Indiana	x		x	7493-7512	Joachim
418	St. Meinard Archabbey 1	Spencer	Indiana	x			3754-3802	Joachim
481	Ray James 1	Crittenden	Kentucky	x		x	4530-4790	Joachim
482	Harry Schaffer Unit 1	Crittenden	Kentucky	x			4485-4565	Joachim
224	H. C. Ford et al C-17	White	Illinois		x	x	7230-7364	Dutchtown
480	M. D. Davis 1	Crittenden	Kentucky	x	x		4480-4554	Dutchtown
190	Webber Unit 1	Saline	Illinois	x		x	8465-8617	Everton (?)
50	S. Shoulders 1	Crawford	Illinois			x	5200-5320	Everton
70	Weaber Horn Unit 2	Fayette	Illinois	x		x	4375-4411	Everton
217	Borowiak 1	Washington	Illinois	x		x	6008-6064	Everton
224	H. C. Ford et al C-17	White	Illinois		x	x	7509-7663	Everton
386	General Electric WD-2	Posey	Indiana	x		x	7878-7903	Everton
473	Cherry 1	Calloway	Kentucky			x	2295	Everton

*See appendices for locations

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Superior Oil, H. C. Ford et al C-17, White Co., Ill. Based on insoluble residues, sample descriptions and geophysical logs, anhydrite appears to be present in the lower Everton Dolomite in Texaco, Cuppy 1, Hamilton Co., southern Illinois, and Maxus Energy, James 1 and Shell Oil, Davis 1, Crittenden Co., western Kentucky. Due to inadequate biostratigraphic control it is uncertain if some (or all) of these "lower Everton" strata should be assigned to the upper Shakopee Dolomite, or a transitional zone analogous to, and probably correlative, with the Middle Ordovician "Brazos" shale interval (Fisher and Barratt, 1985) of the Michigan Basin.

Calcite infilled pseudomorphs after gypsum are present in the lower Wells Creek strata coeval with the Everton. Particularly compelling evidence for hypersaline conditions is provided by pseudomorphs after reworked gypsum (Figure 136); the reworking of crystalline gypsum implies that the water body was sufficiently saline to preclude the dissolution of gypsum clasts. Because the Wells Creek was deposited near the mouth of the early-Middle Ordovician embayment, and assuming an arid to semi-arid climate, this implies salinity was elevated throughout the embayment, except where significant volumes of nonsaline, terrestrial groundwater contributed to the paleogeohydrological system.

Halite

Although pseudomorphs after halite provide evidence of its presence in the past, there are no reliable reports of mineral halite, or other "evaporite" salts from early-Middle Ordovician rocks of the Illinois Basin. The possibility that halite may be present in the central basin cannot be completely discounted because most wells penetrating the early-

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Figure 136: Photomicrograph (cross-polars) of pseudomorphs after detrital calcium-sulfate, Wells Creek Dolomite, 1972.9 ft. (601.4 m), Du Pont, Inc., Geohydrological Survey #1, Humphreys Co., Tennessee. Note siliceous pseudomorphs of tabular morphology (at arrow) and scattered cleavage fragments.

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Middle Ordovician succession have been drilled with undersaturated, freshwater-based drilling fluids.

Rhombic pseudomorphs and pseudomorphs of "hopper" crystals are widespread (Arkansas, Handford and Moore, 1976; Missouri and southern Illinois, Okharvi and Carozzi, 1983). A particularly good example is the carbonate-infilled, hopper-shaped salt cast illustrated by Okharvi and Carozzi (Plate 3, fig. B, 1983). In the type area of the Boles and Defiance Members (Joachim Dolomite), salt casts make-up 10-15% of the rock volume of laminated and thin-bedded dolomudstones that occur at the top of meter-scale depositional cycles (Figure 137).

The poor preservation state of most salt-casts and their diminutive size (<0.5 cm) make it difficult to determine if they formed displacively within the Joachim Dolomite sediments (i.e., Shearman, 1981), or were precipitated in the overlying brine-body at the water-air interface (i.e., Dellwig, 1955). The hopper-cast pseudomorphs observed in cores and outcrops are rhombic and pseudorhombic, crystal-moldic pores that lack diagnostic crystal growth boundaries. However, both the specimen illustrated by Okharvi and Carozzi (1983) and those reported from northeast Arkansas by Handford and Moore (1976) show asymmetrical intergrowth with the matrix. These features suggest that they grew displacively within unlithified sediments (Gornitz and Schreiber, 1981). And, if asymmetric growth can be interpreted as indicating the direction of brine movement (Newhouse, 1941), the preferred, downward-growth orientation indicates that the fluids were being drawn upward from the water table by evaporative pumping (Handford and Moore, 1976).

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Figure 137: Rhombic void spaces interpreted as pseudomorphs after halite in laminated dolomudstone in Joachim Dolomite, northbound lane of U. S. Interstate 55, Zell West section, southeast Missouri.

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The presence of halite pseudomorphs indicates that evaporation rates were high enough to result in suitable conditions for halite deposition and preservation within a few meters of the sediment-water/air interface. However, their diminutive size, low overall abundance and restricted stratigraphic occurrence, suggests that the following factors, or combination of factors, prevented the widespread deposition and/or preservation of halite: 1) arid conditions were not persistent enough to prevent the meteoric dissolution, 2) basin circulation was not sufficiently restricted and evaporative brines were diluted by undersaturated marine waters, and/or 3) penecontemporaneous influx, possibly seasonal, of undersaturated groundwater that diluted evaporative brines, and/or resulted in halite dissolution.

Negative evidence, such as the absence of bedded halite in the subsurface, of pseudomorphs after "foundered mats" of hopper crystals, and/or extensive solution collapse strongly implies, though does not discount, that the Joachim-Dutchtown waters were,on the whole, undersaturated with respect to halite and direct precipitates were not widely deposited. This observation is supported by present-day Cl/Br (259 ± 18) and Na/Br (138 ± 8) ratios for Ordovician aquifers, that are relatively uniform and approximate that of modern sea water (Cl/Br = 286-292; Na/Br = 161; Riley and Chester, 1971; Millero, 1974), interpreted to indicate that although formation waters in Middle Ordovician rocks contain a remnant evaporite brine component, there is little evidence for significant halite dissolution in the subsurface (Walters and others, 1990; Stueben and Walter, 1994).

These observations do not completely preclude the possibility that significant volumes of halite may have been present within the Joachim-Dutchtown sediments in the

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past. First, although specific details are unavailable for approximately half the data set, the samples analyzed by Walters and others (1990) are primarily from central Illinois (Champaign, Douglas Co., and Piatt Co.'s) where groundwater dissolution has already removed most evaporite components, and where formation fluid chemistry has been somewhat influenced by Pleistocene glacial meltwater recharge. Second, vertical diffusion (Ranganathan, 1991), and/or lateral migration of groundwater (Bethke, 1986) of dissolved salts may have removed significant volumes of halite from the Illinois Basin prior to the establishment of the present-day hydrogeologic system. Based on numerical modeling of vertical diffusion, Ranganathan (1991) estimated that halite beds up to 130 m thick could have been completely removed from Cambrian sediments in the central basin. Third, any geochemical contribution by halite dissolution from the comparatively thin, potential halite-bearing intervals of Joachim-Dutchtown interval to the Ordovician aquifer system may be diluted by the geochemical contribution of the thicker, interbedded, overlying and laterally equivalent normal marine carbonates. As a result, it is uncertain if present-day groundwater chemistry provides indirect evidence for the composition of Ancell Group sediments at the time of deposition, or during early burial.

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Non-mineral specific indications of evaporite deposition

Less than 10% of the study area contains anhydrite-bearing strata. Sedimentary structures in carbonates at a number of outcrop localities in southeastern Missouri and in core from central Illinois provide evidence that calcium-sulfate and minor amounts of halite were deposited over a much greater area than the current distribution of evaporites would indicate. Three lines of evidence suggest that evaporites were volumetrically important and widely distributed throughout the study area and that, in contrast to their present distribution, the proportion of sedimentary evaporites increased toward the basin margins.

First, dissolution fabrics are widespread within the Joachim Dolomite carbonates and within the lower Everton Dolomite. Joachim collapse breccias range in scale from microscopic (Figure 138), to bed-scale (Figure 139), to outcrop scale (Figure 140). In most cases, overlying beds are undeformed, implying that dissolution of evaporites is post-lithification.

Okharvi and Carrozi (1983), based on lithofacies relationships, interpreted these breccias as being the product of halite dissolution. Given the potential paleo-environmental implications of halite deposition and lacking direct evidence for the composition of the dissolved phase, I prefer the more general interpretation that these breccias are a product of post-lithification dissolution of evaporites.

Within the Joachim Dolomite, this lithofacies was deposited proximal to the paleoshoreline, as evidence by its association with exposure surfaces, its increasing abundance laterally toward all basin margins with a presumed decrease in paleo-

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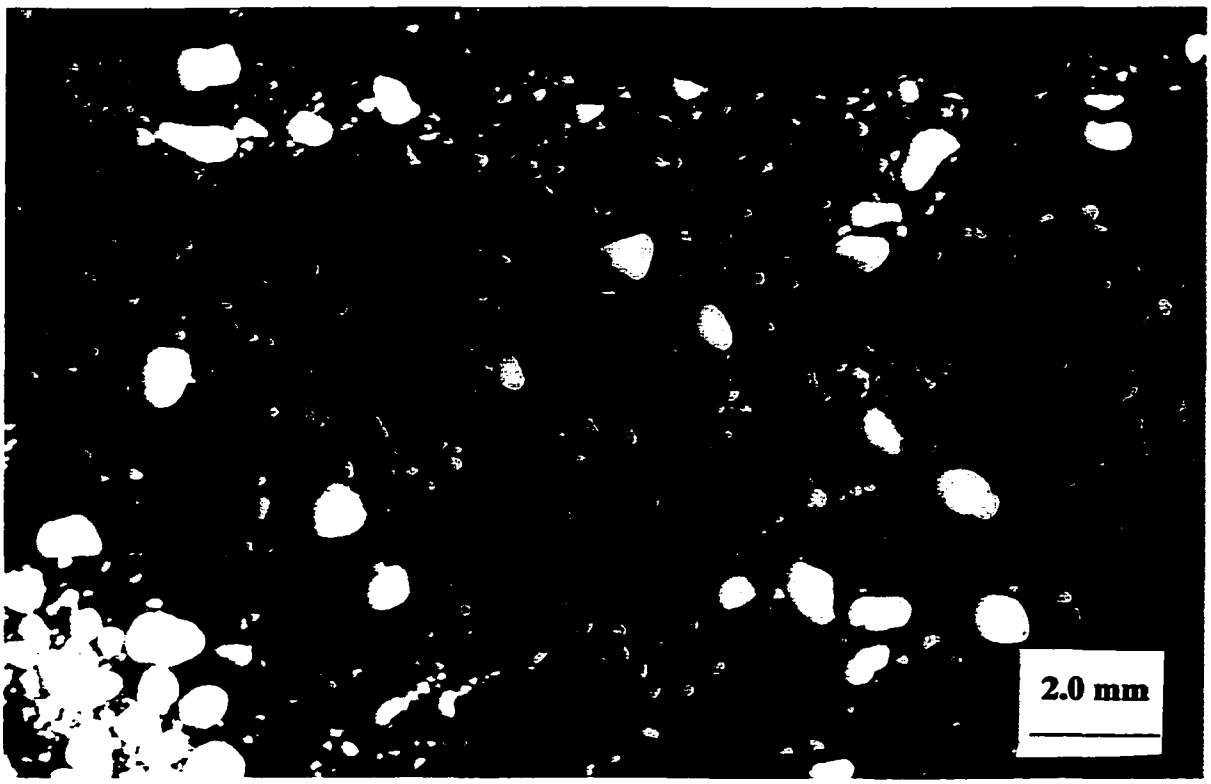

Figure 138: Photomicrograph of collapse breccia, 1001 ft. (305 m), Joachim Dolomite, Pike County Gas Association, Conkright 2, Pike Co., Illinois (ISGS C3500). Note amorphous, "clotted" fabric of matrix of pseudoclasts, concentration of quartz grains and organic matter along pseudostylolite and abundant microcrystalline porosity with irregular pore throats (blue epoxy).

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Figure 139: Core photos of collapse breccias. (A) centimeter scale dissolution dolobreccia, Wells Creek Dolomite, 1998.8 ft. (609 m), Dupont, Inc., Geohydrological Survey #1, Humphreys Co., Tennessee (coin is 1.7 cm diameter); and (B) Everton Dolomite, 7517 ft. (2291 m), H. C. Ford et al C-17, White Co. Illinois (8-inch core, ISGS C2740). Note clotted appearance of matrix and clasts exhibiting soft sediment deformation.

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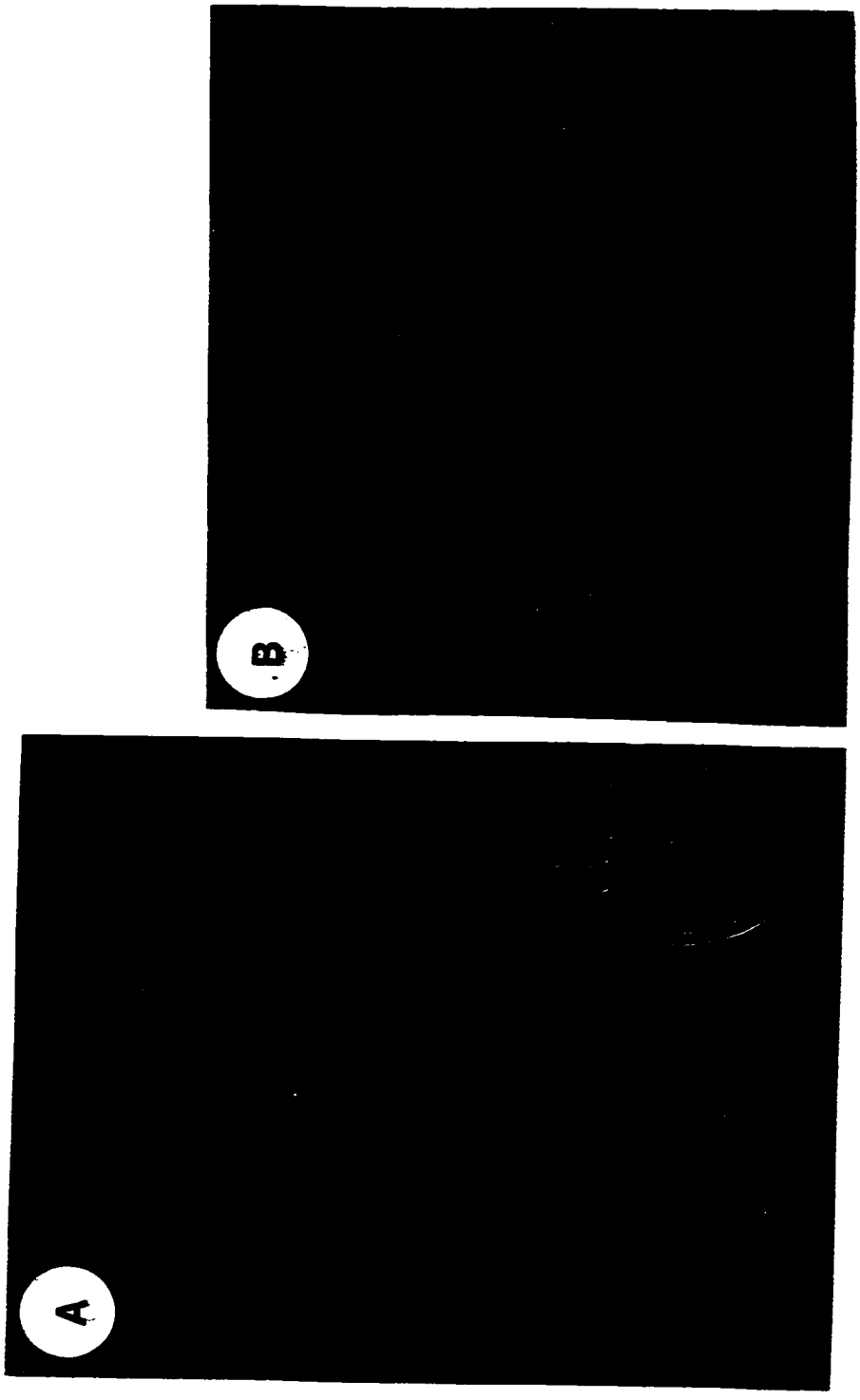

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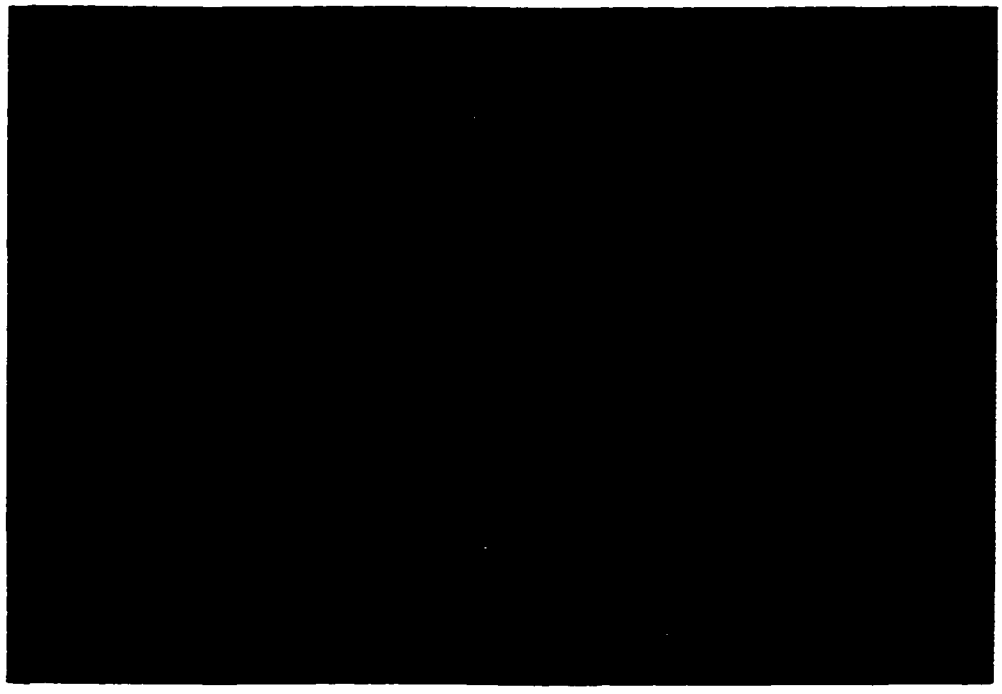

Figure 140: Outcrop photograph of Everton Formation showing outcrop scale collapse features (arrows), Interstate 55, southbound lane, Perry Co., southeast Missouri.. Note meter thick sandstone bed (A) has collapsed into an underlying bed, but upper contact of overlying bed (B) is horizontal.

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bathymmetry, and its increasing abundance vertically reflecting basinward shoreline and sabkha progradation in upper Joachim time.

Dissolution features in sandstone from the lower Everton Dolomite differ from those in the Joachim in that they tend to be on a much larger, outcrop scale (Figure 140) and that overlying beds and pebble- cobble-sized intraclasts exhibit soft-sediment deformation. In magnitudes. The uppermost sand (B) is laterally contiguous and in undeformed. Smaller scale features, indicated by arrows, are evident elsewhere in the outcrop. These features are interpreted as to have formed by the progressive meteoric dissolution of underlying, evaporite-bearing beds prior to lithification of the Everton sands.

Correlative strata in the central basin are calcium-sulfate bearing. If paleo-groundwater flow was toward the Everton embayment and assuming an increasing salinity gradient landward, this implies that the groundwater on the basin margin was either strongly undersaturated with respect to sulfate, resulting in the dissolution of calcium-sulfate, or more likely, these strata formed by dissolution of halite after in the shallow (m's) burial environment. If groundwater flow was away from the basin due to evaporative pumping (Hsü and Siegenthaler, 1969), then it indicates that the loci of evaporite deposition became proximal to undersaturated marine waters by the following mechanisms: 1) continued transgression, 2) became proximal to undersaturated continental ground water due to a decrease in the rate of evaporation, 3) increased precipitation, and/or 4) uplift on the basin margin. An increase in precipitation, or uplift of the basin margin would increase the fluid potential of the groundwater relative to the basin.

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Second, evidence for the depositional reworking of quartz arenite, the formation of *Skolithos* burrow trace fossils, and the presence of meter-scale, polygonal fracture sets within the essentially uncemented, quartz arenites of the St. Peter Sandstone requires an early cement.

Pebble-conglomerate with sub-rounded quartz arenite clasts are locally present within the St. Peter Sandstone in northern Illinois and southern Wisconsin. An excellent example is the reworked pebble- to cobble-sized clasts of fine-grained quartz arenite from the St. Peter Sandstone in the basal mudrock of the Glenwood Formation at the Clay Hollow locality, south of Platteville, Wisconsin (Figures 17 and 141). At present, these clasts are friable to poorly-indurated, but at the time of the mudrock deposition the arenite must have been sufficiently indurated to allow reworking to their present sphericity.

The widely distributed, *Skolithos* trace fossils are characterized by large-diameter burrows (1-2 cm diameter) that cross-cut beds of massive, well- to moderately-sorted fine- to medium-grain quartz arenite (Figure 142). The burrows are infilled with poorly- to moderately-sorted, medium- to coarse-grain quartz arenite, and terminate upsection at a bedding plane. The contrast in grain-size between burrow-fill and matrix, and the termination of burrow traces upsection at bed contacts implies that the burrows were infilled by sediments deposited after the matrix bed was deposited and the burrows were established. It also requires that the burrows were open at the time of deposition of the overlying bed and therefore, an early cement was present in order to prevent granular collapse of the burrow walls.

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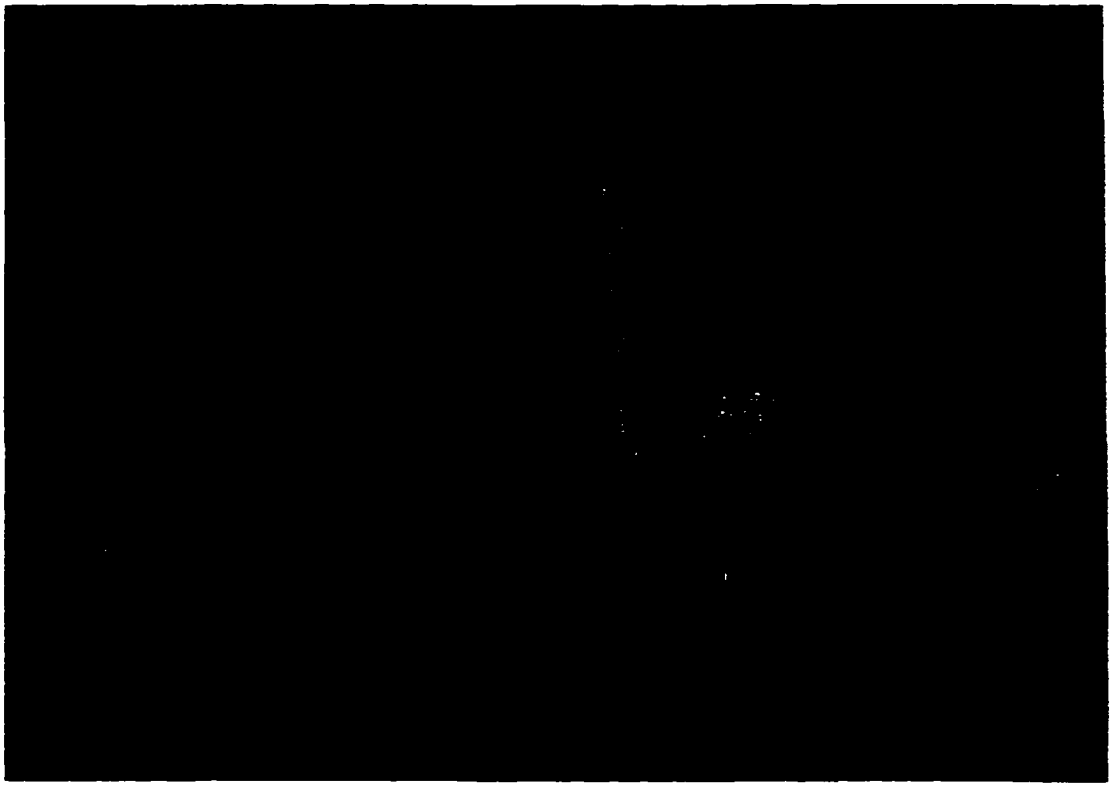

Figure 141: Rounded quartz arenite pebbles in basal green mudrock of Glenwood Formation, Clay Hollow section, southwest Wisconsin. Pebbles are present in a sandy mudrock matrix just above (cm's) above planar contact of Tonti Sandstone Member, St. Peter Sandstone, and overlying Glenwood Formation, Clay Hollow section, southwest Wisconsin (Figure 17).

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Figure 142: Oblique (A) and vertical (B) view core photos of *Skolithos*-bearing quartz arenite, upper St. Peter Sandstone, 7354 ft. (2241 m), Superior Oil, H. C. Ford et al C-17, White Co., Illinois (ISGS C2740). Note that the burrows are well defined by boundary (arrow) of the white, coarse-grain, very well-indurated, overgrowth-cemented quartz arenite burrow fill, and the argillaceous, friable, fine- to medium-grain quartz arenite matrix. Core diameter is 8-inches (20 cm), scale in inches.

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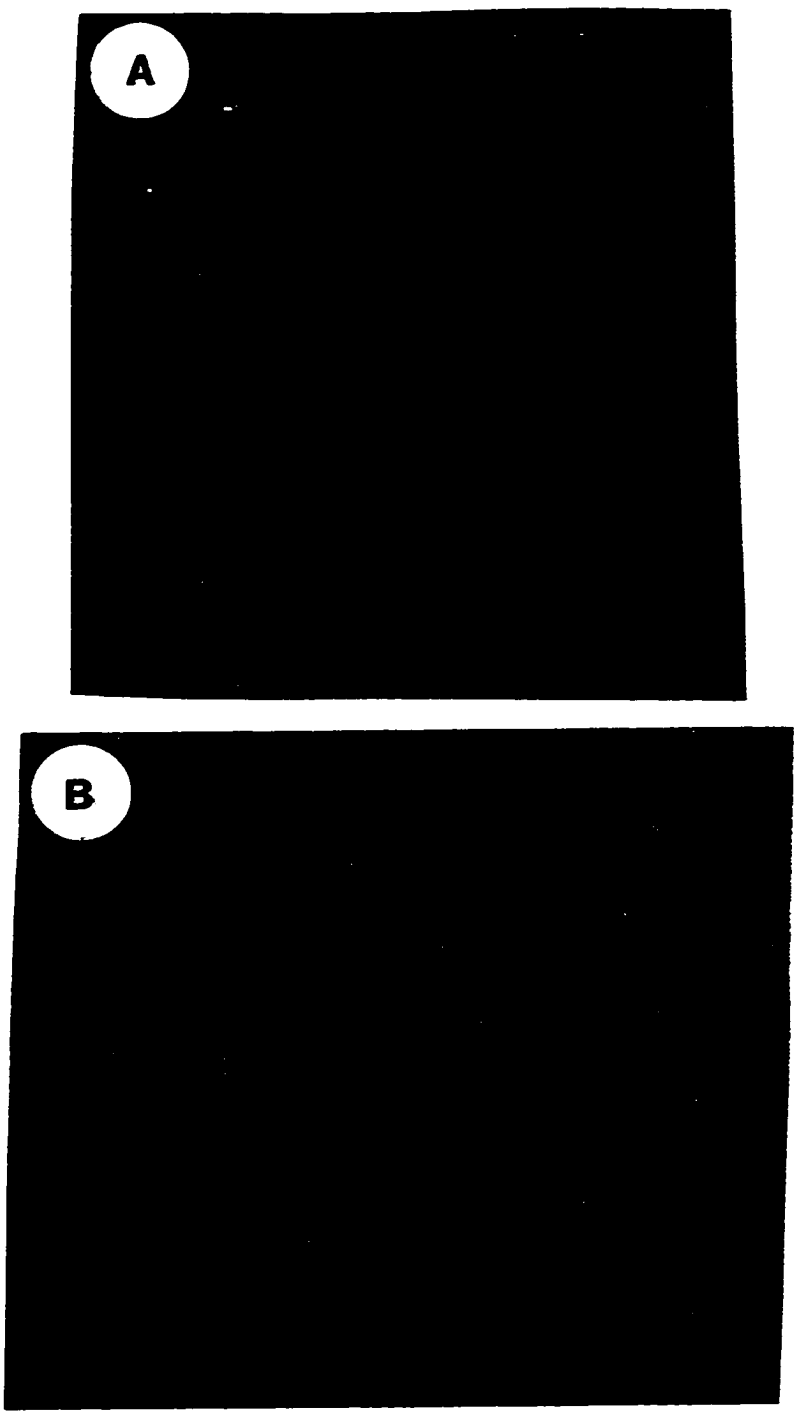

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Many present-day marine organisms line their burrows with an organic secretion, or in some cases calcium carbonate. If the burrow walls had been preferentially indurated, it would be expected that differential compaction of the burrow margins, with the burrow margins raised positively relative to the inter-burrow matrix, would have occurred as the overlying sediments were deposited and the burrow-bearing beds compacted. The absence of such features, although not definitive, strongly suggests early cementation of *Skolithos*-bearing beds penecontemporaneous with the burrowing and deposition of the overlying bed.

Large desiccation fractures observed in profile in core and reported sand-filled polygonal fracture sets on bedding planes (i.e., "suncracks"; Lamar, 1927, p. 36-37) in St. Peter Sandstone quarries in La Salle Co., Ill., may have been produced by tensional forces generated by volumetric changes in evaporites due to thermal effects. Meter-scale, quartz arenite-filled vertical fractures (Figure 143) and polygonal fracture sets on the bedding planes within the Tonti Sandstone Member are nearly identical to those described by Kocurek and Hunter (1986) from the Navajo and Page sandstones (Mesozoic) of Arizona, and by Lope and Haverland (1988) from the carbonates of the Hermosa Formation (Pennsylvanian), southeastern Utah.

As Kocurek and Hunter (1986) noted, fracture sets of this size are difficult, if not impossible to form by desiccation in unconsolidated sands. "Crack-forming" tensional stresses would not be relieved by brittle failure, but by granular dislocation; therefore, "desiccation" polygons in unconsolidated sands are probably formed by the thermal expansion of evaporites, salts or gypsum. Evaporites have high coefficients of bulk

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Figure 143: Core photo (A) and line drawing (B) of deformed quartz arenite-filled, vertical desiccation fracture, Joachim Dolomite, 3187-3189 ft. (971-972 m), Buttercup Energy, Rachel Pensinger #1, Clay Co., Indiana (IGS C640). Fracture extends down into dolomudstone from overlying quartz arenite. Deformation of fracture implies it formed prior to compaction of carbonate mud. Core is 4-inches (10 cm) in diameter.

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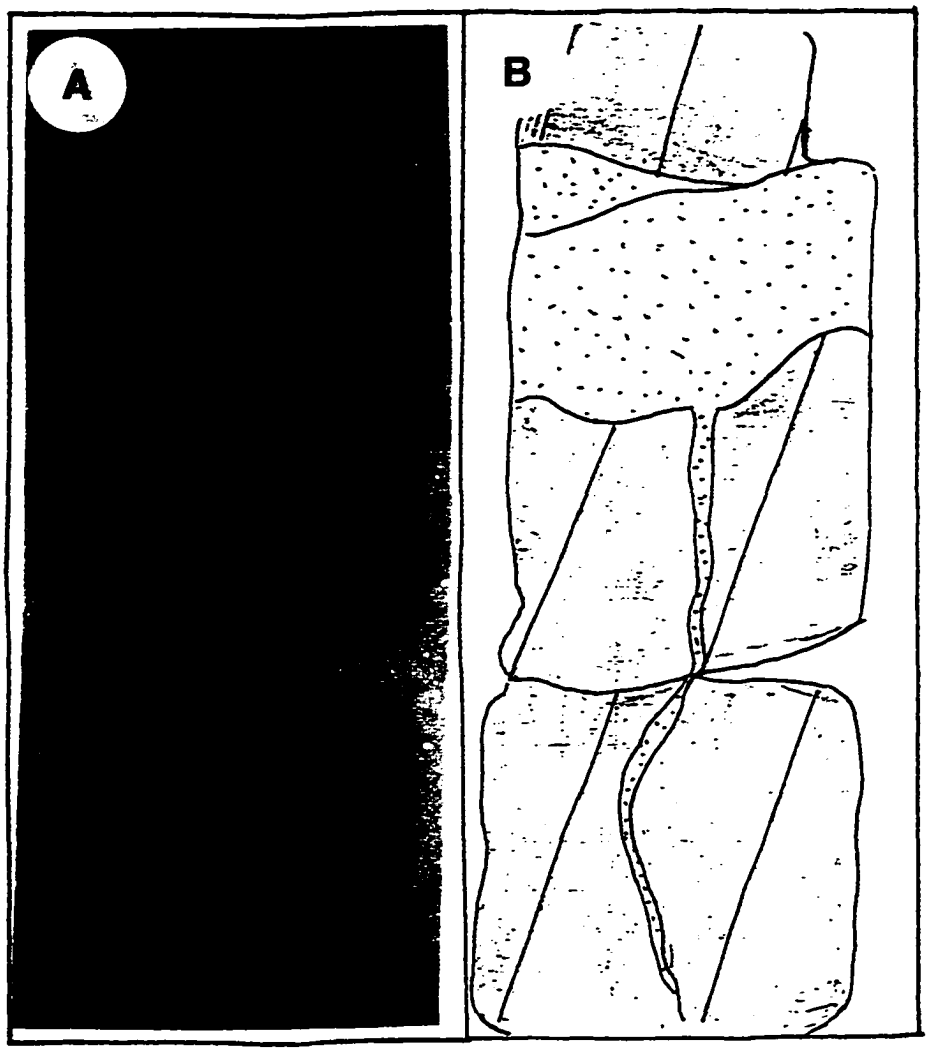

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volume expansion and by a process analogous to ice-wedging can form polygonal fracture sets (Kocurek and Hunter, 1986). In most cases, these features are associated with deflation surfaces where the polygons develop at, or near the groundwater table (Kocurek, 1988; Loope and Haverland, 1988).

As noted by Lamar (1926) beds containing polygonal fractures observed in quarries exposing the upper Tonti Sandstone Member in north-central Illinois are comparatively well-indurated by silica when compared to the friable beds above and below. Samples could not be obtained, but it is likely that the silica cement is replacement after calcium-sulfate, or early silica cementation as a result of large pH changes during the evaporative condition.

Third, the preservation of eolian sediments, in the absence of rooted vegetation, requires rapid burial, deposition in a low energy environment, and/or early cementation (Eschner and Kocurek, 1988). Where the contacts between eolian strata and the overlying marine flooding surface are observable within the St. Peter Sandstone, little to no relief is apparent. At the Clay Hollow (this report) and Monticello (Pryor and Ameral, 1971) sections in southern Wisconsin the contact of eolian strata of the Tonti Member with the overlying Glenwood Formation are near planar at outcrop scale (Figure 17).

The absence of relief on the contact and evidence for extensive reworking of eolian sands, as indicated by the distribution of grain-sizes and grain-types within genetically related, marine-deposited sands within the St. Peter Sandstone (Mazzulo and Ehrlich, 1980; 1983), implies that the marine flooding events overlying St. Peter eolian deposits were erosive. The development of an offshore bar complex during Glenwood-Starved Rock time (Nunn, 1986), and correlative strata in the Michigan Basin (Barnes

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and others, 1992), also provides evidence for a wave-dominated, erosive coastline. As a consequence, gradual burial in a low-energy, tide-dominated transgressive environment, akin to the Holocene Australian coast (Jennings, 1975), is unlikely.

Alternatively, rapid burial and preservation of eolian sediments may occur under the following conditions: 1) rapid rise in relative sea level due to an increase is subsidence rate and/or a rise in eustatic sea level, and/or 2) where eolian deposition was below sea level within a paleotopograhic low (Smith, 1979; (Eschner and Kocurek, 1988). The shallow marine environments of the Glenwood Formation (Fraser, 1976) that overlie the post-St. Peter flooding surface in southern Wisconsin, and the absence of evidence for significant bathymetric change basinward, somewhat precludes rapid submergence of the paleo-dune field below wave-base by a rapid rise in relative sea level. In addition, the preservation of eolian sedimentary strata in the St. Peter Sandstone on the tectonically stable basin-bounding uplifts, Wisconsin Arch and Ozark Dome, makes rapid burial due to accelerated subsidence unlikely.

Preservation of the eolian successions requires that either these sediments were deposited in paleotopographic lows in the post-Knox surface (i.e., Weissliegende Sandstone, Zechstein Basin; Smith, 1979), or that an early cement made these sediments more resistant to erosion during the initial marine transgression and enhanced their preservation potential. Because of the erosive character of transgressive environments, Jones and Blakey (1993) argued that early cementation was necessary for the preservation of eolian strata along the eolian-marine boundary that marks the contact of the Page Sandstone and Carmel Formation (Middle Jurassic), Utah. Although a possible relationship with paleotopographic relief on the post-Knox surface cannot be discounted,

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it is considered an unlikely mechanism given the wide-spread preservation of eolian strata.

In modern siliciclastic-carbonate, sabkha transitions, such as the Dhahran Area, Saudi Arabia (Fryberger and others, 1983), early halite and gypsum cements are common in dunes and interdune sediments where they occur as precipitates at the water table and in the capillary fringe zone. These sediments are sufficiently indurated that they resist compaction when loaded by vehicles and are preserved in the shallow subsurface in the offshore area where they are separated from overlying marine strata by flooding surfaces.

The above features imply that soluble sediments and early cements were wide-spread in both the clastic and carbonate lithotopes of the Ancell Group. The thick carbonate successions above and below the Ancell, as well as the interbedded carbonates, and the general lack of carbonate cements in the St. Peter Sandstone, either at the surface or in the subsurface, implies that the early cement phase was noncarbonate. Although it can be argued that carbonate cements may have been removed by dissolution, it is difficult to envision a mechanism that would selectively remove carbonate the Ancell Group sands and not results in widespread dissolution of the overlying and underlying carbonates. The poor development of quartz overgrowths on grains in the St. Peter Sandstone of the Ozark Dome and Wisconsin Arch, and the insolubility of silica, precludes an early silica cement phase. Therefore, it is highly likely that the early cement phase was either calcium sulfate or halite.

The possibility that the St. Peter Sandstone was initially cemented by sulfate, or halite is supported by the presence of nodular quartz arenite in central Illinois, and the local presence of anhydrite cements in the subsurface. Such a model is also consistent

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with the observed distribution of evaporites in both modern and ancient, semi-arid evaporite environments (see examples in Schreiber, in Reading, 1986; Schreiber, 1990). With the exception of basins characterized by rapid subsidence, particularly in cratonic marine basins the occurrence of evaporite constituents increases toward the basin margin as groundwater salinity increases due to evaporation, and the potential for persistent flooding by normal marine waters decreases.

In siliciclastic sabkha sequences, due to the decreasing availability of Ca^{+} shoreward, the potential for deposition of non-sulfate evaporite phases increases (Schreiber and others, 1982; Fryberger and others, 1983). This suggests that halite may have been a significant constituent of the early-Middle Ordovician sediments on the embayment margins. However, seasonal precipitation (see Paleogeography discussion) in the Illinois Basin area probably impeded evaporite preservation in the sedimentary record and precluded formation of thick accumulations of halite and/or halite cemented arenites, or their preservation in the shallow burial environment.

This observation is supported by the preservation of eolian features indicative of moist conditions and the absence of "disturbed" bedding in the St. Peter Sandstone. Disturbed bedding, such as that observed by Andreason (1992) in halite cemented quartz arenites from the Yates Formation (Permian) of Texas, is attributed to the dissolution of volumetrically significant halite in the shallow burial environment. The lack of disturbed bedding in the St. Peter implies the sediments were primarily grain-supported, or intergranular cements were finely-crystalline and relatively minor volumetric constituents. Cementation by of eolian sandstones by finely-crystalline halite and gypsum cements (<0.25 in. diameter) has been observed in the detrital-dominated sabkhas

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(Recent) of the Dharhan Area, Saudia Arabia (Fryberger and others, 1983). If evaporative cements indurated the St. Peter at the surface and in the shallow burial environment, the present-day porosity of the St. Peter on the basin margin probably provides a crude estimate of the minimum combined volume of evaporite constituents and primary porosity at the time of deposition.

In a semi-restricted, arid to semi-arid basin, the proposed distribution of evaporites implies an increase in salinity and water temperature toward the basin margin. Paleoecological gradients support this by interpretation by indicating that environments became increasingly harsh shoreward. The existence of a early-Middle Ordovician paleo-bathymetric/salinity/temperature gradient is supported by the observed distribution of conodont genera in the Dutchtown-Joachim interval from the central embayment, toward the basin margins. In southwest Missouri and western Tennessee, conodont faunas contain species assignable to the genera *Plectodina* and *Phragmodus* co-occurring with the fibrous forms, *Multioistodus*, *Chiroganthus* and *Ersimodus*. In central Illinois, *Plectodina* is a minor constituent, *Phragmodus* is absent, and fibrous forms dominate the faunal population. In northern Illinois, all of these faunal constituents are absent, and poorly-known, hyaline species make-up the entire fauna. In addition, faunal diversity and total numbers also decreases northward. Similar paleoecologic gradients have been observed in the Cincinnati Arch area (Sweet, 1988) and the Williston Basin (Sweet, 1979) from inferred "normal marine offshore" areas toward increasingly saline and warmer "nearshore" areas. In the Willistion Basin, these "nearshore" areas are increasingly proximal to the evaporite flats of the Red River Formation (Sweet, 1988).

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Macrofauna diversity and abundance also decreases toward the paleoembayment margins. In western Tennessee strata coeval with the Ancell Group contain a low diversity assemblage of gastropods, trilobites, brachiopods, echinoderms, ostracodes and bryzoa. Carbonates of the Joachim Dolomite in southwest Missouri are generally devoid of macrofauna, but some intervals contain monospecific assemblages of ostracodes and rare, linguloid brachiopods. In part, this is a function of decreasing preservation potential and unfavorable paleoecologic factors, but the implied changes in environmental conditions are still valid.

Isotope Geochemistry

To investigate the isotopic geochemistry of the waters that contributed to the formation of early-Middle Ordovician evaporites, six samples of anhydrite-bearing dolomudstones from the Joachim Dolostone underwent isotopic geochemical analysis (sulfur and oxygen). The samples are from bases and tops of anhydrite-bearing sabkha cycles ("episodes" 1 and 4) identified by Okharvi and Carozzi (1983) in the 8-inch (20 cm) core from Superior Oil, H. C. Ford et al C-17, White Co., Ill.

As Claypool and others (1980) noted, marine and meteoric waters have significantly different sulfur isotopic signatures and the $\delta^{34}S$ composition of sedimentary sulfates can be used, with some limitations, to differentiate marine and nonmarine evaporites. Because of sulfide (i.e., pyrite, etc.) can be produced by a variety of organic and inorganic processes, with differing fractionation effects, only sulfur isotopic values from sulfates are considered to reliable indicators of parent brine origin (Holser and Kaplan, 1966; Claypool and others, 1980).

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Using sulfur isotope values from marine evaporites throughout the Paleozoic, Claypool and others (1980) generated a sulfur isotope curve (Figure 144) that demonstrates the varying mean $\delta^{34}S$ composition of marine waters through time and which as been subsequently improved upon by Lindh (1983) and Holser and others (1989). The observed changes are attributed to variations in weathering rates, in the abundance and isotopic composition of sulfur-bearing rocks in the weathering environment, in the evolutionary modification of sulfate-reducing bacteria, in the volume of igneous-sourced sulfur, and in the rate of sulfate/sulfide sedimentation (Claypool and others, 1980; Railsback, 1992). As a result, a narrow range of $\delta^{34}S$ values generally constrains a mean isotopic composition for marine waters during any given period of time. Subsequent compilations have generally substantiated the validity of the curve, but differ in detail.

For the Ordovician, the sulfur isotope curve is constrained by 19 samples, mostly from North America and the Siberian Platform, collected from seven stratigraphic units (Table 8). In reviewing the discrepancies in the published sulfur isotope curves for the early Paleozoic it became clear that some differences are nongeologic. In part, the discrepancies can be attributed to differing interpretation of the small number of Ordovician data points (<10) used to build the curve, but others are due to incorrect age assignments for stratigraphic units sampled. Because the curve values are derived from the mean values for any given period of time, the inaccurate age assignments tend to distort the curve to a greater extent then the scarcity of data points. An excellent example is the two gypsum samples reported from the "Mirage Point Formation" by Claypool and

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Figure 144: $\delta^{34}S$ age curve (Cambrian to Recent)

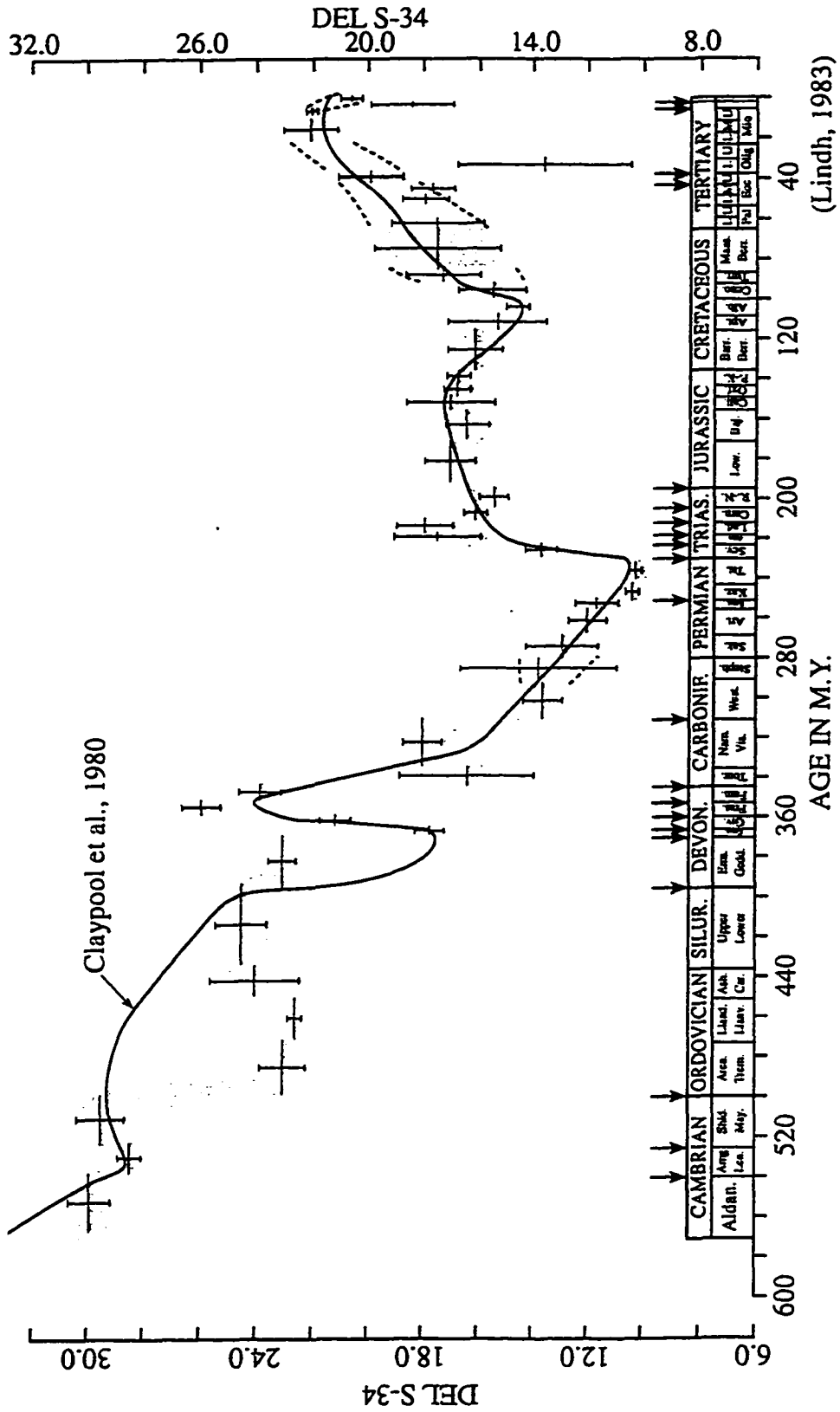

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Table 8: Sulfur and oxygen isotopic composition of Ordovician sulfides and sulfates.

Sample #	Formation	Lithology	Location	S-34 (CDT)	Age (Ma.BP)	O-18 (SMOW)	Conodont zone	Reference
C2740-7105	Joachim Dol.	Anhydritic dolomudstone	Illinois Basin, USA	25.30	464			Thode and Monster, 1963; Thode, written comm., 1995
C2740-7111	Joachim Dol.	Anhydritic dolomudstone	Illinois Basin, USA	26.80	464	13.89	*E. quadradactylus*	This report
C2740-7123.9	Joachim Dol.	Anhydritic dolomudstone	Illinois Basin, USA	26.88	464.1	16.39	*E. quadradactylus*	This report
C2740-7141	Joachim Dol.	Anhydritic dolomudstone	Illinois Basin, USA	27.12	464.2	15.08	*E. quadradactylus*	This report
C2740-7213	Joachim Dol.	Anhydritic dolomudstone	Illinois Basin, USA	27.63	464.9	14.78	*A. delicatulus*	This report
C2740-7218.5	Joachim Dol.	Anhydritic dolomudstone	Illinois Basin, USA	27.92	465	14.41	*A. delicatulus*	This report
C2740-7225	Joachim Dol.	Anhydritic dolomudstone	Illinois Basin, USA	28.14	456.1	11.84	*A. delicatulus*	This report
C2740-7513	Everton Dolomite	Quartzose dolomudstone	Illinois Basin, USA	23.60				Thode and Monster, 1963; Thode, written comm., 1995
Hole 1620-107R	Beekmantown Gp.	Gypsum, micaceous	Ontario, Canada	29.50				Thode and Monster, 1963; Thode, written comm., 1995
Hole 1740-102R	Beekmantown Gp.	Gypsum, micaceous	Ontario, Canada	29.20				Thode and Monster, 1963; Thode, written comm., 1995
Hole 1800-102R	Beekmantown Gp.	Gypsum, micaceous	Ontario, Canada	29.40				Thode and Monster, 1963; Thode, written comm., 1995
Hole 1500-107R	Beekmantown Gp.	Gypsiferous shaley dolomite	Ontario, Canada	33.70				Thode and Monster, 1963; Thode, written comm., 1995
Hole 1740-102R	Beekmantown Gp.	Gypsiferous shaley dolomite	Ontario, Canada	35.10				Thode and Monster, 1963; Thode, written comm., 1995
Hole 1560-107R	Beekmantown Gp.	Gypsiferous shaley dolomite	Ontario, Canada	35.80				Thode and Monster, 1963; Thode, written comm., 1995
not reported	not reported	Gypsum (38 samples)	China	21.2-27.7	442-458	N/A	*A. twaerensis*	Chen and others, 1981; Wang, 1990
Herald #1-9381	Red River Fm.	Fine-grain anhydrite	Williston Basin, Canada	27.60				Thode and Monster, 1963; Thode, written comm., 1995
Carville #8-9042	Red River Fm.	Fine-grain anhydrite	Williston Basin, Canada	25.00				Thode and Monster, 1963; Thode, written comm., 1996
Rupert #15-6303	Red River Fm.	Fine-grain anhydrite	Williston Basin, Canada	24.50				Thode and Monster, 1963; Thode, written comm., 1997
Petung #1-5815	Red River Fm.	Fine-grain anhydrite	Williston Basin, Canada	24.50				Thode and Monster, 1963; Thode, written comm., 1998
SI-34-18	Red River Fm.	Fine-grain anhydrite	Williston Basin, USA	25.00	464	15.86	*A. delicatulus*	Sakai, 1972
26231	Bay Fjord	Gypsum	NW Territory, Canada	28.00	465	N/A	*P. flexuousus*	Claypool and others, 1980
26232	Bay Fjord	Gypsum	NW Territory, Canada	29.00	465	N/A	*P. flexuousus*	Claypool and others, 1980
26229	Bauman Fjord	Gypsum	NW Territory, Canada	25.60	495	N/A	upper fauna B	Claypool and others, 1980
not reported	not reported	not reported	"Moscow syneclise"	25.5-26.3	?	N/A	?	Yeremenko and Pankina, 1971
2	not reported	Pyrite in dolostone	Sayany	22.14	430?	N/A		Vinogradov and others, 1956
3	not reported	Pyrite in clay	Krasnoye selo	22.22	430?	N/A		Vinogradov and others, 1956
4	not reported	Pyrite in green clay	Krasnoye selo	22.41	430?	N/A		Vinogradov and others, 1956
5	not reported	Pyrite in limestone	Estonia	22.56	430?	N/A		Vinogradov and others, 1956
not reported	"Sandy Limestone"	Sulfate	Concrete, Colorado	22.14	400-500	N/A		Thode and others, 1953
24511-7	Mirage Pt.	Gypsum	NW Territory, Canada	22.60	Devonian	N/A		Claypool and others, 1980
24511-8	Mirage Pt.	Gypsum	NW Territory, Canada	15.10	Devonian	N/A		Claypool and others, 1980

(1) Analytical error for Joachim sulfur values +/- 0.15 o/oo; analytical error unreported for other samples.
(2) Analytical error for Joachim oxygen values +/-0.3 o/oo; analytical error unreported for other samples
(3) Absolute ages based on Harland and others (1982); Ordovician absolute ages have a mean analytical error of +/-5 Ma.
(4) Age of Canadian localites based on biostratigraphic data provided by Dr. G. S. Nowlan,
Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, Calgary, Alberta, Canada.
(5) Age of Mirage Point Formation misreported by Claypool and others (1980). No Ordovician age rocks are exposed in vicinity of locality reported, and biostratigraphic data from the Mirage Point Fm. in its type area indicate a Devonian age. The isotopic data are consistent with the Devonian sulfur isotope curve in Claypool and others (1980).
(6) No Ordovician evaporites have been reported from Moscow Basin
(7) Age of units sampled by Vinogradov and others (1956) reported as Cambrian; absolute age indicates latest Ordovician-earliest Silurian.

others (1980). The formation is reported to be "pre-Richmondian, Middle Ordovician" in age. The $\delta^{34}S$ values for this unit are anomalously light, 6-13‰, in comparison to other Ordovician samples in the area and worldwide. In checking to see if additional sedimentologic or biostratigraphic data are available for the unit, it was found that no Ordovician rocks are exposed in the area reported and that the Mirage Point is actually Devonian in age (Dr. G. S. Nowlan, Geological Survey of Canada, written communication, 1994). Although the "Mirage Point" $\delta^{34}S$ values are anomalous for the Ordovician, they are wholly consistent with a Devonian age assignment (Claypool and others, 1980; Pierre and Rouchy, 1986).

World sulfur isotope curves have been widely used as a basis for interpreting sulfur isotope values from sedimentary rocks. Typically sulfur isotope data are, in part, interpreted by comparing new measured values to the Paleozoic sulfur isotope curve to evaluate localized environmental, or temporal variations in the sulfur isotope cycle (Pisarchik and Golubchina, 1975; Fritz and others, 1988). Locally, isotopic data have been used to revise correlation's and age assignments for nonfossiliferous stratigraphic units (Cortecci and others, 1981; Pierre and Rouchy, 1986).

The δ^{34S} and $\delta^{18}O$ values obtained from sulfate in the Joachim Dolomite samples, and those published elsewhere for Ordovician rocks, are given in Table 8. Reported isotope values from Ordovician sulfides are also given; $\delta^{34}S$ values were also measured for the sulfide fractions from two Joachim samples (7225'11" and 7218'6") for comparison with these reports.

The new $\delta^{34}S$ values for the Joachim Dolomite vary from +26.8‰ to +28.14‰, with a mean of +27.42‰, indicate the parent brine was marine. These values are slightly

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heavier than the previous values reported for the Joachim Formation (+25.5‰) and Everton Dolomite (reported as "Knox Group"; +23.5‰) from the same locality (Thode and Monster, 1964; 1965; H. G. Thode, written communication, 1995).

Although stratigraphic and analytical error data are lacking for most samples reported in the literature, and therefore interpretations based upon the published sulfur isotope curves are somewhat equivocal, the mean $\delta^{34}S$ value for the Joachim is in close agreement with the mean marine, North American Ordovician value of +27.6‰ reported in Krouse and Grinenko (1991). In addition, these data compare favorably with mean values from marine-sourced Middle Ordovician gypsums in China (+21.2-27.7‰; Chen and others, 1981), and those for early-Middle Ordovician rocks shown on the sulfur isotope curves of Claypool and others (1980), Lindh (1983), and Nielsen (in, Holser and others, 1989).

The $\delta^{34}S$ values from the Joachim Dolomite exhibit a systematic lightening trend through the section from +28.14‰ at the base, to +26.8‰ just below the upper contact (Figure 145). Two alternative interpretations appear to satisfy the data (Figure 145), but the present data set is inadequate to test either hypothesis. The first alternative assumes that the trend is linear, to semi-linear with respect to stratigraphic position. In this case, the isotopic trend may result from an steady influx of isotopically lighter, meteoric/terrestrial water due to subsidence relative to the recharge area or increased precipitation, and/or a systematic change in the composition of the microbial population. The second alternative suggests that sulfates formed from multiple isotopically distinct brines, an early brine derived from normal marine waters, a later brine that was derived

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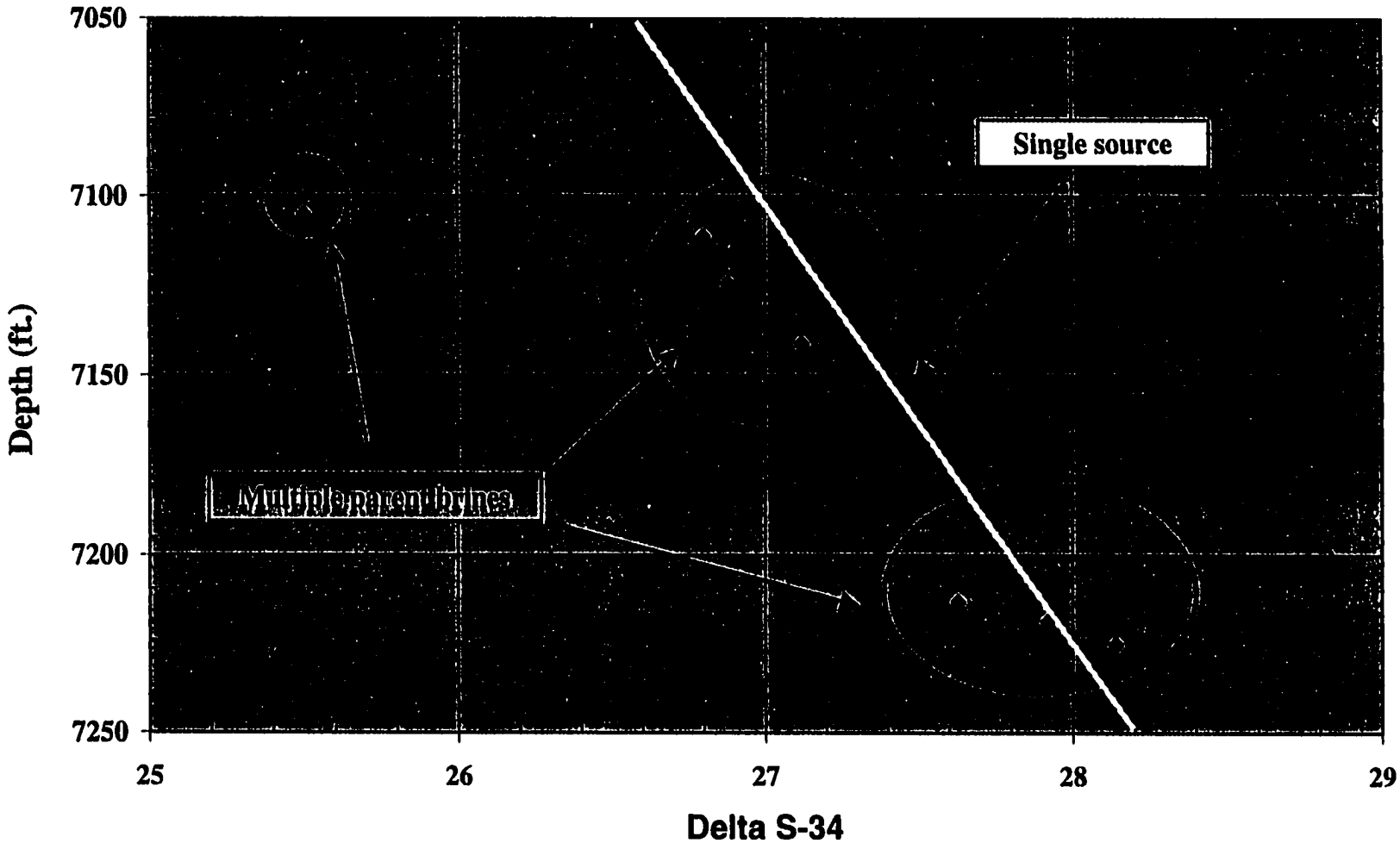
Figure 145: Delta S-34 vs Depth for Joachim Dolomite
Superior Oil, H. C. Ford et al C-17, White Co., IL



from predominantly marine waters with some meteoric/terrestrial input, and yet a later brine with a moderate nonmarine influence.

The latter interpretation is favored based on analogous sabkhas in Kuwait where during arid periods the groundwater table is drawn down, evaporative pumping derives isotopically light, meteoric-sourced groundwater from the landward side of the sabkha, and precipitated sulfates are isotopically lighter (Robinson and Gunatilaka, 1991). If theJoachim sabkha prograded basinward, as proposed herein, then the upper part of the anhydrite-bearing intereval was deposited more proximal to the nonmarine, groundwater system then the lower sequence, and an influx of meteoric waters could have provided a source for isotopically light sulfur. The uppermost data point, from Thode and Monster (1964; 1965), is significantly isotopically lighter, suggesting a moderate nonmarine influence, and corresponds stratigraphically to the maximum progradation of the Joachim sabkha. Additional sampling of the intervening strata and/or from additional localities may provide sufficient data to test this hypothesis.

The two $\delta^{34}S$ values (mean = 2.57‰) for sulfides are significantly lighter than those from the sulfates. The discrepancy between sulfide and sulfate $\delta^{34}S$ for rocks of the same age has long been recognized (Thode and others, 1953; Vinogradov and others, 1956), and is thought to be a product of either progressive isotopic fractionation by isotopic exchange and biological processes through time, or that sulfur may be sourced from thermal degradation of hydrocarbons and that the sulfide is a late diagenetic phase.

Thode and others (1953) found that the difference in $\delta^{34}S$ attributable to isotopic fractionation, due to thermochemical reduction, for sulfides and sulfates of the same age only ranged from 3-8%. The difference for the Joachim Dolomite samples is

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approximately 25‰, or almost 100%. However, these depleted values are wholly consistent with those from sulfides in MVT deposits on the basin margins associated with hydrocarbons (Kesler and others, 1994). Sulfur from thermally degraded oil is generally depleted in ^{34}S by ~15‰ relative to coexisting sulfate (Thode and Monster, 1965). Derivation of sulfur from thermally degraded oil is also consistent with thermal modeling of hydrocarbon maturation in the Illinois Basin that suggests hydrocarbons hosted in the Ancell Group in the White County area would have been cracked to gas in the mid-Paleozoic (Cluff and Byrnes, 1988)

$\delta^{18}O$ varies 4.55‰ from +11.84‰ to +16.39‰, with a mean value of 14.4‰ (Table 8; Figure 146). $\delta^{18}O$ varies 2.5-2.94‰ within each of the stratigraphic intervals sampled. Krouse (1987) demonstrated that $\delta^{18}O$ in sulfate precipitates are 1-2‰ heavier than the parent brine; therefore, the parent brine had an ^{18}O isotopic composition of approximately 14.5-17‰. All the data fall within the range of $\delta^{18}O$ compositions for Ordovician marine sulfates reported by Claypool and others (1980), and the mean value for the Joachim samples (14.4‰) very closely compares with the mean early-Middle Ordovician value (14.0‰).

These $\delta^{18}O$ values are extremely enriched relative to coeval, and minimally-altered early Middle Ordovician brachiopod shells ($\delta^{18}O$ = -5.25; Wadleigh and Veizer, 1992), or nonluminescent brachipod shells ($\delta^{18}O$ = -6.5; Popp and others, 1986) from the adjacent Appalachian Basin. Because calcite precipitated by brachiopods is thought to be in isotopic equilibrium with ambient sea water (Brathurst, 1975), the Joachim values appear to be effected by fractionation and not directly indicative of the ^{18}O isotopic chemistry of the paleoembayment water mass.

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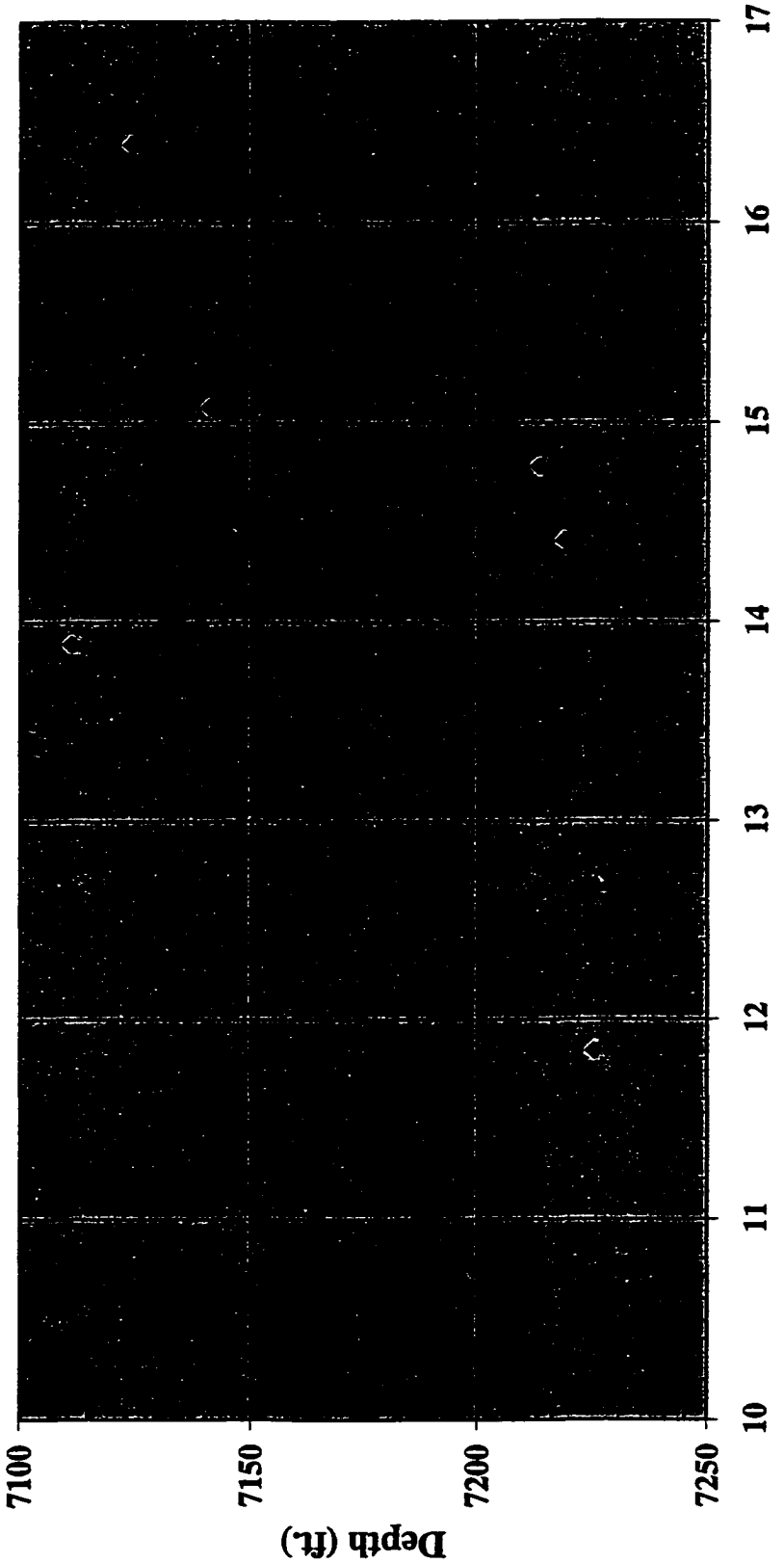

Figure 146: Delta O-18 vs Depth for Joachim Dolomite Superior Oil, H. C. Ford et al C-17, White Co., IL

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As with other Paleozoic evaporites (Cortecci and others, 1981; Pierre and Rouchy, 1986; Fritz, 1988; O'Shea, 1988), no systematic variations in $\delta^{18}O$ are observed with respect to $\delta^{34}S$, or with stratigraphic position (Figure 147). The variability of $\delta^{18}O$ in contrast to $\delta^{34}S$ has been attributed to post-depositional isotopic exchange of ^{18}O with formation waters (Cortecci and others, 1981), isotopic fractionation due to evaporation and halite precipitation (Robinson and Gunatilaka, 1991), and/or redox cycling reactions at the time of deposition (Fritz and others, 1988). Isotopic exchange with formation waters has been generally disregarded, but as Fritz and others (1988) observed it could be significant at elevated temperatures and/or if significant amounts of water are involved. These conditions may existed in the Illinois Basin during the Permian when the Ancell Group was at maximum burial depth (Kolata and Nelson, 1991), Permian igneous intrusions in southern Illinois imply an elevated geothermal gradient, and a regional groundwater flow system may have been in place (i.e., Bethke, 1986).

Where have all the Evaporites Gone?:

Groundwater Dissolution

A fundamental hypothesis of this thesis is that evaporites, primarily calcium-sulfate, but possibly halite, were widely distributed in the early-Middle Ordovician, Illinois embayment. If they were widespread, where are they today? One potential explanation for the absence of evaporite minerals beyond the basin depocenter is dissolution by the influx of undersaturated, meteoric groundwater. To examine the validity of this hypothesis, formation water analysis for lower-Middle Ordovician aquifers were obtained for 93 wells in the Illinois Basin (Appendix III).

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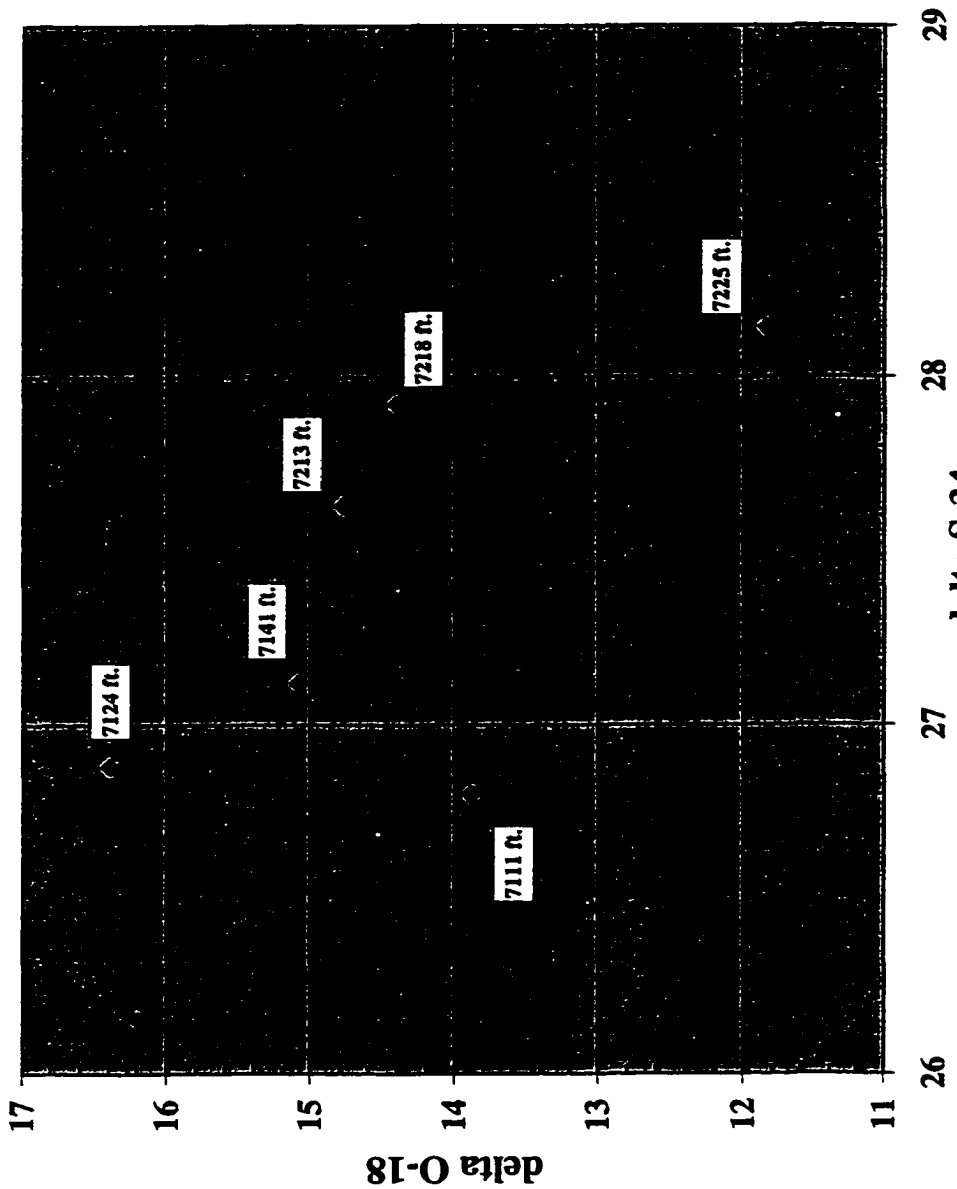
Figure 147: Delta S-34 vs. delta O-18 for Joachim Dolomite Superior Oil, H. C. Ford et al C-17, White Co., IL



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The data are from Faust and others (1980), Graf and others (1966), Keller (1983), Meents and others (1952), Miller and others (1974), Visocky and others (1985), Walker (1959) and unpublished analysis made available by the Illinois, Missouri and Indiana Geological Surveys, and the Illinois and Missouri State Water Surveys.

The quality of the data is variable due to the variety of analytical techniques employed, contamination from up-hole water sources and drilling fluids, and ions contributed from organic sources and gaseous phases (i.e., oil, H_2S). As a consequence, when plotted graphically the data set contains extensive scatter, but still shows a distinct distribution of total dissolved solids with depth (Figure 148).

Total dissolved solids (TDS) include all major constituents in solution. In most cases, the measured components are sodium, calcium, potassium, chlorides, magnesium, manganese, iron, sulfate and silica. Because sodic and potassic salts are major constituents of the total dissolved solids, TDS also serves as a proxy for direct salinity measurements (Collins, 1975). TDS concentrations in excess of 1000 mg/L (1000 ppm) are unsuitable for drinking water or commercial uses and are classified as "brines" (Meents and others, 1952). Classification of subsurface brines by concentration of dissolved solids is somewhat vague. Meteoric waters generally contain less than 10,000 mg/L, interstitial "mixed" waters vary from 10-20,000 mg/L, and connate waters are those with TDS in excess of 20,000 mg/L (Cockroft and Robinson, 1988).

For the available data, samples from depths shallower than 2400 ft. (731 m) show a scatter of values for TDS from 0-91,000 mg/L, but generally concentrate between 100-1000 mg/L (Figure 148). The vast majority of these samples are from the St. Peter Sandstone and their geochemistry is controlled by the meteoric influx from the recharge

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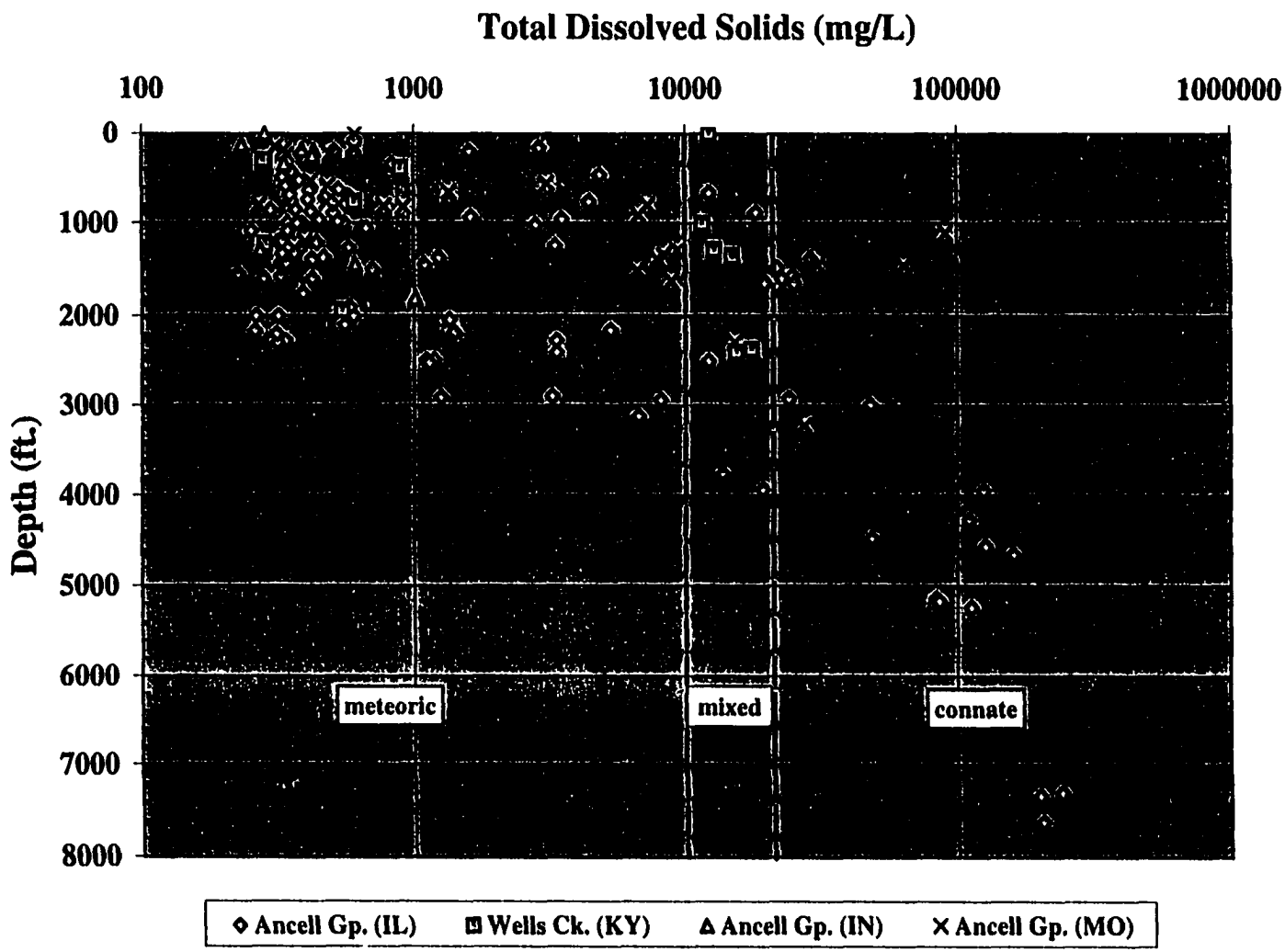
Figure 148: Total Dissolved Solids vs. Depth



areas where the St. Peter is exposed on the basin margins.

The TDS isochore map for the Ancell Group and its equivalents (Figure 149) demonstrates the influence of meteoric recharge. The fluid potential of the basin margins is greater than the central basin due to the gravitational potential of the fluids onthe topographically positive margins. As a result, the 10,000 ppm TDS isochore is deflected basinward south of the Wisconsin Arch outcrop area, but much less to the east of the Kankakee and Cincinnati arches where the Ancell is not exposed at the surface. The outcrop belt along the flanks of the Ozark Dome is relatively narrow (10-20 km), the topographic gradient is comparatively low, and the basinward structural gradient is comparatively high, as a result the meteoric influence is very limited. However, there is a notable deflection of the TDS isochore contours basinward in southwestern central Illinois, just north of St. Louis, Mo., where the Missouri River channel has eroded into the St. Peter and provides a high volume, uninterrupted source for nonsaline waters, and the river valley locally increases the recharge area.

Nearly all samples with TDS values in excess of 10,000 mg/L from depths less than 2000 ft. (610 m) are from Indiana and Missouri. In Kentucky, the aquifers sampled are laterally discontinuous sandstone's immediately overlying the post-Knox disconformity, or low-permeability, peritidal carbonates that are isolated from the primary groundwater recharge areas (Ozark Dome and Wisconsin/Kankakee arches). As result, it appears water geochemistry in this area is controlled by water-rock interactions and not meteoric recharge. This is consistent with the observation of Crawford (1940) that

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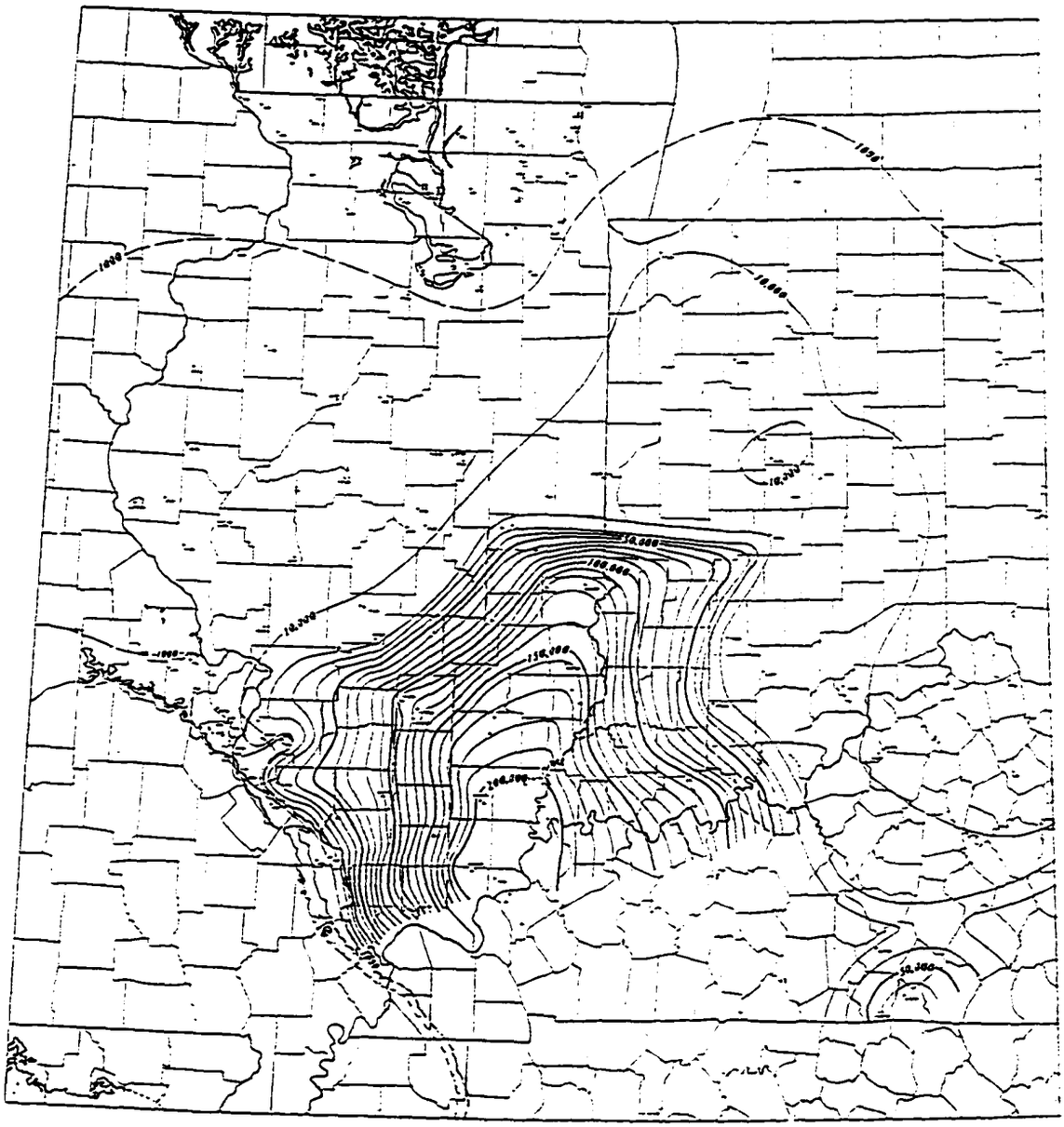

Figure 149: Total dissolved solids (TDS) isochore map for lower-Middle Ordovician aquifers, Ancell Group and its equivalants. Isochore interal 10,000 mg/L.

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salinity is a function of water movement, and that isolated fluids are more saline then those that mix with meteoric fluids.

The elevated TDS values at shallow depths in southeast Missouri, and Cumberland Co., Kentucky, are associated with known mineral deposits, fractures, and/or faults, all of which may be sources for saline extraformational fluids. Weaver and others (1995) observed similar positive TDS anomalies in shallow Pleistocene aquifers on the Algonquin Arch, eastern Michigan Basin. They demonstrated that these anomalies resulted from the cross-formational fluid flow of deeper, Devonian-hosted brines migrating up fractures and mixing with the meteoric waters in the shallow glacial aquifers.

Excluding these points (Figure 150), TDS values increase uniformly with depth below 2000 ft. (610 m). The relatively uniform increase in TDS with depth suggests that the chemistry of formation waters below 2000 ft. (610 m) is primarily controlled by fluid-rock interactions, connate water composition and decreasing meteoric input. Similar trends from outcrop to basin, thought to be the result of decreasing meteoric contribution, are observed for Mississippian strata (Graf and others, 1966).

A better chemical proxy for direct measurements of salinity is the sulfate/chloride (SO_4^+/Cl^-) ratio (Cockroft and Robinson, 1988). Chloride ions are derived from salts, connate marine waters and diagenesis of clay minerals. Chloride concentration increases with depth because more ion sources are available and the dilution effect of meteoric input decreases. Dissolved sulfate is derived from either rocks, or soils containing gypsum, anhydrite, iron sulfides and other compounds, (Miller and others, 1974), or connate formation waters. Sulfate concentrations tend to decrease with depth because

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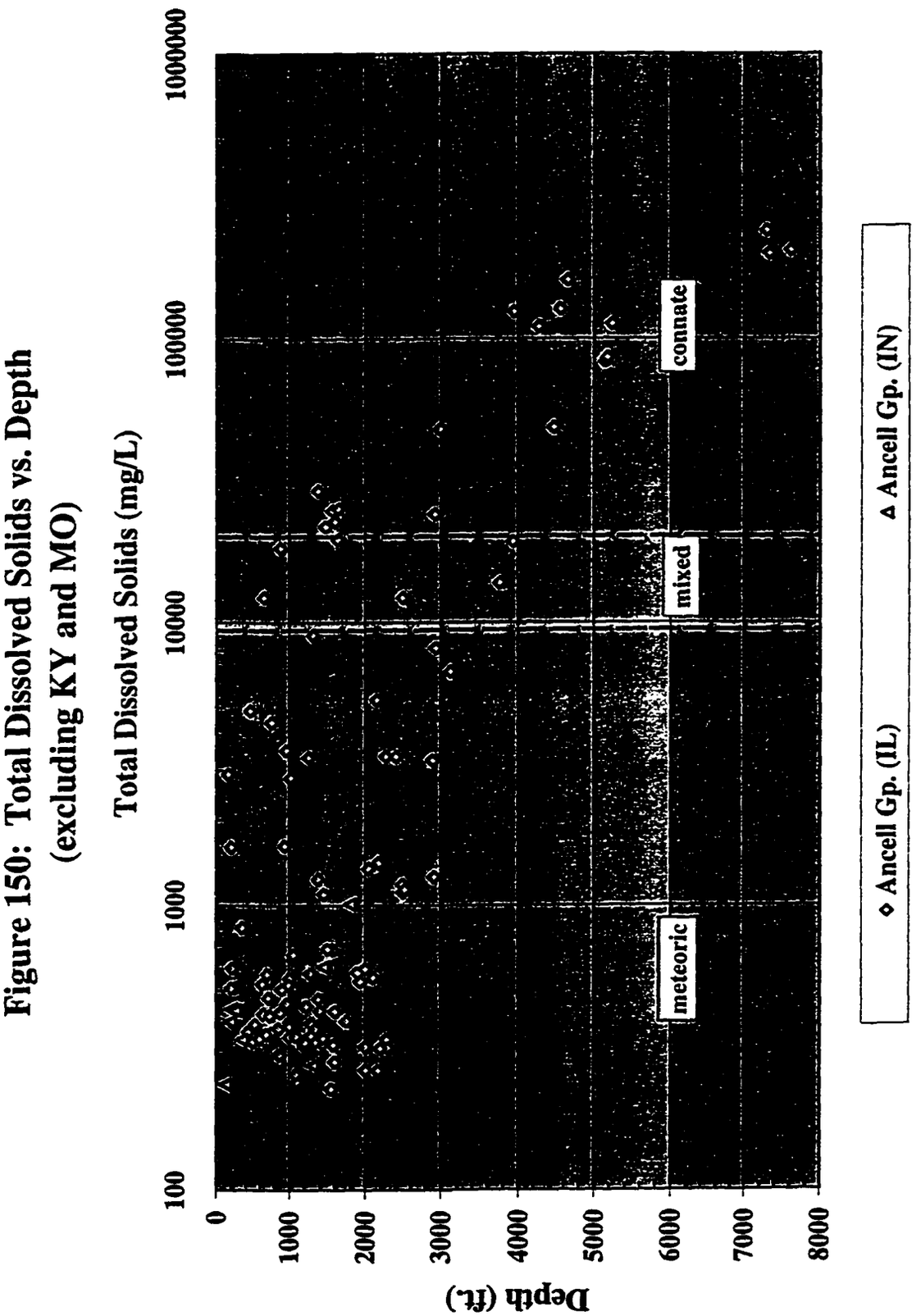
Figure 150: Total Dissolved Solids vs. Depth (excluding KY and MO)



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sulfate depleted with depth due to anaerobic bacterial activity (Collins, 1975), and sulfides are more abundant on the Illinois Basin margins owing to MVT mineralization. As a consequence, the low chloride concentrations and elevated sulfate concentrations, yielding a higher SO_4^+/Cl^- ratio, characterize areas where meteoric influence predominates, and increasing Cl^-content and decreasing SO_4^+ concentrations, yielding low ratios, characterize connate waters.

Intermediate waters, where sulfate concentrations are elevated due to fluid-rock interactions with anhydrite and/or gypsum, yield ratio values around 0.1-0.4. The lower limit is somewhat arbitrary, but the upper limit is based on water analysis from southeast Asia (Cockroft and Robinson, 1988) where most primary connate waters were nonmarine and the meteoric influx is high.

Ratio values of SO_4^+/Cl^- versus depth for Ancell Group sandstones and for the Wells Creek Dolomite carbonates of Kentucky are shown in Figures 151 and 152. As observed from TDS concentrations, meteoric waters are present as deep as 2500 ft. (762 m) in the Ancell Group sandstone aquifers. The concentration of points within the mixed zone at depths of 2000-4000 ft. (762-1219 m) are mostly samples from wells in central Illinois where anhydrite is locally present, but dissolution features are wide spread. Samples below 4000 ft. (1219 m) are solely connate waters.

The water chemistry of early-Middle Ordovician aquifers from meteoric input is more clearly demonstrated in this data set. The scattering of points within the connate field at shallow depths are from wells thought to have tested the St. Peter Sandstone deposited in paleotopographic lows on the post-Knox paleotopographic surface. These

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Figure 151: SO_4^+/Cl^- vs. Depth for Ancell Group Quartz Arenites

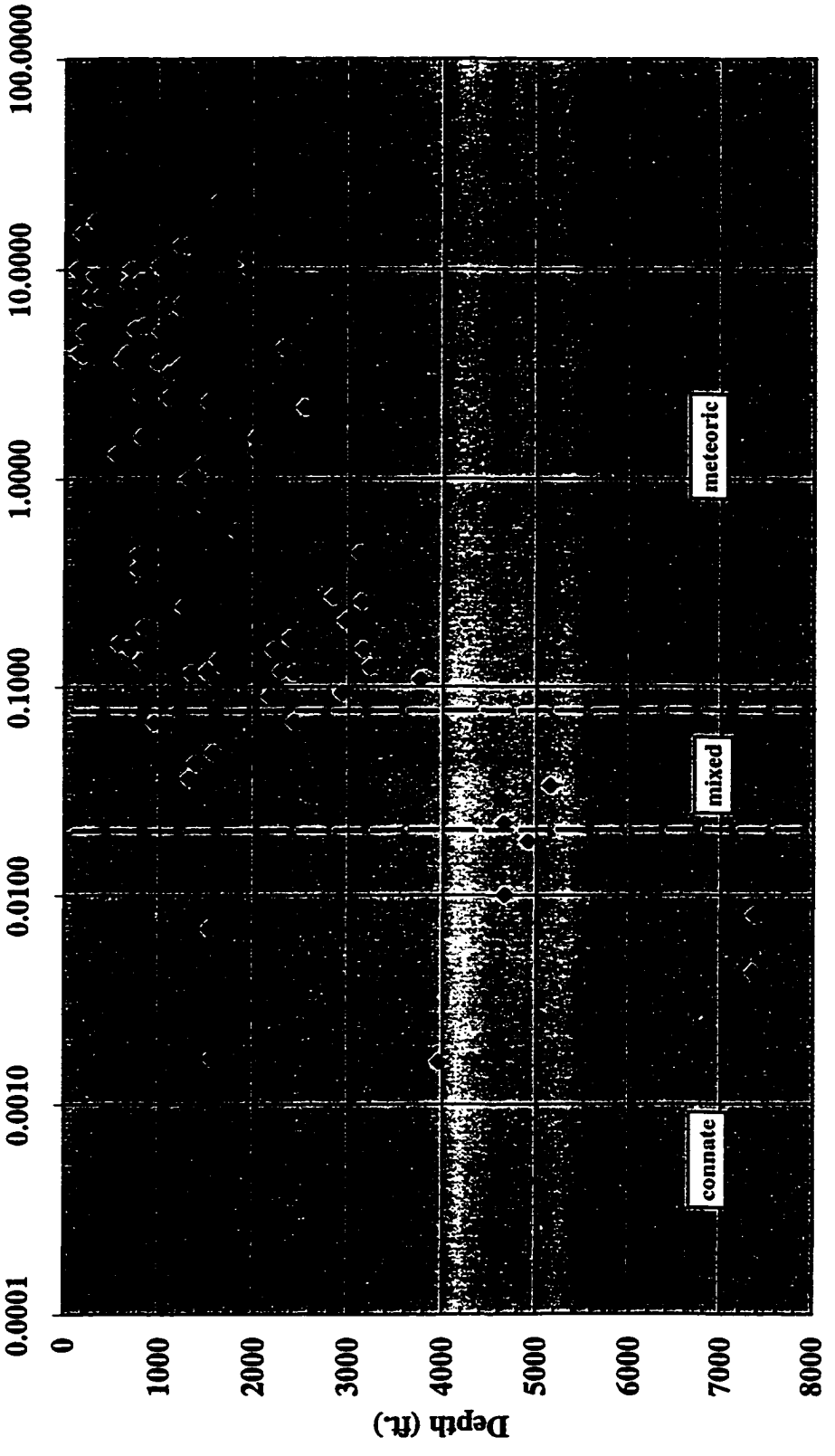

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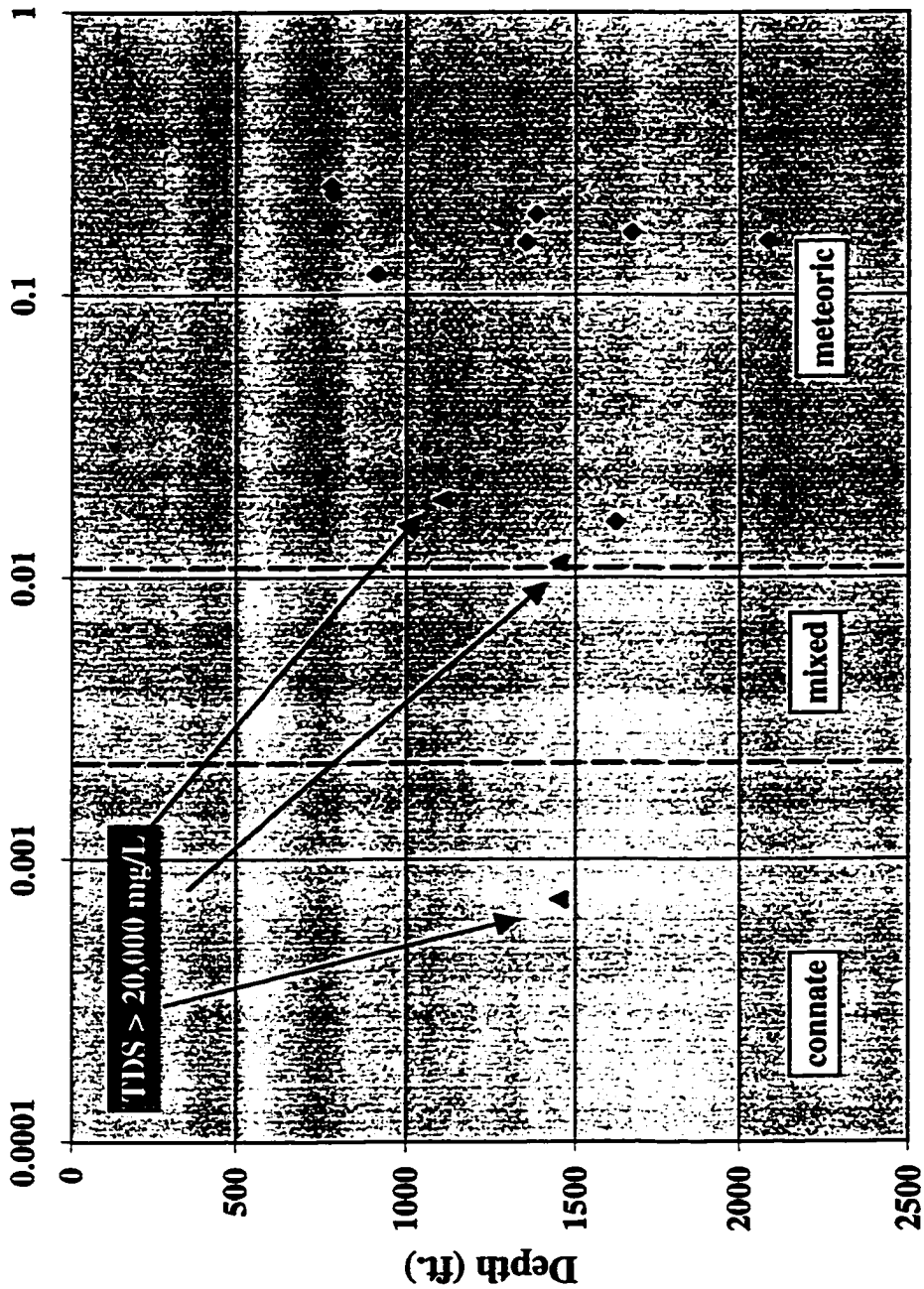
Figure 152: SO_4^+/Cl^- vs Depth for Wells Creek Dolomite, KY



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sands have highly-variable lateral continuity and are bounded by the relatively impermeable mudrocks of the Glenwood Formation and the argillaceous carbonates of the subjacent Knox Dolomite. As result, these sands are, for the most part, isolated from later meteoric input. All of the connate, and most of the mixed water samples from the Wells Creek Dolomite, including the incorrectly assigned "St. Peter Sandstones", have correspondingly elevated TDS concentrations and are believed to be from aquifers isolated from meteoric recharge.

All of the meteoric waters from the Wells Creek Dolomite have low TDS concentrations and were obtained from wells in the vicinity of the Jessamine Dome. The Jessamine Dome serves as a local recharge area where Middle Ordovician carbonates are exposed at the surface. The absence of a relationship of water chemistry with depth is probably due to meteoric input along faults and fractures associated with Pennyrile and Kentucky River Fault zones.

The distribution of dissolved sulfate with depth (Figure 153) and in map view (Figure 154) is much less clear than the more general measurement of TDS concentrations, or SO_4^+/Cl^- ratio. Above 2500 ft. (762 m) the data show extensive scatter that probably reflects the variable sulfate content of percolating meteoric waters, localized input of sulfate from chemical weathering of sulfide minerals, and up-hole contamination by oil field brines mixing with drilling fluids and due to casing leaks.

An example of uphole fluid contamination may be the water sample obtained upon penetration of the St. Peter Sandstone during the drilling of Forrester #1, Perry Co., Ill., which yielded a dissolved sulfate concentration of 1633 mg/L. When sampled one month later, the sulfate concentration increased to 2522 mg/L after the casing had been

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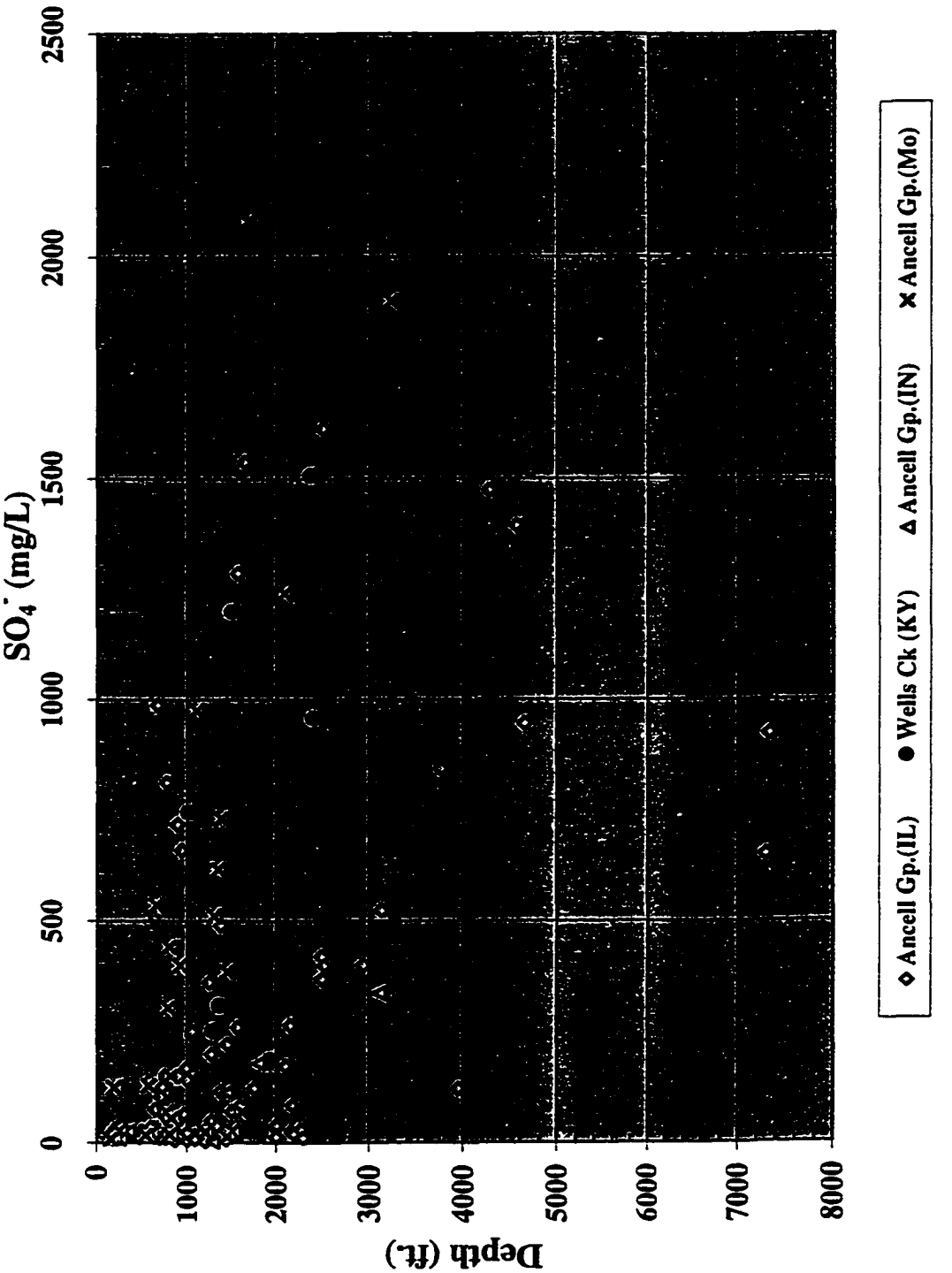
Figure 153: Dissolved Sulfate (SO_4^-) vs. Depth



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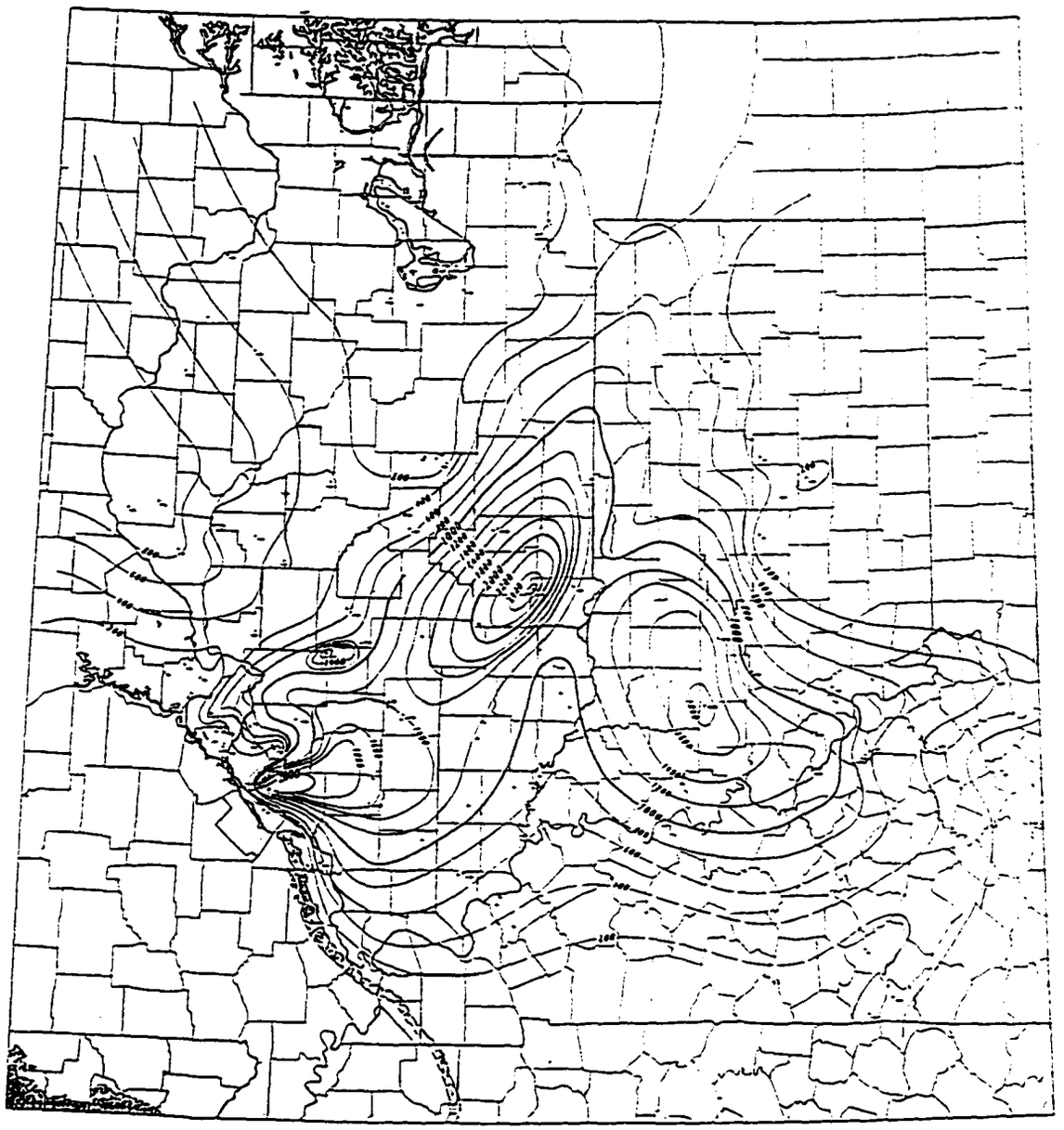

Figure 154: Dissolved sulfate (SO_4^-) isochore map for lower-Middle Ordovician aquifers, Ancell Group and its equivalants. Isochore interval 200 ppm SO_4^-.

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perforated and the Galena Limestone and an unidentified Mississippian sand were tested for oil (Pure Oil Co. records). An anomalously high sulfate concentration (2618 ppm) was also reported for a fluid sample containing oil and H_2S from the Spellbrig #34, Clark Co., Ill.. H_2S is highly uncommon in St. Peter Sandstone waters, even in wells with hydrocarbon shows in the Ancell Group, and its presence is suggestive of possible uphole contamination.

The two Misssouri data points in excess of 1500 mg/L appear to contaminated by extraformational brines that may be sourced from proximal fault/fracture zones, which may serve as conduits for extraformational waters, or failed casing in structurally lower, abandoned oil wells that produced from stratigraphically higher reservoirs (Miller and others, 1974).

Below 2500 ft. (762 m), dissolved sulfate concentrations appears to generally plateau between 900-1600 mg/L. For wells where anhydrite is known to be present in cores or cuttings, sulfate concentrations vary between 600-1200 mg/L. Dissolved sulfate concentrations in the Robinson #1, Marion Co., Ford et al C-17, White Co., Ill., and Allied Chemical #1, Vermilion Co., range from 923-1473 mg/L. This suggests that 1200 mg/L (+/-200 mg/L) approximates the equilibrium concentration of dissolved sulfate for connate waters in the presence of anhydrite in the deep subsurface (>7000 ft. or 2134 m).

In map view, dissolved suflate concentrations are highest along the Joachim-St. Peter Sandstone lithofacies transition. Northwest of this trend the section is almost entirely quartz arenites; southeast the section is mostly carbonate. The influx of low SO_4^- waters in the central basin approximates the limits of the northeast trending, Fluorspar

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and Wabash Valley Fault zones where fractures and faults may provide conduits for meteoric waters to infiltrate to depth.

The saddle between the two area of high concentration in southern Illinois is on trend with a series of positive, and negative, anomalies that trend NW through Pike Co., Ill. It is unclear if this trend is controlled by structure. In addition, the large positive SO_4^- concentration anomaly (>2000 mg/L) in southeast Missouri is associated with localized lead-zinc mineralization in the Everton and Joachim dolomites and the western extent of the Cottage Grove Fault Zone. This anomaly may reflect either meteoric dissolution of sulfate/sulfides phases, or the migration of mineralizing brines from the basin depocenter.

A comparison of the present-day distribution of calcium-sulfate, Figure 130, and the inferred limits of meteoric influence on the groundwater chemistry, as defined by the 10,000 mg/L isochore in Figure 149. The limits of meteoric influence closely, but not completely, correspond to the western and northern limits of present-day evaporite distribution. Southern and southeastern limits of anhydrite distribution do not coincide to groundwater geochemistry due to nondeposition of anhydrite, where the paleoembayment was open to the Iapetus Ocean, and/or paleometeoric dissolution associated with the uplift of the Pascola Arch during the late Paleozoic or early Mesozoic.

The irregular relationship of the limit of meteoric influence and present day distribution of anhydrite along the western margin of the basin, toward the Ozark Dome, and to the north toward the Wisconsin Arch, implies that the differential hydraulic head between the recharge areas and the basin has been greater in the past. A fluid potential in excess of the present-day hydraulic head would allow incursion of nonmarine waters, and the resultant dissolution of evaporites, further basinward. Isotopic data (Siegel and

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Mandle, 1984) suggest that the geochemistry of Cambro-Ordovician formation waters in northern and central Illinois are strongly influenced by large-scale recharge by Pleistocene meltwaters and that the present-day rate of recharge is insufficient to influence groundwater chemistry much beyond the present-day recharge areas.

Stueber and Walter (1994) identified, based on Sr isotope and δD-$\delta^{18}O$ data from Galena Group formation waters, a western shelf "mixing" event in which Galena reservoirs waters west of the Du Quoin Monocline are enriched with radiogenic strontium (^{87}Sr), and depleted (6-8‰) in $\delta^{18}O$ relative to Galena reservoirs in the Fairfield Basin. They attributed these geochemical trends to reflect the influx of Pleistocene meltwaters that are typically enriched with ^{87}Sr, due to water-rock interactions with radiogenic glacial till and/or marine shales (i.e., New Albany Shale), and are oxygen depleted due to cooler thermal equilibrium conditions.

Evaporite dissolution may not be solely related to Cenozoic groundwater flow. Depending on climate and paleotopographic relief, it is possible that undersaturated, nonmarine waters may have been driven basin-ward in the past by topographic flow from paleorecharge areas. Bethke and others (1991) have suggested that groundwater recharge and topographically driven flow from the uplift of the Pascola Arch may have been sufficient to flush formation fluids in the central basin. The present-day flow paths toward the central basin probably initiated with the Late Cretaceous down-warp of the basin and/or the Quaternary incision of the Mississippi, Ohio and Missouri rivers (Bond, 1972; Bethke and others, 1991). However, subcrop of the St. Peter Sandstone beneath Cretaceous sediments on the Pascola Arch and flanks of the Ozark Dome (Thompson, 1991), Pennsylvanian strata on the La Salle Anticline, La Salle Co., Illinois (Kirchner,

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1989), and Devonian strata on the flanks of the Ozark Dome (Thompson, 1991) suggest that other paleorecharge areas, more proximal to the basinal strata, have been available in the past.

The varying basinward limits of nonmarine influences on formation waters through time has resulted in a transitional area in which anhydrite dissolution is incomplete. In the central basin, where connate waters have not been flushed, anhydrite is an abundant constituent, up to 50% by volume, of the Joachim Dolomite and upper Dutchtown Formation. Low geophysical log porosity and the absence of dissolution features in core indicate the lack of porosity enhancement by dissolution. Where formation waters have a meteoric chemistry, evaporites are absent and sedimentary structures provide the only evidence of their presence in the past. Areas where "mixed" waters are present, anhydrite is locally preserved within low-permeability horizons, but moldic and dissolution porosity is well developed in beds adjacent to porous, permeable strata.

Implications of Evaporite Dissolution

In addition to the relatively obvious implications for Middle Ordovician paleogeography, the wide-spread dissolution of evaporites has four important implications for those reconstructing the basin's evolution.

First, basin subsidence models applied to the Illinois Basin to date have assumed a reduction in porosity by physical compaction for St. Peter Sandstone with burial depth (Heidlauf and others, 1986; Watso and Klein, 1989; Klein, 1989). The presence of an early evaporite cement invalidates this assumption, and implies that this compaction model can only be applied where the timing of dissolution can be determined, or the

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model is determined to be insensitive to this parameter. In addition, the conversion from gypsum to anhydrite may serve as a thermal sink (Jowett and others, 1993) and effect the thermal regime of the basin and therefore, impact on thermally-dependent diagenetic reactions that influence physical and chemical compaction.

Second, the dehydration of potentially significant volumes of gypsum with burial may be an added component to the basinal groundwater flow regime that should be taken into account in basin fluid flow models (i.e., Bethke, 1986).

Third, the selective preservation and/or dissolution of these early cements may serve to create "permeable" fluid pathways and focus paleoflow paths (i.e, Bethke and others, 1990) and may help explain the reported short duration of basinwide, regional fluid flow events observed by Rowan and Goldhaber (1995) and Garvin and others (1993).

And lastly, these evaporites may have provided an important source of ions for mineralizing brines, this aspect may be particularly important for understanding the origin of the MVT mineral deposits on the basin margins. Based on Na-Cl-Br brine systematics, Kesler and others (1995) reported that the MVT deposits of the mid-continent, southeast Missouri, Kentucky-Illinois Fluorspar District and Cincinnati Arch area, were formed from brines with compositions diagnostic of evaporite dissolution brines. However, the brine volumes required are well in excess of the presently know distribution of evaporites within this region. Large scale dissolution of halite and calcium-sulfate from the Ancell Group, as well as the underlying Cambro-Ordovician succession clearly offers a source of evaporite-related ions that has not been previously considered in detail.

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Although it can be argued that the early-Middle Ordovician succession is relatively thin and therefore, the errors introduced by not accounting for evaporite constituents in basin subsidence, or fluid flow models are insignificant. However, similar lines of evidence suggest that evaporites were widespread in the much thicker, more geographically extensive Prairie du Chien Dolomite Group (Fisher and Barratt, 1985; Smith and others, 1993; Smith and others 1996). Taken as an aggregate, Cambro-Ordovician evaporites may constitute an important rock volume that has not been accounted for in geochemical and subsidence models of the Illinois Basin.

CONCLUSIONS

The initial objective of this study was to examine the relationship between early-Middle Ordovician subsidence in the Illinois Basin subsidence and the Taconic Orogeny of eastern North America. This objective could not be fully realized because age determinations for the Ancell Group and its regional equivalents still lack the desired level of resolution required for this exercise. This is due to four factors.

First, the total stratigraphic ranges for the component faunas of the peritidal Everton Dolomite, Dutchtown Formation and Joachim Dolomite are still to poorly known to utilize them for graphic correlation. Furthermore, detailed biostratigraphic studies of the coeval carbonates of western Tennessee are lacking. Although on-going studies by Sweet (1995) will eventually address the former and the availability of the core for the Dupont, Geohydrological Survey #1 affords an opportunity to address the later, the current dataset precludes resolution of this problem for now.

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Second, given the absence of biostratigraphic datum's within the early-Middle Ordovician section, age determination for this portion of the section required the assumption of constant net rock accumulation for graphic correlation. Evidence for the development of condensed interval and differential compaction of Ancell sediments and the overlying carbonates due to post-burial dissolution of evaporite constituents suggests this assumption is invalid. However, it is difficult to assess the magnitude of the error introduced. If significant, this implies the age determinations determined in this study are younger than the probable age of these units.

Third, even if the assumption of constant rate for net rock accumulation proves to be valid, higher resolution sampling is required in some sections, notably the Weber Hill, G. Saylor 1, and the MSD DH-71-9(31) localities, will be required to more adequately establish biostratigraphic control those sections.

Lastly, although detailed outcrops studies of the Ancell, Black River, High Bridge and Stones River Groups are available, detailed correlation of these units in the subsurface is still challenging. At present, formation contacts defined for outcrop-based stratigraphic units are difficult to identify with precision in the subsurface, and units widely recognized in the subsurface have not been tied in detail with their correlative surface exposures. Resolving this problem will greatly enhance the resolution afforded the biostratigraphic framework built in this study.

With this said, this study has arrived at four observations that potentially are significant contributions to the understanding of early-Middle Ordovician of the Illinois Basin.

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The gross genetic sequences defined in this study do have a coarse synchronicity with depositional sequences in the Taconic foreland of eastern North America and within the Arbuckle region of the southern Midcontinent. This strongly implies a common control for the creation of accommodation space; however, whether the driver is tectonic or eustatic requires additional study.

Early Middle Ordovician genetic sequences in the Illinois Basin are made up of a complex mosaic of time transgressive clastic, carbonate and evaporite lithologies. Current lithostratigraphic units are mostly time transgressive lithotopes that are indicative of specific inner shelf, restricted marine depositional subenvironments.

Of these subenvironments, evaporite depositional environments appear to have been much more widespread than previously envisioned. Recognition of these environments was previously hampered by the lack of sedimentological study of the St. Peter Sandstone in the subsurface and the apparent dissolution of many of the soluble phases by meteoric groundwater dissolution over time.

The recognition of the wide spread presence of evaporites has important implications for the sourcing of mineralizing brines and for subsidence modeling of the basin. Previously, mass balance required reliance of deep basinal brines for sourcing sulfur, and other ions, for mineralizing brines. This study suggests an additional source for these ions was available at a shallower level within the basin.

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EARLY-MIDDLE ORDOVICIAN LITHOSTRATIGRAPHY, BIOSTRATIGRAPHY, AND DEPOSITIONAL ENVIRONMENTS OF THE ILLINOIS BASIN.

by

THOMAS H. SHAW

VOLUME II

A dissertation submitted to the Graduate Faculty in Earth and Environmental Sciences in partial fulfillment of the requirements for the degree of Doctorate of Philosophy, The City University of New York.

1999

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APPENDIX I: LOCALITY INDEX

Map sheet-1 shows the locations of cores and surface exposures described in this report. Detailed locality descriptions follow and are listed by state, and whether the section is based on outcrop or subsurface data. For subsurface localities, the core repository and catalog number are given. Detailed locality data for each well cored is given in Appendix II.

Abbreviations used for core repositories:

ISGS = Illinois State Geological Survey, Champaign, Illinois

IND = Indiana Geological Survey, Bloomington, Indiana

DGS = Ohio Dept. of Natural Resources, Division of Geologic Survey, Columbus, Ohio

KGS = Kentucky Geological Survey, Lexington, Kentucky

MGS = Dept. of Natural Resources, Divison of Geology and Land Survey, Rolla, Missouri

O = retained by operator

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Surface exposures

Illinois

1. **Starved Rock**: Type section of Starved Rock Sandstone at French Canyon, Starved Rock State Park, south of Uttica, Illinois, T33N-R2E-sec. 22, NW1/4 of NW1/4 of SW1/4, Ottawa, Ill., 7.5-minute quadrangle. Section first described by Willman and Templeton (1963); subsequently described by Nunn (1986). Because permission could not be obtained to sample the section, Nunn's description was field checked and adapted for this report. The type section for the Tonti Member, located in the nearby Tonti Canyon, is a vertical wall and is inaccessible.

Missouri

2. **Geiser Quarry**: Type section of Dutchtown Formation exposed in abandoned quarry, north side of Missouri Highway 74, 1.25 miles east of Dutchtown Missouri, T30N-R13E-sec. 20, SE1/4 NW1/4 SE1/4, Gordonville, Mo., 7.5-minute Quadrangle. Quarry is now cut by private drive.
3. **Dutchtown West**: North bluff on Missouri Highway A, at junction with Cape Girardeau County Road 241 to Allenville, 1.95 miles west of Dutchtown, Missouri, T30N-R12E-sec. 22, NE1/4, Gordonville 7.5-minute quadrangle. Thirty-eight feet of Everton Dolomite exposed in bluff north of Y-intersection.
4. **Black Hollow Branch South**: Dutchtown Formation exposed in roadcut along northbound lane of interstate I-55 at mile marker 121.5; 0.1 miles north of state road "F" overpass. Section is located in NE1/4 of SW1/4, sec. 27, 34N-11E, Friedham, Mo., 7.5-minute quadrangle.

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5. **West Perryville**: Dutchtown Formation exposed in roadcuts along northbound lane of Interstate I-55 from mile marker 131.1 to 131.8; state road "T" overpass is at mile 131.3. Section is located in E1/2 of sec. 23 and SW1/4 of section sec. 14, 35N-10E, Perryville West, Mo., 7.5-minute quadrangle. Thacker and Satterfield (1977) misidentified section as Everton Dolomite. This exposure is proposed herein as the principle reference section for the Dutchtown Formation.
6. **Saline Creek South**: Lower Joachim Dolomite exposed in roadcut along northbound lane of interstate I-55 at mile marker 139.5; 0.2 miles south of Ste. Genevieve County line. Section is located in 36N-10E-sec. 8, Lithium, Mo., 7.5-minute quadrangle.
7. **Zell West**: Joachim Dolomite exposed in roadcut along northbound lane of interstate I-55 at mile marker 152.0; 0.1 miles north of state Road "A" overpass. Section is located in SE1/4 of SE1/4 of SE1/4 of sec. 33, 38N-8E, Wiengarten, Mo., 7.5-minute quadrangle.
8. **Indian Creek North**: Everton Dolomite exposed in roadcut along northbound lane of interstate I-55 at mile marker 154.4. Section is located in NW1/4 of SW1/4 of sec. 29, 38N-8E, Weingarten, Mo., 7.5-minute quadrangle.
9. **Establishment Creek South**: Lower Everton Dolomite exposed in roadcut along northbound lane of interstate I-55 at mile marker 155.9; 0.7 miles south of bridge crossing Establishment Creek. Section is located in SW1/4 of NW1/4 of sec. 19, 38N-8E, Weingarten, Mo., 7.5-minute quadrangle.
10. **Bloomsdale North**: Series of roadcuts along northbound lane of Interstate 55 starting at mile marker 157.9 and continuing to 159.1, T38N-R8E, north of

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Bloomsdale, Missouri, NE1/4 of sec. 14 and W1/2 of sec.11, Bloomsdale 7.5-minute quadrangle. Lower and middle Everton exposed in roadcuts from 157.9-158.4; excellent section of upper Everton at 158.6 and 159.1; complete St. Peter section at 159.1 - contact with Joachim poorly exposed. Section has been described by Thompson (1991, fig. 42) and Thacker and Satterfield (1977, fig. 27).

11. **Bloomsdale Rest Area**: Lower Everton Dolomite exposed in roadcut along northbound lane of interstate I-55 at mile marker 160.2. Section is located at end of on-ramp from rest area in SW1/4 of NW1/4 of sec. 3, 38N- 7E, Danby, Mo., 7.5-minute quadrangle.

12. **Bloomsdale**: Road cut along northbound lane of U. S. Highway 61, 0.8 miles north of junction with Brickey's Rd. (Missouri Highway OO, T39N-R7E-Sec. 29, NE1/4, Danby 7.5-minute quadrangle. St. Peter Sandstone exposed at base of hill; nearly continuous section of Joachim Dolomite to top of hill. Lower Joachim up to 1st algal dome may be equivalant, in part, to Dutchtown Formation.

13. **Festus North**: Roadcut along northbound lane of Interstate I-55 at mile marker 177.2, immediately south of overpass 1.5 miles north of junction of I-55 and Missouri Highway A at Festus, Missouri, T41N-R6E-sec. 31, SW1/4, Festus, Mo., 7.5-minute quadrangle. Small exposure containing contact of St. Peter Sandstone and uppermost Everton Dolomite.

14. **Joachim Creek North**: Roadcut along southbound lane of Interstate I-55, mile marker 179.9 to 180.2, T41N- R6E, W1/2 of NW1/4 sec. 19, 0.45 miles north of Joachim Creek, Heraculeum, Mo., 7.5 minute quadrangle. Section begins just

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north of bridge in drainage ditch and continuous north. Upper Matson Member of Joachim Dolomite through upper Plattin Group exposed (see Thompson, 1991, figs. 69-70). Top of St. Peter ands Lower Joachim exposed on south-side of bridge along northbound lane. Outcrop accessible from access road to trailer park that is parallel to I-55 southbound.

15. **Weber Hill**: Roadcut along southbound lane of Missouri Highway 30, NE1/4 of sec. 27, T43N-R4E, Jefferson Co., Missouri, House Springs, Mo., 7.5-minute quadrangle. Immediately north of junction of Highway 30 and Byrnes Mill Rd.. Exposure of Matson Dolomite and overlying Plattin Group.

16. **Weber Hill South**: Small roadcut along northbound lane of Missouri Highway 30, 600 ft. south of turn-off to trailer park, NE1/4 of sec. 27, T43N-R4E, Jefferson Co., Missouri, House Springs, Mo., 7.5-minute quadrangle. Reference section for lower contact of Matson Dolomite.

17. **St. Albans West**: Railroad cut along the Rock Island Pacific Railroad, 1 mile southwest of St. Albans; SW1/4 of NE1/4 of SW1/4 of sec. 10, 44N-2E, Labidie, Mo., 7.5-minute quadrangle. Section is exposed along rail cut approximately 2900 ft. northeast of junction or County Rd. T and the Chicago Pipeline. Type section for Augusta Member of the Joachim Dolomite (Templeton and Willman, 1963, section 8).

18. **Matson West**: Abandoned quarry in north bluff of the Missouri River Valley, 1 mile southwest of Matson; NE corner of SE1/4 of NE1/4 of SW1/4 of sec. 4, 44N-2E, Labidie, Mo., 7.5-minute quadrangle. Section is located just northwest of abandoned barns, adjacent to abandoned railroad line. Type section for Boles and

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Defiance Members of the Joachim Dolomite (Templeton and Willman, 1963, section 9).

Kentucky

19. **Camp Nelson North**: Road cut on north cutbank beneath Kentucky River Bridge, on U. S. Highway 27, south of Camp Nelson, Jessamine Co., Kentucky, Little Hickman 7.5 quadrangle. Type section for Camp Nelson Limestone. Proposed reference section for Kentucky River Member.

Tennesse

20. **Pierce Mill**: Outcrop on north cutbank of the Stones River north of the abandoned Pierce Mill, immediately south of bridge where Tennessee State Highway 10 crosses the river, 0.5 miles south of Walterhill, Tennessee. Section begins at river level and continues to top of cutbank exposed adjacent to mill. Upper Murfreesboro Limestone and Pierce Limestone exposed; section serves as type section for Pierce Limestone.

Wisconsin

21. **Clay Hollow**: Exposure of St. Peter Sandstone and Glenwood Formation at junction of Clay Hollow Rd. and Wisconsin State Rte. 151 south of Platteville. Section is located in NE1/4 of SE1/4 of SW1/4, sec. 11, 2N-2W, Dickeyville, Wis., 7.5-minute quadrangle.

22. **Airport Road**: Exposure of St. Peter Sandstone and Glenwood Formation at junction or Airport Rd. and Wisconsin Rte. 151, sout of Platteville. Section is located in E1/2 of NW1/4 of NE1/4, Dickeyville, Wis., 7.5-minute quadrangle.

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Proposed type section for Platteville Group (Templeton and Willman, 1963), described by Ostrom (1987).

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Subsurface Control

The following wells were utilized in this study for subsurface stratigraphic control. The location of each well is shown on Map Sheet-2. Information for each well was obtained from the subsurface geologic records on file at the respective state geological survey of the state in which the well is located, or from the operator of the well. Unreported information is noted as "N/R".

The location of each well is reported by township, range and section, except where a local land survey system prevails (i.e., Carter coordinate system in Kentucky and Tennessee; named townships in Ohio, etc.). Footage locations are given and the direction indicated from local unit boundary (i.e., 100 FNL, 330 FWL indicates the well is located 100 ft. from the north line and 330 ft. from the west line).

The elevation, relative to sea level, of the reference datum reported for the geophysical log, or lithologic study utilized may be the elevation of one of the following: ground (GL), derrick floor (DF), kelly-bushing (KB) or casing flange (CF).

The date given is either the reported date of completion, or the date the well log was run. Because drilling fluid temperatures influence the response of certain types of geophysical tools, the date of logging was utilized for wells with geophysical logs.The operator and well name is that reported on the geophyiscal logs. Where wells were deepened or reworked at a later date the initial operator is given in parenthesis. For quarry borings, the mining property is given as the lease name.

Total depth (TD) below the reference datum is reported in feet. The reported TD on geophysical logs was used in preference to the driller's TD.

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Appendix II (cont.)

Table 9: Cores studied

Operator	Lease/WellName	County	State	Core (Repository/ Core #)
Union Hill Gas Storage	A. G. Hunt 1	Champaign	IL	ISGS C4267
Veliscol Chemical	Veliscol Chemical 2	Clark	IL	ISGS C8737
Magnolia Oil	M. T. Rodda 1	Coles	IL	ISGS C3533
Chicago Sanitary Dist.	Test Dh-9	Cook	IL	ISGS C7214
Metropolitan Sanitary Dist.	DH-71-9(3)	Cook	IL	ISGS C9475
Cabot Corp.	Cabot 1	Douglas	IL	ISGS C4884
CarterOil	Jennie Brauer 6D	Fayette	IL	ISGS C970
Herndon Drilling	Fecht 1	Ford	IL	ISGS C1196
Texaco	E. Cuppy 1	Hamilton	IL	ISGS C4785
New Jersey Zinc	Koefer H-2	Hancock	IL	ISGS C7607
R. A. Davis	South 1	Henry	IL	ISGS C4213
Vickery Drilling	J. Taden 1	Iroquois	IL	ISGS C3904
Stanolind Oil & Gas*	Leiner 1	Jackson	IL	ISGS C58
New Jersey Zinc	Alvin Davis F-25	JoDavies	IL	ISGS C6745
Weldron Silica	Prairie State Quarry 76-4	LaSalle	IL	ISGS C12518
Wedron Silica	Prairie State Quarry 76-8	Lasalle	IL	ISGS C12522
Northern Illinois Gas	Feinhold 1	Livingston	IL	ISGS C4636
Central Illinois Light	Hauffe 1	Logan	IL	ISGS C9239
Texaco Inc.	R. S. Johnson 1	Marion	IL	ISGS C4831
Northern Illinois Gas Co.	Pyne 1	McLean	IL	ISGS C10180
Illinois Power	King 1	Montgomery	IL	O-1
Illinois Power	Truitt 2	Montgomery	IL	ISGS C13443
Illinois Power	L. House 1	Montgomery	IL	O-2
Panhandle Eastern Pipeline	Carr 1-16	Morgan	IL	O-3
Panhandle Eastern Pipline	McVaigh 1-15	Morgan	IL	ISGS C13629
Panhandle Easter Pipeline	Thomas 1-15	Morgan	IL	ISGS C13630
Unimin Silica	91-409	Ogle	IL	O-4
Unimin Silica	86/316	Ogle	IL	O-5
Unimin Silica	86/331	Ogle	IL	O-6
Unimin Silica	86/321	Ogle	IL	O-7
Pike County Gas Assoc.	Conkright 2	Pike	IL	ISGS C3500
Battelle-Northwest	G. Saylor 1	Pike	IL	ISGS C12785
D & G Drilling	Mumford 3	Pike	IL	ISGS C13065
D & G Drilling	Elmer Yakley 7	Pike	IL	ISGS C13068
Algona Oil	Charles Cramer 1	Peoria	IL	ISGS C2228
Pure Oil	C. T. Montgomery 18-B	Richland	IL	ISGS C3598
Sun Oil	Maurice Vale 1	St.Clair	IL	ISGS C3200
Miller	G. W. Sample 1	Sangamon	IL	ISGS C28
Central Illinois Light	Witte 701	Stark	IL	ISGS C9240
Commonwealth Edison	UPH 3	Stephenson	IL	ISGS C12996
Central Illinois Light	Mary Wooding 1	Tazewell	IL	ISGS C3766
Illinois Power	Moberg 1	Warren	IL	ISGS C7215
W. C. McBride	A. V. Hunleith 1	Washington	IL	ISGS C2239
Superior Oil*	Ford et al. C-17	White	IL	ISGS C2740
NIPSCO	Betty Leuenberger et al 1	Allen	IND	IND C438
NIPSCO	Gale M. Skinner 1	Cass	IND	IND C227
Indiana Gas & Water	Carl P. Ross 1	Clark	IND	IND C332
Buttercup Energy	Rachel Pensinger 1	Clay	IND	IND C640
Gulf Oil Corp.	Frank Osborne 1	Decatur	IND	IND C316
NIPSCO	E. Morphet 1	Fulton	IND	IND C437
H. Hyslope and W. Simpson	L. Bishop 1	Hendricks	IND	IND C186
NIPSCO	Boezman 1	Jasper	IND	IND C435

*No core description in this report

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Appendix II (cont.)

Table 9: Cores studied (cont.)

Operator	Lease/WellName	County	State	Core (Repository/ Core #)
Shell Oil	L & R 1-24	Lagrange	IND	IND C675
NIPSCO	Alios Knapp 1	Newton	IND	IND C234
NIPSCO	Helen Ames 1	Marshall	IND	IND C455
General Electric	Waste Disposal WD-2	Posey	IND	IND C495
Gulf Oil Corp.	George L. Coon 1	Rush	IND	IND C325
Cominco-American	I. Hudson CA-53	Wabash	IND	IND C504
Cominco American CA-254	J. E. Willen 1	Cumberland	KY	KGS C496
Cominco American CA-58	Ellis 1	Henry	KY	IND C508
E. I. Dupont	Waste Disposal Well (Fee) 1	Jefferson	KY	KYGS C524
Louisville Gas & Electric Co.	F. H. Wainscott 1	Oldham	KY	KYGS C123A
Cities Services Minerals Corp.	James O'Donovan 3	Owen	KY	KYGS 103
Unimin Silica	91-11	Jefferson	MO	O-8
Unimin Silcia	91-12	Jefferson	MO	O-9
Phillips Petroleum	Winge TP-W1	Lincoln	MO	MGS
Getty Mining	Mineral Test 1703-1	St.Genevieve	MO	MGS
Getty Mining	Mineral Test 1701-1	St.Genevieve	MO	MGS
Hammer Lease 1	Lacleade Gas	St.Louis	MO	ISGS C6108
Ohio State Dept. of Geological Survey	C. Beiser 1	Bulter	OH	DGS C2537
Ohio State Dept. of Geological Survey	Sky Valley Recreational Club 1	Clermont	OH	DGS C2536
Ohio State Dept. of Geological Survey	American Aggregates Quarry 1	Warren	OH	DGS C2627
E.I. Dupont*	Geohydrological Test 1	Humphreys	TN	O-9

*No core description in this report

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APPENDIX II: CORE DESCRIPTIONS

The following section contains the lithic descriptions of cores described for this study. Several conventions have been used in compiling the descriptions.

First, depths are reported as feet below the reference datum; the elevation of the reference datum is given in the header on the first page of the description.

Second, depths reported are those labeled on the core, or samples. Depths have not been corrected to true vertical depths using available geophysical logs because reliable datum's could not be identified due to the lack of continuous core and/or geophysical logs for many locations, absence of core recovery reports, and lack of vertical hole surveys for the wells themselves. As a result, any conversion of driller's depth to subsea elevation would be inherently inaccurate, and complicate re-examination of core material at a future date.

Third, because much of the core samples available are representative core chips, and not whole core, and company core descriptions lack adequate detail, lithofacies contacts have been arbitrarily placed at the midpoint between samples and its is assumed that the samples are representative of the interval. With a few noted exceptions, the latter assumption appears to be valid.

Fourth, Lithofacies are designated by alpha-numeric identifiers that refer back to the description of lithofacies in the text (Table #). The identifier is prefixed by either "S"(= sandstone), or "C" (= carbonate) that identifies the primary lithology type, and numeric value refers to the lithofacies number.

Fifth, sample locations for petrographic (P), geochemical (G), biostratigraphic (B) and XRD clay (C) analysis are given. Geochemical samples include those collected for

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oxygen, carbon and sulfur isotopic analysis, and for RockEval pyrolysis. All surplus sample material is retained with the respective state survey where the core is available for study; sample material from operator-retained cores is on-file with the Illinois State Geological Survey.

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Table 10: Lithofacies codes

Siliclastics		Carbonates	
M1	Conglomeratic mudrock	C1	Quartzose dolopack/wackestone
M2	Green mudrock	C2	Microporous dolomudstone
M3	Red mudrock	C3	Laminated dolomudstone
M4	Quartzose mudrock	C4	Stromatolitic dolomudstone
M5	Brown mudrock	C5	Cryptolaminated dolomudstone
M6	Argillaceous siltstone	C6	Mottled dolomudstone
S1	Conglomeratic quartz arenite	C7	Intraformational breccia
S2	Dolomitic/calcareous quartz arenite	C8	Ostracodal dolo/calciwackestone
S3	Planar cross-stratified quartz arenite	C9	Intraclastic dolo/calcipack/grainstone
S4	Low-angle cross-stratified quartz arenite	C10	Patterned calci/dolomudstone
S5	Ripple cross-stratified quartz arenite	C11	Fenestral calci/dolomudstone
S6	Trough cross-stratified quartz arenite	C12	Argillaceous calci/dolomudstone
S7	Laminated quartz arenite	C13	Laminated calcimudstone
S8	*Skolithos*-bearing quartz arenite	C14	Peloidal pack/grainstone
S9	Mottled quartz arenite	C15	Mottled calimudstone
S10	Massive quartz arenite	C16	Stylolitic wacke/mudstone
S11	Nodule-bearing quartz arenite	C17	Bioclastic dolo/calciwacek/packstone
S12	Arkosic quartz arenite	C18	Oolitic grainstone
S13	Lithic quartz arenite	C19	Vuggy siliceous dolomudstone
S14	Silty quartz quartz arenite		
S15	Argillaceous quartz arenite		
S16	Bioclastic quartz arenite		

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Union Hill Gas Storage, A. G. Hunt 1, Sec. 16-R21N-T7E, Champaign Co., Ill., elev. 744 ft., ISGS Core 4267, core chips from 1487-1584 ft.

Depth (ft.)	Litho-facies	Description/Comments
1487	C14	Peloidal calcimudstone, medium-brown-gray, microcrystalline; sparse to abundant fine-grain peloids.
	C1	Quartzose dolowackestone, medium-brown-gray, finely-crystalline to microcrystalline, abundant medium- to coarse-grain, well-rounded, poorly-sorted, mud-supported quartz; abundance of quartz grains decreases upsection.
1490	S9/M2	Interbedded mottled quartz arenite and green mudrock; arenite is fine- to medium-grain, well-sorted, well-rounded quartz with anastomosing, discontinuous, black mudrock laminae; green-gray mudrock laminae at base that thickesn upsection to 3" green-gray mudrock interbed as 1491 ft.; bed is cross-cut by large Skolithos burrow infilled by coarse-grain, well-rounded, well-sorted quartz.
	C12	Argillaceous calcimudstone, gray-green, microcrystal-line; green-gray clay present throughout, abundant dark-green-gray mottles.
	C10	Patterned calcimudstone, light-green-gray, microcrystalline, argillaceous.
1500	C11	Fenestral calcimudstone, medium-brown-gray, microcrystalline matrix; sparse, subvertical fenestrae infilled with coarsely-crystalline calcite.
	C8	Ostracodal wackestone, greenish-medium-gray, microcrystalline, abundant large ostracodes in restricted horizons; locally patterned.
1505		

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Union Hill Gas Storage, A. G. Hunt 1, Champaign Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1510	C11	Fenestral calcimudstone, medium-brown-gray, microcrystalline matrix; sparse, subvertical fenestrae infilled with coarsely-crystalline calcite.
	C6	Mottled calcimudstone, light-medium-brown-gray, microcrystalline, locally fenestral.
1515		

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Union Hill Gas Storage, A. G. Hunt 1, Champaign Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1520		
	C8	Biomoldic ostracodal packestone, light-brown-gray, microcrystalline to finely-crystalline, abundant molds of ostracodes.
1525		
1530	C8	Ostracodal packestone, dark-brown-gray, microcrystalline to finely-crystalline, abundant ostracodes.
	C12	Calcimudstone, dark-brown-gray, microcrystalline, interbedded with black, organic-rich mudrock.

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Union Hill Gas Storage, A. G. Hunt 1, Champaign Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S2	Dolomitic quartz arenite, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz, well-indurated by quartz overgrowths; grain-supported at base, grades upsection to quartzose dolowacke-stone.
1535		
	C4	Vuggy stromatolitic dolomudstone, medium-dark brown-gray to light-brown-gray at base; anastom-osing and planar organic laminae throughout; chalky at base.
		Dolomitic quartz arenite, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz, well-indurated by quartz overgrowths; grain-supported at base, grades upsection to quartzose dolowacke-stone; ostracode molds at base; oil stained.
1540	S2	
	C1	Quartzose dolowackestone, pale-yellow-brown, fine- to medium-grain, well-rounded, well-sorted, mud-supported quartz; somewhat earthy.
	S9	Argillaceous, mottled quartz arenite, very-light-gray to light-green-gray, fine- to coarse-grain, mostly fine- to medium-grain, well-sorted quartz; abundant light-green-gray, argillaceous, clay-sized fraction; locally pyritic; moderately- to well-indurated throughout. No discernable breaks to 1552 ft.
1545		

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Union Hill Gas Storage, A. G. Hunt 1, Champaign Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1550		
	S10	Massive quartz arenite, light-yellowish-gray to light-gray, medium- to coarse-grain, well-rounded, moderately well-sorted quartz; moderately-indurated by quartz overgrowths. No discernable breaks to 1564 ft.
1555		
1560		

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Union Hill Gas Storage, A. G. Hunt 1, Champaign Co., Ill.(cont.).

Depth (ft.)	Litho-facies	Description/Comments
1565	S10	Massive quartz arenite, white to light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; sparse pore-filling calcite; biomoldic at 1568 ft.
1570		
1575	S4	Low-angle cross-stratified quartz arenite, white to light-medium-gray, fine- to medium-grain, well-rounded, well-sorted quartz; moderately- to well-indurated 1570'6"-1572', less well indurated by pore-filling calcite from 1572-1959 ft.; core breaks along subhorizontal planes - suggests planar cross-stratification.

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Union Hill Gas Storage, A. G. Hunt 1, Champaign Co., Ill.(cont.).

Depth (ft.)	Litho-facies	Description/Comments
1580	S10	Massive quartz arenite, white to light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; sparse, pore-filling calcite and sulfide locally.
1584		
		Bottom of cored interval; TD at 1815 ft.

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Velsicol Chemical, Velsicol Chemical #2, Sec. 12-T11N-R12W, Clark Co., Ill., elev. 639 ft., ISGS Core 8737, core chips 4060-4111 ft..

Depth	Litho-facies	Description/comments
4060	C2	Dolomudstone, medium-dark-gray, finely-crystalline with vague mottling, rare pyrite.
	C2	Dolomudstone, brown-gray, massive.
	C2	Dolomudstone, medium-dark-gray, finely-crystalline with vague mottling, rare pyrite.
4065	C10	Patterned dolomudstone, intermottled medium-gray and medium-dark-gray; latter is finely-crystalline.
	C2	Dolomudstone, medium-dark-gray, finely-crystalline with vague mottling, rare pyrite.
	C10	Patterned dolomudstone, intermottled medium-gray and medium-dark-gray; latter is finely-crystalline.
	C2	Dolomudstone, brown-gray, massive.
4070	C2	Dolomudstone, medium-dark-gray, finely-crystalline with vague mottling, rare pyrite.
4072		
		Interval cored, no samples 4072-4079 ft.

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Velsicol Chemical, Velsicol Chemical #2, Clark Co. (cont.).

Depth	Litho-facies	Decription/comments
4080	C3	Laminated dolomudstone, light-medium-gray with black to dark-brown mudrock laminae; laminae increase in abundance up section (GR-log)
	C10	Patterned dolomudstone, intermottled medium-gray and medium-dark-gray; latter is finely-crystalline.
	C3	Laminated dolomudstone, light-medium-gray with black to dark-brown mudrock laminae; laminae increase in abundance up section (GR-log)
	C15	Dolomudstone, black-gray, massive, finely-crystalline, intermottled with dolomudstone, brown-gray, noncrystalline; abundance of brown-gray dolomudstone increases upsection.
4085		
	C8	Ostracodal dolomudstone, black-gray, massive, fine- to medium crystalline; sparse stringers (1-2 mm) of intraclastic dolograinstone.
4090	C4	Stomatolitic dolomudstone, light-brown-gray, earthy, with abundant brown-gray to brown-black shale laminae (1-2 mm).
	C10	Patterned dolomudstone, intermottled medium-gray and medium-dark-gray; latter is finely-crystalline.
	C10	Anhydrite-bearing dolostone, dark-gray to very-dark-gray dolomudstone matrix with mottles of dark-blue-gray anhydrite; patterned, no laminae.

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Velsicol Chemical, Velsicol Chemical #2, Clark Co., Ill. (cont.).

Depth	Litho-facies	Description/comments
4095	C8	Ostracodal dolowackestone, black-gray, massive, fine- to medium crystalline; sparse stringers (1-2 mm) of intraclastic dolograinstone; locally abundance ostracode molds; sparse, anastomosing, brown-gray mudrock partings (stylolaminae?).
	C8	Argillaceous ostracodal dolopackstone, dark-gray to dark-brown-gray, abundant ostracod molds parallel to bedding, pyritic.
4100	C6	Anhydrite-bearing dolostone, dark-gray to very-dark-gray dolomudstone matrix with mottles of dark-blue-gray anhydrite; patterned.
	C8	Argillaceous ostracodal dolopackstone, dark-gray to dark-brown-gray, abundant ostracod molds parallel to bedding, pyritic.
	C10	Patterned dolomudstone, intermottled medium-gray and medium-dark-gray; latter is finely-crystalline.
4105	C6	Anhydrite-bearing dolostone, dark-gray to very-dark-gray dolomudstone matrix with mottles of dark-blue-gray anhydrite; patterned, no laminae.

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Velsicol Chemical, Velsicol Chemical #2, Clark Co., Ill. (cont.).

Depth	Litho-facies	Description/comments
4110	C8	Argillaceous ostracodal dolopackstone, dark-gray to dark-brown-gray, abundant ostracod molds parallel to bedding, pyritic.
4111		
Bottom of cored interval, TD at 6000 ft.		

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Magnolia Oil Co., M. T. Rodda 1, Sec. 4-T1N-R9E, Coles Co., Ill., elev. 609 ft., ISGS Core 3533, core chips each foot 5241-5269 ft.

Depth (ft.)	Litho-facies	Description/Comments
5241	C3	Laminated dolomudstone, olive-black to olive-gray, microcrystalline; dense, anhydritic; mostly massive; black mudrock laminae on core surfaces.
	C6	Mottled dolomudstone, green-gray, microcrystalline, dense, with anhydritic mottles.
5245	C17/C8	Siliceous bioclastic dolopackstone, dark-gray to black, microcrystalline; cherty, silica infills of biomolds and intraclast molds; argillaceous.
	C10	Patterned dolomudstone, green-gray, microcrystalline, sparsely pyritic, mottled, high mciroporosity.
	S9	Massive quartz arenite, light-green-gray, fine- to medium-grain, mostly fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; argillaceous, locally pyritic.
5250	S7/S5	Laminated to massive quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated, locally pyritic; anastomosing, pyritic laminae at 5250 ft.
	C1/C2	Quartzose dolomudstone, light-brown-gray, interbedded dolomitic quartz arenite, light-gray; quartz is fine- to medium-grain, well-sorted, well-rounded; dolomudstone matrix is microcrystalline with mudcracks on bedding plane.
	C3	Laminated to massive quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; locally pyritic, anastomosing, continuous laminae.

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Magnolia Oil Co., M. T. Rodda 1, Coles Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
5255		
	S9	Mottled quartz arenite, light-green-gray, fine- to medium-grain, mostly fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; sparsely argillaceous, argillaceous content increases upsection; clay-lined vertical burrows at top; 1" of black mudrock at base.
	C12/C9	Argillaceous dolopackstone, dark-medium-brown-gray, microcrystalline, with black mudrock partings; rip-ups of mudrock locally.
5260	C8	Siliceous bioclastic dolopackstone, dark-gray to black, microcrystalline; cherty, silica infills of ostracod biomolds and intraclast molds; argillaceous.
	S10	Massive quartz arenite, dark-brown-gray to black, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; oil oil stained.
	S9	Mottled quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated, argillaceous, locally pyritic; mottled.
		No sample 5264 ft.
5265	S9	Mottled quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated, argillaceous, locally pyritic; mottled; possible burrow trace at 5266 ft.

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Magnolia Oil Co., M. T. Rodda 1, Coles Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
5269	S7	Laminated quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated, locally pyritic; anastomosing, green-gray mudrock laminae.
Bottom of cored interval, TD 5389 ft.		

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Chicago Sanitary District, DH-9, Sec. 25-T37N-R41Em Cook Co., Ill., elev. 588 ft., ISGS Core 7214, core chips 987-1047 ft.

Depth (ft.)	Litho-facies	Description/Comments
987	C1/C14	Quartzose dolostone, medium-brown-gray and light-medium-gray, mottled appearance, abundant medium- to coarse-grain, well-rounded, clear quartz grains; abundant brachiopod and ostracod biomolds.
990	C1/S1	Quartzose dolostone and dolomitic quartz arenite, very light-gray to light-brown-gray, with green-gray mudrock laminae at base that increase in abundance upsection; abundant fine-grain and coarse-grain, bimodal, well-rounded quartz throughout; locally, calcite cemented and quartz overgrowth cemented where very light-gray; sparse ostracode biomolds near base.
995	S15	Argillaceous quartz arenite, very light-gray to light-green-gray, fine- to medium-grain, well-sorted to moderately well-sorted quartz; sparse to abundant green-gray argillaceous intervals that contain sparse, to abundant pore-filling sulfide masses; locally calcite cemented; very light-gray where moderately-indurated by quartz overgrowths.
	S8	*Skolithos*-bearing quartz arenite, light-medium-gray to very light-gray to green-gray, fine- to medium-grain quartz matrix with coarse-grain, well-round quartz infilling *Skolithos* burrows; argillaceous and friable where green-gray; locally pyritic; burrows are abundant at 998 ft., and 1000-1001 ft.

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Chicago Sanitary District, DH-9, Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1000		
	S15	Quartz arenite, light-green gray, fine- to medium-grain, well-rounded, moderately- to poorly-sorted quartz, grain-size increases from fine-grain at base to medium-grain at top, silty throughout, thin green-gray mudrock laminae locally; sparse to moderately abundant pore-filling sulfide throughout.
1005		
	S10	Massive quartz arenite, light-gray to very light-gray, fine- to medium-grain, well- to moderately well-sorted, well-rounded quartz; friable to moderately well-indurated by quartz overgrowths.
1010		
	S3/S4	Planar and low-angle cross-stratified quartz arenite, light-gray, medium-grain, well-sorted, well-rounded, moderately-indurated by quartz overgrowths, minor pore-filling calcite at 1012', vague to well-developed planar and low-angle cross-stratification

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Chicago Sanitary District, DH-9, Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded, moderately-argillaceous, pyritic, friable to moderately-indurated by quartz overgrowths; sparse sulfide throughout.
1015	S3/S4	Planar and low-angle cross-stratified quartz arenite, light-gray, medium-grain, well-sorted, well-rounded, moderately-indurated by quartz overgrowths, vague to well-developed, planar and low-angle cross-stratification
	S10	Massive quartz arenite, light-gray to very light-gray, fine- to medium-grain, mostly fine-grain, well- to moderately well-sorted, well-rounded, quartz; moderately- to well-indurated by quartz overgrowths; vague intermottling of fine- and medium-grain sizes in some intervals; sparse to abundant pyrite.
1020		
1025	S4	Low-angle cross-stratifeid quartz arenite, light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by sparse quartz overgrowths, well-developed by low-angle cross-stratification.
	S10	Massive quartz arenite, light-gray to very light-gray, fine- to medium-grain, mostly fine-grain, well- to moderately well-sorted, well-rounded quartz; moderately- to well-indurated by sparse quartz overgrowths; calcite cemented at 1031 ft.; vague intermottling of fine and medium-grain quartz in some intervals, sparse pore-filling sulfide throughout.

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Chicago Sanitary District, DH-9, Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Low-angle cross-stratifeid quartz arenite, light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by sparse quartz overgrowths, well-developed by low-angle cross-stratification.
1030	S10	Massive quartz arenite, light-gray to very light-gray, fine- to medium-grain, mostly fine-grain, well- to moderately well-sorted, well-rounded quartz; moderately- to well-indurated by sparse quartz overgrowths; locally calcite cemented; vague intermottling of fine and medium-grain quartz in some intervals, sparse pore-filling sulfide throughout.
	S4	Low-angle cross-stratifeid quartz arenite, light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by sparse quartz overgrowths, well-developed by low-angle cross-stratification.
1035	S10	Massive quartz arenite, light-gray to very light-gray, fine- to medium-grain, mostly fine-grain, well- to moderately well-sorted, well-rounded quartz; moderately- to well-indurated, extremely well-indurated by quartz overgrowths at 1039 ft.; intermottling of fine- and medium-grain quartz in some intervals; sparse pore-filling sulfide throughout.
1040		

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Chicago Sanitary District, DH-9, Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-gray to very light-gray, fine- to medium-grain, mostly fine-grain, well- to moderately well-sorted, well-rounded quartz; moderately- to well-indurated, intermottling of fine- and medium-grain quartz in some intervals, sparse pore-filling sulfide throughout.
1045		
Bottom of cored interval and TD.		

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Chicago Metropolitan Sanitary District, MSD DH-71-9(31), Sec. 35-T42N-R13E, Cook Co., Ill., elev. 593 ft., ISGS Core 9475, NX core, described 850-942.5 ft.

Depth (ft.)	Litho-facies	Description/Comments
850	C1	Quartzose dolowacketone, light-medium-brown, finely-crystalline, medium- to coarse-grain, moderately-sorted, well-rounded quartz; abundance of quartz decreases upsection; sparse, fine-grain, well-rounded black phosphate at base.
	S9	Mottled quartz arenite, white to dark-gray to green-black, fine- to medium-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths; abundant pyrite in upper 6"; mottled throughout.
855	S10	Massive quatz arenite, white, medium- to fine-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; moderately to well-indurated by quartz overgrowths, sparsely calcareous.
860		
		No core 860-861 ft.
	S10	Massive quatz arenite, white, very-fine- to fine-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; moderately to well-indurated by quartz overgrowths, sparsely calcareous; locally, sparsely pyritic; vague, low-angle cross-stratification in some horizons.

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Chicago Metropolitan Sanitary District, MSD DH-71-9(31), Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
865		
870		
875	S3	Planar-cross-stratified quartz arenite, interbedded light-gray and white quartz arenite; white quartz arenite is very fine-grain to fine-grain, well-sorted, well-rounded quartz, very-well indurated by quartz overgrowths; light-gray quartz arenite is coarse- to medium-grain, well-sorted, well-rounded quartz that is weakly to moderately-indurated by quartz over-growths; core is chatter marked in fine-grain, well-indurated intervals; planar cross-stratification common to abundant throughout, sparse low-angle cross-stratification.

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Chicago Metropolitan Sanitary District, MSD DH-71-9(31), Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Low-angle cross-stratified quatz arenite, light-gray, fine- to medium-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths, sparsely calcareous; abundant low-angle cross-stratification.
880	S10	Massive quatz arenite, white, very-fine- to fine-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths, sparsely calcareous, locally sparsely pyritic; *Skolithos* burrows in upper 1 ft.
	S10	Massive quatz arenite, white, very-fine- to fine-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths, sparsely calcareous, locally sparsely pyritic; *Skolithos* burrows in upper 1 ft.
885	S4	Low-angle cross-stratified arenite, light-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; grain-size decreases upsection.
	S8	*Skolithos* -bearing quatz arenite, white, very fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz overgrowths, sparsely calcareous; sparse to abundant *Skolithos* burrows; burrow fill is coarser-grain then matrix.
	S4	Low-angle cross-stratified arenite, light-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; grain-size decreases upsection.
890	S8	*Skolithos* -bearing quatz arenite, light-gray, fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz overgrowths, sparsely calcareous; sparse to abundant *Skolithos* burrows; burrow fill is coarser-grain then matrix; abundance of burrows increases upsection; low-angle cross-stratification preserved in upper foot.
	S4	Low-angle cross-stratified arenite, light-gray to light-yellow-gray, fine- to medium-grain, moderately-

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Chicago Metropolitan Sanitary District, MSD DH-71-9(31), Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; grain-size decreases upsection.
	S8	*Skolithos* -bearing quatz arenite, light-gray, fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz overgrowths, sparsely calcareous; sparse to abundant *Skolithos* burrows; burrow fill is coarser-grain then matrix; abundance of burrows increases upsection; low-angle cross-stratification preserved in upper foot.
895		
	S3	Planar cross-stratified quartz arenite, light-green-gray, fine to medium-grain, well-sorted, well-rounded quartz; abundant clay-coats, friable to weakly-indurated.
	S15	Argillaceous quartz arenite, light-green-gray, fine to medium-grain, moderately-sorted, well-rounded quartz; abundant clay-coats, friable to weakly-indurated; microfault at 899'6" with 0.75" of displacement.
900		
	S10	Massive quartz arenite, light-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz over-growths.
	S10	Massive quartz arenite, light-gray, grading up-section to low-angle cross-stratified quartz arenite, fine- to medium-grain, well-rounded, well- to moderately-sorted quartz arenite; massive, moderately-sorted at base; upper 6"-10" low-angle cross-stratified quartz arenite, interlaminated medium- and fine-grain, well-sorted quartz arenite. Three sequences bounded by sharp contacts: 903'6"-
905		

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Chicago Metropolitan Sanitary District, MSD DH-71-9(31), Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		904'9". 904'9"-906'1" and 906'1"-909'7".
910	S9	Mottled quartz arenite, very fine- to fine-grain, well-sorted, well-rounded quartz arenite; moderately-indurated by quartz overgrowths; vague mottling.
	S4	Low-angle cross-stratified arenite, light-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-gray, grading up-section to low-angle cross-stratified quartz arenite, fine- to medium-grain, well-rounded, well- to moderately-sorted quartz arenite; massive, moderately-sorted at base, upper 6-10" low-angle cross-stratified quartz arenite, interlaminated medium- and fine-grain quartz arenite.
915	S4	Low-angle cross-stratified arenite, light-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-gray, grading up-section to low-angle cross-stratified quartz arenite, fine- to medium-grain, well-rounded, well- to moderately-sorted quartz arenite; massive, moderately-sorted at base, upper 6-10" low-angle cross-stratified quartz arenite, interlaminated medium- and fine-grain quartz arenite; abundant intergranular pyrite at 917 ft. and 919'6".
920		
		No core 920-921' ft.

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Chicago Metropolitan Sanitary District, MSD DH-71-9(31), Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Low-angle cross-stratified quartz arenite, light-yellow-gray, interlaminated medium- and fine-grain quartz; sparsely pyritic, pyrite present as mottles, irregular masses (< 0.5") and as pore-filling cement in cross-laminae.
	S10	Massive quartz arenite, light-gray, grading up-section to low-angle cross-stratified quartz arenite, fine- to medium-grain, well-rounded, well- to moderately-sorted quartz; massive, friable, sparse green-gray clay-drapes; sparely argillaceous overall.
925		
	S4	Low-angle cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; massive with pyritic mottles in lower 13"; upper contact sharp, lower contact gradational.
930		
	S9	Mottled quartz arenite, light-medium-gray and light-green-gray, fine- to medium-grain, moderately- to poorly-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; upper contact gradational, low contact sharp.
	S10	Massive quartz arenite, light-medium-gray to light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; sparse, small (<0.25"), irregular sulfide masses; green-gray mudrock partings in lower 6"; upper contact sharp, lower contact gradational.

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Chicago Metropolitan Sanitary District, MSD DH-71-9(31), Cook Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
935		Conglomeratic mudrock, green-gray, abundant gray to light-gray, fine-grain to pebble-size, angular, opaque chert and fine- to medium-grain, well-rounded, poorly-sorted quartz; pyritic at base; upper contact gradational, lower contact sharp, irregular.
	M1	
	C19	Vuggy dolopackstone interbedded with argillaceous dolomudstone; dolopackstone is medium-light-gray, moderately- to coarsely crystalline with abundant biomolds; dolomudstone to light-medium-gray with sparse to abundant green-gray mudrock partings, commonly cherty locally. Contains Lower Ordovician microfauna.
940		
	S9	Quartz arenite, light-medium-gray, fine- to medium-grain, well-rounded, well-sorted quartz; massive; well-indurated by quartz overgrowths, calcareous.
Bottom of described interval, TD at 1341 ft.		

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill., elev.698 ft.,
ISGS Core 4884, 4-inch core 3941-4121 ft., described 3957.5-4105 ft.

Depth (ft.)	Litho-facies	Description/Comments
	S8	*Skolithos* -bearing quartz arenite, light-yellow-gray to light-green-gray; matrix is fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; argillaceous locally; sparse to moderately-abundant. *Skolithos* burrows infilled by medium- to coarse-grain, moderately-sorted, well-rounded quartz; burrow fill is commonly well-indurated by quartz overgrowths; argillaceous mottling locally developed.
3960		
	M2	Green mudrock, sparsely pyritic, nonfissle.
	S8	*Skolithos* -bearing quartz arenite, light-yellow-gray to light-green-gray; matrix is fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; argillaceous locally; sparse to moderately-abundant. *Skolithos* burrows infilled by medium- to coarse-grain, moderately-sorted, well-rounded quartz; burrow fill is commonly well-indurated by quartz overgrowths; argillaceous mottling locally.
3965		
3970		

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S15	Argillaceous quartz arenite, light-green-gray to light-yellowish-gray, moderately-sorted, well-rounded quartz; argillaceous, weakly-indurated by quartz overgrowths; sparse to abundant, green mudrock partings that decrease in abundance upsection.
	M5	Dark gray mudrock, medium-dark-gray, sparsely pyritic, thin- to thick-laminae of organic-bearing mudrock; rare burrow mottles, somewhat fissle.
3975	S8	*Skolithos*-bearing quartz arenite, light-yellow-gray to light-green-gray; matrix is fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-to moderately-indurated by quartz overgrowths; argillaceous locally; sparse to moderately-abundant, *Skolithos* burrows infilled by medium- to coarse-grain, moderately-sorted, well-rounded quartz; burrow fill is commonly well-indurated by quartz overgrowths; argillaceous mottling locally.
3980	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; burrow mottles locally.
	S9	Mottled quartz arenite, light-green-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; sparse to abundant, argillaceous mottles throughout; horizontal burrows locally; sparse *Skolithos* burrows.

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3985		
3990		
		Quartzose dolograin/packstone, medium-brown-gray, abundant fine- to medium-grain, well-sorted, well-rounded quartz, ooids(?) and phosphatic
3995	C1	bioclasts; well-indurated by dolomicrite cement.
	S9	Mottled quartz arenite, light-green-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; sparse to abundant, argillaceous mottles throughout; horizontal burrows locally; sparse *Skolithos* burrows.

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
4000		
4005		
4010		

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
4015	S15	Argillaceous quartz arenite, light-green-gray to light-yellowish-gray, moderately-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; sparse green mudrock partings that decrease in in abundance upsection; abundant quartz silt in lower 1.5 ft.
	M2	Green mudrock, nonfissle, abundant quartz silt.
	S9	Mottled quartz arenite, light-green-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; sparse to abundant argillaceous mottles throughout; *Skolithos* burrows locally.
4020		
4025		

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
4030		
4035		
		Lithic arenite, light-yellowish-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz and sparse,
	S13	subrounded quartz arenite intraclasts.
	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-
4040		

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		indurated by quartz overgrowths; burrow mottles locally.
		No core 4041–4059 ft.
4060	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; burrow mottles locally.
	S8	*Skolithos* -bearing quartz arenite, light-yellow-gray to light-green-gray; matrix is fine- to medium-grain, moderately-sorted, well-rounded quartz; argillaceous, weakly-to moderately-indurated by quartz over-growths; sparse to abundant, large diameter (0.25") *Skolithos* burrows infilled by medium- to coarse-grain, moderately-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
4065		
4070		

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
4075	S9	Mottled quartz arenite, light-green-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; sparse to abundant argillaceous mottles throughout; *Skolithos* burrows locally.
4080		Lithic arenite, light-yellowish-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz and fine- to coarse-grain, subrounded to rounded, microcrystalline chert; moderately-indurated by quartz overgrowths.
	S13	
	S8	*Skolithos* -bearing quartz arenite, light-yellow-gray to light-green-gray; matrix is fine- to medium-grain, moderately-sorted, well-rounded quartz; argillaceous, weakly-to moderately-indurated by quartz over-growths; sparse to abundant, large diameter (0.25") *Skolithos* burrows infilled by medium- to coarse-grain, moerately-sorted, well-rounded quartz; well-indurated by quartz overgrowths; burrows terminate at upper contact.
		No core 4082'-4085'3".

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
4085		
	S9	Mottled quartz arenite, light-green-gray to light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; sparse to abundant argillaceous mottles throughout; burrows traces well defined locally; planar to low-angle cross-stratification preserved locally.
4090		
		No core 4090-4095 ft.
4095		
	S8	*Skolithos*-bearing quartz arenite, light-yellow-gray to light-green-gray; matrix is fine- to medium-grain, moderately-sorted, well-rounded quartz; argillaceous, weakly- to moderately-indurated by quartz overgrowths; sparse to abundant, large diameter (0.25") *Skolithos* burrows infilled by medium- to coarse-grain, moderately-sorted, well-rounded quartz, burrow fill is commonly well-indurated by quartz overgrowths.

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Cabot Corp., Cabot 1, Sec. 31-T16N-R8E, Douglas Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
4100	C19	Dolomudstone, dark-brown-gray with green-gray argillaceous partings, microcrystalline to finely-crystalline; vuggy, vugs infilled by quartz arenite and green-gray mudrock.
4105		
Bottom of described interval, TD at 2640 ft.		

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Carter Oil Co., Jennie Brauer 6-D, Sec. 21-T8N-R3E, Fayette Co., Ill.
elev. 528 ft., ISGS core C970, core chips each foot 4464-4486 ft.

Depth (ft.)	Litho-facies	Description/Comments
4464	S8	*Skolithos* -bearing quartz arenite, light-medium-gray, to light-yellowish-green-gray, fine- to medium-grain, matrix is poorly- to moderately well-sorted, well-rounded quartz; argillaceous 4465-4467 ft., *Skolithos* burrows are infilled by medium- to coarse-grain, well-rounded quartz; moderately-indurated by quartz overgrowths throughout; burrows are clay-lined at 4467 ft.
4465		
	S10	Massive quartz arenite, very-light-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; well-indurated by abundant quartz overgrowths.
	S4	Low-angle cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-rounded quartz; moderately-indurated; well defined lown-angle cross-stratification.
4470	S10	Massive quartz arenite, very-light-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; well-indurated by abundant quartz overgrowths.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well- to moderately well-sorted, well-rounded quartz; argillaceous throughout; vague planar cross-stratification at 4475 ft.
4475		
	S8	*Skolithos* -bearing quartz arenite, light-medium-gray, to light-yellowish-green-gray, fine- to medium-grain, poorly- to moderately well-sorted, well-rounded quartz; argillaceous; *Skolithos* burrows are infilled with coarser-grain fraction and are clay-lined; clay content increases upsection.

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Carter Oil Co., Jennie Brauer 6-D, Fayette Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S7	Laminated quartz arenite, light-yellowish-brown to light-brown-gray, fine- to medium-grain, well-sorted quartz; well-indurated; pyritic, argillaceous, green-gray mudrock laminae.
	S8	*Skolithos* -bearing quartz arenite, light-medium-gray, fine- to medium- or coarse-grain, bimodal, well-rounded quartz; abundant *Skolithos* burrows infilled by coarse-grain fraction and well-indurated.
4480	S10	Massive quartz arenite, very-light-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; well-indurated by abundant quartz overgrowths.
	S9	Mottled quartz arenite, light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to poorly indurated by quartz overgrowths; sparse vertical burrow traces, possibly *Skolithos* .
	S10	Massive quartz arenite, very-light-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; sparse quartz overgrowths; very friable to weakly-indurated.
4485		
4486		
Bottom of cored interval, TD at 4679 ft.		

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Herdon Drilling Co., W. J. Fecht #1, Sec. 33-T26N-R9E, Ford Co., Ill., elev. 741 ft., ISGS Core 1196, see comments below.

Depth (ft.)	Litho-facies	Description/Comments
1447	C8	Ostracodal dolopackstone, medium-brown-gray, microcrystalline, scatter biomolds of ostracodes. (core sample 2-1)
	C1	Quartzose dolopackstone, medium-brown-gray with dark-brown mudrock laminae; abundant, mud-supported, coarse- to medium-grain, well-rounded, moderately-sorted quartz; grain-size and abundance of quartz decreases upsection. (core sample 2-2)
1450		
	S2	Calcareous quartz arenite, light-brown-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; moderately- to well-indurated, dolomitic and argillaceous at base. (core samples 2-3 and 2-4)
	S15	Argillaceous quartz arenite, medium-green-gray, medium- to fine-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; abundant green-gray detrital clay. (sample 2-5)
	S10	Massive quartz arenite, very-light-green-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; disseminated intergranular green-gray clay; moderately- to weakly-indurated. (core samples 2-6 and 2-7)
1455		
	S2	Dolomitic quartz arenite, very-light-green-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; disseminated intergranular green-gray clay; moderately- to weakly-indurated by dolomicritic cement. (2-8)
	S10	Massive quartz arenite, light-medium-brown, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; nonargillaceous. (core sample 2-9)
1460		

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Herdon Drilling Co., W. J. Fecht #1, Ford Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1462	S2	Dolomitic quartz arenite, very-light-green-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; disseminated inter-granular green-gray clay; moderately- to weakly-indurated by dolomicritic cement; pyritic. (2-10)
		Bottom of cored interval, TD at 2237 ft.

Note: Well was drilled in 1944 and core obtained by W. Meents, ISGS, 11/53. Core chips were retained from core #2 which penetrated 1447-1462 ft., but no footages were noted on sample bags. Depths as reported above are based on interpretation of drilling rates and electric log.

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Texaco, Inc., E. Cuppy 1, Sec. 6-T6S-R7E, Hamilton Co., Ill., elev. 393 ft., ISGS Core 4785, discontinuous whole core 7609-7631 ft.

Depth (ft.)	Litho-facies	Description/Comments
7610	S4 S10	Cross-stratified quartz arenite, medium- to coarse-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; well-defined, low-angle cross-stratification.
7615	S10	Massive quartz arenite, light-medium-gray to very light-brown-gray, fine- to coarse-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz overgrowths; patchy distribution of dolomite and anhydrite cements.
7620	S10	As above, but very well-indurated by quartz over-growths, nonporous.
	S10/S9	Massive quartz arenite with minor interbeds of ripple cross-stratified and planar cross-stratified quartz arenite; fine- to coarse-grain, well- to moder-ately-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; burrow trace at 7617 ft.; planar- and ripple-laminated from 7619'4"-7619'8".
	S10	Massive quartz arenite as above, but very well-indurated by quartz overgrowths; very low porosity.
	S10	Massive quartz arenite, white to light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated

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Texaco, Inc., E. Cuppy 1, Hamilton Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		by quartz overgrowths; stylolitic at 7623 ft.; green-gray mudrock partings in lower 1 ft.
7625		
	S10	Massive quartz arenite, white to light-medium-gray, mostly fine-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz overgrowths.
	S9	Mottled quartz arenite, white to light-medium-gray, fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; sparse pyrite; elliptical, dolomite-cemented patches at 7276 ft.; vague burrow traces throughout; green-gray mudrock partings in lower 1 ft.
	S9	As above, but very well-indurated by quartz over-growths; very low porosity.
7630	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths; locally pyritic.
	S10	As above, but very well-indurated.
7631	S15	Argillaceous quartz arenite, light-medium-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by quartz over-growths; sparse green-gray mudrock partings.
Bottom of cored interval, TD at 13,051 ft.		

Note: Company core description reports cored interval as 7609-7633.5 ft. (26.5 ft.) with 85% recovery.
Lithic contacts are based on company core description.

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New Jersey Zinc. Co., Koefer H-2, Sec.13-T4N-R9W, Hancock Co., Ill., elev. 690 ft., ISGS Core 7607, BX core 72-973 ft., described 949-973 ft.

Depth (ft.)	Litho-facies	Description/Comments
949	C1	Quartzose dolowackestone, medium-brown-gray, vuggy; mottled; abundant fine- to medium-grain, well-rounded, moderately-sorted, mud-supported quartz; irregular vugs (<0.2-0.5") partially infilled by coarsely-crystalline calcite.
950	S13	Lithic quartz arenite, light-medium-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; sparse to abundant, coarse- to pebble-size, sub-rounded clasts of quartz arenite; grain-size decreases upsection; grades into overlying quartzose dolostone.
	S10	Massive quartz arenite,medium-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, abundant clay-coats.
955	S10	Massive quartz arenite, white to light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-sorted by quartz over-growths, locally calcareous. No discernable breaks to 968 ft.
960		

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New Jersey Zinc. Co., Koefer H-2, Hancock Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
965		
		Argillaceous to massive quartz arenite, light-medium-gray to pale-greenish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by overgrowths; green-gray claystone drapes locally; finely argillaceous in lower foot; 2" of organic-rich, brown mudrock overlain by quartzose green-gray mudrock at base.
	S15	
970	S10	Massive quartz arenite, white to light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-sorted by quartz overgrowths locally silty; core breaks into thin, concavo-convex biscuits -- suggests cross-stratification; green-gray mudrock drapes at 970'1" and 972'; rare, *Skolithos* burrow traces.
973		
Bottom of cored interval and TD.		

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R. A. Davis Co., South #1, Sec. 30-R16N-T1E, Henry Co., Ill., elev. 794 ft., ISGS Core 4213, core chips each foot 1184-1316 ft.

Depth (ft.)	Litho-facies	Description/Comments
1184	C17	Bioclastic wackestone, medium-brown-gray microcrystalline, abundant complete brachiopods.
1185		
	C1	Quartzose dolopackstone, dark-brown-gray, micro-crystalline, abundant coarse- to medium-grain, well-rounded, frosted and clear, quartz grains; grain-size and abundance of quartz grains increases upsection; sparse pyrite and ostracod molds.
1190		
	S9	Mottled quartz arenite, white with light-brown-gray mottles, fine-grain, well-sorted, well-rounded, quartz; locally argillaceous; friable where argillaceous, moderately-indurated by quartz overgrowths where nonargillaceous; clay content decreases upsection.
1195	S8	*Skolithos*-bearing mudrock,green-gray; thin, fine-grain quartz arenite laminae; cross-cut by *Skolithos* burrows filled by well-sorted, well-rounded quartz.
	S10	Quartz arenite, light-brown-gray, fine-grain, well-rounded, moderately sorted quartz; moderately-indurated by quartz overgrowths, abundant clay-coats.
	S10	Massive quartz arenite, white to light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, sparse pore-filling calcite; massive.

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R. A. Davis Co., South #1, Henry Co., Ill, (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1200		
	S10	Massive quartz arenite, white to light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, abundant pore-filling calcite.
	S15	Argillaceous quartz arenite, light-gray-green, fine-grain, well-sorted, well-rounded, moderately rounded quartz; moderately-indurated to friable, quartz overgrowths locally common.
	S10	Massive quartz arenite, light-brown to light-brown-gray, well-sorted, well-rounded, quartz; poorly-indurated, abundant clay coats; gray-green claystone parting at 1210'6".
1205		
1210		

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R. A. Davis Co., South #1, Henry Co., Ill, (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10/S9	Mottled to massive quartz arenite, light-green-gray to very-light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz, sparse to abundant, mostly-detrital green-gray claystone throughout; friable to moderately well-indurated by quartz overgrowths; coarse-grain intervals less indurated; very argillaceous 1221-1229 ft.
1215		
1220		
1225		

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R. A. Davis Co., South #1, Henry Co., Ill, (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1230	S8	*Skolithos*-bearing mudrock, green-gray. *Skolithos* burrows filled with coarse-grain, well-sorted quartz; burrow fill well-indurated by quartz overgrowths.
		No samples 1230-1245 ft.
1245	S10/S9	Mottled to massive quartz arenite, light-gray-green, fine- to medium-grain, well-sorted, well-rounded, quartz; poorly- to moderately well-indurated; argillaceous throughout, mostly detrital claystone; minor mottling locally.
	C1	Quartzose dolowackestone, light-brown to medium-brown-gray, micro- to finely-crystalline; abundant fine- to medium-grain, poorly-sorted, well-rounded, mud-supported quartz grains thoughout.
1250		
		No samples 1250-1301 ft.

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R. A. Davis Co., South #1, Henry Co., Ill, (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1301	S10	Massive quartz arenite, white- to light-gray, fine- to medium-grain, well-sorted, well-rounded, quartz; moderately well-indurated by quartz overgrowths.
		No sample at 1302 ft.
	S10	Massive quartz arenite, white- to light-gray, fine- to medium-grain, well-sorted, well-rounded, quartz; well-indurated by quartz overgrowths.
1305	M1	Conglomeratic mudrock, green-gray, pyritic; abundant fine- to coarse-grain, angular lithic fragments of light-brown-gray, crystalline dolostone with opaque light-gray, microcrystalline chert.
	C12	Argillaceous dolomustone, light-gray with abundant green-gray mudrock laminae, medium- to coarsely-crystalline.
	C19	Cherty mcirocrystalline dolostone, medium-brown-gray to green-gray, argillaceous, vuggy; sparse to abundant silicified ooids.
1310	S15	Argillaceous quartz arenite, green-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by abundant quartz overgrowths, calcareous.
	M2	Green mudrock, green-gray, waxy, nonfissle, pyritic,"slickensides" locally.
	C12	Argillaceous dolomustone, light-gray with abund-ant green-gray claystone laminae, medium- to coarsely-crystalline.

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R. A. Davis Co., South #1, Henry Co., Ill, (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1315		
Bottom of cored interval, TD at 3863 ft.		

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Vickery Drilling Co., J. Taden #1, Sec. 11-T26N-R13W, Iroquois Co., Ill., elev. 653 ft., ISGS Core 3904, core chips each foot 1196.5-1390 ft.

Depth (ft.)	Litho-facies	Description/Comments
	C1/C8	Quartzose dolopackstone grading upsection to ostracodal wackestone, medium-dark-gray, microcrystalline; quartz is medium- to coarse-grain, moderately-sorted, well-rounded, grain- to mud-supported, decreases in abundance upsection.
1200		
	S9	Mottled quartz arenite, fine- to coarse-grain, mostly medium-grain, moderately- to poorly-sorted, well-rounded quartz; well-indurated by quartz over-growths, calcareous; abundant green-gray and dark-brown mudrock partings.
1205	C8	Ostracodal wackestone, medium-brown-gray, microcrystalline, locally peloidal.
	C17	Bioclastic dolowackestone, medium-brown-gray, micro- to finely-crystalline, increasingly calcareous upsection, sparse to abundant, complete spiriferid brachiopods.
1210		

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1215	S9	Mottled quartz arenite grading upsection to quartz-bearing dolowackestone, light- to medium-brown-gray; quartz arenite is medium- to coarse-grain, moderately-sorted, well-rounded quartz, pyritic, well-indurated by quartz overgrowths; grains dolomicrite supported upsection; lower contact sharp, upper contact gradational.
	S9	Mottled quartz arenite, fine- to coarse-grain, mostly medium-grain, moderately- to poorly-sorted, well-rounded quartz; well-indurated by quartz over-growths, calcareous; abundant green-gray and dark-brown mudrock partings.
1220	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, bimodal sorting, well-rounded quartz; weakly- to well-indurated by quartz over-growths, induration increases upsection; vague disrupted cross-stratification locally.
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, moderately-sorted, well-rounded quartz; well-indurated by quartz overgrowths; moderately- to well-developed low-angle cross-stratification

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1225		
	S4/S3	Cross-stratified quartz arenite, light-medium-gray or light-brown-gray, interlaminated medium-grain, well-sorted, well-rounded, light-brown-gray quartz arenite and fine-grain, well-sorted, well-rounded, light-medium-gray, quartz arenite; well-indurated throughout by quartz overgrowths; cross-laminae are low-angle to planar; lower contact sharp, upper is gradational.
1230		
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated by quartz over growths.
1235		

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1240		
		Cross-stratified quartz arenite, light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; low-angle cross-laminae terminate against subhorizontal planar surfaces.
1245	S4	
	S10	Massive quartz arenite, light-medium- to light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; low-angle cross-laminae.
	S10	Massive quartz arenite, light-medium- to light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
1250		

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1255	S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; vague to well-defined, low-angle cross-laminae.
	S10	Massive quartz arenite, light-medium- to light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; well-defined, low-angle cross-laminae.
1260	S10	Massive quartz arenite, light-medium- to light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; well-defined, low-angle cross-laminae.
1265		

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; weakly-indurated, sparse quartz overgrowths; sparsely argillaceous.
1270	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; well-defined, low-angle cross-laminae; grain-size increases upsection.
1275		
1280	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		rounded quartz; well-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; well-defined, low-angle cross-laminae.
	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
1285	S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; well-defined, low-angle cross-laminae; sparse, very fine-grain, sub-elliptical black tourmaline locally.
1290		

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1295	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, sparse interstitial green-gray clay.
1300	S4	Cross-stratified quartz arenite, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths, locally calcareous; well-defined, low-angle cross-laminae.
1305	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths.
	S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; well-defined low-angle cross-laminae.
	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths.
	S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz;

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		well-indurated by quartz overgrowths; well-defined low-angle cross-laminae.
	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths.
1310		
	S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; well-defined low-angle cross-laminae.
	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths.
1315		
1320		
	S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz;

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		well-indurated by quartz overgrowths; well-defined low-angle cross-laminae.
1325		
	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths.
1330		
	S14	Silty quartz arenite, yellow-brown-gray, fine-grain, well-sorted, well-rounded quartz; weakly-indurated; dolomitic grain-coats.
1335	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; silica healed fracture at 1307 ft.

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1340	S9	Mottled quartz arenite, light-yellowish-gray with sparse light-green-gray mottles, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; pore-filling sulfides locally.
1345	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths.
1350	S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; well-defined low-angle cross-laminae.

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S9	Mottled quartz arenite, light-yellowish-gray with sparse light-green-gray mottles, fine- to medium-grain, poorly-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; well-defined low-angle cross-laminae.
1355	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths.
	S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; well-defined low-angle cross-laminae.
1360	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, moderately-well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; well-defined low-angle cross-laminae.

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1365		
	S10	Massive quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
1370		
	S10	Massive quartz arenite, light-medium- to light-yellow-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths, locally pyritic.
1375		
	S10	Massive quartz arenite, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, calcareous at 1377 ft.

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Vickery Drilling Co., J. Taden #1, Iroquois Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S13	Lithic quartz arenite, light-yellow-gray with light-green-gray mudrock partings; fine- to coarse-grain, poorly-sorted, well-rounded quartz and subround microcrystalline chert and dolomudstone; green-gray, nonfissle mudrock interbeds at 1379'6" and 1380 ft.; argillaceous content decreases upsec-tion.
1380		
	C19	Dolomudstone, light-brown-gray with green-gray mudrock partings, micro- to finely-crystalline, coarse-grain quartz arenite stringers and green-gray mudrock partings throughtout; 2" nonfissle, pyritic green-gray mudrock at 1382'6"; vuggy 1385-1386 ft.
1385		
	S15	Argillaceous quartz arenite, light-green-gray to light-yellow-gray, fine- to coarse-grain, moderately-sorted, well-rounded quartz; interbed of green-gray mudrock at 1387 ft.
	C19	Dolomudstone, light-brown-gray with green-gray mudrock partings, micro- to finely-crystalline.
1390		
Bottom of cored interval, TD at 3475 ft.		

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New Jersey Zinc Co., Alvin Davis F-25, Sec. 5-T28N-R2E, Jo Davies Co., Ill.
elev. 856 ft., ISGS Core 6745, BX core 305-313 ft.

Depth (ft.)	Litho-facies	Description/Comments
305	C1	Vuggy quartzose dolowackestone, medium-brown-gray, finely-crystalline, abundant medium- to coarse-grain, well-rounded quartz, abundance decreases upsection; black, subrounded phosphatic pebbles at base; lower contact sharp.
	M2/S15	Interbedded green-gray mudrock, sandy green-gray mudrock, and argillaceous quartz arenite; sand-sized constituents are medium- to coarse-grain, well-rounded, very poorly-sorted quartz and sparse, coarse- to pebble-sized, subrounded, black phosphate; mudrock is massive, locally quartzose, lacks silt-sized fraction, and is pyritic; very feldspathic from 308-309'10"; green-gray mudrock 306'4"-306'7", 308'-308'6", and 308'7"-309'9".
310	S15	Argillaceous quartz arenite, as above but may be stromatolitic; friable.
	C1/C4	Quartzose stromatolitic dolomudstone, light-green-gray, very argillaceous, abundant medium- to coarse-grain, well-rounded, poorly-sorted quartz; friable; grades upsection into overlying quartz arenite.
313	S2/S15	Argillaceous dolomitic quartz arenite, medium-greenish-gray, medium- to coarse-grain, poorly-sorted, well-rounded quartz; locally dolomicrite supported; intensely mineralized, moderately- to well-indurated by sulfide cements
Bottom of cored interval and TD		

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Wedron Silica, Prairie State Quarry boring 76-4, Sec. 2-T34N-R1E, La Salle Co., Ill., elev. 660 ft., ISGS Core 12518, NX core 28-138 ft.

Depth (ft.)	Litho-facies	Description/Comments
28	S10	Massive quartz arenite, yellowish-gray, medium- to coarse-grain, mostly coarse-grain, moderately- to well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; core in poor condition.
30		
35		
	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; abundant, interlaminated coarse- to medium-grain and fine-grain planar laminae; grain-size decreases upsection.
40		
	S10	Massive quartz arenite, light-medium-gray, medium- to coarse-grain, mostly medium-grain, moderately- to well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths.

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Wedron Silica, Prairie State Quarry boring 76-4, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4/S3	Cross-stratified arenite, light-medium-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; abundant low-angle cross-stratification and sparse planar cross-stratification; weakly to moderately-indurated by quartz overgrowths.
45		
	S8	*Skolithos* -bearing quartz arenite, medium- to coarse-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; burrows are very abundant (piperock), small diameter (<0.2") and lack infilling sediment.
	S4/S3	Cross-stratified arenite, light-medium-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; abundant low-angle cross-stratification and sparse planar cross-stratification; weakly- to moderately-indurated by quartz overgrowths.
50		
	S8	*Skolithos* -bearing quartz arenite, medium- to coarse-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; burrows are very abundant (piperock), small diameter (<0.2") and lack infilling sediment; subrounded pebbles of well-indurated, cross-stratified quartz arenite in lower 6-inches.
55		

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Wedron Silica, Prairie State Quarry boring 76-4, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S3	Planar cross-stratified quartz arenite, pale-yellow-gray, fine-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; abundant planar laminae; quartz silt locally.
	S10	Massive quartz arenite, white to very light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; vague cross-stratification in some intervals.
60		
	S4/S3	Cross-stratified arenite, light-medium-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; abundant low-angle cross-stratification and sparse planar cross-stratification; weakly- to moderately-indurated by quartz overgrowths.
	S8	*Skolithos*-bearing quartz arenite, medium- to coarse-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; burrows are very abundant (piperock), are small diameter (<0.2") and lack infilling sediment.
65		
	S4	Cross-stratified arenite, light-medium-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; abundant low-angle cross-stratification.
	S3	Planar cross-stratified quartz arenite, pale-yellow-gray, silty to fine-grain, moderately-sorted quartz; weakly-indurated by quartz overgrowths.
	S8	*Skolithos*-bearing quartz arenite, medium- to coarse-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; limonite stained, sharp bedding-contacts at 67'3" and 68 ft., lower contact gradational.

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Wedron Silica, Prairie State Quarry boring 76-4, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
70	S10	Massive quartz arenite, light-gray to dark-yellow-orange, medium- to coarse-grain, moderately-sorted, well-rounded quartz; sparse limonitic stain; massive.
	S3	Planar cross-stratified quartz arenite, pale-yellow-gray, fine-grain to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths.
75	S10	Massive quartz arenite, light-gray to dark-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; abundant limonite stain, locally banded appearance; friable to weakly-indurated by quartz overgrowths.
80	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; lacks ferroan staining.

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Wedron Silica, Prairie State Quarry boring 76-4, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
85		
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated; abundant limonite staining.
	S8	*Skolithos* -bearing quartz arenite, very fine- to medium-grain, poorly-sorted, well-rounded quartz arenite; sparse *Skolithos* burrows infilled with medium-grain quartz; burrows increase in abundance upsection.
90	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; lacks ferroan staining.
	S4	Cross-stratified arenite, light-medium-gray to pale-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; abundant low-angle cross-stratification; weakly-indurated by quartz overgrowths; sparse ferroan stain.
95	S9	Mottled quartz arenite, very light-gray to dark-yellow-orange, very fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse, small diameter *Skolithos* -burrows; abundant limonite stain where predominantly medium-grain quartz; vague cross-stratification locally.

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Wedron Silica, Prairie State Quarry boring 76-4, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
100	S10	Massive quartz arenite, light-medium-gray, to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths.
105		
110		
	S15	Argillaceous quartz arenite, light-medium-gray, silty to medium-grain, moderately-to poorly-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths.

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Wedron Silica, Prairie State Quarry boring 76-4, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S8	*Skolithos*-bearing quartz arenite, light-medium-gray to light-green-gray, very fine- to medium-grain, moderately to poorly-sorted, well-rounded quartz arenite; sparse *Skolithos* burrows infilled with medium-grain quartz; burrows increase in abundance upsection; weakly-indurated by quartz overgrowths.
	S15	Argillaceous quartz arenite, light-medium-gray, silty to medium-grain, moderately-to poorly-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths.
115	S8	*Skolithos*-bearing quartz arenite, very fine- to medium-grain, poorly-sorted, well-rounded quartz arenite; sparse *Skolithos* burrows infilled with medium-grain quartz; burrows increase in abundance upsection; weakly-indurated by quartz overgrowths; a burrow cross-cuts lower contact and penetrates 3" into underlying argillaceous quartz arenite.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; abundant light-green-gray claystone partings; friable; upper and lower contacts sharp -- upper contact cross-cut by *Skolithos* burrow.
120	S15/S8	Argillaceous quartz arenite, light-green-gray, very fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; average grain-size decreases upsection; green-gray mudrock partings at base; locally pyritic; sparse *Skolithos* burrows in upper 10".
	S4	Cross-stratified quartz arenite, light-gray to pale-yellow-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; well-developed low-angle cross-stratification at base, increasingly massive upsection; grain-size decreases upsection.
	S8	*Skolithos*-bearing quartz arenite, very fine- to medium-grain, poorly-sorted, well-rounded quartz arenite; sparse *Skolithos* burrows infilled with medium-grain quartz; burrows increase in abundance upsection; weakly-indurated by quartz overgrowths; argillaceous near base.

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Wedron Silica, Prairie State Quarry boring 76-4, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
125	S15	Argillaceous massive quartz arenite, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; argillaceous content decreases upsection.
	S15	Argillaceous quartz arenite, light-gray-green, fine- to coarse-grain, poorly-sorted, well-rounded quartz; friable, locally moderately-indurated with dolomicrite cement; cross-cut by large *Skolithos* burrows infilled by medium- to coarse-grain quartz.
130	S15	Poor core recovery, only 1'4" of core for 4' interval. Argillaceous quartz arenite, light-green-gray to pale-green-gray, coarse- to medium-grain, well-sorted quartz; uncemented to friable, increasingly indurated upsection.
	S4	Cross-stratified arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; disseminated green-gray clay; abundant low-angle cross-laminae, sparse planar laminae.
	S10	Massive quartz arenite, white, fine- to medium-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths.
135	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted quartz grading upsection to quartzose mudrock, green-gray, nonfissle, pyritic; sparse, medium- to coarse-grain, poorly-sorted, well-rounded quartz; mudrock rip-ups at base; two successions 134'9"-135'6", 135'6"-136'3".
	S10	Massive quartz arenite, very light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz; sparse, very coarse-grain quartz; weakly-indurated by quartz overgrowths; massive.
138		**Bottom of cored interval and TD.**

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Wedron Silica, Prairie State Quarry boring 76-8, Sec. 2-T34N-R1E, La Salle Co., Ill., elev. 615 ft., ISGS Core 12522, NX core 22-87 ft.

Depth (ft.)	Litho-facies	Description/Comments
22	S10	Massive quartz arenite, white to very light-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable; pervasively ferroan stained; massive.
25	S6	Trough cross-stratified quartz arenite, very light-gray to pale-yellowish-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; mean grain-size decreases up-section.
	S10	Massive quartz arenite, yellowish-gray to dark-orange yellow, fine- to medium-grain, well-sorted, well-rounded quartz; friable; intensely ferroan stained.
30	S10	Massive quartz arenite, yellowish-gray to light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable.
35	S10	Massive quartz arenite, pale-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; planar limonite stain locally -- suggests cross-stratification may be present.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded

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Wedron Silica, Prairie State Quarry boring 76-8, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		quartz; moderately-indurated by quartz overgrowths; irregular masses of pore-filling sulfide (<0.25").
	S15	Argillaceous quartz arenite, light-medium-gray to light-green-gray, fine- to medium-grain, poorly- to moderately-sorted, well-rounded quartz; friable to weakly- indurated by quartz overgrowths; locally pyritic, some irregular masses (<0.25") of pore-filling sulfide; locally mottled.
40		
	S4	Low-angle cross-stratified arenite, light-pale-yellowish-gray, medium- to coarse-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; abundant low-angle cross-stratification.
45		
	S10/S9	Massive- to mottled-quartz arenite, light-medium-gray, fine- to medium-grain, poorly- to moderately-sorted, well-rounded quartz; weakly-indurated by quartz over-growths; locally pyritic; vague, planar laminae in upper 2 ft.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz;

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Wedron Silica, Prairie State Quarry boring 76-8, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
50		abundant green-gray clastone drapes and partings; uncemented to friable, locally pyritic.
	S15	Argillaceous mottled arenite, light-green-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz over-growths.
55		
	S10/S9	Massive- to mottled-quartz arenite, light-medium-gray, fine- to medium-grain, poorly- to moderately-sorted, well-rounded quartz; weakly-indurated by quartz over-growths; locally pyritic; vague, planar laminae in upper 2 ft.
60		
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz over-growths; massive.

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Wedron Silica, Prairie State Quarry boring 76-8, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
65	C1/S15	Interbedded quartzose dolowackestone and argillaceous quartz arenite; quartzose dolowacketone is pale-yellow-gray, sparse to abundant fine- to medium-grain, well-sorted, mud-supported quartz; well-indurated by dolomicrite; sharp basal contact, upper contact gradational; overlain by argillaceous massive quartz arenite fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated at base, less indurated upsection; clay content grades from sparse at base, to abundant at top. Dolowacketone at 64'6"-65'3", 65'8"-66', 67'3"-67'9", 70'-70'3", and 71'9"-72'3".
70		
	S13	Lithic quartz arenite, light-medium-gray, medium-grain to coarse-grain, poorly-sorted, subrounded to well-rounded quartz; moderately-abundant, pebble-size, subrounded, quartz arenite clasts at base.
	S2	Dolomitic sandstone, pale-yellow-brown, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by dolomicrite; upper contact sharp and burrowed, burrows are infilled with medium- to coarse-grain, well-rounded quartz.
75	S15	Argillaceous quartz arenite, light-medium-gray to olive-gray, medium- to coarse-grain, poorly-sorted, well-rounded quartz; increasingly argillaceous up-section; friable.
	S2	Dolomitic sandstone, pale-yellow-brown, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by dolomicrite.
	S8	*Skolithos*-bearing quartz arenite, light-medium-gray, fine- to coarse-grain, mostly medium-grain, poorly-

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Wedron Silica, Prairie State Quarry boring 76-8, La Salle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; abundant, small diameter (<0.2") *Skolithos* burrows (piperock).
80	S10	Massive quartz arenite, fine- to coarse-grain, mostly medium-grain, poorly-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; irregular pore-filling sulfide (<0.2") locally.
85	S15	Argillaceous quartz arenite, pale-olive-gray, coarse- to fine-grain, poorly-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; massive; grain-size decreases upsection; sparse to common olive-gray mudrock partings.
	C19	Biomoldic chert, light-medium-gray to white, opaque, microcrystalline chert with abundant, large ostracode molds.
	M1	Silty conglomeratic mudstone, medium-green-gray, pyritic; subangular pebbles of light-gray, opaque, laminated chert; sparse to abundant, fine- to coarse-grain, poorly-sorted, well-rounded quartz; all grains mud-supported by green-gray, waxy, nonfissle mud-rock; grain-size decreases upsection.
Bottom of cored interval and TD.		

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Northern Illinois Gas Co., Fienhold 1, Sec. 33-T28N-R6E, Livingston Co., Ill., elev. 730 ft., ISGS Core 4636, NX core biscuits each foot 1050-1243 ft.

Depth (ft.)	Litho-facies	Description/Comments
1050	C8	Ostracodal dolopack/wackestone, medium-dark-brown-gray to dark-brown-gray, finely- to medium-crystalline, abundant ostracods.
1055	C11	Fenestral dolomudstone, light-brown-gray to medium-brown-gray, microcrystalline; sparse to moderately-abundant, subhorizontal, subelliptical, calcite filled-fenestrae; locally pyritic.
	C1	Quartzose dolowackestone, light-brown-gray, micro-crystalline; locally dolomitic, very finely-crystalline dolomite; sparse to common, interbeds of mottled, medium-grain, moderately well-sorted quartz arenite with thin, anastomosing laminae of black mudrock.
1060	M6	Siltstone, dark-gray-brown, massive, pyritic.
	C1	Quartzose dolopackstone, medium-brown-gray to light-brown-gray, microcrystalline, increasingly calcareous upsection; fine- to coarse-grain, poorly-sorted, well-rounded, mud-supported quartz-grains throughout; abundance of quartz-grains decreases upsection.
	S9	Mottled quartz arenite, light-brown-gray to light-green-gray; fine- to medium-grain, moderately-

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		sorted; well-indurated by moderately abundant quartz-overgrowths; calcareous, argillaceous mottles.
1065	S10	Massive quartz arenite, white to light-gray, fine- to medium-grain, well-rounded, moderately- to well-sorted quartz; moderately well-indurated by pore-filling calcite and moderately-abundant quartz over-growths.
	S4	Low-angle cross-stratified quartz arenite, very-light-brown-gray, fine- to medium-grain, well-sorted, quartz; abundant, graded, thin-laminae (< 0.2") ; well-indurated by quartz overgrowths and abundant pore-filling calcite.
1070	S10	Massive quartz arenite, white to light-gray, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz; trace amounts of black, sub-rounded, very-fine-grain tourmaline, rare zircon; moderately- to well-indurated, sparse- to moderartely-abundant quartz overgrowths, sparse to abundant, pore-fillingcalcite; core biscuits break along sub-horizontal planes - suggests thin-bedding; mostly mostly massive, vague low-angle cross-stratification locally. No discernable break to 1096 ft.
1075		

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	
1080		
1085		
1090		

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	
1095		
	S4	Low-angle cross-stratified quartz arenite, very-light-brown-gray, fine- to medium-grain, well-sorted quartz; abundant, graded, thin-laminae (<0.25") ; weakly- to moderately-indurated by pore-filling calcite and moderately-abundant quartz-overgrowths.
1100	S10	Massive quartz arenite, white to light-gray, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz; trace amounts of black, subrounded very-fine-grain tourmaline, rare zircon; moderately- to well-indurated, sparse- to moderately abundant quartz overgrowths, and sparse to abundant, pore-filling calcite; core biscuits break along subhorizontal planes -- suggests thin-bedding; mostly massive, vague low-angle cross-stratification locally. No discernable break to 1119 ft.
1105		

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	
1110		
1115		

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1120	S4	Low-angle cross-stratified quartz arenite, very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant graded, thin-laminae (< 0.25"); friable to weakly-indudrated by sparse, quartz over-growths and abundant pore-filling calcite in lower 1 ft.; thick laminae of medium-grain, well-sorted quartz arenite at base.
	S10	Massive quartz arenite, white to light-gray, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz, trace amounts of black, sub-rounded, very-fine-grain tourmaline in upper 3 ft.; moderately- to well-indurated by sparse to moderately-abundant quartz overgrowths and sparse to abundant, pore-fillingcalcite; core biscuits break along subhorizontal planes - suggest thin-bedding; mostly massive, vague low-angle stratification locally.
1125		
		No discernable break to 1133 ft.
1130		
	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz;

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		coarsens upsection; moderately-indurated by quartz overgrowths; pore-filling calcite locally.
1135		
	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz, and sparse, black, very-fine-grain tourmaline; well-indurated by sparse to moderately abundant, quartz overgrowths and evenly distributed pore-filling calcite.
1140		
	S8	*Skolithos* -bearing quartz arenite, light-brown-gray, fine-grain, well-rounded, well-sorted quartz; abundant grain-coats; moderately-indurated by calcite and quartz overgrowths; vertical burrows are are small (<0.25") and lack fill, burrow walls are clay-lined.
1145	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz, moderately well-indurated by sparse quartz over-growths and evenly distributed pore-filling calcite.

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Low-angle cross-stratified quartz arenite, very-light-gray, medium-grain, well-sorted, abundant, thin cross-laminae (< 0.25"); moderately-indurated by sparse quartz overgrowths and abundant, pore-filling calcite.
1150	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by sparse to moderately-abundant quartz overgrowths and pore-filling calcite.
1155		**No samples 1154-1155 ft.**
	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by sparse to moderately-abundant quartz overgrowths and pore-filling calcite.
1160	S8	*Skolithos* -bearing quartz arenite, light-brown-gray, fine-grain, well-rounded, well-sorted quartz; abundant grain-coats; moderately-indurated by calcite and quartz overgrowths; vertical burrows are are small (< 0.25") and lack fill, burrow walls are clay-lined.

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1165		
	S11	Nodular-bearing quartz arenite, light-brown-gray matrix and medium-gray dolomite-cemented nodules; matrix is fine- to medium-grain, well-sorted, grain-supported quartz; moderately-indurated by sparse to abundant quartz overgrowths; nodules are composed of dolomite-cement supported, fine- to medium-grain, well-sorted quartz grains lacking quartz overgrowths; nodules are best developed at 1168 ft..
1170	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by sparse quartz over-growths, locally calcareous.
1175	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz; friable, abundant poorly-developed quartz over-growths, sparsely pyritic from 1175-1176 ft..

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S11	Nodule-bearing quartz arenite, light-brown-gray matrix and medium-gray nodules; matrix is fine- to medium-grain, well-sorted, grain-supported quartz; moderately-indurated by sparse to abundant quartz overgrowths; subelliptical nodules (0.25-2") composed of dolomite-cement supported, fine- to medium-grain, well-sorted quartz grains that lack quartz overgrowths; nodules exhibit concentric zoning with pyritic rims.
1180		**No sample at 1179 ft.**
	S4	Low-angle cross-stratified quartz arenite, very-light-gray, medium-grain, well-sorted quartz; abundant, thin graded cross-laminae (<2 mm); moderately-indurated by quartz-overgrowths.
1185		**No samples 1184-1185 ft.**
	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, poorly-sorted, well-rounded quartz; moderately-indurated by moderately-abundant quartz overgrowths. No discernable to 1194 ft.

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1190		
	S4	Low-angle cross-stratified quartz arenite, very-light-brown-gray, medium-grain, well-sorted quartz; abundant thin, graded cross-laminae (< 0.25"); moderately-indurated by quartz-overgrowths.
1195		
	S4	Argillaceous, low-angle cross-stratified quartz arenite, very light-green-gray and light-medium-gray, fine- to medium-grain, well-rounded quartz; thin, graded cross-laminae (< 0.25"); thick inter-laminae made up of very well-sorted, medium-grain quartz; laminae contact sharp and well defined; argillaceous throughout except for patchy areas that are extremely well-indurated by quartz overgrowths.
1200		
1203		

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		No samples 1203-1210 ft.
1211	S4	Low-angle cross-stratified quartz arenite, very-light-brown-gray, medium-grain, well-sorted quartz; abundant, thin, graded cross-laminae (< 0.25"); moderately-indurated by quartz-overgrowths.
	S10	Massive quartz arenite, light-gray to white, fine- to medium-grain, poorly-sorted, well-rounded quartz; weakly- to moderately-indurated by sparse to moderately-abundant quartz overgrowths; oil stained at 1214 ft.
1215	S4	Low-angle cross-stratified quartz arenite, very-light-gray that become increasingly light- to medium-brown-gray, fine- to medium-grain, well-rounded quartz that coarsens upsection; thin, graded cross-laminae (< 0.25"); moderately-indurated by quartz overgrowths; increasing abundance of grain-coats upsection corresponds with changes in mean grain-size and color; possible nodule or burrow (only margin in sample).
1220	S3	Planar cross-stratified quartz arenite, very-light-brown-gray, very-fine- to fine-grain, well-sorted quartz; thin (< 0.25"mm), graded, planar cross-laminae; well-indurated by quartz-overgrowths.
	S10	Massive quartz arenite, light-gray to white, fine- to very-fine- to medium-grain, poorly-sorted, well-rounded quartz, moderately- to well-indurated, by sparse to moderately-abundant quartz over-growths; calcareous at 1224 ft. and 1233-1237 ft.; sparsely pyritic 1225-1227 ft.. No discernable breaks to 1238 ft.

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1225		
1230		
1235		

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Northern Illinois Gas Co., Fienhold 1, Livingston Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Low-angle cross-stratified quartz arenite, very-light-brown-gray, fine- to medium-grain, well-sorted quartz; thin, graded cross-laminae (< 0.25"); moderately-indurated by quartz-overgrowths and moderately-abundant pore-filling calcite.
1240		
1243		
		Bottom of cored interval; TD at 1406 ft.

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Central Illinois Light Co., Hauffe #1, Sec. 31-T20N-R3W, Logan Co., Ill., elev. 597 ft., ISGS Core 9239, core chips 2175-2225 ft.

Depth (ft.)	Litho-facies	Description/Comments
2175	C8	Ostracodal dolowacke/packstone, brown-gray, sparse to abundant, complete ostracodes.
	C10	Patterned dolomudstone, light-brown-gray to medium-brown-gray, microcrystalline, featureless.
2180	C17	Bioclastic wackestone, medium-brown-gray, abundant complete ostracodes, brachiopod fragments.
	C8	Ostracodal dolowacke/packstone, brown-gray, sparse to abundant, complete ostracodes, locally stylolitic.
2185	C2	Dolomudstone, light-brown, chalky, earthy, high microporosity.
	C10	Patterned dolomustone, light-brown-gray to medium-brown-gray to light-green-gray, micro-crystalline, featureless.

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Central Illinois Light Co., Hauffe #1, Logan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C8	Ostracodal dolowacke/packstone, brown-gray, abundant, complete ostracodes.
2190	C10	Patterned calcimudstone, light-brown-gray and light-green-gray, sparsely dolomitic in light-brown gray mottles.
	C8	Ostracodal dolowacke/packstone, brown-gray, abundant ostracodes; ostracodal packstone at 2193 ft.
2195	C10	Argillaceous patterned dolomudstone, medium-brown-gray and light-green-gray, minor laminae of quartz arenite, fine- to very-fine-grain, well-rounded, very well-sorted.
	C3	Laminated dolomudstone, medium-brown-gray to light-brown-gray, planar laminae of brown-gray, organic-bearing mudrock (<0.2"); vague patterned fabric.
2200	C8	Ostracodal dolopackstone, brown-gray, complete ostracodes, stringers of fine-grain, well-sorted quartz arenite.

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Central Illinois Light Co., Hauffe #1, Logan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C2	Dolomudstone, tan to light-brown, mottled fabric, high microcrystalline porosity; fine-grain quartz arenite infills mudcracks at upper contact.
	C1	Quartzose dolowackestone, light-brown-gray, with sparse grains of well rounded, fine-grain, quartz.
2205	C2	Chalky dolomudstone, light-brown-gray, earthy, high microporosity, clotted fabric; rare, molds of lathes with acute terminations (anhydrite dissolution); organic-rich brown mudrock at top.
	S9	Mottled quartz arenite, light-brown-gray with abundant dolomicrite intergranular matrix, fine-grained, well-sorted quartz; moderately well-indurated by quartz overgrowths; mottled.
2210	S15	Argillaceous quartz arenite, white to light-medium-gray, fine-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths, anastomosing green-gray mudrock laminae; possibly stromatolitic at 2208 ft.
		No core 2210-2215 ft.
2215	S10	Massive quartz arenite, white to medium-gray, fine- to medium-grain, well sorted quartz; moderately- to well-indurated by sparse to abundant quartz overgrowths.

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Central Illinois Light Co., Hauffe #1, Logan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S9/S15	Mottled argillaceous quartz arenite, light-green-gray to light-medium-gray, fine- to medium-grain, mostly medium-grain quartz; moderately- to well-indurated by sparse to abundant quartz overgrowths; green-gray argillaceous mottles throughout.
2220	S9	Mottled quartz arenite, intermottled light-brown-gray and medium-gray; light-brown-gray arenite is fine-grain, moderately-sorted, well-rounded quartz; moderately-indurated by calcite and sparse quartz overgrowths; medium-gray arenite is medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; calcite cemented arenite has moderate porosity; quartz overgrowth cemented arenite is tight. Medium-gray arenite is probably burrow infill.
2225	S10	Massive quartz arenite, light gray, fine-grain, well-sorted, well rounded quartz; moderately-indurated by sparse quartz overgrowths; probable *Skolithos* burrows at 2223 ft.
Bottom of cored interval, TD at 2302 ft.		

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Texaco, Inc., R. S. Johnson 1, Sec. 6-T1N-R2E, Marion Co., Ill., elev. 541 ft.; ISGS Core 4831, complete core 5237-5252 ft.

Depth (ft.)	Litho-facies	Description/Comments
5237	S4	Cross-stratified quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; low-angle cross-stratification in upper 6"; well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately- to poorly-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; possible ripple-laminae at top; stylolitic at base; irregular lower contact overlies thin, gray mudrock parting (stylolaminae?).
5240	C10	Patterned dolomudstone, light-medium- to medium-gray, microcrystalline dolomite, anhydritic locally; moderately abundant, vertical and subvertical burrows infilled by quartzose dolopackstone or anhydritic dolomudstone; burrows are similar in character and morphology to *Skolithos burrows*.
	S3/S4	Cross-stratified quartz arenite, light-medium-gray, fine- to medium-grain, moderately- to well-sorted; well-rounded quartz; well-indurated by quartz over-growths; planar lamine at base; increasingly inter-laminated with low-angle cross-stratification upsection
5245	S9	Mottled quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; massive to vaguely mottled; ripple laminae locally; nonporous except at 5243 ft.
	S9	As above, but with stylolites and patchy cement distribution.
5250	S9	Mottled quartz arenite, light-gray to white, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; massive to vaguely mottled; ripple laminae locally; nonporous; burrow trace at 5248'8".

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Texaco, Inc., R. S. Johnson 1, Marion Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
5252	S10	Massive quartz arenite, light-medium-gray to very light-green-gray, fine-grain, well-sorted, well-rounded, quartz; moderately-indurated by quartz overgrowths; sparely argillaceous; pyritic locally; mottled.
Bottom of cored interval, TD at 9195 ft.		

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Northern Illinois Gas Co., Pyne 1, Sec. 14-T25N-R3E, Mc Lean Co., Ill., elev. 746 ft., ISGS Core 10180, core chips each foot 1542-1706 ft.

Depth (ft.)	Litho-facies	Description/Comments
1555	C1	Quartzose dolopack/wackestone, medium-brown-gray with light-brown-gray mottles throughout; sparse to abundant, fine- to coarse-grain, moderately-sorted, well-rounded quartz that decreases in abundance and grain-size upsection; laminae of ostracodal wackestone with calcite infilled biomolds locally.
	S9	Mottled quartz arenite, medium-light-brown, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-abundant, anastomosing, black mudrock laminae; well-indurated by quartz overgrowths.
1560	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths and calcite; pyritic.
	S9	Mottled quartz arenite, light-green-gray, coarse- to fine-grain, poorly-sorted quartz; argillaceous; friable to weakly-indurated.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated; sparse to abundant, anastomosing green-gray mudrock partings; sparse quartz overgrowths, locally pyritic.
1564		
		No samples 1565-1570 ft.
1571	S10	Massive quartz arenite, light-brown-gray to light-medium-gray, fine- to medium-grain, well-sorted to moderately well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; calcareous 1571-1573 ft.

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Northern Illinois Gas Co., Pyne 1, Mc Lean Co., Ill. (cont.),

Depth (ft.)	Litho-facies	Description/Comments
1570		
1575		
1580	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to well-indurated by quartz overgrowths, patchy distribution of calcite cement.
1581		**No core samples 1581-1589 ft.**

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Northern Illinois Gas Co., Pyne 1, Mc Lean Co., Ill. (cont.),

Depth (ft.)	Litho-facies	Description/Comments
1589		
1590	S4	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; thin, low-angle cross-laminae throughout.
		No sample at 1593 ft.
1595	S4	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; thin, planar- to low-angle cross-laminae throughout.
1600		**No samples 1596-1600 ft.**
	S10	Massive quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths.
	S4/S3	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, sparse quartz overgrowths; thin, palnar- to low-angle cross-laminae throughout; frosted grains abundant.

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Northern Illinois Gas Co., Pyne 1, Mc Lean Co., Ill. (cont.),

Depth (ft.)	Litho-facies	Description/Comments
		No sample at 1603 ft.
	S3/S4	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, sparse quartz overgrowths; thin, planar- to low-angle cross-laminae throughout.
1605	S10	Massive quartz arenite, light-medium-gray to white, fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; massive;
1610		
1611		
		No samples 1611-1662 ft.
1663	S3/S4	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, sparse quartz overgrowths; thin, planar- to low-angle cross-laminae throughout.
	S10	Massive quartz arenite, light-medium-gray to white, fine-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; massive.
1665		**No sample at 1665 ft.**
	S4/S3	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded
	S8	*Skolithos* -bearing quartz arenite, light-green-gray with light-gray vertical streaks; light-green-gray is fine- to medium-grain, moderately-sorted, well-rounded quartz with an abundant green-gray, argillaceous

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Northern Illinois Gas Co., Pyne 1, Mc Lean Co., Ill. (cont.),

Depth (ft.)	Litho-facies	Description/Comments
		fraction; vertical *Skolithos* burrows infilled by medium- to coarse-grain, poorly-sorted, well-rounded quartz; matrix is friable to weakly-indurated, burrow infills are well-indurated by quartz overgrowths.
1670		**No core sample at 1670 ft.**
	S10	Massive quartz arenite, light-brown-gray to light-gray, fine-grain, well-sorted, well-rounded quartz; friable.
	S4	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by sparse quartz overgrowths; thin, low-angle cross-laminae.
1675		**No samples 1674-1676 ft.**
	S4	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; thin, low-angle cross-laminae.
		No sample at 1578 ft.
	S4	Cross-stratified quartz arenite, very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, sparse quartz overgrowths; thin, low-angle cross-laminae; locally pyritic.
1680		**No samples 1680-1683 ft.**

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Northern Illinois Gas Co., Pyne 1, Mc Lean Co., Ill. (cont.),

Depth (ft.)	Litho-facies	Description/Comments
	S4	Cross-stratified quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, sparse quartz overgrowths; thin, low-angle cross-laminae; locally pyritic.
1685		**No sample at 1685 ft.**
	S8	*Skolithos* -bearing quartz arenite, light-green-gray with light-medium-gray vertical streaks; light-green-gray is fine- to medium-grain, moderately-sorted, well-rounded quartz with an abundant green-gray, argillaceous fraction; vertical *Skolithos* burrows infilled by medium- to coarse-grain, poorly-sorted, well-rounded quartz; matrix is friable to weakly-indurated, burrow infills are well-indurated by quartz overgrowths.
		No samples 1688-1692 ft.
1690		
	S4	Cross-stratified quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, sparse quartz overgrowths; thin, low-angle cross-laminae; locally pyritic; irregular masses (<0.2"diameter) of green-gray clay cement locally - probably altered feldspar grains.
1695		

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Northern Illinois Gas Co., Pyne 1, Mc Lean Co., Ill. (cont.),

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray with patches (<0.2" diameter) of medium-green-gray; fine- to medium-grain, moderately-sorted, well-rounded quartz; friable; patches are irregular masses of green-gray clay - probably altered feldspar grains.
		No samples 1698-1702 ft.
1700		
	S4	Cross-stratified quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, sparse quartz overgrowths; thin, low-angle cross-laminae; locally pyritic.
	S10	Massive quartz arenite, light-medium-gray, fine-fine- to medium-grain, moderately-sorted, well-rounded quartz; friable; locally pyritic.
1705		
1706		
		Bottom of cored interval, TD at 4002 ft.

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Illinois Power Co., King 1, Sec. 16-T9N-R3W, Montgomery Co., Ill., elev. 659 ft., company core, slabbed 4-inch core 3355-3364 ft.

Depth (ft.)	Litho-facies	Description/Comments
3355	S13	Lithic quartz arenite, light-medium-brown and light-brown-gray; fine-grain to cobble-size, angular dolostone clasts; martix is fine- to medium-grain, poorly-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; sharp, irregular lower contact
	C6	Mottled dolomudstone, dark-brown-gray and light-brown-gray; microcrystalline, porous, abundant mud-supported, medium- to coarse-grain, well-rounded quartz at upper contact and at 3337 ft.; lower and upper contacts sharp and irregular.
3360	M4	Quartzose mudrock, green-gray, abundant medium- to fine-grain, poorly-sorted, well-rounded quartz in green-gray to yellow-green-gray, nonfissle mudrock matrix; greatly expanded - possible bentonite.
	C6	Mottled dolowackestone, brown-gray and light-green-gray, finely-crystalline, porous; abundant fine- to medium-grain, well-rounded, mud-supported quartz throughout; mudcracks at 3359'10"; stylocontact at 3361'6"; may be stromatolitic in lower 4".
Bottom of cored interval and TD.		

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Illinois Power Co., L. Truitt 1, Sec. 4-T9N-R3W, Montgomery Co., Ill., elev. 650 ft., company core, slabbed 4" core 2893-3320 ft., described 3003-3320 ft.

Depth (ft.)	Litho-facies	Description/Comments
3005	C17/C15	Mottled bioclastic pack/wackestone, brown-gray, fine- to coarse-grain, subangular to subrounded bioclasts; bioclasts increase in abundance upsection; grades to a brachiopod grainstone (coquina) at 3005'-3005'5"; thin- to medium-stylobedding at 3005" throughout.
	C15/C17	Mottled bioclastic pack/wackestone, brown-gray, fine- to coarse-grain, subangular to subrounded bioclasts bounded by stylocontacts.
3010	C15/C17	Same as above, but medium-green-gray, argillaceous, slight mottling.
	C4	Stromatolitic boundstone, light medium-gray, low-relief (<2") domal structures.
	C15	Mottled calcimudstone, green-gray, microcrystalline, argillaceous; thin laminae of ostracodal wackestone.
	C11/C12	Interbedded calcareous mudrock and fenestral calcimudstone; mudrock is blue-gray to light-green-gray, sparsely pyritic, thin-bedded (<1"), thickness of beds decreases upsection, green-clay content increases upsection; fenestral calcimudstone is medium-gray, microcrystalline with calcite spar-filled, sub-vertical fenestrae; becomes somewhat argillaceous and mottled upsection.
3015		Vuggy stromatolitic dolomud/wackestone, medium-gray to light-yellowish-gray; sparse, fine- to medium-grain, well-rounded, well-sorted, mud-supported quartz and intraclasts; vugs (<0.25") are irregular and locally infilled by coarsely-crystalline calcite; lower contact gradational, upper contact sharp.
	C4	
	C3	Laminated dolomudstone, light-yellowish-gray, microcrystalline, high microporosity; laterally-continuous, brown mudrock laminae increase in abundance upsection.
	C1	Quartzose dolowackestone, light-brown-gray, microcrystalline, high microporosity; sparse to abundant, fine-grain, well-rounded, well-sorted, mud-supported quartz, abundance increases upsection.

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3020	C10/C2	Patterned dolomudstone, medium-green-gray, micro-crystalline, high microporosity, locally pyritic; peloidal ghosts (3 mm, ellipsoidal) at 3022'6", 3022'6" and and 3024'.
3025	C3	Laminated dolomudstone, bluish-medium-gray, calcareous, microcrystalline, high microporosity; laterally-continuous, brown, mudrock laminae increase in abundance upsection; lower contact stylolitic, upper contact sharp.
	C16	Stylolaminated calcimudstone, light-medium-brown-gray, microcrystalline, dense; thin-laminae (0.1-0.2") of organic-bearing, brown mudrock.
3030		
	C9	Intraclastic grain/packstone, medium-brown-gray, fine- to coarse-grain, poorly-sorted, subrounded intra-clasts and sparse bioclasts; 0.25" interbed of brown mudrock at base; upper and lower stylocontacts; abundance of intraclasts decreases upsection.
	C15	Mottled calcimudstone, light- to dark-brown-gray, microcrystalline, dense; moderately-continuous mottling throughout.

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3035		
	C9/C15	Mottled intraclastic wackestone grading upsection to mottled calcimudstone, medium-brown-gray to light-brown-gray; locally peloidal; sparsely argillaceous near base.
3040	C9	Intraclastic grain/packstone, medium-brown-gray, fine- to coarse-grain, moderately-sorted, fines-upward, subrounded intraclasts and ostracode fragments, lower contact stylolitic, upper contact gradational.
	C11	Calcimudstone, light-brown-gray, microcrystalline, dense; fenestral in upper 9", stylobedded at base; upper and lower contacts stylolitic.
	C15	Argillaceous mottled calcimudstone, light-green-gray to light-brown-gray; microcrystalline, dense; argillaceous content decreases upsection.
	C11	Fenestral calcimudstone, light-brown-gray, microcrystalline, dense; coarsely-crystalline calcite infills irregular, subhorizontal fenestrae; upper contact sharp, lower contact gradational.
3045	C9	Intraclastic grainstone grading upsection to wackestone, medium- to light-brown-gray, fine- to coarse-grain, angular to subrounded intraclasts with sparse bioclasts; thin-beds of argillaceous calcimudstone at 3044'6"-3045'"; upper contact gradational, lower contact sharp and irregular.

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C15	Argillaceous mottled calcimudstone, light-greenish-gray, microcrystalline, dense, with lenses of ostracodal packstone; argillaceous content decreases upsection; stylobedding contacts at 3047'2" and 3047'6"; upper contact sharp, lower contact stylolitic.
3050	C9/C8	Stylobedded intraclastic grainstone and ostracodal packstone; intraclasts are fine- coarse-grain, moderately-sorted, subrounded to subangular; bioclasts are incomplete and complete ostracodes; grain-sizes decrease upsection; abundance of complete ostracodes increases upsection; upper and lower contacts stylolitic.
	C15	Mottled calcimudstone, light-medium-brown-gray, microcrystalline, dense, with lenses of ostracodal packstone; upper contact stylolitic, lower contact sharp.
3055	C15/C11	Mottled calcimudstone, light-brown-gray to medium-brown-gray, microcrystalline, dense; sparsely fenestral in upper 1' 4", fenestrae infilled with coarsely-crystalline calcite; core is fractured - poor recovery; upper contact sharp, lower contact stylolitic.
	C10	Patterned calcimudstone, microcrystalline, sparesly argillacous, upper and lower contacts stylolitic.
3060	C16	Stylolaminated calcimudstone, light-brown-gray, microcrystalline, dense; sparse, ostracodal packstone laminae.

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C10	Patterned dolomudstone, light-yellowish-gray to light-medium-brown-gray; microcrystalline, high micro-porosity; slightly calcareous in upper 1 ft.
3065	C1/C12	Quartzose dolowackestone grading upsection to argillaceous calcimudstone; light-greenish-gray, microcrystalline; quartz is fine- to medium-grain, well-rounded, moderately-sorted quartz; contacts stylolitic.
	C10	Patterned calcimudstone, light-brown-gray to light-green-gray, microcrystalline, dense; mottled through-out; upper and lower contacts stylolitic.
	C16	Stylolaminated calcimudstone, light-brown-gray, micro-crystalline, dense; sparse laminae of ostracodal pack-stone and brown organic-bearing mudrock; lower 4" intraclastic grainstone/conglomerate, medium-brown-gray, fine-grain to pebble-size, subangular to sub-rounded intraclasts.
3070	C10	Patterned dolomitic calcimudstone, light-green-gray to light-brown-gray, microcrystalline, increasingly dolomitic upsection; thin interbeds of laminated dolo-mudstone at 3070'-3070'4", 3071'-3071'3" and 3071'11"-3072'.
		No core 3071'5"- 3074'10"

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C3	Laminated dolomudstone, dark-yellowish-gray, micro-crystalline, porous; subplanar, thin laminae of organic-bearing, brown mudrock.
3075	C12	Argillaceous calcareous dolomudstone grading up-section to patterned dolomudstone; dark- to light-yellow-brown; microcrystalline; increasingly cal-careous upsection, micropore-filling calcite; lower contact sharp and irregular.
	C2/C3	Vuggy laminated dolomudstone, light-yellowish-gray, chalky, vuggy, microcrystalline, very porous; irregular laminae of brown, organic-rich mudrock; coarsely-crystalline calcite infilling of vugs.
	C3	Laminated dolomudstone, light-yellowish-gray, chalky, microcrystalline, high microporosity; planar to irregular laminae of brown, organic-bearing mudrock; sparse, fine-grain, well-rounded, well-sorted, mud-supported quartz throughout; quartz increases in abundance upsection.
3080		
	C1	Quartzose dolowacke/packstone, medium-yellowish-gray, microcrystalline, low porosity; abundant to sparse, fine- to medium-grain, well-rounded, mud-supported quartz that decreases in abundance upsection; upper contact gradational, lower contact sharp; large vug (0.5") at 3080'4".
	C10	Patterned dolomudstone, light-yellowish-gray to light-green-gray, microcrystalline, porous; sparse, thin laminae of fine-grain quartz arenite and green-gray mudrock throughout.
3085		
	C4/C7	Interbedded stromatolitic dolomudstone and dolo-breccia; stromatolitic dolostone is light-yellowish-gray, chalky, vuggy, very porous; laminae of brown mudrock are irregular and laterally discontinuous; interbedded dolobreccia is made up of disrupted beds of chalky patterned dolomudstone that is locally anhydritic; dead oil stain at 3087'3". Stromatolitic at 3085'6"-3086', 3087'-3087'5", and 3088'1"-3089'2".

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3090		
	C3	Laminated dolomudstone, light-yellow-brown, chalky, microcrystalline, porous; thin laminae of organic-bearing, brown mudrock throughout; thick laminae (>0.25") at 3090'7" and 3090'4"; 1" interbed mudrock at lower contact.
3095		
	C10	Patterned dolomudstone, light-yellow-gray and light-green-gray, microcrystalline, porous; chalky at 3095-3095'5" and 3097'6"-3098"; upper contact sharp, lower contact stylolitic.
	C1	Quartzose dolopackstone to patterned dolomudstone, light-yellow-gray to light-yellow-brown with light-green-gray mottles, microcrystalline, porous; sparse to abundant, fine- to medium-grain, well-sorted, well-rounded, mud-supported quartz; abundance of quartz decreases rapidly upsection; upper contact gradational, lower contact sharp.
3100		
	C4	Stromatolitc dolomudstone, light-yellow-brown, micro-crystalline, porous, chalky; moderately abundant, planar to irregular, organic-bearing, brown mudrock laminae.
		Quartzose dolopackstone grading upsection to

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C1	microcrystalline dolomudstone, light-medium-yellow-gray to light-yellow-gray; dolopackstone is darker in color and contains fine- to medium-grain, well-rounded, fining-upsection, mud-supported quartz; microcrystalline dolomudstone is lighter in color, chalky, porous, vuggy and possibly pisolitic from 3104-3105 ft., locally has patterned appearance; lower contact sharp and stylolitic, upper contact gradational.
3105		
	C4/C7	*Dolobrecciate and stomatolitic dolomudstone*, light-yellow-gray, microcrystalline, chalky, vuggy (<0.2"); lower contact stylolitic.
	C2/C5	Microcrystalline dolomudstone, dark-yellow-gray, microcrystalline, vaguely laminated; coarsely-crystalline pore-filling dolomite locally in upper 2 ft.; sparse planar, organic-bearing brown mudrock laminae in lower 2 ft.; minor amounts of fine-grain, well-rounded, mud-supported in lower 3"; lower contact sharp and irregular, upper contact stylolitic.
3110		
	C3	Laminated dolomudstone, yellow-gray, microcrystalline, chalky, porous; sparse to abundant laminae of organic-bearing, brown mudrock with associated thin-laminae of fine-grain, well-rounded quartz; locally vuggy, breccia at 3113'6", vugs infilled with coarsely-crystalline calcite; vague patterned appearance in lower 9"; mudcracks at upper contact infilled with fine-grain quartz and lithic intraclasts; lower contact stylolitic.
3115		
	C10	Patterned dolomudstone and microcrystalline dolomudstone, light-yellow-brown to light-green-gray; mottles are light-green-gray; microcrystalline, porous; intensely mottled at 3119'4" and 3115'8"; stylolaminae

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		of brown, organic-bearing mudrock at 3115'2" and 3116'2".
3120	C1	*Quartzose dolowackestone grading upsection to* argillaceous dolomudstone; microcrystalline, porous; fine- to medium-grain, well-rounded, moderately-sorted, mud-supported quartz in lower 1 ft., laminae of quartz arenite occur throughout, but decrease in abundance upsection; increasingly "patterned" appearance up-section; lower contact sharp, upper gradational.
3125	C4	Stromatolitic dolomudstone, light-yellow-brown, micro-crystalline, chalky, porous; irregular laminae of brown, organic-bearing mudrock throughout; vuggy locally.
	C3	Laminated dolomudstone, yellow-gray, microcrystal-line; chalky, porous; sparse to abundant laminae of organic-bearing, brown mudrock with associated thin laminae of fine-grain, well-rounded quartz; abun-dance of laminae increases upsection; stringers of lithic quartz arenite in lower 6"; lower contact sharp, upper contact gradational.
	C3/C2	Laminated dolomudstone, yellow-gray, microcrystal-line; chalky, porous; sparse to abundant laminae of organic-bearing, brown mudrock with associated thin-laminae of fine-grain, well-rounded quartz; abundance of laminae increase upsection; stringers of quartz arenite increasingly abundant downsection; lower contact stylolitic.
3130	C4	Stromatolitic dolomudstone, light-yellow-brown, micro-crystalline, chalky, porous; irregular laminae of brown, organic-bearing mudrock throughout; vuggy locally.

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C3/C2	Laminated dolomudstone, yellow-gray, microcrystalline, chalky, porous; sparse to abundant laminae of organic-bearing, brown mudrock with associated thin-laminae of fine-grain, well-rounded quartz; abundance of laminae increases upsection; stringers of quartz arenite increasingly abundant downsection; thin (0.5-1.25") interbeds of green-gray mudrock at 3134'4", 3123'3" and 3132'9".
	C6/M5	Interbedded mottled dolomudstone, light-yellowish-gray, and bown mudrock, dark-brown; mottled dolomudstone is microcrystalline, porous, with green-gray anhydritic mottles; brown mudrock is thinly- to thickly laminated, fissle, organic-bearing; 1-2" mudrock interbeds at 3132' and 3132'5".
	C4/C3	
3135		Stromatolitic/laminated dolomudstone, light-yellowish-gray to medium-brown with dark-brown mudrock laminae; microcrystalline, chalky at top; abundant organic-bearing, brown mudrock laminae throughout, domal and planar geometries; color lightens upsection; laminae disrupted 3135' 7" to 3136' 3", possible dissolution feature.
	C6/M5	Interbedded mottled dolomudstone, light-yellowish-gray, and brown mudrock, dark-brown; mottled dolomudstone is microcrystalline, porous, with green-gray anhydritic mottles; brown mudrock is thinly- to thickly laminated, fissle, organic-bearing; 1-2" mudrock beds at 3138' 1" and 3138' 10".
3140	C6	Mottled dolomudstone, light-yellowish-gray with medium-green-gray, anhydritic mottles, microcrystalline, high microporosity, locally fenestral.
	C6/C10	Anhydritic mottled to patterned dolomudstone, light-green-gray to dark-green-gray, microcrystalline, low porosity, very argillaceous.
3145		

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	M5	Brown mudrock, dark-brown to black, thinly- to thickly-laminated, mostly planar laminae, fissle, organic-bearing
	C2	Microporous dolomudstone, light-yellowish-gray, micro-crystalline, high microporosity.
3150	C4/C3	Stromatolitic/laminated dolomudstone, light-yellowish-gray to medium-brown with dark-brown mudrock laminae; microcrystalline, chalky at top; abundant organic-bearing, brown mudrock laminae throughout, domal and planar geometries; color lightens upsection.
3155	C6/M5	Interbedded mottled dolomudstone, light-yellowish-gray, and brown mudrock, dark-brown; mottled dolo-mudstone is microcrystalline, porous, with green-gray anhydritic mottles; brown mudrock is thinly- to thickly laminated, fissle, organic-bearing; 1-2" mudrock beds at 3153' 4" and 3155' 6".
	C2/C3	Microporous dolomudstone, light-yellowish-gray, micro-crystalline, high microporosity, locally vuggy with coarsely-crystalline calcite infill; vague planar to irregular laminae of pyritic quartz arenite; quartz is fine-grain, very well-sorted, well-rounded quartz; abund-ance and thickness of quartz laminae increases downsection.

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3160	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray and light green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; burrows defined by green-gray argillaceous margins.
	S9	Mottled quartz arenite, light-yellow-gray, dolomitic, fine- to medium-grain, well-sorted, well-rounded quartz; friable; mottles defined by green-gray clay content.
	S7	Stromatolitic quartz arenite, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz with thin (0.1-0.2") anastomosing black to brown-gray, laminae of organic-bearing mudrock; thin-interbeds of fissle, brown, organic-bearing mudrock at 3156'6" and 3157'3".
	S9	Mottled quartz arenite, light-yellow-gray, dolomitic, fine- to medium-grain, well-sorted, well-rounded quartz; friable; mottles defined by green-gray clay content; argillaceous content increases upsection, pyritic near top.
3165		
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; irregular pore-filling sulfide masses (0.1-0.2") in upper 3 ft.
3170		

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3175		
	S10	Massive quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths.
3180		
	S4/S3	Cross-stratified quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; low-angle to planar cross-laminae throughout.
3185		

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S3/S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths, low intercrystalline porosity; planar to low-angle cross-laminae, thin-bedded.
3190		
	S5	Ripple cross-stratified arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths, low intercrystalline porosity; thin- to medium-bedded (2"-4").
3195	S3/S4	Cross-stratified quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths, low intercrystalline porosity; planar to low-angle cross-laminae, thin-bedded.
	S10	Massive quartz arenite, light-brown-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.
3200	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; vague planar laminae in upper 3 ft.

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3205	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; vague mottling throughout.
3210		
3215		

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths, pore-filling calcite locally.
		No discernable lithologic breaks to 3203'3".
3220		
3225		

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3230		
	S10	Massive quartz arenite with thin-interbeds of planar-laminated quartz arenite; light-yellowish-gray, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; thin planar-laminae at 3235'4", 3234'4" and 3236'3" defined by minor variations in grain-size.
3235		
		Core rubbly and poorly preserved 3237'6"-3242'6"
3240		
	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray, fine- to coarse-grain, poorly- to moderately-indurated,

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		well-rounded quartz; weakly-indurated by quartz over-growths; abundant, large diameter (>0.25") Skolithos burrow; burrow infills are coarser-grain, better sorted, are more indurated than matrix.
3245	S10	Massive quarts arenite, light-yellowish-gray, fine- to medium-grain, well-rounded, poorly-sorted quartz; moderately-indurated by quartz overgrowths.
	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray and light-green-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; sparse to abundant, large diameter (>0.25") Skolithos burrows, burrow infills are coarser-grain, better sorted, and are more indurated than matrix; light-green-gray argillaceous fraction concentrated in matrix; abundance of burrows and argillaceous content decrease upsection.
3250		
3255		

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3260		
	S9	Mottled quartz arenite grading upsection to planar-laminated quartz arenite; light-yellowish-gray with light-green-gray mottles; fine- to medium-grain, moderately well-sorted, well-rounded quartz; mottles defined by argillaceous content; friable to weakly-indurated by quartz overgrowths; planar laminated in upper 6", thick-laminae;laminae defined by alternating fine and medium-grain sizes.
3265	S14	Silty quartz arenite, light-yellow-gray, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz; vague, silty laminae; weakly-to moderately-indurated by sparse quartz overgrowths and pore-filling calcite; lower contact sharp and irregular, upper contact gradational.
3270	C9/S10	Interbedded intraclastic dolowacke/packstone and burrowed quartz arenite; dolostone is medium-brown-gray, micro- to finely-crystalline, mottled fabric; sparse to abundant, fine- to coarse-grain, subangular to angular, poorly-sorted intraclasts locally; quartz arenite is light-yellow-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; well-indurated by quartz over-growths; pore-filling calcite locally abundant; upper and lower contacts sharp and stylolitic.

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Illinois Power Co., L. Truitt 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3275		
	C1	Quartzose dolowackestone, medium-brown to light-medium-brown-gray, finely-crystalline, sparse to abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz; locally vuggy (<0.5"), vugs lined by drusy quartz; stylolitic locally; contains Middle Ordovician microfauna.
Bottom of cored interval, TD at 3320 ft.		

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Illinois Power Co., L. House 1, Sec. 29-T10N-R3W, Montgomery Co., Ill., elev. 614 ft., company core, whole 4-inch core 3311-3377 ft.

Depth (ft.)	Litho-facies	Description/Comments
3311	S6	Trough cross-stratified quartz arenite, light-yellow-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; cross-stratification weakly-developed in upper 2 ft.; large, horizontal burrow trace at 3316'6" cross-cuts stratification; lower and upper contacts gradational.
3315		
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; moderately well-indurated by quartz over-growths, pore-filling calcite locally.
3320		
	S8	Skolithos-bearing quartz arenite, light-yellowish-gray with minor patches of light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; moderately- to poorly-indurated by quartz over-growths; abundant, large diameter (0.5") Skolithos burrows, abundance of burrows decreases up-section; burrows are locally lined by green-gray clay; and infill is coarser-grain than matrix.

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Illinois Power Co., House 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3325		
3330		
	S13	Lithic quartz arenite, light-yellowish-gray, fine- to very-coarse-grain, poorly-sorted; well-rounded quartz (85%); subrounded to well-rounded chert (10%), and sub-angular mudrock; argillaceous throughout; weakly-indurated; lower contact sharp, upper contact gradational.
	S8	Skolithos-bearing quartz arenite, light-yellowish-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; poorly-indurated by quartz overgrowths; sparse, large diameter (0.5") Skolithos burrows; burrow infills are coarser than matrix; lower contact gradational, upper contact sharp.
3335		
	S9	Mottled quartz arenite, light-yellowish-gray with light-green-gray mottles; fine-to medium-grain, poorly-sorted, well-rounded quartz; weakly-indurated by quartz over-growths; light-green-gray argillaceous mottles through-out.

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Illinois Power Co., House 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
3340		
	S15	Argillaceous quartz arenite, light-green-gray to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated, clay-cemented; thin interbeds (0.25-0.75") of green mudrock at 3344' and 3345'6"; pyritic mottles and subangular, pebble-size intraclasts of green mudrock locally; lower contact is sharp, upper contact is irregular.
3345		
	S8	Skolithos-bearing quartz arenite, light-yellowish-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; poorly-indurated by quartz overgrowths; sparse, large diameter (0.5") Skolithos burrows; burrow infill is coarser-grain than matrix; laterally discontinuous cross-stratification present locally; upper contact is sharp, lower contact is gradational.
3350	S4/S3	Cross-stratified quartz arenite, light-yellowish-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated; abundant low-angle and planar cross-laminae.
	S10	
		Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths.

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Illinois Power Co., House 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		No core 3351' 6" to 3354"10".
3355	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths.
3360	S9	Mottled quartz arenite, light-green-gray to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated, clay-cemented; pyritic mottles locally.
3365	S15	Argillaceous quartz arenite, light-green-gray to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated, clay-cemented; thin interbeds of green-gray mudrock 3361-3362'8"; pyritic mottles and subangular, pebble-size intraclasts of mudrock locally; upper contact is gradational, lower is sharp and irregular.
	C1	Quartzose dolowackestone, medium-brown-gray with light-brown-gray mottles; medium-brown-gray is micro-crystalline; light-brown-gray mottles are finely- to

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Illinois Power Co., House 1, Montgomery Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		medium-crystalline; quartz is medium- to coarse-grain, well-rounded, poorly-sorted; locally vuggy (<0.75"); some vugs infilled by coarsely-crystalline calcite; thin interbed of medium-grain quartz arenite at 3066'6".
	S13/M1	Lithic quartz arenite, green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz (90%); fine- to coarse-grain, poorly-sorted, subrounded to angular, chert, and light-green-gray dolomudstone; 4" of bitumen-stained, dark- to light-gray, fused-chert residuum at base; lower contact sharp and irregular, upper contact gradational.
	M2	
3370		Green mudrock, medium-green-gray, nonfissle, sparse stringers of fine-grain, well-rounded quartz arenite; pyritic.
	C4/C19	Stromatolitic dolomudstone, light-brown-gray to light-green-gray, argillaceous, microcrystalline; concave and convex, green-gray mudrock laminae; fine- to medium-grain, dolomitic quartz arenite stringers locally; locally vuggy; contains Lower Ordovician microfauna.
3375		
3377	C19	Chert breccia, dark- to light-gray, pebble- to cobble-size, angular, opaque chert; vuggy (<0.75"), vugs may contain medium- to coarse-grain, well-rounded quartz.
Bottom of cored interval and TD.		

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Sec. 16-T13N-R8W, Morgan Co., Ill., elev. 664 ft., company core, 4" core 1885-2041.5 ft.

Depth (ft.)	Litho-facies	Description/Comments
1885	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse to abundant, green-gray clay throughout; friable to weakly-indurated, locally calcareous; sparse *Skolithos* burrows in 2 ft.
1890	S15/S8	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse to abundant, green-gray clay throughout; friable to weakly-indurated, locally calcareous; sparse *Skolithos* burrows in upper 14".
1895		

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1900	S15/S8	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse to abundant, green-gray clay throughout; friable to weakly-indurated, locally calcareous; sparse *Skolithos* burrows in upper 2 ft.
1905	S15/S8	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse to abundant, green-gray clay throughout; friable to weakly-indurated, locally calcareous; sparse *Skolithos* burrows in upper 8", burrows are only partially infilled, 0.2-0.5" diameter.
1910		

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1915	S15/S8	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse to abundant, green-gray clay throughout; friable to weakly-indurated, locally calcareous; sparse, *Skolithos* burrows in upper 8", infilled with fine-grain, well-sorted, well-rounded quartz - all grains are frosted.
1920		**No core 1919.5-1923 ft.**
1925	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz locally associated with poorly-defined, medium-bedded, fining-upward sequences; well- to moderately-indurated by quartz overgrowths, pore-filling sulfide locally; vague mottling locally.

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1930		
		No core 1930-1933 ft.
1935	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths.
1940	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, poorly- to moderately-sorted, well-rounded quartz; sparse to abundant, green-gray clay throughout; friable to weakly-indurated, locally calcareous; shaly-partings 1935-1936 ft.; poor core recovery.

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1945	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths.
1950		**No core 1948-1956 ft.**

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1955		
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; no apparent breaks to 1968 ft.
1960		
1965		

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
1970	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz; moderately well-indurated by quartz over-growths; pore-filling sulfide locally; vague mottling.
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
1975	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz; moderately well-indurated by quartz over-growths; pore-filling sulfide locally; vague mottling.
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
1980	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz; moderately well-indurated by quartz over-growths; pore-filling sulfide locally; vague mottling.
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths.

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
1985	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz; moderately well-indurated by quartz over-growths; pore-filling sulfide locally; vague mottling.
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
1990	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz locally associated with poorly-defined, medium-bedded, fining-upward sequences; moderately- to indurated by quartz overgrowths, pore-filling sulfide locally; vague mottling.
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
1995	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz locally associated with poorly-defined, medium-bedded, fining-upward sequences; moderately- to indurated by quartz overgrowths, pore-filling sulfide locally; vague mottling.
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz;

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz locally associated with poorly-defined, medium-bedded, fining-upward sequences; moderately- to indurated by quartz overgrowths, pore-filling sulfide locally; vague mottling locally.
2000	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz locally associated with poorly-defined, medium-bedded, fining-upward sequences; moderately- to indurated by quartz overgrowths, pore-filling sulfide locally; vague mottling.
2005	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae that are laterally discontinuous near lower contact.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; stringers of coarse-grain, well-rounded, well-sorted quartz locally associated with poorly-defined, medium-bedded, fining-upward sequences; moderately- to indurated by quartz overgrowths, pore-filling sulfide locally; vague mottling.

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
2010		
	S14	Silty quartz arenite, light-yellowish-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; sparse to abundant quartz silt, sparse green-gray mudrock partings locally.
	S4	Cross-stratified quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths; well-developed low-angle and planar cross-laminae;
2015	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by quartz overgrowths, pore-filling sulfide locally; vague mottling.
2020		
	S14	Silty quartz arenite, light-yellowish-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; sparse to abundant quartz silt, sparse, angular green-gray mudrock intraclasts.

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Cross-stratified quartz arenite, light-yellowish-gray, medium-grain, very well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; sparse, fine-grain clay grains - probably altered feldspar.
2025	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by quartz overgrowths, pore-filling sulfide locally; mottling locally.
2030	S10	Massive quarz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant quartz silt in lower 6".
	M2	Yellow-green-gray mudrock, fissle; possible altered bentonite, greatly expanded in core.
	S15	Argillaceous quartz arenite, light-yellow-gray and medium-green-gray, fine- to medium-grain, moderately-sorted well-rounded quartz; moderately well-indurated by quartz overgrowths, sparse to abundant pore-filling sulfide locally; abundant green-gray mudrock partings, waxy, abundance of partings decreases upsection.
	S10	Massive quarz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths.
2035	S15	Argillaceous quartz arenite, light-yellow-gray and medium-green-gray, fine- to medium-grain, moderately-sorted well-rounded quartz; moderately well-indurated by quartz overgrowths, sparse to abundant pore-filling sulfide locally; abundant green-gray mudrock partings, waxy, abundance of partings decreases upsection.
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths.
	S15	Argillaceous quartz arenite, light-yellow-gray and medium-green-gray, fine- to medium-grain, moderately-sorted well-rounded quartz; moderately well-

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Panhandle Eastern Pipeline Co., E. W. Carr 1-16, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		indurated by quartz overgrowths, sparse to abundant pore-filling sulfide locally; abundant green-gray, waxy, mudrock partings; abundance of partings decreases upsection.
2040	S10	Massive quarz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths; sparse green-gray mudrock partings in lower 6".
	M1	Conglomeratic mudrock, dark-green-gray mudrock matrix with fine- to medium-grain, well-sorted, well-rounded quartz and pebble- to cobble-size, angular, solution pitted, argillaceous dolomudstone, light-green-gray, moderately-crystalline.
		Bottom of cored interval and TD.

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Panhandle Eastern, McVaigh 1-15, Sec.15-T3N-R8W, Morgan Co., Ill., elev. 634 ft., ISGS Core 13629, 4-inch core described from 1733-1743 ft.

Depth (ft.)	Litho-facies	Description/Comments
1733	C17	Bioclastic pack/wackestone, medium-brown-gray with brown-gray mudrock partings (0.1-1"); microcrystalline, sparse to abundant ostracodes; thin-bedded.
1735	C11	Fenestral calcimudstone, medium-brown-gray, micro-crystalline; abundant vertical fenestrae infilled by crystalline calcite; fenestrae are 0.25" in diameter, subvertical with subcircular cross-sections; upper contact is probable hard-ground.
	M2	Green mudrock, fissle, pyritic, no biotite.
	C11	Fenestral calcimudstone, medium-brown-gray, micro-crystalline; abundant vertical fenestrae.
	C17/C18	Bioclastic grain/packstone, medium-brown-gray, microcrystalline; sparse to abundant ostracodes, abundant fine- to coarse-grain, subangular to sub-rounded, poorly-sorted intraclasts, oolitic.
	M2	Green mudrock, fissle, pyritic, no biotite.
	C11	Fenestral calcimudstone, medium-brown-gray, micro-crystalline; abundant vertical fenestrae.
	C17	Bioclastic grain/packstone, medium-brown-gray, microcrystalline; sparse to abundant ostracodes, abundant fine- to coarse-grain, subangular to sub-rounded, poorly-sorted intraclasts, possibly oolitic.
1740	M1	Green mudrock, fissle, pyritic, no biotite.
	C10	Patterned calcimudstone, light-medium-green-gray, microcrystalline, argillaceous; mottling increases in abundance upsection.
1743	C10	Patterned calcimudstone, light-medium-green-gray, microcrystalline, very argillaceous; mottling increases in abundance upsection; vertical, calcite-infilled burrows in upper 6".
		Bottom of described interval, TD at 1847 ft.

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Panhandle Eastern, Thomas 1-15, Sec. 15-T3N-R8W, Morgan Co., Ill., elev. 652 ft., ISGS Core 13630, 4-inch core described from 1791-1815 ft.

Depth (ft.)	Litho-facies	Description/Comments
1791	C10	Patterned dolomudstone, medium-green-gray to light-brown-gray, microcrystalline, increasingly argillaceous upsection; sparse to abundant mottles that increase in abundance upsection.
1795	C3	Laminated dolomudstone, light-yellow-brown, micro-crystalline, earthy, microporous; sparse to moderately-abundant, thin- to thick-laminae of brown mudrock; abundant quartz silt in upper 1 ft.
	C10	Patterned dolomudstone, medium-green-gray to light-brown-gray, microcrystalline, increasingly argillaceous upsection; sparse to abundant mottles, increase in abundance upsection; locally calcareous.
1800	C12	Argillaceous dolomudstone, light- to medium-brown-gray, microcrystalline, abundant planar partings of brown and green-gray mudrock that decrease in abundance upsection.
	C9	Intraclastic dolograinstone, medium-brown-gray, fine-grain to pebble-size intraclasts of dolomudstone, and fine- to medium-grain ooids; increasingly mud-supported upsection.
	C2	Dolomudstone, light-yellow-gray, microcrystalline, earthy; medium-bedded, abundant small angular vugs in many beds; clotted fabrics well-developed at 1803', 1806' and 1808'.

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Panhandle Eastern, Thomas 1-15, Morgan Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1805		
1810		**No core 1808'3"-1811 ft.**
	C2	Dolomudstone, light-yellow-gray, microcrystalline, earthy; medium-bedded, abundant small angular vugs in many beds; clotted fabric well-developed locally.
	C3	Laminated dolomudstone, light-yellow-brown, micro-crystalline, earthy, microporous; sparse to moderately-abundant, thin- to thick-laminae of brown mudrock; abundant fine-grain, well-rounded quartz in lower 1ft.
		Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated by dolomicrite; argillaceous
1815	S15	throughout.
Bottom of described interval, TD at 1847 ft.		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill.,
elev. 833 ft., NX core 18-408 ft., described 18-48 ft.and 200-408 ft.

Depth (ft.)	Litho-facies	Description/Comments
18	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, well-rounded, bimodal quartz; weakly-indurated to friable, massive.
20	S8	*Skolithos* -bearing argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, well-rounded, bimodal quartz, weakly-indurated to friable.
	M2	Green-gray mudrock, locally silty, pyritic, massive.
	C4	Argillaceous stromatolitic dolomudstone, medium-gray to light-green-gray, microcrystalline, planar- and anastomsing laminae, abundant ferroan staining.
25	M2/M6	Interbedded green mudrock and argillaceous siltstone; green mudrock is medium-green-gray, fissle, pyritic; silty mudrock to medium-green gray with sparse to abundant quartz silt and some coarse- to medium-grain, well-rounded quartz; ferroan stained in upper 9". Silty 24-24'8" and 25'9"-26'3".
	S2	Dolomitic quartz arenite, light-gray-green, fine- to coarse-grain, bimodal, well-rounded quartz, silty-stringers throughout, dolomicrite abundant.
30	C1/C6	Mottled quartzose dolowackestone, light-green-gray to light-medium-gray, microcrystalline, abundant medium- to coarse-grain, well-rounded quartz; abundant vertical burrows, 0.25" in diameter - similar in character to small diameter *Skolithos* burrows in underlying arenite lithofacies, no infilling of burrows.

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
35		
	S8	*Skolithos*-bearing argillaceous quartz arenite, very-pale-green to white, fine- to coarse-grain, bimodal, well-rounded quartz; abundant small (<1 cm diameter) *Skolithos* burrows; moderately-indurated to friable, increasingly indurated up-section by dolomicrite; increasing clay content upsection reflected by color change from very light-gray at base to pale-light-green at top; grains locally mud-supported above 37'9", grades into overlying unit; lower contact sharp.
40		
	S3/S4	Interbedded planar and low-angle cross-stratified arenite, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz; friable to weakly-indurated; limonite stained in upper 2 ft.; upper contact is sharp.
45		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
48		
		Interval from 48-200 ft undescribed.
200	S10	Massive quartz arenite, white to light-medium-gray, very-fine-grain to fine-grain, well-sorted, well-rounded quartz; sparse thin (<2 cm) interbeds of fine- to medium-grain, moderately-sorted, well-rounded quartz arenite; friable to weakly-indurated by poorly-developed quartz overgrowths; appears thin- to medium-bedded. No discernable lithologic breaks to 240'9".
205		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
210		
215		
220		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
225		
230		
235		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
240		
245	S10	Massive quartz arenite, light-yellowish-gray, very-fine- to medium-grain, well-sorted to moderately-sorted, well-rounded quartz (95-98%); locally feldspathic (0.1-5%); thin- to medium-bedded; yellow-orange ferroan staining 249'9"-252', 250'10"-252'3", 254'3"-254'8", 256-4"-257'0", 258'4"-260'8", 261'2"-263'2"; staining cross-cuts bedding. Unpublished study by Illinois State Geological Survey Industrial Minerals Section of nearby quarry indicates staining is a weathering product of K-feldspar; uncertain if k-feldspar is authigenic, or detrital. Other than color variation, no discernable lithologic breaks to 268 ft.
250		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
255		
260		
265		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray to pale-yellow-orange to dark-red-brown, fine- to medium-grain, well-rounded, well- to moderately-sorted quartz (95-99%), variable amounts to plagioclase feldspar (0.1-5%); thin- to medium-bedded, friable to weakly-indurated; ferroan staining locally, pale-yellow-orange where limonitic; dark-red-brown where hematitic; ferroan-stain more prevalent in less well-sorted arenites.
270		
		No discernable sedimentary breaks to 318'5"; variable color and ferroan staining 268'-318'5".
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable; limonite stained.
275		
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable.
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable; limonite stained; moderately-indurated

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		by hematite at top.
280	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable.
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable, limonite stained.
	S10	Massive quartz arenite, pale-yellow-orange or light-medium-gray, fine- to medium-grain, moderately- to well-sorted quartz; friable, limonite stained at 283'9"-284'.
285	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable, limonite stained.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable.
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; limonite stained; moderately- to well indurated by pore-filling hematite near top.
290	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, featureless.
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; limonite stained, hematite cemented at top.

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
295		
	S10	Massive quartz arenite, light-medium-gray, friable.
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; limonite stained; moderately-indurated by hematite at top.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable.
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable, moderately-indurated by hematite at top.
300	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable.
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable, limonite stained; moderately-indurated by hematite at top.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz. friable; fine-grain size patches of light-red-brown locally, probable partially weathered K-feldspar.
305		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable, limonite stained.
310		
	S10	Massive quartz arenite, red-brown, very fine- to fine-grain, very well-sorted, well-rounded quartz; comparatively abundant palgioclase feldspar (5%); weakly-indurated by hematite.
	S10	Massive quartz arenite, pale-yellow-orange, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable, limonite stained; hematite banding at 310'10', hematite nodule at 317'3". No discernable lithologic breaks to 318'5".
315		
	S10	Massive quartz arenite, white to very light-medium-gray, locally pale-yellow-gray, fine- to medium-grain, well- to moderately-well-sorted, well-rounded quartz; rare, very fine- to fine-grain, subrounded plagioclase feldspar; friable; thin- to medium-bedded; possible meter-scale fining upward sequences developed locally; limonite stained 324'-326', 328'6"-329'8", 330'7"-331'8", 333'7"-336'.
320		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		No discernable lithologic breaks to 336 ft.
330		
335		
	S10	Massive quartz arenite, white to very light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; rare, very fine- to fine-grain, subrounded plagioclase feldspar; friable; thin- to medium-bedded; possible meter-scale fining upward sequences; rare limonite staining, no hematite. No discernable lithologic breaks to 348' 6".
340		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
345		
350	S10	Massive quartz arenite, white to very light-medium-gray, locally pale-yellow-gray, fine- to medium-grain, well- to moderately-well-sorted, well-rounded quartz; rare, very fine- to fine-grain, subrounded plagioclase feldspar; friable to weakly-indurated by limonite in restricted intervals; thin- to medium-bedded; possible meter-scale fining upward sequences developed locally; limonitic 348'6"-355'3", 358-359'4", 360-365'2", 367'8"-373'1"; limonite indurated at 362'. No discernable lithologic breaks to 366'10".

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
355		
360		
365		
	S10	Massive quartz arenite, white to very light-medium-gray, fine- to medium-grain, well- to moderately-well-sorted, well-rounded quartz; rare, very fine- to fine-grain, subrounded palgioclase feldspar; friable to weakly-indurated; thin- to medium-bedded.

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		No discernable lithologic breaks to 379 ft.
370		
375		
380	S10	Massive quartz arenite, light-brown-gray to light-yellow-brown, very fine- to fine-grain, well-sorted, well-rounded, quartz; moderately-indurated by iron sulfides at base, otherwise friable; upper 6" limonite stained.

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	M4/S10	Interbedded gray quartzose mudrock and massive quartz arenite; mudrock is light-medium-gray, waxy, fissle to non-fissle, quartz silt is locally abundant, oxidized organics, thin-bedded (0.25-1"); quartz arenite, light-yellow-gray to light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths, limonite stained near top; mudrock interbeds at 383', 383'10", 385'2" and 386'.
385		
	S10	Massive quartz arenite, light-medium-gray to white, very fine- to fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths.
390		
	S10	Massive quartz arenite, light-yellow-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant limonite staining.
	M4/S10	Interbedded gray quartzose mudrock and silty, argil-laceous quartz arenite; mudrock is light-medium-gray, waxy, fissle to non-fissle, quartz silt is locally abundant, no organics, thin-bedded (0.25-1"); quartz arenite, light-yellow-gray to light-medium-gray, fine to medium-grain, moderately-sorted, well-rounded quartz and quartz silt in meter-scale fining upward sequences; quartz grains moderately-indurated by quartz overgrowths; no ferroan staining; mudrock interbeds at 394'1"-394'5", 396'0"-396'2".
395		

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Unimin Silica Quarry Boring H91-409, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-yellow-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; limonite staining; well-indurated by hematite at top.
	S10	Massive quartz arenite, light-medium-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; moderately-indurated by calcite.
400	S10	Massive quartz arenite, light-yellow-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; friable except where moderately-indurated by hematite cement in upper 4"; limonite stained, hematitic at top.
	S10	Massive quartz arenite, light-medium-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; moderately-indurated by calcite.
	S10	Massive quartz arenite, light-yellow-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; friable in upper 7 ", otherwise moderately-indurated by quartz overgrowths; limonite staining common.
405	S2	Dolomitic quartz arenite, pale-yellow-gray, fine- to coarse-grain, poorly sorted, locally dolomicrite supported, well indurated; mudrock partings at 404'3" and 405'2", mudcracks on bedding planes underlying mudrocks.
	M3	Red mudrock, brick red to dark-red-brown with interbeds of light-gray mudrock, nonfissle, waxy appearance, pseudo-slickensides;
408	M2	Conglomeratic mudrock, green-gray, waxy with abundant angular, pebble-size, microcrystalline chert and gray dolomudstone, abundant pyrite; 1" of gray-green dolomudstone at base - uncertain if in-place.
Bottom of cored interval and TD.		

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Unimin Silica Quarry Boring 86-316, Sec. 8-T23N-R10E, Ogle Co., Ill., elev. 846 ft., NX core 30-110 ft..

Depth (ft.)	Litho-facies	Description/Comments
30	M3/M2	Red-brown and green mudrock, dark-red-brown and medium-green-gray, pyritic, silty, sparse medium- to coarse-grain, well-rounded quartz; moderately- to nonfissle; lower contact gradational.
	S8	Argillaceous Skolithos-bearing quartz arenite, grades from pale-yellow-brown at base to light-green-gray upsection, coarse- to fine-grain, well-rounded, poorly-sorted quartz; fines upward; sparse Skolithos burrows, abundance of burrows increases upsection; burrows are infilled with medium- to coarse-grain quartz; lower contact sharp and irregular.
35		
	S8	Argillaceous Skolithos-bearing quartz arenite, grades from pale-yellow-brown at base to light-green-gray upsection, coarse- to fine-grain, well-rounded, poorly-sorted quartz; fines upward; moderately- to well-developed, sparse to abundant Skolithos burrows, burrow abundance increases upsection; burrows are infilled with medium- to coarse-grain quartz; upper and lower contacts sharp and irregular.
40		
	S14	Silty quartz arenite, color varies progressively from light-medium-gray at base to pale-yellow-orange to light green-green-gray at top, silt-sized to fine-grain, poorly-sorted, well-rounded quartz; dolomicrite abundant from 43'8"-45'2".

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Unimin Silica Quarry Boring 86-316, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
45		
	S2	Dolomitic quartz arenite to quartzose dolopackstone, green-gray; sand is fine- to coarse-grain, poorly-sorted, well-rounded quartz that fines-upward; dolomicrite increasingly abundant upsection, sand grains locally mud-supported in upper 2 ft.
50		
	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, bimodal-sorting, well-rounded quartz with abundant green-gray clay-size fraction; upper contact gradational, lower contact sharp.
55		
	S10	Massive quartz arenite, light-medium-gray to white, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable, vague planar- to low-angle cross-stratification in some horizons; sparse limonite staining; locally staining follows near vertical trends - may be burrow margins or fractures; thin- to medium-bedded.
		No discernable breaks from 54'10"-102'.

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Unimin Silica Quarry Boring 86-316, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray to white, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable, vague planar- to low-angle cross-stratification in some horizons; sparse limonite staining; locally staining follows near vertical trends - may be burrow margins; thin- to medium-bedded.
65		
70		

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Unimin Silica Quarry Boring 86-316, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
75		
	S10	Massive quartz arenite, light-medium-gray to white, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable, vague planar- to low-angle cross-stratification in some horizons; sparse limonite staining; locally staining follows near vertical trends - may be burrow margins or fractures; thin- to medium-bedded.
80		
85		

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Unimin Silica Quarry Boring 86-316, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
90		
	S10	Massive quartz arenite, light-medium-gray to white, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable, vague planar- to low-angle cross-stratification in some horizons; sparse limonite staining; locally staining follows near vertical trends - may be burrow margins or fractures; thin- to medium-bedded.
95		
100		

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Unimin Silica Quarry Boring 86-316, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray to white, fine- to medium-grain, well- to moderately-sorted quartz; friable to weakly-indurated by poorly-developed quartz overgrowths; hematitic and Skolithos burrows in upper 2 ft., otherwise massive.
105	S6/S3	Trough cross-stratified quartz arenite, white to light-aple-yellow-gray, fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; well-developed trough cross-stratication at base grading rapidly upsection to planar-cross-stratification.
	S4	Low-angle cross-stratified arenite, light-pale-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; well developed low-angle cross-stratification.
110	S2	Dolomitic quartz arenite, pale-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz with sparse to abundant dolomicrite; sand-grains locally mud-supported, vague laminae - may be stromatolitic. Trace of green-gray mudrock at base.
		Bottom of cored interval and TD at 111 ft.; core removed by company described as 1" green mudrock underlain by 7" of light-brown-gray dolostone. Top of Prairie du Chien Dolomite Group at 110'4".

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Unimin Silica Quarry Boring 86-331, Sec. 8-T23N-R10E, Ogle Co., Ill., elev. 856 ft., NX core 10-105 ft.

Depth (ft.)	Litho-facies	Description/Comments
10	S15	Argillaceous quartz arenite, fine- to coarse-grain, bimodal, well-rounded quartz; abundant green-gray clay throughout; Skolithos burrow at 11 ft.
	S10	Massive quartz arenite, white to light-medium-gray, fine- to medium-grain, well-sorted quartz; mostly massive, vague cross-stratification locally; thin- to medium-bedded; friable to weakly-indurated; sparse quartz overgrowths. No discernable breaks to 22 ft.
15		
20		
	S10	Massive quartz arenite, white to light-medium-gray, or red-brown-gray to reddish-yellow-gray, fine- to medium-grain, well-sorted quartz; mostly massive, vague cross-stratification locally; thin- to medium-bedded; friable to weakly-indurated;

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Unimin Silica Quarry Boring 86-331, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		sparse quartz overgrowths; sparse red-brown intervals are hematite stained.
		No discernable breaks to 37'.
25		
30		
35		

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Unimin Silica Quarry Boring 86-331, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, red-brown-gray with light-medium-gray, fine- to medium-grain, well-sorted quartz; massive, vague cross-stratification locally; thin- to medium-bedded; friable to weakly-indurated, sparse quartz overgrowths and calcareous; hematite stain pervasive.
		Poor recovery and jumbled core 39'6"-80'
80	S4	Low-angle cross-stratified quartz arenite, white to light-medium-gray, fine- to medium-grain, well-sorted quartz; friable to weakly-indurated by quartz overgrowths; abundant low-angle cross-stratification.
85		
	S4	Low-angle cross-stratified quartz arenite, white to light-medium-gray, fine- to medium-grain, well-sorted quartz; friable to weakly-indurated by quartz overgrowths; silty at base, grain-size increases upsection.
	S2	Dolomitic quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted quartz; abundant dolomicrite, microcrystalline; sand-grains are

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Unimin Silica Quarry Boring 86-331, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		locally mud-supported; vague laminae - may be stromatolitic.
90		
	S4	Low-angle cross-stratified quartz arenite, white to light-medium-gray, fine- to medium-grain, well-sorted quartz; friable to weakly-indurated; poorly-developed quartz overgrowths; sparse, green-gray mudrock drapes; lower 6" is ferrigenous and well-indurated by quartz overgrowths.
95		
	S4/M2	*Interbedded green mudrock and low-angle* cross-stratified quartz arenite; mudrock is dark-green-gray to light-green-gray, pyritic, waxy, non-fissle with minor fine- to medium-grain sand-stringers; arenite is fine- to medium-grain, moderately well-sorted, well-rounded quartz, medium-bedded, beds fine-upward and may be shaly at base; color varies from light-medium-gray to very light-yellowish-gray to light-red-brown due to variable ferroan staining. Mudrock at 98'10"-99'1", 101'1"-101'6", and 104'1"-104'6".
100		

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Unimin Silica Quarry Boring 86-331, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		Lithic quartz arenite, light-medium-gray, fine- to coarse-grain, moderately-sorted quartz matrix with abundant sand to pebble-size, angular, cream to white, opaque chert; thin- to thick-partings of green-gray, waxy mudrock-partings. Top of Prairie du Chien Dolomite Group not penetrated.
105	S13	
Bottom of cored interval and TD.		

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Unimin Silica, Quarry Boring 86-321, Sec. 8-T32N-R10E, Ogle Co., Ill., elev. 846 ft., NX core 11-125 ft., described from 11-45 ft..

Depth (ft.)	Litho-facies	Description/Comments
11	C1/C4	Quartzose dolowackestone, yellow-brown with red-brown mottling, abundant medium- to coarse-grain well-rounded, mud-supported quartz grains, possible stromatolitic, vuggy.
	S15	Argillaceous quartz arenite, greenish-brown-gray, coarse- to medium-grain, moderately-sorted, well-rounded quartz; friable to moderately-indurated; argillaceous.
	C1	Quartzose dolowackestone, yellow-brown with red-brown mottling, abundant medium- to coarse-grain well-rounded, mud-supported quartz; some sub-rounded to well-rounded, black phosphatic pebbles near base.
15	C8	Ostracodal dolowackestone, brown-gray, sparse medium- to coarse-grain, well-rounded, quartz grains, abundant large ostracodes, sharp basal contact.
	M2	Green mudrock, blue-gray-green, red-brown in upper 2 ft., fissle, sparse fine- to coarse grain, poorly-sorted, well-rounded quartz; pyritic.
20	S15	Argillaceous quartz arenite, gray to gray-green, coarse- to medium-grain, well-rounded, moderately- to poorly-sorted, grain-size decreases upsection, argillaceous; well-indurated by quartz overgrowths; lower contact sharp and irregular.
	S15	Argillaceous quartz arenite, gray-green, argillaceous, fine- to coarse-grain, moderately- to well-sorted quartz; grain-size decreases upsection; friable to weakly-indurated by quartz overgrowths.

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Unimin Silica, Quarry Boring 86-321, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
25	S15	Argillaceous quartz arenite, green-gray to dusky-orange, coarse-grain, moderately-sorted, well-rounded quartz with abundant limonite staining; argillaceous, clay content increasing up section.
	C12/M2	Argillaceous dolomudstone, dusky orange with red-brown stain, 1-2" green mudrock interbeds at 29'2" and 27'6".
30		
	M6	Dolomitic siltstone, gray-green, very argillaceous, sparse, well-rounded quartz throughout; grain-size decrease upsection, grades to argillaceous dolomudstone.
35	S15	Argillaceous quartz arenite, green-gray to dusky-orange, bimodal, coarse- and fine-to-medium-grain, well-rounded quartz ("Glenwood texture"), argillaceous, thin interbeds (1-3 cm) of argillaceous dolomudstone, possibly stromatolitic; basal contact is sharp, upper contact is gradational.

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Unimin Silica, Quarry Boring 86-321, Ogle Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S11	Massive quartz arenite, light-gray, medium- to fine-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths, nonporous.
40	S10	Massive quartz arenite, light-gray to yellowish-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; friable.
45		
Bottom of described interval; TD at 125 ft.		

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Pike County Gas Assoc., Conkright 2, Sec. 4-T4S-R4W, Pike Co., Ill., elev. 856 ft., ISGS Core 3500, NX core biscuits each foot 712-1212 ft., described 950-1212 ft.

Depth (ft.)	Litho-facies	Description/Comments
950	C14	Peloidal calcimudstone, medium-brown-gray, micro-crystalline; locally peloidal, otherwise massive.
955	S13/C9	Lithic quartz arenite grading up-section to quartzose bioclastic wackestone; lithic quartz arenite is medium- to coarse-grain, well-rounded, quartz and coarse-grain to pebble-size clasts of dolo-mudstone; grades up-section into quartzose bioclastic wackestone, medium-brown-gray, microcrystalline to finely-crystalline, abundant biomolds of ostracodes.
960	C18	Oolitic grainstone interbedded with intraclastic packstone; oolitc grainstone in medium-brown-gray, medium- to coarse-grain, well-sorted; intra-clastic packstone is fine- to coarse-grain, moder-ately sorted, subrounded to angular intraclasts with microcrystalline matrix.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C1/C12	Argillaceous wackestone, light-medium-brown-gray, microcrystalline, with sparse to moderately-abundant, medium- to coarse-grain, well-rounded quartz and intraclasts; abundant, anastomosing, thin-partings of organic-rich, dark-brown mudrock; abundance of sand-size fraction increases up-section.
965		
	C1/C12	Argillaceous wackestone, light-medium-brown-gray, microcrystalline, with sparse to moderately-abundant, medium- to coarse-grain, well-rounded quartz and intraclasts; abundant, anastomosing, thin-partings of green-gray mudrock; abundance of sand-size fraction increases up-section.
970		
	C11	Fenestral calcimudstone, medium-brown-gray, vuggy, finely-crystalline, moderately abundant spar-filled vertical fenestrae.
	C3	Laminated dolomudstone, pale-yellowish-brown, moderately-abundant, sub-planar, irregular brown laminae; very porous, chalky; abundance of laminae decreases down-section; lower portion is massive.
975	C1/C12	Argillaceous dolowackestone, medium-brown-gray microcrystalline, with sparse to moderately-abundant, medium- to coarse-grain, well-rounded intraclasts; abundant, anastomosing, thin-partings of dark-brown mudrock; abundance of sand-size fraction decreases up-section; increasingly biomoldic up-section, locally vuggy; biomolds and vugs locally calcite infilled.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C1/C12	Argillaceous dolowackestone, light-medium-brown-gray, microcrystalline, with sparse to moderately-abundant, medium- to coarse-grain, well-rounded intraclasts; abundant, anastomosing, thin-partings of dark-brown mudrock; abundance of sand-size fraction increases up-section; increasingly biomoldic up-section; thick (>0.4") organic-rich mudrock partings at 982 ft. and 979 ft.
980		
	C1/C12	Argillaceous dolowackestone, light-medium-brown-gray, microcrystalline, with sparse to moderately-abundant, medium- to coarse-grain, well-rounded quartz and intraclasts; abundant, anastomosing, thin-partings of dark-brown mudrock; abundance of sand-size fraction increases up-section.
985		
	C17	Dolowacke/packstone, medium-brown-gray, sparse- to abundant ostracodes and fine-grain, angular bioclasts throughout; biomoldic porosity increases up-section; locally vuggy in upper 2 ft.
990		

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C2	Dolomudstone, medium-brown-gray to brown-yellowish-gray, microcrystalline; sparse intraclasts and abundant fine- to medium-grain, well-rounded quartz at base; calcareous at 992 ft.; possible mudcracks on bedding plane at 992 ft.
995	C3	Laminated dolomudstone, light-yellow-brown with dark-brown laminae; dolomudstone is microcrystalline, earthy, vuggy; laminae are convoluted; quartz arenite stringers associated with some laminae.
	C2/C8	Dolomudstone, medium-brown-gray to brown-yellowish-gray, microcrystalline; sparse intraclasts and ostracod molds at base.
	C3	Laminated dolomudstone, light-yellow-brown with dark-brown laminae; dolomudstone is microcrystalline, earthy, vuggy; laminae are convoluted; fine-grain quartz arenite stringers associated with some laminae.
1000	C2/C8	Dolomudstone, light-brown-gray to yellowish-gray, microcrystalline; sparse intraclasts and ostracod molds at base; chalky, earthy.
	C7	Brecciated dolomudstone, yellow-brown-gray, vuggy, thick-laminae of organic-rich mudrock locally, fine-grain quartz locally.
	C3	Laminated dolomudstone, light-yellow-brown with dark-brown laminae; dolomudstone is microcrystalline, earthy, vuggy; laminae are convoluted; quartz arenite stringers associated with some laminae.
1005	C6	Mottled dolomudstone, dark-yellow-brown, micro-crystalline, earthy, locally pyritic; sparse, fine-grain, well-sorted, well-rounded quartz; vague mottling throughout.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C3	Laminated dolomudstone, light-yellow-brown with dark-brown laminae; dolomudstone is microcrystalline, earthy, vuggy; laminae are convoluted; quartz arenite stringers associated with some laminae.
	C2/C9	Dolomudstone, light-brown- to yellowish-gray, microcrystalline; chalky, earthy; sparse intraclasts and ostracode molds at base.
1010		
	S2/C1	Dolomitic quartz arenite grading up-section to quartzose dolowackestone; abundant to sparse, fine- to medium-grain, well-rounded quartz; increasing dolomicrite up-section; vuggy, vugs infilled with coarsely-crystalline, twinned calcite.
	S15	Argillaceous quartz arenite, fine- to coarse-grain, well-sorted, well-rounded quartz; friable; increasingly argillaceous up-section; dark-brown to black, convoluted laminae in upper 2 ft.; increasingly pyritic up-section; grain-size increases up-section.
1015		
	S10	Massive arenite, light-medium-gray to light-pale-green-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; locally pyritic and argillaceous at 1025-1026 ft.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1020		
1025		
	S8/S9	Mottled quartz arenite, light-brown-gray to light-green-gray, fine- to coarse-grain, mostly medium-grain, moderately- to well-sorted, well-rounded quartz; friable; green-gray mottles; probable *Skolithos* burrow at 1028 ft.
1030		
	S9	Mottled quartz arenite, light-brown-gray to light-green-gray, fine- to coarse-grain, mostly coarse-grain, moderately- to poorly-sorted, well-rounded quartz; friable; green-gray mottles; low-angle cross-strati-. fication at 1032 ft.
	S10	Massive arenite, very-light-green-gray to light-medium-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; locally pyritic, silty at 1036 ft.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1035		
	S9	Mottled quartz arenite, light-brown-gray to light-green-gray, fine- to coarse-grain, mostly medium-grain, moderately- to poorly-sorted, well-rounded quartz; friable; green-gray mottles.
	S10	Massive arenite, very-light-green-gray to light-medium-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; silty at 1043 ft.
1040		
	S9	Mottled quartz arenite, light-brown-gray to light-green-gray, fine- to coarse-grain, mostly medium-grain, moderately- to poorly-sorted, well-rounded quartz; friable; green-gray mottle.
1045	S10	Massive arenite, very-light-green-gray to light-medium-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; silty at 1047 ft.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S8	*Skolithos*-bearing quartz arenite, very light-pale-green-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; coarser-fraction infills burrows; burrow infills well-indurated by quartz overgrowths; matrix is finer-grain and less well indurated.
1050	S10	Massive arenite, very-light-green-gray to light-medium-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, calcareous at 1051 ft.; finely-disseminated clays throughout.
1055		
	S9	Mottled quartz arenite, light-brown-gray to light-green-gray, fine- to coarse-grain, mostly medium-grain, moderately- to poorly sorted, well-rounded quartz; friable; green-gray mottles throughout.
1060		

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1065		
	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; nonporous where well-indurated.
1070		
	S9	Mottled quartz arenite, light-medium-gray to light-green-gray, fine- to coarse-grain, mostly medium-grain, moderately- to poorly sorted, well-rounded quartz; friable; green-gray mottles throughout.
	S10	Massive quartz arenite, light-medium-gray to light-green-gray, fine- to coarse-grain, mostly medium-grain, moderately- to poorly sorted, well-rounded quartz; friable.
1075		

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S8	*Skolithos* -bearing quartz arenite, light-green-gray to light-brown-gray, fine- to coarse-grain, mostly medium-grain, poorly-sorted, well-rounded quartz; burrows poorly defined by green-gray, vertical argillaceous streaks.
1080	S10	Massive quartz arenite, light-green-gray to pale-green, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; low porosity where well-indurated; silica-filled fracture at 1080 ft., more argillaceous on hanging-wall then foot-wall of microfault.
	S4	Cross-stratified arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately- to well-indurated by quartz overgrowths.
1085	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; low porosity where well-indurated.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1090	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately- to well-indurated by quartz overgrowths.
1095	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; low porosity where well-indurated.
1100	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately- to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; low porosity where well-indurated; bitumen in thin-section.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1105		
1110		
	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately- to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; low porosity where well-indurated.
1115		
	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately- to well-indurated by quartz overgrowths.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; low porosity where well-indurated; locally cal-careous.
1120		
	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately- to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; low porosity where well-indurated.
	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately- to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to well-indurated by quartz over-growths; low porosity where well-indurated.
1125		
1130	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately- to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, white to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths; low porosity.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray, very fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths, noncalcareous; porous; core biscuits are consistently coarser-grain and argillaceous on one-side than other; suggests-graded, thin-bedding; samples 1137-1139 ft. silty, green-gray mudrock partings at 1137 ft.
1135		
1140	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification interbedded up-section with trough cross-stratification; moderately- to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-medium-gray, very fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths, noncalcareous; porous; core biscuits are consistently coarser-grain on one side than other -- suggests graded, thin-beds; samples 1145-1146 ft. silty.
1145		

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-medium-gray, very fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths, noncalcareous; porous; core biscuits are consistently coarser-grain on one side than other -- suggest graded, thin-beds; sample at 1149 ft. silty.
1150	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately-to well-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-medium-gray, very fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths, noncalcareous; porous; core biscuits are consistently coarser-grain on one side than other -- suggests graded, thin-beds; vague cross-stratification at 1159 ft., sample at 1158 ft. silty.
1155		

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1160		
1165		
	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately-indurated by quartz overgrowths.
1170	S10	Massive quartz arenite, light-medium-gray, very fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths, noncalcareous; porous; core biscuits are consistently coarser-grain on one side than other -- suggests graded, thin-beds.
	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; moderately indurated by quartz overgrowths.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray, very fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths, noncalcareous; porous to tite; vague cross-laminae at 1198 ft.; irregular sulfide masses give speckled appearance; core biscuits are consistently coarser-grain on one side than other -- suggest graded, thin-beds.
1175		
1180		
	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundance low-angle cross-stratification; moderately indurated by quartz overgrowths; sparse, irregular sulflide masses (<0.25") cement grains locally and give rock a speckled appearance.
1185		
	S10	Massive quartz arenite, light-medium-gray, very fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths, noncalcareous; low porosity; vague cross-laminae at 1198 ft.; irregular sulfide masses give speckled appear-ance.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	
1190		
1195		
1200	S4	Cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; abundant low-angle cross-stratification; bitumen in thin-section.

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Pike County Gas Association, Conkright 2, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray, very fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths, noncalcareous; porous; vague cross-laminae at 1206 ft.; biscuits have sharp, planar surfaces -- suggests cross-stratification.
1205		
	M1	Conglomeratic mudrock, green-gray, waxy, pyritic; abundant medium-grain to pebble-size, angular to subangular, poorly-sorted lithic fragments of argillaceous dolomudstone and light-gray, opaque chert; mean grain-size appears to decrease up-section; all clasts are mud-supported by dark-green-gray, pyritic, waxy mudrock. Dolomudstone clast at 1211 ft. contains Lower Ordovician microfauna.
1210		
Bottom of cored interval and TD.		

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PB-KBB, Inc., G. Saylor 1, Sec. 17-T5S-R4W, Pike Co., Ill.,
elev. 804 ft., ISGS Core 12785, NX core 65-734 ft., described 709.5-734 ft.

Depth (ft.)	Litho-facies	Description/Comments
709	C1/C6	Mottled quartzose dolowackestone, light-medium-brown-gray, finely-crystalline; moderately-abundant, fine-grain, well-rounded quartz throughout; locally mottled.
710		
	S15	Argillaceous quartz arenite grading up-section to burrowed quartz arenite, light-brown-gray, fine- to medium-grain, well-rounded, moderately-sorted quartz; moderately well-indurated by pore-filling calcite; anastomosing, medium-brown, discontinuous mudrock partings at base; upper contact gradational, lower contact sharp.
	C12	Argillaceous calcimudstone grading up-section to quartzose stromatolitic dolomudstone; medium-green-gray to light-yellow-brown; microcrystalline throughout; calcimudstone is silty and massive; dolomudstone is microporous and argillaceous; stromatolotic, brown mudrock laminae at 713-713'4" and 714'2"-714'7"; fine-grain, well-rounded, well-sorted quartz is moderately-abundant in stromatolitic intervals.
715		
	C6	Mottled calcimudstone, medium-green-gray to brown-gray, microcrystalline; vertical burrow traces at 716'1" bounded by 1" beds of brown, organic-bearing mud-rock at 716" and 716'11".
	C10	Patterned calcimudstone, medium-green-gray to light-brown-gray, microcrystalline, nonporous, massive, locally pyritic; upper contact sharp, lower contact gradational.
720		
	C8	Ostracodal wacke/packstone; medium-brown-gray, microcrystalline, sparse to abundant ostracodes; calcite-infilled ostracodal biomolds locally.
	C12/C1	Interbedded argillaceous calcimudstone and quartzose dolopackstone, light-brown-gray to medium-brown-gray, abundant, fine- to coarse-grain, poorly-sorted,

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PB-KBB, Inc., G. Saylor 1, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		well-rounded quartz and subangular intraclasts decreasing in abundance up-section; angular quartz arenite pebbles at 722 ft.; carbonate is microcrystalline.
	C2	Massive dolomudstone grading up-section to stromatolitic dolomudstone, medium-brown-gray to light-yellow-gray, microcrystalline throughout; microporous in upper 1 ft., intraclastic dolograinstone at base, 1" organic-bearing brown mudrock at 723 ft. bounded by stylolites.
725	C3	Laminated dolomudstone, light-yellowish-gray, microcrystalline, chalky, microporous, planar and anastomosing, sparse to abundant, organic-bearing brown mudrock laminae; abundance and irregular geometry of mudrock laminae increases up-section; upper contact is sharp, lower contact is stylolitic.
	C1	Quartzose dolowackestone, light-brown-gray, microcrystalline, sparse to abundant, very-fine- to fine-grain, well-rounded, well-sorted quartz; abundance of quartz grains decrease up-section; calcite-infilled voids (<0.25") biomolds or fenestrae; lower contact sharp, upper contact stylolitic.
730	C8	Ostracodal dolopackstone, light-brown-gray, microcrystalline, abundant ostracodal biomolds locally infilled by calcite.
	C12	Argillaceous mottled calcimudstone, medium-brown-gray, finely- to microcrystalline, calcite-infilled irregular fenestrae, locally; upper and lower contacts stylolitic.
	C8	Ostracodal dolopackstone, light-brown-gray, microcrystalline, abundant ostracodal biomolds locally infilled with calcite.
	C15	Argillaceous mottled calcimudstone, medium-brown-gray, finely- to microcrystalline, calcite-infilled irregular fenestrae locally; upper and lower contacts stylolitic.
	C6/C11	Mottled fenestral dolomudstone, green-gray to light-brown, microcrystalline, mottles are locally pyritic; lenses of ostracodal dolowackestone at base; pyritic in upper 1 ft.; lower contact gradational, upper is stylolitic.
	C6	Mottled dolomudstone, light-brown-gray, microcrystalline; massive.
	C8	Ostracodal dolopackstone, light-brown-gray, microcrystalline, abundant ostracodal biomolds locally infilled with calcite.
Bottom of cored interval and TD.		

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PB-KBB, Inc., Mumford 3, Sec. 21-T5S-R4W, Pike Co., Ill.,
elev. 769 ft., ISGS Core 13065, NX core 534-705.5 ft., described 617-705.5 ft.

Depth (ft.)	Litho-facies	Description/Comments
617	C12	Argillaceous calcimudstone grading upsection to ostracodal wackestone; dark-medium-gray to light-medium-gray; argillaceous calcimudstone is microcrystalline with abundant, thin (1-2 mm), anastomosing partings of dark-brown, organic-rich mudrock; ostracodal wackestone is microcrystalline with spare ostracodes.
620	C1	Quartzose dolopack/wackestone, medium-brown-gray, finely-crystalline to microcrystalline; sparse to abundant, medium- to coarse-grain, moderately-sorted, well-rounded, mud-supported quartz; abundance of quartz decreases upsection.
	C17/C18	Bioclastic packstone and oolitic grainstone, light-medium-brown-gray, fine- to medium-grain, sub-rounded to well-rounded, moderately-sorted ooids and bioclasts; medium-bedded, thin-beds (<1.5") of dark-green-gray and dark-brown mudrock separate beds.
		No core 622'9"-643'. (core of Joachim-Plattin contact missing in all PB-KBB wells)
643	C15	Mottled dolomudstone with thin-interbeds of ostracodal dolowacke/packstone; medium-brown-gray to olive-gray; mottled dolomudstone is micro-crystalline, locally argillaceous and pyritic, abundant mottling; thin (1") interbeds of ostrocodal dolo-wacke/packstone present throughout section; ostracodal dolowacke/packstone is medium-brown-gray, microcrystalline with sparse to abundant, complete ostracodes; locally biomolds infilled by coarsely-crystalline calcite. (poor core recovery 643'-648'6")
645		

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PB-KBB, Inc., Mumford 3, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C17/C8	Vuggy bioclastic dolopack/wackestone, medium-brown-gray, microcrystalline to finely-crystalline, sparse- to abundant, fine- to coarse-grain, angular to subrounded bioclasts and intraclasts; mostly bioclasts of incomplete ostracodes; intraclasts abundant at base, but rapidly decrease in abundance up-section; abundant biomolds after ostracodes.
650		
	C3	Laminated dolomudstone, light-yellow-brown, microcrystalline, porous, vuggy; planar, thin-laminae of fissle, dark-brown, organic-bearing mudrock at base; laminae increasingly abundant and irregular geometry upsection; irregular vugs (<0.25") locally infilled by coarsely-crystalline calcite.
	C6	Mottled dolomudstone, light-brown-gray to medium-brown-gray, microcrystalline, locally porous and argillaceous, variable mottling throughout.
655		
	C6	Argillaceous dolomdustone, medium-brown-gray, microcrystalline; thin (1-2mm), dark-brown-gray anastomosing mudrock partings thoughout; 1" intraclastic dolograin/packstone at base; upper contact gradational, lower contact stylolitic.
	C3	Laminated dolomudstone, light-brown-gray to light-green-gray; microcrystalline, locally pyritic; upper foot is vaguly mottled; sparse to abundant, thin (1-2 mm), planar to irregular laminae of dark-brown, organic-bearing mudrock; stylocontact at 659'3" separates light-brown and light-green-gray dolomudstones.
660		

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PB-KBB, Inc., Mumford 3, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C6	Mottled dolomudstone grading upsection to laminated dolomudstone; light- to medium-brown-gray, microcrystalline mottled dolostone is argillaceous, locally quartzose and sparsely pyritic at base; grades upsection to less argillaceous, pyritic intensely mottled dolomustone; laterally, discontinuous dark-brown mudrock laminae (1 mm) present in upper 1 ft.; upper contact is gradational, lower is stylolitic.
665		
	C6	Mottled dolomudstone, medium-green-gray, microcrystalline, sparsely pyritic, abundance of mottling decreases upsection.
670	C12	Argillaceous dolomdustone, medium-brown-gray, microcrystalline; thin (0.1-0.2"), dark-brown-gray anastomosing mudrock partings thoughout.
	C3	Laminated dolomudstone, light-brown-gray to light-green-gray; microcrystalline, locally pyritic; upper foot is vaguely mottled; sparse to abundant, thin (1-2 mm), planar to irregular laminae of dark-brown, organic-bearing mudrock.
	C1	Quartzose dolowackestone, yellowish-gray, microcrystalline, mottled, vuggy; sparse to abundant, fine-grain, well-rounded, well-sorted quartz; 1.5" lithic arenite overlain by thin-bed of dark-brown mudrock at base; lower contact sharp, upper contact gradational.
	C2	Vuggy dolomudstone, medium-gray-brown to yellowish-gray, microcrystalline, locally pyritic, very argillaceous from 674'-675'.
675		

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PB-KBB, Inc., Mumford 3, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C1/C3	Quartzose laminated dolomudstone, light-brown-gray to yellow-gray; microcrystalline, locally pyritic; sparse to abundant, thin (1-2 mm) planar to irregular laminae of dark-brown organic-bearing mudrock; abundance of laminae increases upsection; moderately-abundant to abundant, fine- to medium-grain, well-sorted, well-rounded mud-supported quartz; locally vuggy.
	S7	Laminated quartz arenite; as above but quartz sand is grain-supported; abundant laminae at base; irregular clasts of dolomudstone at 678' 5".
680	S9	Mottled argillaceous quartz arenite, pale-yellow-green to light-brown-gray, fine- to coarse-grain, mostly medium- to coarse-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; dolomitic in upper foot, argillaceous content decreases upsection.
685	S15	Argillaceous quartz arenite, pale-yellow-green, fine- to coarse-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; abundant green-gray argillaceous fraction throughout.
	S10	Massive quartz arenite, light-medium-gray, very-fine- to fine-grain, very well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths.

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PB-KBB, Inc., Mumford 3, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
690	S15	Argillaceous quartz arenite, fine- to coarse-grain, mostly medium-grain, moderately-sorted, well-rounded quartz; friable, decreasing argillceous content upsection.
	S10	Massive quartz arenite, light-medium-gray to pale-yellow-gray, fine-grain, well-sorted, well-rounded quartz; moderately indurated by quartz overgrowths; locally pyritic; argillaceous at base.
695	S10	Massive argillaceous quartz arenite, pale-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; mean grain-size increases upsection; locally pyrtic, pyrite content increases upsection; increasingly argillaceous from 694'7"-696'; lower contact is sharp.
	S8	*Skolithos* -bearing quartz arenite, light-green-gray, argillaceous, fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; well defined large diameter *Skolithos* burrows at 696'3"-6".
700	S10	Massive quartz arenite, light-pale-green to light-green-gray, argillaceous; fine- to coarse-grain, mostly medium-grain, moderately- to poorly-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; argillaceous content decreases upsection; thin intervals of moderately-indurated quartz arenite are lighter in color and give upper 2 ft. a banded appearance (possible planar laminae).
	S8	*Skolithos* -bearing quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; small diameter *Skolithos* burrows (<0.5"), burrows lack coarse-grain infills; weakly- to moderately-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-medium-gray to pale-green-gray; fine- to medium-grain, well-sorted,

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PB-KBB, Inc., Mumford 3, Pike Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		well-rounded quartz; moderately- to weakly-indurated by quartz overgrowths; sparsely argillaceous; abundant pyrite in upper 5", pyritic mass at 703'5" may infill burrow trace.
705		
		Bottom of cored interval and TD.

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PB-KBB, Inc., Elmer Yakley 7, Sec. 21-T5S-R4W, Pike Co., Ill.,
elev. 804 ft. ISGS Core 13068, NX core 165-612 ft., described 580-612 ft.

Depth (ft.)	Litho-facies	Description/Comments
580	C1	Quartzose mottled wackestone grading up into mottled calcimudstone, medium-brown-gray to light-brown-gray; moderately-abundant, fine- to medium-grain, well-sorted, well-rounded, mud-supported quartz that decreases in abundance upsection.
		No core from 582-592.2" (core of Plattin-Joachim contact missing from all PB-KBB cores)
593	C10	Patterned dolomudstone, light-brown-gray to medium-olive-gray, microcrystalline, variable mottling throughout; moderately-abundant fine-grain well-rounded, well-sorted quartz from 594'-592'3"; organic-rich, brown mudrock parting at 593'1".
595		
	C3	Laminated dolomudstone, light-yellowish-gray to light-brown-gray, microcrystalline, porous, earthy; sparse to abundant, planar to anastomosing, thin- to thick laminae of organic-rich, brown, fissle mudrock; abundance and irregularity of laminae increases upsection; vuggy breccia at 599'8"-600'1".
600		

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PB-KBB, Inc., Elmer Yakley 7, Pike Co., Ill. (cont.).

Depth (ft.)	Lith-ology	Description/Comments
	C6	Mottled dolomudstone, light-brown-gray with green-gray mottling, microcrystalline, locally pyritic, fine-grain, well-rounded, poorly-sorted quartz and intraclasts at base; irregular contact with underlying laminated dolostone; vuggy 602'-602'3", biomoldic and moderate-size (>0.25") irregular vugs.
	C3	Laminated dolomudstone, light-brown-gray, microcrystalline, porous, earthy; sparse laminae.
	C10	Patterned dolomudstone, light-brown-gray to medium-olive-gray, microcrystalline, mottled.
605	C2/C3	Interbedded vuggy dolomudstone and laminated dolomudstone; laminated dolomudstone is light-yellowish-gray to light-brown-gray, microcrystalline, porous, earthy, sparsely laminated; vuggy dolomudstone is light-brown-gray microcrystalline, massive; moderately-abundant, small (<0.25 "), irregular vugs infilled with calcite locally.
	C10	Patterned dolomudstone, light-brown-gray to medium-olive-gray, microcrystalline, variable mottling throughout; lense of biomoldic dolowackestone at 607'3"-607'6".
	C3	Laminated dolomudstone, light-yellowish-gray to light-brown-gray, microcrystalline, porous, earthy; sparse to abundant, planar to anastomosing, thin- to thick laminae of organic-rich, brown, fissle mudrock; abundance and irregularilty of laminae increases upsection; locally, coarsely-crystalline calcite infills irregualr vugs (<0.25").
610	C6	Mottled dolomudstone, light-brown-gray with green-gray mottling, microcrystalline, locally pyritic.
	C8	Ostracodal dolopackstone, light-brown-gray, finely-crystalline, abundant biomolds after ostracodes.
		No core 610'9"-611'6".
612	C6/C10	Vuggy patterned dolomudstone, light-green-gray to medium-brown-gray; locally vuggy, vugs occur where geometry of mottling pattern changes.
Bottom of cored interval, TD at 692 ft.		

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Algonia Oil Co., Charles Cramer 1, Sec. 27-T8N-R5E, Peoria Co., Ill.
elev. 629 ft., ISGS Core 2228, NX core biscuits each foot 1480-1560 ft.

Depth (ft.)	Litho-facies	Description/Comments
1473	C17	Bioclastic dolopackstone, medium-brown-gray to dark-brown-gray, micro- to finely-crystalline, sparse to abundant, well-rounded, moderately-sorted, medium- to coarse-grain quartz that decreases in abundance upsection; abundant complete ostracodes and brachiopods.
1475		
	S8	Argillaceous, *Skolithos* -bearing quartz arenite, light-green-gray to light-medium-gray, fine- to coarse-grain, mostly medium-grain, well-rounded poorly-sorted to bimodal quartz; coarse-grain fraction infills *Skolithos* burrows; non- to very-argillaceous.
1480		
	S8	*Skolithos* -bearing quartz arenite grading upsection into argillaceous quartz arenite; grades from white to light-medium-gray upsection to light-green-gray; grades upsection from fine- to medium-grain, moderately well-sorted, well-rounded quartz arenite to fine- to coarse-grain, poorly-sorted quartz arenite; lower 2 ft. is well indurated by quartz overgrowths, becomes increasingly friable upsection as clay content increases; somewhat massive in lower 2 ft., *Skolithos* burrows increase in abundance upsection and are infilled by nonargillaceous, coarser-grain quartz arenite.
1485		

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Algonia Oil Co., Charles Cramer 1, Peoria Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, white to light-medium-gray, fine- to medium-grain, well- to moderately sorted, well-rounded quartz; massive, featureless.
1490		
	S10	Massive quartz arenite, white to light-medium-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; mostly massive, some vague cross-stratification; core breaks along sub-horizontal planes - suggests thin- to medium-bedding.
1495		
	S3	Planar cross-stratified arenite, light-yellowish-gray, medium- to coarse-grain, moderately-sorted, well-rounded, quartz; moderately-indurated by quartz overgrowths; thin- to thick, graded, planar laminae.
1500	S10	Massive quartz arenite, light-medium-gray to light-yellowish gray, fine- to medium-grain, well-sorted,

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Algonia Oil Co., Charles Cramer 1, Peoria Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		well-rounded quartz; core biscuits break along sub-horizontal planes - suggests thin- to medium-bedding
1505	S4	Low-angle cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz over-growths; moderately calcareous.
1510	S8	*Skolithos* -bearing quartz arenite, light-medium-gray and very-light-green gay; fine- to coarse-grain, bimodal, well-rounded quartz; burrow infills are medium- to coarse-grain and weakly-indurated by quartz overgrowths; matrix is fine- to medium-grain, well-sorted, argillaceous; moderately- to weakly-indurated by sparse quartz overgrowths; locally calcareous; abundant large diameter (>0.25") *Skolithos* burrows.

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Algonia Oil Co., Charles Cramer 1, Peoria Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1515	S8	*Skolithos* -bearing quartz arenite, light-medium-gray, fine- to coarse-grain, bimodal, well-rounded, quartz; burrow infills are medium- to coarse-grain, and well-indurated by quartz overgrowths; matrix is fine- to medium-grain, well-sorted and well-rounded, quartz moderately-indurated by quartz overgrowths. Abundant small diameter *Skolithos* burrows; large burrows (>0.25") uncommon.
1520	S8	*Skolithos* -bearing quartz arenite, light-medium-gray, fine- to coarse-grain, bimodal, well-rounded quartz; burrow infills are medium- to coarse-grain, well-indurated by quartz overgrowths; matrix is fine- to medium-grain, well-sorted and moderately-indurated by sparse quartz overgrowths; sparse, large diameter (>0.25") burrows, no small diameter burrows.
1525	S10	Massive quartz arenite, light-medium-gray to light-yellowish gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; core breaks along subhorizontal planes - suggests thin- to medium-bedding, vaguely defined vertical burrows in upper 10 ft. No discernable breaks to 1540 ft.

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Algonia Oil Co., Charles Cramer 1, Peoria Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	
1530		
1535		
1540		

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Algonia Oil Co., Charles Cramer 1, Peoria Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1545	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, mostly medium-grain, well-sorted, well-rounded, quartz; very well- to well-indurated by abundant quartz overgrowths. No discernable breaks to 1555 ft.
1555	S4	Low-angle cross-stratified arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz over-growths; moderately calcareous.

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Algonia Oil Co., Charles Cramer 1, Peoria Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S-4	
1560		
Bottom of cored interval and TD		

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Pure Oil Co., C. T. Montgomery 18-B, Sec. 4-T3N-R9E, Richland Co., Ill., elev. 503 ft., ISGS C3598, core chips each foot 6761-6800 ft.

Depth (ft.)	Litho-facies	Description/Comments
6761	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths; possible burrow trace at 6761 ft.
	S9	Mottled quartz arenite, white to light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparsely argillaceous, silty; moderately-indurated by quartz overgrowths.
6765	S3/S4	Cross-stratified quartz arenite, light-medium-gray to light-greenish-gray, fine-grain, well-sorted, well-rounded quartz; sparsely pyritic; argillaceous 6764-6765 ft.; well-indurated by quartz over-growths throughout; abundant planar and low-angle cross-laminae.
6770	S3/S4	Cross-stratified quartz arenite, light-medium-gray with light-greenish-gray cross-laminae; fine-to coarse-grain, moderately-sorted, well-rounded quartz; sparsely pyritic; sparse argillaceous cross-laminae in upper 2 ft.; well-indurated by quartz overgrowths throughout; abundant planar and low-angle cross-stratification; mean grain-size increases upsection.
	S10	Massive quartz arenite interbedded with cross-stratified quartz arenite; light-medium-gray; massive arenite is fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; cross-stratified arenite is coarse- to medium-grain, well-sorted, well-rounded quartz with abundant low-

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Pure Oil Co., C. T. Montgomery 18-B, Richland Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
6775		angle cross-laminae; all units well-indurated by quartz overgrowths, cross-stratified intervals have high intercrystalline porosity.
	S6	Trough cross-stratified arenite, medium-gray to light-medium-green-gray, medium-grain, well-sorted, well-rounded quartz; argillaceous; well-developed trough cross-stratification characterized by arcuate cross-laminae.
	S4	Cross-stratified quartz arenite, light-medium-gray to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz over-growths; abundant low-angle cross-stratification.
6780	S9	Mottled quartz arenite, light-medium-gray, fine- to coarse-grain, moderately-sorted, grain-size decreases upsection, well-rounded quartz; well-indurated by quartz growths; sparse pyritic masses (<0.2").
	S10	Massive quartz arenite, light-medium-gray, fine- to coarse-grain, moderately-sorted, well-rounded quartz; moderately-indurated by quartz over-growths; coarse-grain fraction has patchy distri-bution, may be burrow infills.
6785	S10	Massive quartz arenite interbedded with cross-stratified quartz arenite; massive quartz arenite is white, fine- to corase-grain, poorly- to moderately-sorted, well-rounded quartz; cross-stratified arenite is light-brown-gray, coarse- to medium-grain, well-sorted, well-rounded quartz with abundant low-angle cross-laminae; well-indurated by quartz overgrowths throughout, cross-stratified intervals have high intercrystalline-porosity and increase in abundance upsection.

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Pure Oil Co., C. T. Montgomery 18-B, Richland Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S15	Argillaceous quartz arenite, light-greenish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; vague cross-laminae delineated by concentrations of green-gray, intergranular clay.
6790	S4	Cross-stratified quartz arenite, light-medium-gray to very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz over-growths; abundant low-angle cross-stratification; coarse-grain interlaminae increases in abundance upsection.
6795		
	S10	Massive quartz arenite with thin interbeds of green-gray to light-medium-brown quartz arenite; massive quartz arenite is white to light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz well-indurated by quartz overgrowths; thin interbeds (<0.25-1") of fine- to medium-grain, well-sorted, well-rounded quartz well-indurated by quartz overgrowths and stained by ferroan grain-coats; slightly- to non-argillaceous.
6800		
Botton of cored interval and TD.		

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Mississippi River Fuel Corp. (Sun Oil), M. E. Vale 1, Sec. 8-R2S-T8W, St. Clair Co., Ill, elev. 450 ft.; ISGS Core 3200, core chips 1833-1961 ft.

Depth (ft.)	Litho-facies	Description/Comments
1833	C2	Dolomudstone, yellow-brown-gray, massive, earthy, microcrystalline.
1835		
	M2	Green mudrock, grayish-blue-green, possibly anhydritic, nonfissle, sparsely pyritic.
	C3	Laminated dolomudstone, brown-yellowish-gray, microcrystalline, earthy, with anastomosing green mudrock laminae (1-3 mm); coarsely-crystalline calcite locally infills intercrystalline porosity, some some lath-shaped crystal-moldic porosity.
1840	C2	Dolomudstone, mottled yellow-brown-gray and greenish-gray, massive, microcrystalline, locally pyritic.
	C3	Laminated dolomudstone, brown-yellowish-gray, microcrystalline, earthy, with anastomosing green mudrock laminae (1-3 mm), coarsely-crystalline calcite locally infills intercrystalline porosity, some some lath-shaped crystal-moldic porosity; sparse laminae (1-5 mm) of fine-grain, well-sorted, well-rounded, quartz arenite throughout.
1845		

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Mississippi River Fuel Corp., M. E. Vale 1, St. Clair Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
1850	S1	Dolomitic quartz arenite, blue-gray, anhydritic coarse-grain, well-sorted, well-rounded quartz with dark-blue-gray anhydritic shale partings (0.1-0.3"); well-indurated by quartz overgrowths.
1855		
1861		**No core preserved 1856-1861 ft.**
	C1/C2	Dolomudstone, light-brown-gray to medium-brown-gray, microcrystalline with pore-filling coarsely-crystalline calicite; grading upsection into quartzose dolowackestone and dolomitc quartz arenite, very-pale-green, fine- to coarse-grain, mostly medium-grain, poorly-sorted, well-rounded quartz.

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Mississippi River Fuel Corp., M. E. Vale 1, St. Clair Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
1865		
	S9	Mottled quartz arenite, blue-gray to light-medium-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; argillaceous, locally dolomitic; well-indurated by quartz overgrowths where light colored, less well-indurated where dark-colored and argillaceous.
1870	S11	Massive quartz arenite, very-light-green-gray, fine-grain, well-sorted, well-rounded quartz; massive, locally pyritic, sparsely argillaceous.
1875	S8	*Skolithos* -bearing quartz arenite, brown-gray to light-green-gray, fine- to medium-grain, bimodal-sorting, well-rounded quartz; friable; burrow infills are coarser-grain and moderely-indurated by quartz overgrowths; matrix is locally argillaceous.

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Mississippi River Fuel Corp., M. E. Vale 1, St. Clair Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
	S8	
1880		
1885		
1890	S15/S10	Argillaceous quartz arenite, light-green-gray to green-gray, fine- to medium-grain, moderately- to well-sorted, quartz; argillaceous, friable.

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Mississippi River Fuel Corp., M. E. Vale 1, St. Clair Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
	S15/S10	
1895		
1900		
1905		

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Mississippi River Fuel Corp., M. E. Vale 1, St. Clair Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
	S1/S11	
1910		
	S9	*Skolithos* -bearing quartz arenite, green-gray to light-green-gray, fine- to medium-grain, bimodal, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; burrow infills are coarser-grain and moderately-indurated by quartz over-growths; matrix is locally argillaceous.
1915		
	S9	

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Mississippi River Fuel Corp., M. E. Vale 1, St. Clair Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
1920		
1925		
1930		
	S9	
	S9/S11	Quartz arenite, yellow-gray, fine-grain, well-sorted, well-rounded quartz moderately-indurated by pore-filling crystalline calcite; sparse *Skolithos* burrow traces, mostly massive.

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Mississippi River Fuel Corp., M. E. Vale 1, St. Clair Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
1935		
1940		
	S10	Mottled quartz arenite, very-light-yellow-gray to white, fine-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths, vague blue-gray mottles, sparsely argillaceous; possibly anhydritic.
		No samples 1942-1943 ft.
	C5	Mottled dolomudstone, blue-green-gray and light-brown-gray, pyritic, possibly anhydritic; locally massive.
1945	C5	

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Mississippi River Fuel Corp., M. E. Vale 1, St. Clair Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
	C5	Mottled dolomudstone, blue-green-gray, pyritic; anhydritic with blue-gray mudstone laminae (1-2 mm) and dark-blue-gray argillaceous mottles.
1950		
		No samples 1951-1954 ft.
	C1	Quartzose dolomudstone, light-brown-gray to dark-brown-gray, with abundant medium- to coarse-grain, well-rounded, well-sorted, mud-supported quartz grains (typical Dutchtown lithology).
1955		
	C1	
1960		
1961		
Bottom of cored interval and TD.		

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Miller, G. W. Sample 1, Sec. 11-T15N-R3W, Sangamon Co., Ill., elev. 596 ft., ISGS Core 28, NX core 632-2732 ft., described 2600-2732 ft.

Depth (ft.)	Litho-facies	Description/Comments
2595	C8/M2	Interbedded green mudrock and ostracodal packstone, light-brown-gray, dolomitic; green-gray mudrock is green-gray, locally pyritic, nonfissle, non-calcareous, and thin- to medium-bedded; burrowed hardgrounds at 2585'7" and 2587'.
2600	C18	Oolitic grainstone, medium-brown-gray, fine-grain, moderately-sorted ooids and subrounded to rounded intraclasts; sparse to abundant partings of green-gray mudrock, abundance increases up-section; mudcracks and burrowed hardgrounds locally.
	C13	Laminated calcimudstone, medium-brown-gray with green-gray mottling, microcrystalline, dolomitic, vuggy.
	C8/C16	Interbedded ostracodal packstone and stylo-laminated calcimudstone undifferentiated, medium-brown-gray, microcrystalline, medium- to thick-bedded; dolomitic throughout; typical Matson Member.

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Miller, Sample 1, Sec. 11-T15N-R3W, Sangamon Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
2605		
2610		
2615		

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Miller, Sample 1, Sec. 11-T15N-R3W, Sangamon Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
2620		
2625	C3	Laminated dolomudstone, light-yellowish-brown, microcrystalline, porous; thin, anastomosing and planar laminae of brown mudrock; sparse ostracodal biomoldic porosity, high microporosity; abundance of laminae increases upsection.
	C3	Laminated dolomudstone, light-yellowish-brown, microcrystalline, porous; thin, anastomosing and planar laminae of brown mudrock; sparse ostracodal biomoldic porosity, high microporosity; mudcracks at upper contact; brown mudrock laminae in upper 6".
2630	C11	Fenestral dolomudstone, light-yellowish-gray, micro-crystalline, sparse to moderately-abundant, small vertical fenestrae infilled with crystalline calcite.
	C8	Ostracodal dolowackestone, medium-brown-gray, microcrystalline, nonporous; sparses, laterally-discontinuous laminae of brown mudrock; sparse whole ostracodes locally.

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Miller, Sample 1, Sec. 11-T15N-R3W, Sangamon Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C10	Patterned dolomudstone, light-green-gray, micro-crystalline, massive, argillaceous, mottled through-
		out, lower contact gradational, upper contact sharp.
2635		
	C10	Patterned calcimudstone, light-green-gray to light-brown-gray, massive, sparsely argillaceous, mottled throughout; lower contact sharp; upper contact gradational.
	M2	Green mudrock, calcareous, nonfissle, pyritic.
	C10	Patterned calcimudstone, light-green-gray to light-brown-gray, massive, sparsely argillaceous, mottled throughout; lower contact sharp, upper contact sharp.
2640		
	C10	Patterned calcimudstone, light-green-gray to light-brown-gray, massive, increasingly argillaceous up-section, mottled throughout, locally pyritic; dolomitic at base, dolomite content decreases upsection.
2645		

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Miller, Sample 1, Sec. 11-T15N-R3W, Sangamon Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
2650		
	M5	Brown mudrock with nodules of calcimudstone.
	C10	Patterned dolomudstone, light-yellow-gray, micro-crystalline; microporous with moderate to abundant, calcite-infilled, needle-shaped pores.
2655		Intraclastic dolograinstone, medium-brown-gray, abundant fine-grain to pebble-size, subangular to
	C9	angular, dolomudstone intraclasts.
	C7	Brecciated dolomudstone, light-yellowish-gray, microcrystalline, earthy, clotted-fabric, sparse irregular, angular clasts of dolomustone and angular vugs infilled with coarsely-crystalline calcite.
	C6	Mottled dolomudstone, light-yellowish-gray, micro-crystalline, microporous, massive; sparse to abundant graded laminae of fine-grain to silt-size quartz.
	C2/C7	Dolomudstone interbedded with breccia; thin- to medium-bedded dolomudstone, light-yellow-gray, microcrystalline, earthy, abundant needle-shaped voids, high microporosity, interbedded with thin-beds of dolomudstone breccia, yellow-gray, with pebble- to cobble-size angular clasts of dolomudstone and abundant angular vugs; some
2660		

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Miller, Sample 1, Sec. 11-T15N-R3W, Sangamon Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		vugs infilled with coarsely-crystalline calcite; most bedding planes have mudcracks.
2665	C6	Mottled dolomudstone, light-yellowish-gray, micro-crystalline, microporous, massive, graded laminae locally; sparse to abundant quartz silt.
	C1	Quartzose dolowackestone, light-yellow-gray, abundant, fine- to medium-grain, moderately-sorted, well-rounded, mud-supported quartz.
	C3	Laminated dolomudstone, light-yellow-brown, micro-crystalline, abundant thin- to thick-laminae of brown mudrock increase in abundance upsection 1" of brown mudrock at 2667 ft.
2670	C6	Mottled dolomudstone, light-yellowish-gray, micro-crystalline, microporous, massive, graded laminae locally; sparse to abundant quartz silt.
	C1	Quartzose dolopack/wackestone, light-yellow-gray, abundant, fine- to medium-grain, moderately-sorted, well-rounded, mud-supported quartz; abundance of quartz decreases upsection.

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Miller, Sample 1, Sec. 11-T15N-R3W, Sangamon Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
2675	C1	Quartzose dolowackestone, light-yellow-gray, abundant, fine- to medium-grain, moderately-sorted, well-rounded, mud-supported quartz.
2676		
		No core 2676-2703 ft.
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated to friable, poorly-developed quartz overgrowths.
2705	S9	Mottled quartz arenite, light-yellowish-gray, fine- to medium-grain, moderately-well-sorted, well-rounded quartz; moderately well-indurated by quartz overgrowths, locally calacreous; well-indurated by dolomicrite cement at upper contact; upper contact stylolitic, lower contact gradational; massive to thick-bedded; rare *Skolithos* burrows. Poor recovery 2704.5-2724.75 ft.
2710		

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Miller, Sample 1, Sec. 11-T15N-R3W, Sangamon Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
2715		
2720	S4/S3	Cross-stratified quartz arenite, medium-yellow-gray, fine- to coarse-grain, predominantly medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by pore-filling calcite; abundant low-angle to planar cross-laminae; thin- to medium-bedded.
2730		
2732		
Bottom of cored interval and TD.		

Note: Poor recovery from St. Peter Sandstone; only 22 ft. (68%) of core from 2703-2732 ft.; contacts based, in part, on company core description and marked footages.

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Central Illinois Light Co., Witte 701, Sec. 11-T35N-R5E, Stark Co., Ill., elev. 750 ft., ISGS Core 9240, core chips from selected intervals 1149-1333.5 ft.

Depth (ft.)	Litho-facies	Description/Comments
1149	S2	Dolomitic quartz arenite grading upsection to quartzose dolopack/wackestone, medium-yellow-brown to medium-brown-gray, medium- to fine-grain, moderately- to poorly-sorted, well-rounded quartz; well-indurated by dolomicrite; becomes mud-supported in upper 2 ft.
1150		
		No samples 1152.5-1153.5 ft.
	S4/S3	Cross-stratified quartz arenite, light-brown-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; locally, weakly calcareous; cross-laminae weakly- to well-developed; where well developed, laminae are alternately fine- and coarse-grain; laminae are low-angle to planar; grain-size increases upsection.
1155		
	S10	Massive quartz arenite, light-yellow-brown, fine- to coarse-grain, poorly-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz over-growths, sparsely calcareous.
1160		
	S10	Massive quartz arenite, light-yellow-brown, fine-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz over-growths, sparsely calcareous.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1165		
	S4/S3	Cross-stratified quartz arenite, light-brown-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, locally weakly calcareous; cross-laminae weakly- to well-developed; where well developed, laminae are alternately fine- and coarse-grain; laminae are low-angle to planar; grain-size increases upsection.
1170		
	S4/S3	Cross-stratified quartz arenite, light-brown-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, locally weakly calcareous; cross-laminae weakly- to well-developed; where well developed, laminae are alternately fine- and coarse-grain; laminae are low-angle to planar; grain-size increases upsection.
1175	S4/S3	Cross-stratified quartz arenite, light-brown-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-brown-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant low-angle cross-stratification.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1180	S4	Cross-stratified quartz arenite, light-brown-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant low-angle cross-stratification.
1185	S10	Massive quartz arenite, light-yellow-brown to very light-green-gray, fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; weakly-indurated by quartz growths, sparsely argillaceous.
	S10	Massive quartz arenite, light-yellow-brown, fine-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz over-growths, sparsely calcareous.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1190	S10	Massive quartz arenite, light-yellow-brown to very light-green-gray, fine- to coarse-grain, moderately-poorly-sorted, well-rounded quartz; weakly-indurated by quartz growths, sparsely argillaceous.
	S10	Massive quartz arenite, light-yellow-brown, fine-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz over-growths, sparsely calcareous.
1195	S8	*Skolithos* -bearing quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz matrix with large large diameter (0.5") *Skolithos* burrows infilled by light-yellow-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; matrix is weakly-indurated and argillaceous, burrow infills moderately-indurated by quartz over-growths; sparse pyrite distributed along burrow margins.
1200	S4	Cross-stratified quartz arenite, light-brown-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; cross-laminae well developed.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, non-calcareous, argillaceous throughout; rare to sparse, very fine-grain, well-rounded, well-sorted, dark purple tourmaline.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1205		
1210		
1215		

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1220		
1225		
1230	S15	Argillaceous quartz arenite, light-green-gray, fine-grain, grading upsection to coarse-grain, well-rounded quartz; poorly-sorted at base, increasingly well-sorted upsection; argillaceous throughtout, weakly-indurated to friable.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1235		
	S8	*Skolithos* -bearing quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz matrix with large diameter (0.5") *Skolithos* burrows infilled by light-yellow-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; matrix weakly-indurated and argillaceous, burrow infills moderately-indurated by quartz overgrowths.
1240	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted to bimodal, well-rounded quartz; argillaceous, friable.
	S15/M2	Interbedded green-gray mudrock and argillaceous quartz arenite; mudrock is dark-green-gray, nonfissle, locally pyritic, sparse coarse-grain, well-rounded quartz locally, cross-cut by *Skolithos* burrows infilled by medium- to coarse-grain, poorly-sorted quartz; quartz arenite interbeds at 1239'6"-1244'; quartz arenite, light- to medium-green-gray, fine- to medium- and coarse-grain, bimodal, well-rounded quartz; very argillaceous, friable ("Glenwood texture").
1245		
	S15	Argillaceous quartz arenite, light-green-gray, fine-grading upsection to coarse-grain, poorly-sorted at base grading upsection to well-sorted at top, well-

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		rounded quartz; argillaceous throughtout, weakly-indurated to friable; green-gray mudcrock partings in lower 2 ft.
1250	S4	Cross-stratified quartz arenite, black to dark-gray-brown, medium- to coarse-grain, moderately-sorted, well-rounded quartz; well-indurated by quartz over-growths and pore-filling sulfide; low-angle cross-stratification.
1255	S10	Massive quartz arenite, light-yellow-brown, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to very well-indurated by quartz over-growths, sparsely pyritic.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1260		
	S8	*Skolithos*-bearing quartz arenite, light-brown-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz matrix with large large diameter (0.5") *Skolithos* burrows infilled by light-yellow-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; matrix is weakly-indurated to friable, burrow infills are moderately-indurated by quartz overgrowths; sparse pyrite locally.
1265	S4	Cross-stratified quartz arenite, light-yellowish-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated, abundant pore-filling calcite; low-angle cross-laminae well-defined.
1270	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated, sparse to abundant pore-filling calcite; irregular, pore-filling iron sulfide (1-2 mm) locally.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1275		
1280		
1285		
	S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to very fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; silty; vague to poorly-defined, low angle cross-laminae; sparsely calcareous.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1290		
	S4	Cross-stratified quartz arenite, medium-yellow-gray, fine- to coarse-grain, moderately-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths; well-defined, fine- and coarse-grain, low-angle cross-laminae, locally calcareous.
1295		
	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated, pore-filling calcite locally.
1300		

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1305		
		Trough cross-stratified quartz arenite, light-yellow-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; well-defined concavo-linear cross-laminae.
	S6	
		Nodule-bearing quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz matrix, moderately-indurated by quartz overgrowths; sparse to abundant, interlocking, subround to subelliptical nodules (0.25-2") of calcite-cemented quartz arenite, white,fine- to medium-grain, well-sorted, well-rounded quartz.
	S11	
1310		
		No samples 1308-1315 ft.
1315		
	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		quartz overgrowths; sparse to moderately-abundant pore-filling calcite.
1320		
1325	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; sparse to moderately-abundant pore-filling calcite; grain-size decreases upsection.
	M1	Conglomeratic mudrock, medium-green-gray to yellow-green-gray, mudrock matrix is green-gray, nonfissle, locally pyritic, pseudo-slickensides locally; sparse to abundant, fine-grain to pebble-size, angular to subrounded chalky dolomudstone, medium-brown-gray, and microcrystalline chert, white to light-gray opaque; abundant fine to coarse-grain, well-rounded quartz in lower 2 ft.

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Central Illinois Light Co., Witte 701, Stark Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1330		
	M2	Green mudrock, green-gray, nonfissle, pyritic, pseudo-slickensides.
Bottom of cored interval, TD at 2822 ft.		

*Note: lithofacies contacts based on company core description and interpretation of microlog.

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Commonwealth Edison, UPH-3, Sec. 7-T28N-R6E, Stephenson Co., Ill., elev. 989.6 ft., ISGS Core 12996, Nx core 32-2176 ft., described 341-480 ft.

Depth (ft.)	Litho-facies	Description/Comments
	C17	Bioclastic dolowacke/packstone, medium-brown-gray, finely-crystalline, locally argillaceous; sparse to abundant ostracodes and brachiopods; locally pyritic in lower 1 ft.
340		
	C1	Quartzose dolopackstone, medium-brown-gray, finely- to microcrystalline, sparse to abundant, medium-grain, well-sorted, well-rounded, mud-supported quartz.
		No core 342.75-343.33 ft.
	C1	Same as 342', more sand.
	S15	Argillaceous quartz arenite, light- to medium-green-gray, medium- to coarse-grain, poorly-sorted, well-rounded quartz; friable, locally pyritic; 2" of conglomeratic mudrock dark-green-gray, with pebble-size clasts of green-gray mudrock and argillaceous dolostone.
345		
	C6	Mottled dolomudstone grading to stromatolitic dolostone, medium-green-gray, finely-crystalline; pyrite infilled burrows 345'6"-345'9".
	C12	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable; argillaceous, mudrock partings locally.
	C1	Quartzose dolowacke/packstone, medium-green-gray; sparse to abundant, fine- to medium-grain, poorly-sorted, well-rounded quartz and fine-grain to pebble-size, subangular to subrounded clasts of dolostone; abundant mudrock-filled vertical burrows (0.25" diameter); rounding of dolostone grains increases upsection; abundance of quartz decreases upsection.
	S9	Mottled dolomudstone grading to stromatolitic dolomudstone, medium-green-gray, finely-crystalline; pyritic locally; digitate stromatolites in upper 4".
	S15	Argillaceous quartz arenite, same as 346 ft.
	S15/S2	Argillaceous quartz arenite grading upsection to dolomitic quartz arenite with vertical burrows.
350		Argillaceous quartz arenite grading upsection to quartzose stromatolitic dolostone, light-green-gray to medium-green-gray; abundant to sparse, fine- to medium-grain, poorly sorted, well-rounded quartz;

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		friable; abundance of quartz and grain-size decreases upsection; stomatolitic in upper 4".
	C1/S2	Interbedded quartzose dolowackestone and dolomitic quartz arenite, light-green-gray to green-gray, fine- to coarse-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; small-scale (2"-3") fining-upward sequences.
	S15	Argillaceous quartz arenite, black-green to green-gray, medium-grain, moderately-well-sorted, well-rounded quartz; weakly- to well-indurated by pyrite; green-gray mudrock partings throughout.
	S3	Planar cross-stratified quartz arenite, green-gray; medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; argillaceous throughout.
355	S10	Massive quartz arenite, light-gray to light-greenish-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths, locally dolomitic; green-gray mudrock partings in lower 6".
	S8	*Skolithos* -bearing quartz arenite, light-gray to light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated, locally argillaceous; sparse small diameter *Skolithos* burrows.
	S9	Mottled quartz arenite, light-green-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated; cross-stratification locally (352'4"); green-gray mudrock partings in lower foot.
360	S3	Planar cross-stratified quartz arenite, light-green-gray, medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; argillaceous throughout; locally cross-laminae are cross-cut by *Skolithos* burrows.
	S10	Massive quartz arenite, light- to medium-green-gray, medium- to coarse-grain, poorly-sorted, well-rounded quartz; friable, argillaceous throughout; locally mottled.
	S6	Trough-cross-stratified quartz arenite, medium- to light-green-gray, medium-grain, well-sorted, well-rounded quartz; friable, argillaceous throughout; abundant, variable-angle cross-laminae, many appear arcuate.
	S3	Planar cross-stratified quartz arenite, light-green-gray, medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; argillaceous throughout; locally cross-laminae are cross-cut by *Skolithos* burrows.
	S4	Low-angle cross-stratified quartz arenite, light-green-gray, fine- to medium-grain, well-sorted well-rounded quartz; friable, argillaceous throughout; abundant low-

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
365	S4	angle cross-laminae that grade upsection to planar.
	S3	Planar cross-stratified quartz arenite, light-green-gray, medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; argillaceous throughout.
	S10	Massive quartz arenite, pale-yellow-green, medium-grain, well-sorted, well-rounded quartz; friable.
	S3	Planar- to low-angle cross-stratified quartz arenite, light-green-gray to yellowish-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; planar cross-laminae from 366'-367', and 367.5'-368.5'; thin interbeds (1") of coarse-grain quartz arenite at 367'7" and 368'5", similar in character to underlying massive quartz arenite.
	S10	Massive quartz arenite, light-green-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; friable, argillaceous throughout.
370	S3/S4	Planar- to low-angle cross-stratified quartz arenite, light-green-gray to yellowish-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; well-developed planar cross-laminae 370-370'2".
	S10	Massive quartz arenite, light-green-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; friable, argillaceous throughout.
	S3/S4	Planar- to low-angle cross-stratified quartz arenite, light-green-gray to yellowish-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-green-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; friable, argillaceous throughout.
	S3/S4	Planar- to low-angle cross-stratified quartz arenite, light-green-gray to yellowish-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; well-developed low-angle cross-laminae in lower 6".
375	S10	Massive quartz arenite, very-light- to light-green-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; grain-size increases upsection; vague mottling in upper 6".
	S15	Argillaceous quartz arenite, light-green-gray to medium-green-gray, fine-grain, well-sorted quartz arenite; friable, very argillaceous throughout; no apparent sedimentary features.
	S3/S4	Planar- to low-angle cross-stratified quartz arenite, light-green-gray to medium-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		to weakly-indurated by quartz overgrowths; thin interbeds (<1") of coarse-grain quartz arenite abundant from 381'6"-384', and sparse from 389'1"; pyrite locally present as intergranular masses.
380		
385		
390		

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
395	S4	Cross-stratified quartz arenite, light-green-gray, medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated, argillaceous throughout; well-developed low-angle and planar-cross-laminae.
	S15	Argillaceous quartz arenite, light-green-gray, fine-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; sulfide nodule (0.25" diameter) at 395'3"; planar laminae at 394'10"-395'2".
		No core 396'6"-396'11".
	S15	Argillaceous quartz arenite, light-green-gray, fine-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; green-gray mudrock parting at 398'4".
	S4	Low-angle cross-stratified arenite, light-gray to light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated; sparse abundant low-angle cross-laminae; abundant green-gray mudrock partings in lower 6-inches.
400	S15	Argillaceous quartz arenite, light-green-gray, fine-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; sulfide nodule at 404'4".
	S4	Low-angle cross-stratified arenite, light-gray to light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated; sparse abundant low-angle cross-laminae.
405		**No core 401-405 ft.**
	S15	Argillceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; lower 4-inches is medium-grain; green-gray mud-rock partings at 405'4"-6", and 405'10".

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		No core 406–421 ft.
422	S15	Argillaceous quartz arenite, light-green-gray to light-gray, fine-to medium-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; low-angle cross-laminae at 421'6"–421'10" and 422'6"; green-gray mudrock partings at 421'6"and 421'10"–422'2".
	S10	Massive quartz arenite, light-yellow-gray, fine-grain, well-sorted, well-rounded quartz; weakly-indurated; massive.
425	S10/S4	Massive quartz arenite, light-yellow-gray to light-green-gray, fine- to medium-grain, moderately-to well-sorted, well-rounded quartz; friable to weakly-indurated; medium-grain laminae (<0.25") at 424'5", 435'8", 426'3" and 426'7"; low-angle cross-laminae at 424'2" and 425'8".
		No core 427–428 ft.
	S4	Low-angle cross-stratified quartz arenite, medium-yellow-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz; irregular ferroan sulfide masses (<0.5" diameter).
		No core 428.33–429 ft.
430	S4	Low-angle cross-stratified quartz arenite, medium-yellow-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz; irregular ferroan sulfide masses (<0.25" diameter).
		No core 430–430.75 ft.
	S10	Massive quartz arenite, dark-yellow-gray to yellow-orange, fine-grain, well-sorted, well-rounded quartz; weakly-indurated; thin interlaminae of medium-grain quartz.

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
435		
	S4	Low-angle cross-stratified quartz arenite, light-yellow-gray to red-brown, fine-grain, well-sorted, well-rounded quartz; weakly-indurated; sparse to abundant low-angle cross-laminae; pseudospherical (<0.25") ferroan sulfide masses locally.
	S10	Massive quartz arenite, yellow-orange to red-brown, fine-grain, well-sorted, well-rounded quartz; weakly-indurated; sparse to abundant hematite staining; sulfide nodule at 337 ft.
	S4	Low-angle cross-stratified quartz arenite, light-yellow-gray to fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated; sparse to abundant low-angle cross-laminae; sulfide nodule at 438'8".
440	S10/S9	Massive to mottled quartz arenite, red-brown with light-yellow-gray "spots", fine- to medium-grain, moderately-well-sorted, well-rounded quartz; weakly-indurated; hematite staining throughout; light-colored subspherical "spots" (2-6 mm) 440-441 ft.; thin-bed (<2") of medium-grain quartz arenite with sulfide nodule at base.
	S4	Cross-stratified quartz arenite, red-brown, fine- to very fine-grain, well-sorted, well-rounded quartz; weakly-indurated; grain-size decreases upsection; upper 6" contains abundant, thin planar laminae.
	S6	Trough cross-stratified quartz arenite, yellow-brown, medium-grain, well-sorted, well-rounded quartz; weakly-indurated; abundant arcuate cross-laminae.
	S10	Massive quartz arenite, yellow-orange to red-brown, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated; sulfide nodules (<0.25") at 443'3"-6", 443'10-444'2", and 444'8".
445	S4	Low-angle cross-stratified quartz arenite, light-yellow-gray to fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated; sparse to abundant low-angle cross-laminae. **No core 445'3"-6", 446'1"-10",** and 447'0"-7".

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Low-angle cross-stratified quartz arenite, light-yellow-gray to fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated; sparse to abundant low-angle cross-laminae.
	S3	Planar cross-stratified quartz arenite, red-brown, fine- to very fine-grain to silty,, well-sorted, well-rounded quartz; moderately-indurated; sparse to abundant planar cross-laminae.
450	S4	Low-angle cross-stratified quartz arenite, light-yellow-gray to fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated; sparse to abundant low-angle cross-laminae.
	S10	Massive quartz arenite, light-yellow-gray to yellow-orange to red-brown, medium-grain with thin interbeds of fine-grain, poorly- to well-sorted, well-rounded quartz; friable to weakly-indurated; fine-grain interbeds are well-sorted and decrease in abundance and thickness upsection; sulfide nodules 451'6"-452'4".
455	S10	Massive quartz arenite, red-brown to yellow-orange-gray, fine-to medium-grain, moderately-well-sorted, well-rounded quartz; weakly-indurated; vague cross-laminae locally; thin (<2") interbeds of medium-grain quartz arenite at 454'10", 455'6", and 456'4"; abundant ferroan staining throughout.
460	S10	Massive quartz arenite, red-brown to yellow-orange-gray, fine- to medium-grain, moderately-well-sorted, well-rounded quartz; weakly-indurated; vague cross-laminae locally; thin (<2") interbeds of medium-grain quartz arenite at 454'10", 455'6", and 456'4"; abundant ferroan staining throughout.
	S10	Massive quartz arenite, red-brown to yellow-orange-gray, fine- to medium-grain, moderately-well-sorted, well-rounded quartz; weakly-indurated; vague cross-laminae locally; thin (<2") interbeds of medium-grain quartz arenite at 6"-3" intervals; abundance of

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		interbeds decreases upsection, bed thickness
		increases upsection; abundant ferroan staining
		throughout, mostly hematite, some limonite; staining
		cross-cuts bedding features; microfaulting locally;
		no breaks to 471'10".
465		
470		
		Lithic quartz arenite, yellow-gray, silty to coarse-grain,
		poorly-sorted, well-rounded quartz; weakly-indurated;
	S13	sparse, subangular sand-size siltstone at base.
		Conglomeratic mudrock grading upsection to mudrock
	M1/M4	to interlaminated silty mudrock and fine-grain quartz
		arenite; mudrock is green-gray or brick red, green-gray
		at base, silty, feldspathic; sand- to pebble-size,
		subangular dolostone and chert at base; mudrock is
		fissle with pseudo-slickensides locally; grades into
		overlying interbedded silty mudrock and quartz
		arenite; quartz arenite is fine-grain, well-sorted, well-
		rounded quartz, moderately-indurated by quartz
		overgrowths; interlaminae of mudrock increasingly
475		silty upsection; mudrock locally contains reworked
		Lower Ordovician microfauna.
		Vuggy argillaceous dolomud/wackestone, light-green-
	C19	gray to light-brown-gray, finely- to microcrystalline,
		locally pyritic; biomolds at 476'6"; green-gray mudrock

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Commonwealth Edison, UPH-3, Stephenson Co., Ill., (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		partings from 475'-477'6", 2" bed at 477'6"; Lower Ordovician microfauna throughout.
480		
Bottom of described interval, TD at 5272 ft.		

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Central Illinois Light Co., Mary Wooding 1, Sec. 5-T23N-R6W, Tazewell Co., Ill. elev. 518 ft., ISGS Core 3766, 2.5" core biscuits each foot 1419-1445 ft.

Depth (ft.)	Litho-facies	Description/Comments
1419	C1	Quartzose dolopackestone, brown-gray to medium-brown-gray, crystalline, abundant coarse- to medium-grain, well-rounded, mud-supported quartz grains; grain-size decreases upsection; locally vuggy (<0.5").
1420		
	S9	Mottled quartz arenite, white to light-green-gray, slightly argillaceous, fine- to very-fine-grain, and medium-grain, well-rounded, bimodal quartz; light-green-gray, very fine- to fine-grain matrix is argillaceous; coarser-grain, very light-gray, infills small diameter burrows (<0.2")(*Skolithos* ?), friable 1427-1429 ft.; moderately-indurated by quartz over-growths 1425-1427 ft.
1425		
	S15	Argillaceous quartz arenite, green-gray to medium-brown-gray to light-gray, very-fine to medium-grain, argillaceous, small scale (1-2") fining-upward sequences; fine-grain intervals are moderately-indurated by quartz overgrowths, coarser-grain intervals are friable and argillaceous; sparsely pyritic throughout.
1430	S15	Argillaceous quartz arenite, green-gray to medium-brown-gray to light-gray, very-fine to medium-grain, argillaceous, small scale (1-2") fining-upward sequences; fine-grain intervals are moderately-indurated by quartz overgrowths, coarser-grain are friable and argillaceous; sparsely pyritic throughout.

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Central Illinois Light Co., Mary Wooding 1, Tazewell Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
	S8	*Skolithos* -bearing quartz arenite, fine- to medium-grain, well-rounded, bimodal, quartz; burrow infills are coarser-grain and moderately indurated by quartz overgrowths.
1435	S13	Lithic quartz arenite, light-medium-brown with medium-green-gray claystone intraclasts; fine- to medium-grain, well-rounded, poorly-sorted quartz with pebble-size, angular intraclasts of massive claystone.
	S15	Argillaceous quartz arenite, green-gray to medium-brown-gray to light-gray, very-fine to medium-grain, argillaceous, small scale (1-2") fining-upward sequences; fine-grain intervals are moderately-indurated by quartz overgrowths, coarser-grain are friable and argillaceous; sparsely pyritic throughout.
	S7	Laminated quartz arenite, medium-green-gray to medium-light-gray, fine- to medium-grain, moderately-well-sorted, well-rounded quartz; thin, medium-green-gray, claystone laminae (< 0.1") subparallel bedding.
1440	S15	Argillaceous quartz arenite, green-gray to medium-brown-gray to light-gray, very-fine to medium-grain, argillaceous, small scale (1-2") fining-upward sequences; fine-grain intervals are moderately-indurated by quartz overgrowths, coarser-grain are friable and argillaceous; sparsely pyritic throughout.
	S13	Intraclast-bearing quartz arenite, light-medium-brown with medium-green-gray claystone intraclasts; fine- to medium-grain, well-rounded, poorly-sorted quartz with pebble-size, angular intraclasts of massive claystone.
		Laminated quartz arenite, medium-green-gray to medium-light-gray, fine- to medium-grain, moderately-well-sorted, well-rounded quartz; thin, medium-green-gray, claystone laminae (< 0.1") subparallel bedding.
1445	S15	Argillaceous quartz arenite, green-gray to medium-brown-gray to light-gray, very fine- to medium-grain, moderately-sorted, well-rounded quartz; argillaceous, friable to moderately-indurated by quartz overgrowths, pore-filling sulfide locally.
Bottom of cored interval, TD at 1561 ft.		

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Illinois Power Co., Moberg 1, Sec. 3-T12N-R1W, Warren Co., Ill., elev. 737 ft., ISGS Core 7215, core chips each foot 985-1175 ft.

Depth (ft.)	Litho-facies	Description/Comments
985	C17	Bioclastic dolowackestone, medium-brown-gray, abundant, complete stromophacean brachiopods.
990	C8	Ostracodal dolowackestone, light- to medium-brown-gray, microcrystalline, abundant ostracode molds; locally vuggy (<0.25" diameter); stringers of echinoid debris.
	S2	Dolomitic quartz arenite, light-brown-gray, medium- to coarse-grain, moderately- to well-sorted, well-rounded quartz; well-indurated by dolomicrite, ostracode molds at top; basal contact sharp, upper contact gradational.
995	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowth cement, abundant pore-filling calcite.
	S4	Low-angle cross-stratified quartz arenite, light-brown-gray to light-medium-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths, sparse to abundant pore-filling calcite.

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
1000		
1005	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
	S4	Low-angle cross-stratified quartz arenite, light-brown-gray to light-medium-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths, sparse to abundant pore-filling calcite.
1010	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
	S4	Low-angle cross-stratified quartz arenite, light-brown-gray to light-medium-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz;

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
		moderately- to well-indurated by quartz over-growths, sparse to abundant pore-filling calcite.
	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
1015		
	S4	Low-angle cross-stratified quartz arenite, light-brown-gray to light-medium-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths, sparse to abundant pore-filling calcite.
	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
1020	S4	Low-angle cross-stratified quartz arenite, light-brown-gray to light-medium-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths, sparse to abundant pore-filling calcite.
1025	S4	Low-angle cross-stratified quartz arenite, light-brown-gray to light-medium-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz; sparse, black, fine-grain, subrounded tourmaline; well-indurated by quartz overgrowths; locally calcareous.

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Illinois Power Co., Moberg 1, Warren Co., Ill.(cont.)

Depth (ft.)	Litho-facies	Description/Comments
1030	S10	Massive quartz arenite, light-brown-gray, fine- to coarse-grain, poorly-sorted, possibly bimodal, well-rounded quartz; sparse, fine-grain tourmaline; moderately-indurated by quartz overgrowths, locally calcareous.
1035	S4	Low-angle cross-stratified quartz arenite, light-brown-gray to light-medium-gray, fine- to medium-grain, moderately well-sorted, well-rounded quartz; sparse, black, fine-grain, subrounded tourmaline; well-indurated by quartz overgrowths, calcareous.
1040	S15	Argillaceous quartz arenite, light-green-gray to light-brown-gray, fine- to coarse-grain, bimodal, well-rounded quartz; sparse, fine-grain tourmaline; moderately-indurated by quartz overgrowths, locally calcareous.

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1045	S9	Mottled argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, bimodal, well-rounded quartz; sparse, fine-grain tourmaline; moderately- to well-indurated by quartz overgrowths, locally calcareous; sparse, small diameter (<0.25") vertical burrows.
	S10	Massive quartz arenite, light-brown-gray, fine- to coarse-grain, poorly-sorted, possibly bimodal, well-rounded quartz; very well-indurated by by quartz overgrowths; high-angle fracture at 1049 ft.
1050	S15	Argillaceous quartz arenite, very light-green-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; abundant green-gray mudrock partings.
	S9	Mottled argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, moderately well-sorted, well-rounded quartz; sparse, fine-grain tourmaline; moderately- to well-indurated by quartz over-growths, very calcareous; moderately-abundant green-gray mudrock partings.

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1055	M2	Green mudrock, medium-green-gray, nonfissile, pyritic; lenses of fine- to coarse-grain, bimodal, well-rounded quartz; sparse, *linguloid* brachiopod debris.
1060	S15	Argillaceous quartz arenite, light-green-gray, fine-grain with sparse coarse-grain, moderately-sorted, well-rounded quartz; rare, fine-grain tourmaline; moderately-indurated by quartz over-growths; noncalcareous; moderately-abundant green-gray mudrock partings at base.
1065	S10	Massive quartz arenite, light-brown-gray, fine- to coarse-grain, poorly-sorted to bimodal, well-rounded quartz; very well-indurated by quartz over-growths.
	S15	Argillaceous quartz arenite, light-green-gray, fine-grain with sparse coarse-grain, moderately-sorted, well-rounded quartz; rare, fine-grain tourmaline; friable to weakly-indurated by quartz overgrowths, noncalcareous; abundance of coarse-grain quartz increases upsection.

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1070		
	C1/C12	Quartzose dolopack/wackestone, pale-green-gray, abundant mud-supported, fine- to coarse-grain, bimodal quartz; 1" interbed of gray-green mudrock at base.
1075		
	S15	Argillaceous quartz arenite, light-green-gray, fine-grain with sparse coarse-grain, moderately-sorted, well-rounded quartz; rare, fine-grain tourmaline; friable to weakly-indurated by quartz overgrowths, noncalcareous; abundance of argillaceous fraction increases upsection; patchy distribution of quartz overgrowths at base.
1080		

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S15	Argillaceous quartz arenite, light-green-gray to light-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; argillaceous in upper 2 ft., clay content increases upsection; weakly- to to moderately-indurated by quartz overgrowths, locally calcareous.
1085		
	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths, calcareous.
1090		
	S8	*Skolithos*-bearing quartz arenite, light-brown-gray, fine- to coarse-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; burrow infills well-indurated, gives "splotchy" appearance.
	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; very well-indurated by quartz overgrowths.
	S15	Argillaceous quartz arenite, light-green-gray to light-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; argillaceous in upper 2 ft., clay contend increases up-section; weakly- to moderately-indurated by quartz overgrowths.
1095		

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S15	Argillaceous quartz arenite, light-green-gray to light-brown-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparsely argillaceous throughout; weakly-indurated by sparse quartz overgrowths, slightly calcareous.
1100		
	S15	Argillaceous quartz arenite, light-pale-green to light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparsely argillaceous throughout; moderately-indurated by sparse quartz overgrowths, noncalcareous.
1105	S10	Massive quartz arenite, light-brown-gray with minor light-green-gray, coarse- to medium-grain, poorly- to moderately well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths.
	S10	Massive quartz arenite, light-brown-gray with patchy distribution of light-green-gray, coarse- to medium-grain, moderately well-sorted, well-rounded quartz; well-indurated by quartz over-growths, calcareous.
1110	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, moderately well-sorted, well rounded quartz; well-indurated by quartz over-growths, noncalcareous.

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-brown-gray with patchy distribution of light-green-gray, coarse- to medium-grain, moderately well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, calcareous, slightly argillaceous.
1115		
	S15	Argillaceous quartz arenite, pale-green-gray, to light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable; slightly- to very argillaceous, increasingly argillaceous upsection.
1120	S15	Massive argillaceous quartz arenite, pale-green-gray to light-brown-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated to friable, calcareous; green-gray clay disseminated throughout.

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1125		
	S4	Low-angle cross-stratified quartz arenite, light-brown-gray to pale-green-gray, coarse- to medium-grain, moderately well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths, sparse pore-filling calcite.
1130	S3/S4	Cross-stratified quartz arenite, light-brown-gray with patches of light-pale green, fine- to medium-grain, well- to moderately well-sorted, well-rounded quartz; well-indurated throughout; locally calcareous; very argillaceous in upper 3"; low-angle laminae cosets terminate against planar surfaces; cross-stratification poorly developed in upper 4 ft.
1135		

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1140		
1145		
	S3/S4	Cross-stratified quartz arenite, light-brown-gray with patches of light-pale green, fine- to medium-grain, well- to moderately well-sorted, well-rounded quartz; well-indurated throughout; sparsely argillaceous, clay is concentrated along low-angle and planar cross-laminae contacts.
1150	S10	Massive quartz arenite, light-yellow-gray, fine- to coarse-grain, moderately-sorted, well-rounded quartz; well-indurated by abundant quartz over-growths; upper contact gradaitional.

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1155		
	S13	Lithic quartz arenite grading upsection to argillaceous quartz arenite, light-pale-yellow-gray with green-gray partings locally; fine- to coarse-grain, moderately- to poorly-sorted, well-rounded quartz; angular to subrounded, white to light-gray, medium- to coarse-grain, opaque chert at base, decreasing in abundance upsection; green-gray mudrock partings at base that decrease in abundance upsection.
1160		
1165	M1	Conglomeratic mudrock, green-gray, nonfissle, abundant fine-grain to pebble-size, light-gray, angular to subrounded, microcrystalline, opaque chert; very poor sorting; "slickensides" common; strongly ferroan stained interval at 1166 ft.; upper contact gradiational, lower contact sharp and irregular.

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Illinois Power Co., Moberg 1, Warren Co., Ill. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C19	Dolomudstone, red-brown-gray to light-brown-gray with green-gray, pyritic mudrock partings; finely- to coarsely-crystalline; very vuggy; light-medium-gray, coarse-grain arenite infilling vug at 1172 ft.
1170		
1175		
Bottom of cored interval, TD at 2640 ft.		

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McBride, Inc., A. V. Hunleth 1, Sec. 29-T3S-R4W, Washington Co., Ill., elev. 542 ft., ISGS core C2239; select core chips 3938-3948 ft., see comments below.

Depth (ft.)	Litho-facies	Description/Comments
3938	C1	Quartzose dolowackestone, light-brown-gray, micro-crystalline, sparse to abundant, fine- to medium-grain, well-rounded, mud-supported quartz; laminae of dolomitic quartz arenite, fine-grain, well-sorted, well-rounded, grain-supported quartz; well-indurated.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to moderately-indurated, clay-cemented.
3940	C1	Quartzose dolowackestone, light-brown-gray, micro-crystalline, sparse to abundant, fine- to medium-grain, well-rounded, mud-supported quartz; laminae of dolomitic quartz arenite, fine-grain, well-sorted, well-rounded, grain-supported quartz; well-indurated.
	S2	Dolomitic quartz arenite, very-light-gray to light-geen-gray, fine-grain, well-sorted, well-rounded quartz; moderately-indurated by dolomicrite cement; argillaceous.
	C1	Quartzose dolowackestone, light-brown-gray, micro-crystalline, sparse to abundant, fine- to medium-grain, well-rounded, mud-supported quartz; laminae of dolomitic quartz arenite, fine-grain, well-sorted, well-rounded, grain-supported quartz; well-indurated.
	S9	Mottled quartz arenite, very-light-gray to light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; pore-filling sulfide locally with horizontal distribution; high porosity.
3945		
	S4	Low-angle cross-stratified quartz arenite, light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; sparse pore-filling pyrite; vague low-angle cross-stratification. *Porosity and permeability test at 3945 ft.: 15.3% porosity and 700 md permeability.*
3948		
Bottom of cored interval, TD at 3984 ft.		

Note: Representative core samples collected by W. F. Meents, ISGS, 1948. Sample depths unreported. Above core description based on description of core samples, Superior Oil Co. core study, core description by Meents and available geophysical log.

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NIPSCO, Betty Leuenberger 1, Sec. 14-T29N-R14E, Allen Co., Ind., elev. 797 ft., IGS C438; core chips 1730-1875 ft., described 1815-1830 ft.

Depth (ft.)	Litho-facies	Description/Comments
1815		Ostracodal pack/wackestone, light-brown-gray, microcrystalline, pyritic, peloidal locally; sparse to abundant, complete ostracodes; pyritic.
1820		
		Argillaceous calcimudstone, light-green-gray, with thin stringers of ostracodal packstone, micro-crystalline, micritic; sparse to abundant, green-gray *mudrock partings*.
1825		
		Argillaceous calcimudstone, light-green-gray, with microcrystalline, micritic; locally dolomitic; sparse to to abundant, green-gray mudrock partings; calcite infilled vertical fenestrae locally.

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NIPSCO, Betty Leuenberger 1, Allen Co., Ind. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
1830		
Bottom of described interval, TD at 3672 ft.		

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Northern Indiana Power Co., Gale W. Skinner 1, Sec. 10-T28N-R1W, Cass Co., Ind., elev. 721 ft.; IGS Core 227, 2.5-inch described 1302-1374.5 ft.

Depth (ft.)	Litho-facies	Description/Comments
1302	S9	Mottled quartz arenite, light-yellow-gray, fine-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths, locally calcareous; abundant, laterally discontinuous brown-mudrock partings; horizontal burrow traces locally.
1305		
	C17	Bioclastic grain/packstone, medium-brown-gray, abundant planospiral gastropods and complete brachiopods; sparse green-mudrock partings.
	M5	Organic-bearing brown mudrock, pyritic, burrowed, nonfissle.
1310	C10	Patterned dolomudstone, light-yellowish-gray, micro-crystalline, locally fenestral, stringers of ostracodal dolopackstone; burrowed upper contact.
	C10	Patterned dolomudstone, medium-green-gray to medium-brown-gray, microcrystalline, locally pyritic, abundant argillaceous mottles.
	C8	Ostracodal packstone, medium-brown-gray, micritic, abundant biomolds after ostracodes.
1315		

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Northern Indiana Power Co., G. Skinner 1, Cass Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1320	C2	Massive dolomudstone, light-yellow-brown, micro-crystalline, microporous, somewhat earthy; fenestrae infilled by calcite at 1317-1317'5" and 1315'10"-1316'2".
	C3	Laminated dolomudstone, light-yellow-gray, earthy, microcrystalline, high intercrystalline porosity, sparse to abundant, angular vugs; sparse to abundant, irregular brown mudrock laminae; upper contact is burrowed.
	C10	Patterned dolomudstone, light-brown-gray, finely-crystalline massive; mottled throughout.
1325	C8	Ostracodal dolowackestone, light-brown-gray, micro-crystalline, rare to sparse ostracodes; mottled locally; stringer of intraclastic dolograinstone at base with angular, green-gray mudrock intraclasts.
	C10	Patterned to massive dolomudstone, light-yellow-brown, micro- to finely-crystalline; sparse to moderately-abundant mottling; locally stylolitic.

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Northern Indiana Power Co., G. Skinner 1, Cass Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1330	C10	
1335		
1340	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, poorly-sorted quartz; friable, abundant green-mudrock partings.
	C8	Ostracodal dolowackestone, light-brown-gray, micro-crystalline, argillaceous throughout.
	S14	Silty quartz arenite, medium-green-gray, fine- to coarse-grain, bimodal, well-rounded quartz, friable to weakly-indurated, increasingly well-indurated up-section by dolomicrite.
	M2	Dolomitic green mudrock grading upsection to dolomitic siltstone, dark-green-gray throughout.

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Northern Indiana Power Co., G. Skinner 1, Cass Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		locally pyritic, dolomitic at base, ostracodes locally.
1345	C8	Ostracodal dolowackestone, light-brown-gray, micro-crystalline, very argillaceous; 1" green-gray mudrock at base.
1350	C8/C9	Ostracodal dolowacke/packstone, dark-brown-gray to black, microcrystalline, U-shaped burrows locally; sparse to abundant stringers of fine-grain quartz, abundance of stringers decreases upsection; 1" lithic quartz arenite at base with green-mudrock intraclasts.
	C2	Dolomudstone, light-yellowish-gray, microcrystalline, massive, no sand or ostracodes; 1" lithic arenite stringer at base with green-mudrock intraclasts.
1355	C12	Argillaceous quartz arenite, green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable, argillaceous throughout; sparse green-gray mudrock partings in lower 2 ft.
	S8	*Skolithos*-bearing quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz matrix, argillaceous, friable, cross-cut by

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Northern Indiana Power Co., G. Skinner 1, Cass Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		vertical, large diameter (0.5") *Skolithos* burrows infilled with medium-grain, well-sorted, well-rounded quartz; burrow infills are moderately-indurated by quartz overgrowths and are light-yellow-gray in color; green-mudrock intraclasts at base.
1360	S8	*Skolithos* -bearing quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz matrix, argillaceous, friable, cross-cut by vertical, large diameter (0.5") *Skolithos* burrows infilled with medium-grain, well-sorted, well-rounded quartz; burrow infills are moderately-indurated by quartz overgrowths and are light-yellow-gray in color; green-gray mudrock intraclasts at base.
	S8	*Skolithos* -bearing quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz matrix, argillaceous, friable, cross-cut by vertical, large diameter (0.5") *Skolithos* burrows infilled with medium-grain, well-sorted, well-rounded quartz; burrow infills are moderately-indurated by quartz overgrowths and are light-yellow-gray in color; green-gray mudrock intraclasts at base.
1365	S8	*Skolithos* -bearing quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz matrix, sparsely argillaceous, moderately-indurated; abundant vertical, large diameter (0.5") *Skolithos* burrows infilled with medium-grain, well-sorted and rounded quartz; burrow infills moderately-indurated by quartz overgrowths and are light-yellow-gray in color; green-gray mudrock intraclasts at base; silicified ooid grains 1368'6"-1369'.
1370	S8	*Skolithos* -bearing quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz matrix, argillaceous, friable, cross-cut by vertical, large diameter (0.5") *Skolithos* burrows infilled with medium-grain, well-sorted, well-rounded quartz; burrow infills are moderately-indurated by quartz overgrowths and are light-yellow-gray in color; green-gray mudrock intraclasts at base.
	S13/S15	Lithic quartz arenite, medium-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz,

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Northern Indiana Power Co., G. Skinner 1, Cass Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		sparse, fine- to coarse-grain, subrounded micro-crystalline chert; moderately-indurated; argillaceous throughout, green-gray mudrock partings in lower 1 ft.
1374	C19	Vuggy dolomudstone, medium-brown-gray, coarsely-crystalline, cherty, with sparse to abundant green-gray mudrock partings and fine-grain, well-sorted, well-rounded, mud-supported quartz.
Bottom of described interval, TD at 2251 ft.		

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Indiana Gas & Water Co., Inc., C. P. Ross #1, Gr. 93-T1S-R7E, Clark Co., Ind., elev. 482 ft., IGS C332, NX core 1360-1481 ft., described 1393-1481 ft.

Depth (ft.)	Litho-facies	Description/Comments
	C12	Argillaceous calcimudstone, medium-brown-gray, microcrystalline; abundant anastomosing, thin-laminae of brown mudrock; stringers of ostracodal pack/grainstone throughout.
1395		
	C10	Patterned calcimudstone, medium-green-gray to medium-brown-gray, microcrystalline, dense; abundant argillaceous mottles throughout; upper contact sharp, lower gradational.
1400		
	C12	Argillaceous calcimudstone, medium-brown-gray, microcrystalline; abundant anastomosing, thin-laminae of brown mudrock; stringers of ostra-codal pack/grainstone throughout.
1405		
	C9	Intraclastic grainstone, light-brown-gray to light-green-gray, fine-grain to pebble-size, subrounded to angular, poorly-sorted quartz and intraclasts of chalky dolomudstone; lower contact sharp, upper gradational.
	C12/C2	Massive calcimudstone medium-brown, grading upsection to chalky dolomudstone, light-yellow-gray.

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Indiana Gas & Water Co., Inc., C. P. Ross #1, Clark Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C3	Laminated dolomudstone, light-brown-gray, micro-crystalline, porous, with laminae of brown mudrock, 1" of brown, organic-bearing mudrock at base.
	C10	Patterned calcimudstone, light-brown-gray to light-green-gray, microcrystalline; mottled through-out; 0.5" of green argillaceous mudrock at base.
1410	C8	Ostracodal pack/wackestone, medium-brown-gray, microcrystalline, sparse to abundant ostra-codes.
		No core 1410-1413 ft.
	C2	Chalky dolomudstone, light-yellow-gray, silty, microporous.
1415	C8	Ostracodal wackestone, brown-gray, microcrystal-line, mottling increasingly developed upsection; lower contact stylolitic, upper contact gradational.
	C12	Argillaceous calcimudstone, medium-brown-gray to light-green-gray, microcrystalline; abundant thin-laminae of green mudrock; stringers of ostracodal pack/grainstone locally; 3" green mudrock interbed at base.
	C17	Bioclastic grainstone/packstone, medium-brown-gray, fine-grain, poorly-sorted, subangular to sub-rounded bioclasts and intraclasts; grains are mostly mud-supported in upper 6"; contacts sharp.
1420	C10	Patterned dolomudstone, medium-brown-gray and light-green-gray, microcrystalline, calcareous; mottled throughout; 1" interbed of brown mudrock at base.
	C12	Argillaceous calcimudstone, medium-brown-gray to light-green-gray, microcrystalline; abundant thin-laminae of green mudrock; stringers of ostracodal

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Indiana Gas & Water Co., Inc., C. P. Ross #1, Clark Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		pack/grainstone locally.
1425		
	C10	Patterned dolomudstone, medium-brown-gray and light-green-gray, microcrystalline, calcareous.
	C16	Stylolaminated calcimudstone, medium-brown-gray, microcrystalline, abundant subhorizontal stylolites; siliceous in lower 2 ft., light-gray chert nodule at 1428 ft.
1430	C6	Mottled dolomudstone, medium-brown-gray, micro-crystalline, locally argillaceous and pyritic; mottled throughout; 0.5" brown mudrock interbed at 1432'6".

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Indiana Gas & Water Co., Inc., C. P. Ross #1, Clark Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1435		
	C16	Stylolaminated calcimudstone, medium-brown-gray, microcrystalline, abundant subhorizontal stylolites; upper and lower contacts sharp and stylolitic.
	C1/C10	Quartzose patterned dolowackestone, medium-brown-gray and light-green-gray; sparse to abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz.
	C16	Stylolaminated calcimudstone, medium-brown-gray, microcrystalline, abundant subhorizontal stylolites; upper and lower contacts sharp and stylolitic.
1440	C1	Quartzose patterned dolowackestone, medium-brown-gray and light-green-gray; sparse to abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz.
	C16	Stylolaminated calcimudstone, medium-brown-gray, microcrystalline, abundant subhorizontal stylolites; upper and lower contacts sharp and stylolitic.
	C10/C1	Quartzose patterned dolowackestone, medium-brown-gray and light-green-gray; sparse to abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz.
1445		
	C12	Calcimudstone, medium-brown-gray, microcrystalline, sparse subhorizontal stylolites; 1" of green mudrock at base, lower contact sharp, upper contact is gradational.

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Indiana Gas & Water Co., Inc., C. P. Ross #1, Clark Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1450	C12	Argillaceous calcimudstone, medium-brown-gray, abundant anastomosing laminae of brown mudrock.
	C12/C11	Argillaceous fenestral calcimudstone, medium-brown-gray and light-green-gray, microcrystalline; vertical fenestrae are infilled by green-gray mudrock; 1" interbed of brown mudrock at base.
1455	C12	Argillaceous dolomudstone, light- to medium-green-gray, microcrystalline, abundant quartz silt; some fine-grain, well-rounded quartz in lower 5 ft.; very-thin interbed of green-gray mudrock, nonfissle at 1444 and 1456'2"; 1" interbed of intraclastic dolo-grainstone at base containing fine- to coarse-grain, angular poorly-sorted, dolomudstone intraclasts.
1460	C3	Laminated dolomudstone, light-green-gray to light-yellow-brown, microcrystalline, planar laminae of brown mudrock at 1458-1458'3", and 1459'1"-1459'4".
	C12	Argillaceous dolomudstone, light- to medium-green-gray, microcrystalline, abundant quartz silt, sparse fine-grain, well-rounded quartz throughout; thin interlaminae of green-gray mudrock 1462'-1463'; 5" of intraclastic dolograinstone at base containing fine- to coarse-grain, angular dolomudstone and green mudrock intraclasts.

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Indiana Gas & Water Co., Inc., C. P. Ross #1, Clark Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1465	M2	Green mudrock, nonfissle, pyritic, abundant quartz silt.
	C12/C11	Argillaceous fenestral calcimudstone, medium-green-gray and light-green-gray, microcrystalline; vertical fenestrae are infilled by green-gray mudrock.
1470	C12	Argillaceous dolomudstone, light- to medium-green-gray, microcrystalline, abundant quartz silt; sparse to abundant fine-grain, well-rounded, mud-supported quartz; mottled in upper 2 ft., vertical burrow traces locally; upper contact gradational.
	S13	Lithic arenite, light-green-gray, mostly very-fine- to fine-grain, well-rounded, well-sorted quartz; silty, dolomicrite cemented; abundant green-gray intergranular clay; fine-grain to pebble-size intraclasts of dolomudstone and silicified ooids locally.
	S10/S13	Massive quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; grading upsection to argillaceous lithic arenite with intraclasts of silicified oolitc grainstone and dolomudstone; vertical burrows at top.
1475	S10/S13	Massive quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; grading upsection to argillaceous lithic arenite with intraclasts of silicified oolitc grainstone and dolomudstone; vertical burrows at top.
	S13	Lithic quartz arenite, light-green-gray, fine- to medium-grain, well-rounded, well-sorted quartz; silty, argillaceous, abundant green-gray intergranular clay; fine-grain to pebble-size intraclasts of dolomudstone and silicified oolitic grainstone decrease in

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Indiana Gas & Water Co., Inc., C. P. Ross #1, Clark Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		abundance upsection; vertical burrows (*Skolithos*?) at upper contact infilled by quartz arenite, light-medium gray, fine- to medium-grain, well-sorted, well-rounded quartz.
1480	C19	Dolomudstone, brown-gray, finely-crystalline, with laminae of green-gray mudrock; vug infilled by argillaceous quartz arenite at 1480 ft.
1431		
		Bottom of cored interval, TD at 1608 ft.

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Buttercup Energy, R. Pensinger 1, Sec. 32-T10N-R6W, Clay Co., Ind., elev. 595 ft., IGS Core 640, 3.5-inch core 3169-3194 ft.

Depth (ft.)	Litho-facies	Description/Comments
3170	C12	Argillaceous dolomudstone, medium-brown-gray, microcrystalline, sparsely mottled; sparse to moderately-abundant mudrock partings locally; 1" stinger of intraclastic dolopackstone at base.
	C4	Stomatolitic dolomudstone, light-yellow-brown, micro-crystalline, planar and anastomosing laminae of brown mudrock; chalky, clotted fabric.
	C12	Argillaceous dolomudstone, medium-brown-gray, microcrystalline, sparsely mottled; sparse to moderately-abundant mudrock partings locally; biomolds after ostracodes in upper 6", infilled with crystalline calcite.
3175	C10	Patterned dolomudstone, medium-brown-gray with green-gray mottles, microcrystalline, fluid-escape structure.
	C4	Stomatolitic dolomudstone, light-yellow-brown, micro-crystalline, planar and anastomosing laminae of brown mudrock; chalky, clotted fabric.
	C10	Patterned dolomudstone, medium-brown-gray with green-gray mottles, microcrystalline, abundant burrow traces at 3178 ft.
3180	C12	Argillaceous dolomudstone, medium-brown-gray, microcrystalline, sparsely mottled; sparse to moderately-abundant mudrock partings locally; stringer of intraclastic dolograinstone at base.
	C4	Stomatolitic dolomudstone, light-yellow-brown, micro-crystalline, planar and anastomosing laminae of brown mudrock; chalky, clotted fabric; locally vuggy and brecciated; vugs infilled with coarsely-crystalline calcite.

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Buttercup Energy, R. Pensinger 1, Clay Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C12	Argillaceous dolomudstone, very dark-brown-gray, microcrystalline, sparsely mottled; sparse to moderately-abundant mudrock partings locally; biomolds after ostracodes in upper 6", infilled with crystlline calcite; 2" stringer of fine-grain quartz arenite at base.
3185		
	C10	Patterned dolomudstone, green-gray to medium-brown-gray, microcrystalline, abundant argillaceous green-gray mottles
	S15	Argillaceous quartz arenite, green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by dolomicrite and crystalline calcite.
3190	C1/C10	Quartzose patterned dolomudstone, green-gray to medium-brown-gray, microcrystalline, abundant argillaceous green-gray mottles; fluidization structures; sparse to abundant fine-grain, well-sorted, well-rounded, mud-supported quartz throughout; large mudcrack infilled by coarse-grain quartz arenite.
	C12	Argillaceous dolomudstone, very dark-brown-gray, microcrystalline, sparsely mottled; abundant brown mudrock partings throughout; stringer of intraclastic quartzose dolopackstone at base.
	C1/C10	Quartzose patterned dolomudstone, light-brown-gray, microcrystalline, porous, abundant argillaceous green-gray mottles; fluidization structures; sparse to abundant fine-grain, well-sorted, well-rounded, mud-supported quartz throughout.
3194		
Bottom of cored interval, TD at 2640 ft.		

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Gulf Oil Co., F. Osborne 1, Sec. 33-T12N-R11E, Decatur Co., Ind., elev. 1061 ft., IGS Core 316, 4-inch core 1525-1575 ft.

Depth (ft.)	Litho-facies	Description/Comments
	C10	Patterned dolomudstone, medium-green-gray to light-green-gray, microcrystalline, argillaceous sparse vertical burrows.
		No core 1526-1526'4".
	S9	Mottled quartz arenite, light-green-gray to light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by dolomicrite; abundant mottling, patterned appearance.
	C12	Argillaceous dolomudstone, dark-green-gray, microcrystalline, very argillaceous, somewhat fissle.
1530	S4	Cross-stratified quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by dolomicrite cement; abundant low-angle cross-laminae.
	S9	Mottled quartz arenite, light-green-gray to light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by dolomicrite; abundant mottling, patterned appearance.
	C12	Argillaceous dolomdustone, dark-green-gray, microcrystalline, very argillaceous, somewhat fissle.
	S10	Massive quartz arenite, light-medium-gray, medium-grain, well-sorted, well-rounded quartz; well-indurated by dolomicrite; stringers of lithic arenite with dolomudstone intraclasts at 1535'3", 1534' and 1533'; quartz grains are locally mud-supported 1534'7"-1534'11".
1535		
	C2/S10	Interbedded dolomudstone, light-yellow-brown, microcrystalline, featureless, and massive quartz arenite, very-light-gray to white, fine-grain to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; quartz arenite is thin- to medium-bedded, dolomudstone is medium-bedded; arenite beds fine-upward.

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Gulf Oil Co., F. Osborne 1, Decatur Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arente grading upsection to stromatolitic dolomudstone with brown mudrock
1540		laminae; quartz arenite is very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz, well-indurated by dolomicrite cement, grains are increasingly mud-supported upsection; dolomudstone is light-medium-gray to light-yellow-brown, microcrystalline, microporous; mudcracks at upper contact infilled by quartz arenite.
	S4	Cross-stratified quartz arenite, medium-gray to light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to very-well-indurated by quartz overgrowths, abundant pore-filling calcite locally; well-developed and abundant low-angle cross-laminae.
1545	S4	Cross-stratified quartz arenite, medium-gray, medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by sparse quartz overgrowths and pore-filling calcite; abundant low-angle cross-stratification.
	S10	Massive quartz arenite, medium-gray with laminae of light-medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths and pore-filling calcite.
1550	S3	Cross-stratified quartz arenite, medium-gray, medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by sparse quartz overgrowths and pore-filling calcite; abundant low-angle cross-stratification.

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Gulf Oil Co.. F. Osborne 1, Decatur Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1555	S9	Mottled quartz arenite, light-medium-gray and medium-gray, fine- to very fine-grain, well-sorted and rounded quartz; sparse quartz overgrowths, sparse to abundant crystalline calcite cement; calcite cement distributed in thick planar laminae - gives banded appearance; sparse mottling.
	S4	Cross-stratified quartz arenite, medium-gray, medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by sparse quartz overgrowths and pore-filling calcite; abundant low-angle cross-stratification; ostracod-bearing stinger at 1557'10".
		No core 1558-1568 ft.
1568	S4	Cross-stratified quartz arenite, medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant planar cross-laminae.
	S9	Mottled quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated, sparse to abundant quartz overgrowths and patchy, pore-filling calcite; sparse mottling.
1570	S4	Cross-stratified quartz arenite, medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant planar cross-laminae.
	S9	Mottled quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated, sparse to abundant quartz overgrowths and patchy, pore-filling calcite; sparse mottling.
	S4	Cross-stratified quartz arenite, medium-gray, medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant planar cross-laminae.

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Gulf Oil Co., F. Osborne 1, Decatur Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	M1	Conglomeratic mudrock, medium-green-gray.
1575	C19	Cherty dolomudstone, light-brown-gray, crystalline.
Bottom of cored interval; TD at 1772 ft.		

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Northern Indiana Power Co., E. L. Morphet 1, Sec. 17-T29N-R1E, Fulton Co., Ind. elev. 758 ft., IGS Core 437, NX core 1007-3023 ft., described 1375-1445 ft.

Depth (ft.)	Litho-facies	Description/Comments
1375	S15	Argillaceous quartz arenite, medium-brown-gray, medium- to fine-grain, moderately-sorted, well-rounded, quartz; abundant anastomosing dark-brown mudrock partings; stringers of oolitic grainstone.
	C17	Bioclastic pack/wackestone, medium-brown-gray, abundant fine-grain to pebble-size intraclasts and bioclasts.
1380		
	M5	Organic-bearing mudrock, brown, calcareous, fissle to thin-bedded.
	C17	Bioclastic dolopack/grainstone, medium-brown-gray, abundant fine-grain to pebble-size intraclasts and bioclasts; sharp lower contact.
	C12	Argillaceous grainstone grading upsection to fenestral calcimudstone, light-green-gray to medium-brown-gray, upper contact is burrowed hardground; abundant fine- to coarse-grain intraclasts in lower 8".
	C11/C12	Argillaceous fenestral calcimudstone, light-green-gray, upper contact burrowed.
1385	C8	Ostracodal pack/wackestone, medium-brown-gray; sparse to abundant complete ostracodes.
	C10	Patterned dolomudstone, light-green-gray to medium-brown-gray, microcrystalline, upper contact burrowed.
	C8	Ostracodal dolowackestone, light-brown-gray, micro-crystalline, abundant calcite-infilled biomolds after ostracodes, some calcite-infilled fenestrae.

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Northern Indiana Power Co., E. L. Morphet 1, Fulton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C12	Argillaceous dolomudstone, light-brown-gray, finely-crystalline; sparse to abundant, thin-partings of brown-mudrock.
1390		
	C8	ostracodal dolowackestone, light-brown-gray, micro-crystalline, abundant calcite-infilled biomolds after ostracodes, some calcite-infilled fenestrae.
	C12	Argillaceous dolomudstone, light-brown-gray, finely-crystalline; sparse to abundant, thin-laminae of brown-mudrock.
1395	C8	ostracodal dolowackestone, light-brown-gray, micro-crystalline, abundant calcite-infilled biomolds after ostracodes, some calcite-infilled fenestrae; 1" brown mudrock bed at base.
	C10	Patterned dolomudstone, light-brown-gray to green-gray, microcrystalline, sparse calcite-infilled biomolds after ostracodes, mottled throughout.
	C12	Argillaceous dolomudstone, light-brown-gray, finely-crystalline; sparse to abundant, thin-laminae of green-mudrock.
1400		
	C11	Fenestral dolomudstone, light-green-gray, micro-crystalline; sparse to abundant, calcite-infilled vertical fenestrae.
	C1	Quartzose dolowackestone, medium-brown-gray, finely-crystalline, sparse to moderately-abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz.

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Northern Indiana Power Co., E. L. Morphet 1, Fulton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1405	C12	Argillaceous dolomudstone, dark-green-gray, sparse fine-grain, well-rounded, well-sorted quartz; very argillaceous, thin-bedded to fissle.
	C1	Quartzose dolopackwackestone, medium-brown-gray, sparse to abundant, fine- to medium-grain, well-sorted, well-rounded, mud-supported quartz; stringers of quartz arenite locally; quartz grains in lower 8" are grain-supported; upper contact sharp and irregular, lower contact gradational.
1410	S15	Argillaceous quartz arenite, green-gray, fine- to *medium-grain, biomodal sorting, well-rounded quartz*; friable to weakly-indurated.
	M6	Argillaceous siltstone, medium-green-gray, abundant green-gray clay; upper and lower contacts gradational.
	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline, abundant green-gray mudrock partings, thin-bedded to fissle.
1415		*Skolithos*-bearing quartz arenite, green-gray, fine- to medium-gray, well-sorted, well-rounded quartz matrix with abundant *Skolithos* burrows infilled by medium-grain, poorly-sorted, well-rounded quartz; burrow fill more indurated than matrix; upper contact sharp, lower contact gradational.
	S8	

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Northern Indiana Power Co., E. L. Morphet 1, Fulton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline, abundant green-gray mudrock partings, thin-bedded to fissle.
	M6	Argillaceous siltstone, medium-green-gray, abundant green-gray clay; upper and lower contacts gradational.
1420	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly indurated, sprasely argillaceous.
	S15	Argillaceous quartz arenite, light-yellow-gray to light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; increasingly argillaceous upsection, upper contact sharp and burrowed.
1425	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; sparse to abundant mottling; bivalve biomolds locally.
		No core 1425'6"-1426'6".
	S15	Argillaceous quartz arenite, medium-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, abundant green-gray mudrock partings up to 1" thick.
	S8	*Skolithos*-bearing quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-sorted quartz; friable, locally well-indurated by sulfide; abundant, small diameter (<0.2"), open *Skolithos* burrows.
1430	S8	*Skolithos*-bearing quartz arenite, light-medium-gray, fine- to medium-grain, moderately- to well-sorted, quartz; moderately-indurated by quartz overgrowths; abundant, small diameter (<0.2"), open *Skolithos*

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Northern Indiana Power Co., E. L. Morphet 1, Fulton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		burrows.
	S2	Dolomitic quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by dolomicrite; bed cross-cut by large diameter (0.25") *Skolithos* burrow infilled with medium-grain, well-rounded and sorted quartz moderately-indurated by quartz overgrowths.
	S8	*Skolithos* -bearing quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-sorted quartz; moderately-indurated by quartz over-growths; abundant, small diameter (<0.2"), open *Skolithos* burrows; sparse, fine- to coarse-grain, subangular to subrounded, microcrystalline chert.
1435		
	S8	*Skolithos* -bearing quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-sorted quartz; moderately-indurated by quartz over-growths; abundant, small diameter (<0.25"), *Skolithos* burrows infilled by medium-grain quartz arenite; sparse to moderately-abundant, fine- to coarse-grain, subangular to subrounded, micro-crystalline chert.
	M1	Conglomeratic mudrock, green-gray, grading up-section to argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse to abundant, fine-grain to pebble-size, subangular to subrounded chert and dolomudstone intraclasts.
1440	C19	Vuggy dolomudstone, medium-brown-gray with green-gray argillaceous partings, finely- to coarsely-crystalline, cherty, vuggy.

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Northern Indiana Power Co., E. L. Morphet 1, Fulton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1445		
Bottom of described interval, TD at 3023 ft.		

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Citizens Byproducts Coal Co., L. & M. Bishop 1, Sec. 12-T14N-R1E, Hendricks Co., Ind., elev. 766 ft., IGS Core 186; core chips 1793-1802 ft.

Depth (ft.)	Litho-facies	Description/Comments
	C1	Quartzose dolopack/wackestone, medium-brown-gray to medium-green-gray, microcrystalline, sparse to abundant fine- to coarse-grain, well-rounded quartz and rare, medium-grain, silicified ooids; abundance of grains decreases upsection; argillaceous throughout.
1795		
	M1	Conglomeratic mudrock, green-gray mudrock matrix with fine-grain to cobble-sized, angular to subangular, microcrystalline chert and vuggy dolomudstone; fused breccia 1796-1796'8".
	C19	Vuggy dolomudstone, green-gray to medium-brown-gray, finely-crystalline; very vuggy to rubbly; sparse to abundant partings of pyritic green mudrock; sparse to abundant, microcrystalline chert, white to light-gray, opaque.
1800		
1802		
Bottom of cored interval, TD at 1972 ft.		

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NIPSCO, H. & L. Boezman #1, Sec. 6-T31N-R7W, Jasper Co., Ind., elev. 668 ft., IGS C435, NX core 1260-1345 ft.

Depth (ft.)	Litho-facies	Description/Comments
1260	S9	Mottled quartz arenite, green-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; argillaceous mottles throughout.
	C1	Quartzose dolowacke/packstone, light-yellow-brown, abundant, fine- to medium-grain, poorly-sorted, well-rounded, mostly mud-supported quartz; mottled throughout.
	S15	Argillaceous quartz arenite, medium-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; friable, abundant green-gray clay; massive.
	C11	Fenestral dolomudstone, light-green-gray, micro- to finely-crystalline, abundant calcite-spar infilled vertical burrows.
1265	C10	Patterned dolomudstone, light-medium-brown, microcrystalline, mottled throughout; locally pyritic; stringers of ostracodal dolopackstone at base with biomoldic porosity.
		No core 1267-1268 ft.
	S8	*Skolithos* -bearing quartz arenite, light-yellow-gray with green-gray burrow infills; fine- to medium-grain, poorly-sorted, well-rounded quartz matrix; *Skolithos* burrows infilled with green mudrock.
1270	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz over-growths; no discernable sedimentary structures or lithologic breaks to 1285 ft.

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NIPSCO, Inc., H. & L. Boezman #1, Jasper Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1275		
1280		
1285		
	S14	Silty quartz arenite, light-yellowish-gray, fine-grain, very-well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; massive.
	S4/S3	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; abundant planar and low-angle cross-laminae.

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NIPSCO, Inc., H. & L. Boezman #1, Jasper Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1290		
	S10	Massive quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths.
	S3	Planar cross-stratified quartz arenite, light-yellow-gray, fine-grain, well-sorted, well-rounded quartz; well-defined, thin, planar laminae.
1295		
	S10	Massive quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; vague, poorly-defined cross-laminae locally.
1300		

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NIPSCO, Inc., H. & L. Boezman #1, Jasper Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S15	Argillaceous quartz arenite, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated; sparsely argillaceous throughout.
1305		
	S3/S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; abundant planar and low-angle cross-laminae.
1310		
1315		

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NIPSCO, Inc., H. & L. Boezman #1, Jasper Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1320		
1325		
	S15	Argillaceous quartz arenite, medium-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; well-indurated by abundant quartz overgrowths; green-gray mudrock partings locally.
	S10	Massive quartz arenite, medium- to coarse-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths.

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NIPSCO, Inc., H. & L. Boezman #1, Jasper Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1330		
	S13	Lithic quartz arenite, medium-gray, medium- to coarse-grain, moderately-sorted, well-rounded quartz; sparse to abundant, fine- to coarse-grain, subangular to subrounded intraclasts of light-medium-gray, microcrystalline, nodular chert.
	S15	Argillaceous quartz arenite, medium-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; well-indurated by abundant quartz overgrowths; green-gray mudrock partings locally.
1335		
1340		
	C19	Dolomudstone, light-brown-gray, finely-crystalline, vuggy; abundant nodules of microcrystalline chert.

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NIPSCO, Inc., H. & L. Boezman #1, Jasper Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1345		
Bottom of cored interval, TD at 3661 ft.		

Note: Quartz arenites from 1325.5-1342 ft. are atypical for St. Peter Sandstone. These arenites are darker colored, more uniformly coarser-grained, and more indurated then the St. Peter Sandstone. Top of Knox Dolimite Group is at 1325'6". Quartz arenite/dolostone contact at 1342" is probably the Oneota-New Richmond Sandstone disconformity.

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Shell Oil Co., L & R, Inc. 1-24, Sec. 24-T38N-R10E, La Grange Co., Ind., elev. 944 ft., IGS Core 675, slabbed 4" core 2920-2980 ft., described 2932.5-2980 ft.

Depth (ft.)	Litho-facies	Description/Comments
2935	C10	Patterned calcimudstone, medium-brown-gray, microcrystalline, slightly argillaceous, large (0.5-1") diameter, vertical burrows, upper contact is a hardground; sparse fine-grain quartz in lower 6".
	S16	Bioclastic quartz arenite, medium-brown-gray, medium- to coarse-grain, well-sorted, well-rounded quartz; well-indurated by dolomicrite; moderately abundant spiriferid brachiopods; abundant interstitial sulfide; upper contact gradational, lower contact sharp.
	C1	Quartzose packstone, medium-brown-gray, medium- to coarse-grain, well-rounded, moderately-sorted, mud-supported quartz; argillaceous mottling throughout; sparse ostracode and brachiopod bio-clasts.
2940	M2	Green mudrock, pyritic, locally fissle; pyritic, fiborous conodonts on bedding planes locally; lower and upper contacts are sharp and irregular.
	C8	Ostracodal calicwackestone, medium-brown-gray, microcrystalline, sparse to abundant, complete ostracodes; brown mudrock partings locally; upper contact is pitted with clay-lined vertical burrows; lower contact gradational, upper contact is hardground.
2945		

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Shell Oil Co., L & R, Inc. 1-24, La Grange Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
2950	C12	Argillaceous wackestone with stringers of bioclastic packstone, medium-brown-gray, abundant thin-laminae of brown mudrock; sparse to rare, complete ostracodes.
	C9	Intraclastic pack/grainstone, light-brown-gray, fine- to coarse-grain, poorly-sorted, subangular to rounded intraclasts and bioclasts; sparse to abundant partings of brown mudrock; abundance of partings and intraclasts decreases upsection.
2955	C19	Vuggy dolomudstone, medium-gray, finely-crystalline, abundant, irregular vugs (0.1-0.25"), commonly infilled with crystalline dolomite; some biomolds locally.
2960		

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Shell Oil Co., L & R, Inc. 1-24, La Grange Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
2965		
2970	C12	Dolomudstone, medium-brown-gray to yellow-brown, finely-crystalline, sparse mudrock laminae, pyritic; biomoldic porosity 2971-2974 ft.
2975		

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Shell Oil Co., L & R, Inc. 1-24, La Grange Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4/S5	Cross-stratified quartz arenite, light-medium-gray to light-yellowish-brown, fine- to medium-grain, bimodal, well-rounded quartz; well-indurated by quartz over-growths; abundant low-angle and ripple cross-laminae.
2980	C9	Dolowackestone, light-brown-gray, finely-crystalline, sparse bioclasts; healed fracture.
Bottom of described interval, TD at 4737 ft.		

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Northern Indiana Power Co., A. Knapp 1, Sec. 15-T31N-R8W, Newton Co., Ind., elev. 675 ft., IGS Core 234, NX core 108-1382 ft., described 1246-1380 ft.

Depth (ft.)	Litho-facies	Description/Comments
	C6	Mottled dolomudstone, dark-gray to light-brown-gray, microcrystalline, mottled throughout; sulfide nodule at 1248'10", chert nodules at 1248'9" and 1251'3".
1250		
	C8	Ostracodal dolowacke/packstone, light-brown-gray, microcrystalline, somewhat earthy; abundant biomoldic and microporosity, bimoldic porosity predominantly after ostracodes and occurs in pack-stone stringers; sulfide infills biomolds and inter-crystalline porosity locally; cherty in lower 1 ft.
1255		

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Northern Indiana Power Co., A. Knapp 1, Newton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1260		
	C1	Quartzose dolowacke/packstone, light-brown-gray, microcrystalline, abundant fine- to medium-grain, well-sorted, well-rounded quartz present as isolated mud-supported grains and as thin (<0.25") stringers; sparse, small diameter (<0.25") vertical burrows; well-indurated by dolomicrite.
		No core 1263-1281 ft.
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; featureless, except for vague, discontinuous, low-angle cross-laminae locally.
1285		

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Northern Indiana Power Co., A. Knapp 1, Newton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1290	S10	
		No core 1291'2"-1291'8"
	S4	Cross-stratified quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowth cement; abundant low-angle, well-defined cross-laminae.
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; sparse, intergranular, pore-filling sulfide locally.
1295		
		No core 1296'1"-1296'9"
	S4	Cross-stratified quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowth cement; abundant low-angle, well-defined cross-laminae.
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; sparse, intergranular, pore-filling sulfide locally.
1300		
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; featureless, except for vague, discontinuous, low-angle cross-laminae locally.

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Northern Indiana Power Co., A. Knapp 1, Newton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1305	S10	
1310		
1315		

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Northern Indiana Power Co., A. Knapp 1, Newton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S14	Silty quartz arenite, light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz; abundant quartz silt; weakly- to moderately-indurated, sparsely argillaceous; rubbly.
1320	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; featureless, except for vague, discontinuous, low-angle cross-laminae locally.
	S14	Silty quartz arenite, light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz; abundant quartz silt; weakly- to moderately-indurated, sparsely argillaceous; rubbly.
1325	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; featureless, except for vague, discontinuous, low-angle cross-laminae locally.
1330		

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Northern Indiana Power Co., A. Knapp 1, Newton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; sparse to abundant sulfide, present as irregular masses (<1"), isolated pore-filling cement, and laterally persistent cement along possible laminae.
1335		
		No core 1337-1337'4".
	S4	Cross-stratified quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; abundant low-angle cross-laminae.
	S10	Massive quartz arenite, white to light-medium-gray, fine-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
1340		
		No core 1341-1341'6"
	S4	Cross-stratified quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; abundant low-angle cross-laminae.
	S10	Massive quartz arenite, white to light-medium-gray, fine-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
1345		
	S15	Argillaceous quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-

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Northern Indiana Power Co., A. Knapp 1, Newton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		rounded quartz; moderately-indurated by quartz overgrowths; green-gray mudrock partings locally, sulfide locally present; lower contact is sharp.
	S4	Cross-stratified quartz arenite, light-medium-gray, and light-yellowish-gray, fine- to medium-grain, well-sorted and rounded quartz; moderately- to weakly-indurated by quartz overgrowths; abundant low-angle cross-laminae; mean grain-size increases upsection, coarser-grain intervals have weak limonite stain.
1350		
1355		
	S4	Cross-stratified quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; abundant low-angle cross-laminae; thin-bedded with sparse, thin interbeds of massive quartz arenite; lower contact sharp and irregular, upper contact gradational.
1360		

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Northern Indiana Power Co., A. Knapp 1, Newton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	
		No core 1364'-1364-6"
1365	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; sparse, *Skolithos* burrows infilled by fine- to medium-grain, moderately-sorted, well-rounded quartz; burrow infill is well-indurated by quartz overgrowths.
		No core 1366'9"-1366'11"
	S10	Massive quartz arenite, white to light-medium-gray, fine-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
		No core 1367'9"-1368'.
	S10	Massive quartz arenite, white to light-medium-gray, fine-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
		No core 1369-1369'5"
1370	S10	Massive quartz arenite, white to light-medium-gray, fine-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
		No core 1370'3"-1370'9"
	S13	Lithic quartz arenite, light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse, angular intraclasts of green mudrock; well-indurated by quartz overgrowths.
	S4	Cross-stratified quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; abundant low-angle cross-laminae; sparse, fine-grain to pebble-size, angular intraclasts of green mudrock.
	M1	Conglomeratic mudrock, green-gray, pyritic, nonfissle; sparse to abundant, fine- to coarse-grain, poorly-sorted, well-rounded quartz; sparse, fine-grain, well-

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Northern Indiana Power Co., A. Knapp 1, Newton Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		sorted silicified ooids: pseudo-slickensides locally.
1375	C19	Vuggy dolomudstone, medium-brown-gray to light-green-gray, coarsely-crystalline, sparse to abundant green-gray mudrock partings 0.2-1" thick; sparse to abundant irregular vugs (0.1-1"); silicified ooids and nodular chert locally
1380		
Bottom of cored interval and TD.		

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NIPSCO, Helen Ames 1, Sec. 21-T24N-R3E, Marshal Co., Ind.,
elev. 789 ft., IGS C455; core chips 1730-1785 ft., described 1730-1770 ft.

Depth (ft.)	Litho-facies	Description/Comments
1730		Bioclastic packstone, light-brown-gray, micro-crystaline, nonporous, micritic, sparse to abundant complete brachiopods, bryzoa and ostracodes; sparse to common, green-gray mudrock-partings at base that decrease in abundance upsection.
1735		
		Ostracodal dolowackestone, medium-brown-gray to brown-gray, finely-crystalline, minor intercrystalline porosity; sparse to abundant biomoldic porosity after ostracodes; minor iron sulfide mineralization.
1740		Ostracodal dolowackestone, medium-brown-gray to brown-gray, finely-crystalline, minor intercrystalline porosity; sparse biomoldic porosity after ostracodes; locally peloidal.

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NIPSCO, Helen Ames 1, Marshal Co., Ind. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
1745		
		Ostracodal dolopack/wackestone, medium-brown-gray to brown-gray, finely-crystalline, minor inter-crystalline porosity; sparse to abundant biomoldic porosity after ostracodes; minor iron sulfide mineralization.
1750		
		Massive quartz arenite, very-light-gray to yellowish-gray, fine-grain, well-sorted, well-rounded quartz; friable to moderately-indurated by quartz over-growths.
1755		
		Low-angle cross-stratified quartz arenite, very-light-gray to yellowish-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; vague low-angle cross-stratification.

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NIPSCO, Helen Ames 1, Marshal Co., Ind. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
1760		Vuggy dolomudstone, medium-green-gray to light-brown-gray, medium-crystalline, high intercrystalline and vugular porosity.
1765		Cherty vuggy dolomudstone, medium-green-gray to light-brown-gray, medium-crystalline, high inter-crystalline and vugular porosity; sparse to abundant, white, microcrystalline stromatolitic chert, locally chalky.
1770		
Bottom of described interval; TD at 4082 ft.		

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General Electric, Wast Disposal 2, Sec. 19-T7S-R13W, Posey Co., Ind., elev. 395 ft., IGS Core 495, 4-inch core 7865-7905 ft.

Depth (ft.)	Litho-facies	Description/Comments
	S9	Mottled quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; vertical burrow (*Skolithos* ?) trace cross-cuts bed.
	S9	Mottled quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; sparse to abundant, black mudrock partings, locally stylolitic.
	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, well-sorted quartz; very well-indurated by quartz overgrowths; sparse, anastomosing, laterally discontinuous black mudrock partings.
7870	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by quartz overgrowths; argillaceous throughout.
	S8	*Skolithos* -bearing quartz arenite, light-green-gray to light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; well-indurated by quartz overgrowths; sparse, large diameter *Skolithos* burrows infilled by medium-grain quartz arenite.
	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, well-sorted quartz; very well-indurated by quartz overgrowths; sparse, anastomosing, laterally discontinuous dolomicrite laminae.
7875	S10	Massive quartz arenite, light-medium-gray to light-yellowish-brown, fine- to medium-grain, well-sorted quartz; very well-indurated by quartz overgrowths, locally weakly-indurated; abundant black mudrock partings associated with stylolites.
	C1	Quartzose dolopack/grainstone, very dark-brown, finely-crystalline; abundant fine- to medium-grain, well-rounded, well-sorted, grain-supported quartz;

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General Electric, Wast Disposal 2, Posey Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		well-indurated by dolomicrite.
7880	C12	Argillaceous quartz arenite, light-medium-gray to light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz over-growths; abundant to sparse black mudrock partings, decreasing in abundance upsection; bounding contacts are sharp.
	C9	Intraclastic dolopack/grainstone, medium-brown-gray, finely-crystalline; abundant fine- to coase-grain, well-rounded, poorly-sorted, mostly mud-supported quartz; abundant coarse-grain to cobble-size, sub-angular to subrounded intraclasts of dolomudstone; conglomeratic at base.
7885	C1	Quartzose dolowacke/mudstone, dark-brown-gray, finely-crystalline; sparse to locally abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz; stylolites locally; upper contact has large mudcracks infilled with medium-grain quartz arenite.
7890	S13	Lithic quartz arenite, medium-gray to light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse to abundant, coarse-grain to cobble-size, subangular intraclasts of dolomudstone; clasts exhibit soft sediment deformation.
	C1	Quartzose dolowacke/mudstone, dark-brown-gray, finely-crystalline; sparse to locally abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz; stylolites locally; upper contact has large mudcracks infilled with medium-grain quartz arenite.
	C9	Intraclastic dolopack/grainstone, medium-brown-gray, finely-crystalline; abundant fine- to coase-grain, well-rounded, poorly-sorted, mostly mud-supported

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General Electric, Wast Disposal 2, Posey Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		quartz: abundant coarse-grain to cobble-size, sub-angular to subrounded intraclasts of dolomudstone; conglomeratic at base, some clasts exhibit soft-sediment deformation; increasing quartz content; grades upsection to 4" of cross-stratified quartz arenite.
7895	C1	Quartzose dolowacke/mudstone, dark-brown-gray, finely-crystalline; sparse to locally abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz; stylolites locally; upper contact has large mudcracks infilled with medium-grain quartz arenite.
	C8	Ostracodal dolowackestone, medium-brown-gray, finely-crystalline, abundant complete, large ostracodes.
	C2	Massive dolomudstone, medium-brown-gray, finely- to coarsely-crystalline; sparse, fine-grain, well-sorted, well-rounded, mud-supported quartz; stylolitic in lower 2 ft.
7900		
	C1	Quartzose dolowacke/mudstone, dark-brown-gray, finely-crystalline; sparse to locally abundant, fine-grain, well-sorted, well-rounded, mud-supported quartz; stylolites locally.
7904		
Bottom of cored interval, TD at 7980 ft.		

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Gulf Oil Co., G. L. Coon 1, Sec. 20-T13N-R11E, Rush Co., Ind., elev. 1066 ft., IGS Core 325, 4-inch core 1515-1550 ft.

Depth (ft.)	Litho-facies	Description/Comments
	M2-C12	Dolomitic green mudrock, locally pyritic, abundant quartz silt and microcrystalline dolomite; thin-bedded to somewhat fissle.
	C1-C10	Quartzose patterned dolowackestone, medium-green-gray, microcrystalline; sparse, poorly-sorted, well-rounded, mud-supported quartz; argillaceous.
	M5	Organic-bearing mudrock, brown, somewhat fissle.
	C1/C10	Quartzose patterned dolowackestone, medium-green-gray, microcrystalline, argillaceous throughout; sparse to abundant, fine-grain, well-sorted, mud-supported quartz; mudcracks on upper bedding plane.
	M5	Organic-bearing mudrock, brown, somewhat fissle.
1520	C10/C12	Argillaceous patterned dolomustone, medium-green-gray, microcrystalline, motteld throughout.
	M5	Organic-bearing mudrock, brown, weakly fissle.
	C1	Quartzose dolowackestone grading upsection to dolograinstone; medium-green-gray, microcrystalline, argillaceous; sparse to abundant, fine- to medium-grain, moderately-sorted, well-rounded quartz, abundance of quartz grains increases upsection.
	M4	Organic-bearing mudrock, brown, 1" quartz arenite at top, iron-sulfide cemented locally.
	C1	Quartzose dolowackestone grading upsection to dolograinstone; medium-green-gray, microcrystalline, argillaceous; sparse to abundant, fine- to medium-grain, moderately-sorted, well-rounded quartz, abundance of quartz grains increases upsection.
	S1/S15	Argillaceous quartzose dolopackstone, medium-green-gray, microcrystalline, abundant green-gray mudrock partings, upper contact burrowed and pyritic.
1525	S4	Cross-stratified quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, pore-filling sulfide locally; abundant, well-defined, low-angle and planar cross-laminae; thin-interbeds have ripple cross-laminae.
	S4	Cross-stratified quartz arenite, very light-gray, fine-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths; weakly-defined

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Gulf Oil Co., G. L. Coon 1, Rush Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		planar and low-angle cross-laminae; medium-bedded.
	S4	
1530	S9	Mottled quartz arenite, light-medium-gray to light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated to friable, sparse quartz overgrowths, locally calcareous.
	S4	Cross-stratified quartz arenite, very light-gray, fine-grain, well-sorted, well-rounded quartz; very well-indurated by quartz overgrowths; weakly-defined planar and low-angle cross-laminae.
	S9	Mottled quartz arenite, light-medium-gray to light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated to friable, sparse quartz overgrowths, locally calcareous.
1535		
	S10	Massive quartz arenite, medium-light-gray to light-brown-gray, fine-grain, well-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths, locally calcareous; thin-bedded.
1540		

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Gulf Oil Co., G. L. Coon 1, Rush Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	
1545		
	C19	Vuggy dolomudstone, medium-gray, coarsely- to finely-crystalline; green-gray mudrock partings locally; sparse to moderately-abundant microcrystalline chert.
1550		
Bottom of cored interval, TD at 1564 ft.		

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Cominco-American, Ivan Hudson CA-53, Sec. 25-T29N-R6E, Wabash Co., Ind., elev. 773 ft., IGS Core 504, NX core 1430-1447 ft.

Depth (ft.)	Litho-facies	Description/Comments
1430	C1	Quartzose dolowacke/packstone, light-medium-gray to light-brown-gray, microcrystalline, abundant fine-grain, well-rounded, well-sorted quartz; abundance of quartz decreases upsection; well-indurated by dolomicrite; blue-gray, semi-translucent, micro-crystalline nodular chert in upper 5".
	S9	Mottled quartz arenite, light-medium-gray to light-green-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; moderately- to well-indurated, well-indurated in lower 2 ft. where dolomicrite cemented; argillaceous in lower 1 ft; mottles throughout, but less well-defined upsection.
1435		
	C17	Bioclastic packstone, medium-brown-gray, microcrystalline, abundant complete and incomplete ostracodes and sparse bryzoa.
	C8/C17	Interlaminated to interbedded, ostracodal calci-wackestone and bioclastic packstone, medium-brown-gray to dark-brown-gray, micritic, abundance and thickness of packstone increases upsection.
1440		
	C8	Ostracodal dolowackestone, dark-gray to black, microcrystalline, abundant black mudrock laminae, sparse ostracodes.

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Cominco-American, Ivan Hudson CA-53, Wabash Co., Ind. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1445	C19	Vuggy dolomudstone, medium-brown-gray, finely-crystalline, sparsely argillaceous; abundant irregular vugs (0.1-0.25"), some infilled by crystalline calcite.
1447		
Bottom of described interval, TD at 1563 ft.		

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Cominco American CA-254, J. E. Willen 1, Sec. 16-D-52, Cumberland Co., Ky., elev. 860 ft., KGS C496; Bx core 20-2500 ft., described 1598-1850 ft.

Depth (ft.).	Litho-facies	Description/Comments
1598	C12	Argillaceous calcimudstone, light-green-gray to medium-brown-gray, microcrystalline; upper contact sharp, lower contact stylolitic.
1600		
	C17/C14	Bioclastic packstone, medium-brown-gray, fine- to medium-grain, peloidal; abundant incomplete, moderately- to well-rounded, mud-supported bioclasts and peloids; sparse stylolites throughout; upper and lower contacts stylolitic.
	C12	Argillaceous calcimudstone, light-brown-gray, micro-crystalline, locally peloidal, with sparse to abundant, thin (<0.2"), anastomosing, brown mudrock partings.
	C14	Bioclastic grainstone, medium-brown-gray, fine- to medium-grain, moderately well-sorted, sub-rounded bioclasts and peloids; micrite cement.
1605	C12	Argillaceous calcimudstone, light-brown-gray, micro-crystalline, locally peloidal, with sparse to abundant, thin (<0.2") anastomosing brown mudrock partings.
	C14	Bioclastic grainstone, medium-brown-gray, fine- to medium-grain, moderately well-sorted, sub-rounded bioclasts and peloids; micrite cement.
	C12	Argillaceous calcimudstone, light-brown-gray, micro-crystalline, locally peloidal, with sparse to abundant, thin (<0.1"), anastomosing, brown mudrock partings; upper and lower contacts sharp.
1610		
	C10	Patterned calcimudstone, light-green-gray and medium-brown-gray, microcrystalline, abundant

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
		mottling throughout; upper contact sharp and burrowed, lower contact gradational.
	C12	Argillaceous calcimudstone, light-green-gray to medium-brown-gray, microcrystalline; upper contact sharp, lower contact stylolitic.
	C12	Argillaceous calcimudstone, light-brown-gray, micro-crystalline, locally peloidal, with sparse to abundant, thin (<0.2"), anastomosing, brown mudrock partings; upper and lower contacts sharp.
	C14	Bioclastic grainstone, medium-brown-gray, fine- to medium-grain, moderately well-sorted, subrounded bioclasts and peloids; microcrystalline calcite cement; lower contact stylolitic, upper contact gradational.
1615	C16	Stylolitic wackestone, medium-brown-gray, fine- to medium-grain, peloidal; sparse subangular bioclasts and peloids; stylolites throughout; upper contact stylolitic, lower contact sharp.
	C10	Patterned calcimudstone, light-green-gray and medium-brown-gray, microcrystalline, abundant mottling throughout; upper contact sharp and burrowed, lower contact gradational.
	C12	Argillaceous calcimudstone, light-green-gray to medium-brown-gray, microcrystalline; upper contact sharp, lower contact stylolitic.
1620	C17	Bioclastic pack/wackestone, medium-brown-gray, fine- to coarse-grain, poorly-sorted, angular to sub-rounded bioclasts; mud-supported; sparse to abundant, anastomosing, brown-mudrock partings; upper contact stylolitic, lower contact gradational.
1625		

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
	C12	Argillaceous calcimudstone, light-green-gray to medium-brown-gray, microcrystalline; sparse to abundant, green-gray mudrock partings; upper contact gradational, lower contact sharp.
1630		
	C10	Patterned calcimudstone, light-green-gray and medium-brown-gray, microcrystalline, abundant mottling throughout; upper contact sharp and burrowed, lower contact gradational
	C12	Argillaceous calcimudstone, light-green-gray, micro-crystalline; abundant green-mudrock partings, somewhat fissle; upper and lower contacts gradational.
	C16	Stylolitic packstone, medium-brown-gray, fine- to coarse-grain, poorly-sorted, angular to sub-rounded bioclasts; mud-supported; sparse to abundant stylolites; upper and lower contact gradational. **no core 1633-1634 ft.**
1635		
	C12	Argillaceous calcimudstone, light-brown-gray, micro-crystalline; abundant brown-mudrock partings, somewhat fissle; upper contact gradational, lower contact stylolitic.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.).	Litho-facies	Description/Comments
1640		
1645		
	C16	Stylolitic packstone, medium-brown-gray, fine- to coarse-grain, poorly-sorted, angular to subrounded bioclasts; mud-supported; sparse to abundant stylolites; upper and lower contact gradational.
1650		
	C17/C14	Argillaceous bioclastic packstone, medium- to dark-brown-gray, microcrystalline, fine- to coarse-grain, poorly-sorted peloids, intraclasts and bioclasts, stylolitic; abundant, dark-brown mudrock partings; upper and lower contacts stylolitic.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
		Bioclastic packstone, light-brown-gray, microcrystalline, fine- to coarse-grain, poorly-sorted intraclasts and bioclasts, stylolitic; upper and lower contacts stylolitic.
	C9	
	C10	Patterned calcimudstone, medium-brown-gray, micro-crystalline, mottled; upper and lower contacts stylolitic
1655	C9	Bioclastic packstone, light-brown-gray, microcrystalline, fine- to coarse-grain, poorly-sorted intraclasts and bioclasts, abundant stylolites; upper and lower contacts stylolitic.
	C10	Patterned calcimudstone, medium-brown-gray, micro-crystalline, mottled; upper and lower contacts stylolitic
	C12	Argillaceous calcimudstone, medium-brown-gray, micro-crystalline; very argillaceous, brown-mudrock partings throughout, 1" brown-mudrock interbed at top; upper and lower contacts stylolitic.
	C16	Stylolitic wackestone, light-brown-gray, micro-crystalline, sparse ostracodes; stringers of ostacodal packstone locally; sparse to abundant stylolites, abundance increases upsection; lower and upper contact stylolitic.
1660		
	C10	Patterned calcimudstone, light-green-gray to medium-brown-gray, microcrystalline; mottled throughout, pyritic; stylopartings of mudrock at 1662', 1662'10" and 1664'1"; lower and upper contacts stylolitic.
1665		
	C10	Patterned dolomudstone, medium-green-gray, micro-crystalline; mottled throughout, pyritic; lower and upper contacts stylolitic.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
	C12	Argillaceous calcimudstone, medium-green-gray, micro-crystalline; very argillaceous, green-mudrock partings (<0.25") at 1668'6" and 1668'8"; upper and lower contacts stylolitic.
1670	C16	Stylolitic wackestone, light-brown-gray, micro-crystalline, sparse ostracodes; stringers of ostacodal packstone locally; sparse to abundant stylolites, abundance increases upsection; lower and upper contact stylolitic.
1675	C12	Argillaceous calcimudstone, light-green-gray, massive, microcrystalline; locally patterned and dolomitic; abundant quartz silt in lower 1 ft.; lower and upper contacts stylolitic.
1680	C8	Ostracodal wackestone, medium-brown-gray, micro-crystalline; sparse, whole ostracodes; stringers of ostracodal packstone locally; upper and lower contacts stylolitic.
	C10	Patterned dolomudstone, light-brown-gray, massive, microcrystalline; lower and upper contacts stylolitic.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.).	Litho-facies	Description/Comments
	C16	Stylolitic wackestone, medium-brown-gray, micro-crystalline, sparse ostracodes; stringers of ostacodal packstone locally; sparse to abundant stylolites, abundance increases upsection; lower contact gradational, upper contact stylolitic.
1685	C17/C9	Bioclastic packstone, medium-brown-gray, fine- to coarse-grain, poorly-sorted, subrounded bioclasts and intra-clasts, abundant ostracodes and echinoid debris; lower contact sharp and irregular, upper contact gradational.
	C10	Patterned calcimudstone, medium-brown-gray, massive, locally dolomitic; lower contact stylolitic, upper contact sharp and irregular.
1690	C11	Fenestral calcimudstone, light-brown-gray, micro-crystalline, locally stylolitic; lower contact stylolitic, upper contact gradational.
1695	C10	Patterned calcimudstone, medium-brown-gray, massive, 1" styloparting of brown-mudrock at base; upper and lower contacts stylolitic.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
	C16	Stylolitic wackestone, medium-brown-gray, micro-crystalline, sparse ostracodes; stringers of ostacodal packstone locally; abundant stylolites.
1700	C10	Patterned calcimudstone, medium-brown-gray, massive, 1" styloparting of green-mudrock at base; upper and lower contacts stylolitic.
	C16	Stylolitic wackestone, medium-brown-gray, micro-crystalline, sparse ostracodes, abundant stylolites; stringer of bioclastic packstone at 1702'2" with high biomoldic porosity.
1705	C10	Patterned calcimudstone, medium-brown-gray, massive, upper and lower contacts stylolitic.
	C10	Patterned calcimudstone, medium-brown-gray, massive, 1" styloparting of brown mudrock at 1706'2"; upper and lower contacts stylolitic.
	C9	Intraclastic wacke/packstone, medium-brown-gray, abundant bioclasts and black dolomudstone pebbles; upper contact and lower contacts sharp and stylolitic.
	C10	Patterned dolomudstone, light-medium-gray and light-green-gray, microcrystalline, pattern mottling throughout, stringers of quartz silt locally; brown mudrock stylolaminae at 1709'6", 1710'10" and

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
1710		1713'2": upper and lower contacts gradational.
1715		
	C1	Quartzose dolowacke/packstone, microcrystalline, abundant quartz silt, slightly calcareous; upper contact gradational, lower contact stylolitic.
1720	C10	Patterned dolomudstone. light-medium-gray and light-green-gray, microcrystalline, pattern mottling throughout, stringers of quartz silt locally; brown mudrock stylo-laminae at 1722'; upper and lower contacts stylolitic.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
	C9	Intraclastic dolopackstone, light-brown-gray, abundant, fine- to medium-grain, well-rounded quartz and pebble-size, subangular, dolomudstone intraclasts.
1725	C17	Bioclastic dolopackstone, medium-brown-gray, micro-crystalline, abundant biomolds infilled by coarsely-crystalline calcite; lower contact gradational, upper contact sharp.
	C6	Mottled dolomudstone, medium-green-gray, microcrystalline; upper and lower contacts sharp.
1730	C10	Patterned dolomudstone, light-medium-gray and light-green-gray, microcrystalline, pattern mottling throughout, stringers of quartz silt locally; green mudrock stylolaminae at 1731'4" and 1731'6"; chert at base; upper and lower contacts stylolitic.
1735		
	C10	Patterned dolomudstone, light-medium-gray and light-green-gray, microcrystalline, pattern mottling throughout, stringers of quartz silt locally; green mudrock stylolaminae at 1737'2".

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.).	Litho-facies	Description/Comments
1740		
1745		
	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline; sparse to abundant, fine- to medium-grain, moderately-sorted, well-rounded quartz in lower 1 ft.; stylolitic in lower 6"; lower contact sharp, upper contact gradational.
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, laminae convoluted and laterally disrupted; lower contact gradational, upper contact sharp.
	C5	Cryptolaminated dolomudstone, light-medium-gray, microcrystalline, massive; lamine of quartz silt locally.
1750		

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
	C6	Mottled dolomudstone, medium-green-gray, microcrystalline; stringers of fine- to medium-grain, moderately-sorted, well-rounded quartz throughout. upper and lower contacts sharp.
1755		
	S15	Argillaceous quartz arenite, light-green-gray, fine-grain, well-sorted, well-rounded quartz; grading upsection to intra-formational breccia, fine-grain to pebble-size, poorly-sorted, subangular chert clasts; lower and lower contact sharp.
	C6	Mottled dolomudstone, medium-green-gray, microcrystalline; stringers of fine- to medium-grain, moderately-sorted, well-rounded quartz throughout. upper and lower contacts sharp.
1760		
	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline; sparse to abundant, fine- to medium-grain, moderately-sorted, well-rounded quartz in lower 1 ft.; 1" green mudrock interbed at top; upper and lower contacts sharp.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
1765	C1	Quartzose dolopack/wackestone, medium-green-gray, microcrystalline; sparse to abundant, fine- to medium-grain, moderately-sorted, well-rounded quartz; fine- to coarse-grain, subangular chert intraclasts at 1766'; upper contact sharp, lower contact gradational.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, fines-upward, well-rounded quartz; micro-crystalline dolomite cemented; becomes mud-supported at gradational upper contact; lower contact sharp.
1770	C1	Quartzose dolopack/wackestone, medium-green-gray, microcrystalline; sparse to abundant, fine- to medium-grain, moderately-sorted, well-rounded quartz; sparse, fine- to coarse-grain, subangular chert intraclasts; 1" green mudrock interbed at top; upper contact sharp, lower contact gradational.
	S15/S13	Argillaceous lithic quartz arenite, green-gray, fine- to coarse-grain, poorly-sorted, well-rounded to subrounded, quartz and dolomudstone intraclasts; convoluted, green-gray mudrock laminae at 1772'1"-1772'6" and 1773-1773'5"; dolomitic 1772'6"-1773'; upper and lower contacts gradational.
1775	C7	Intraformational breccia, light-green-gray, abundant, fine-grain to pebble-size, poorly-sorted, angular dolomudstone and chert intraclasts; chert is opaque white and medium-gray, translucent; lower contact sharp, upper contact gradational.
	C6	Mottled dolomudstone, light-brown-gray, micro- to finely crystalline, locally argillaceous; finely stylolaminated in upper 1 ft.; very siliceous at 1777'4".
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, chert at 1778'6"; lower contact gradational.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
		upper contact sharp.
1780	C3	Laminated dolomudstone, light-green-gray to medium-brown-gray, microcrystalline, sparsely- to very-argillaceous, finely laminated with thin, brown mudrock laminae.
1785	C8	Ostracodal dolowackestone, light-green-gray, micro-crystalline, slightly- to moderately-argillaceous, sparse whole ostracodes; locally vuggy (<0.25"); mottled where argillaceous.
1790		
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, siliceous; lower contact gradational, upper contact sharp.
	C3	Laminated dolomudstone, light-green-gray to medium-brown-gray, microcrystalline, planar to slightly irregular

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
		lamine; lower contact irregular, upper contact gradational.
	C9	Intraformational breccia, light-green-gray to medium-green-gray, argillaceous, cherty; abundant dolopackstone and dolowackestone clasts, microcrystalline, angular; green-gray mudrock partings locally.
1795		
1800	C6	Mottled dolomudstone, light-brown-gray, microcrystalline, argillaceous; locally pyritic; stringers of ostracodal dolopackstone; lower and upper contact gradational.
	C7	Intraformational breccia, light-green-gray to medium-green-gray, argillaceous, cherty; abundant dolopackstone and dolowackestone clasts, microcrystalline, angular; green-gray mudrock partings locally.
	C6	Mottled dolomudstone, light-brown-gray, microcrystalline, argillaceous; locally pyritic; stringers of ostracodal dolopackstone; lower and upper contact gradational.
1805		

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
	C8	Ostracodal dolowackestone, light-green-gray, micro-crystalline, slightly to moderately-argillaceous, sparse whole ostracodes; locally vuggy (<0.25").
1810	C6	Mottled dolomudstone, light-brown-gray, microcrystalline, sparse quartz silt, argillaceous; locally pyritic; lower and upper contact gradational.
1815	C12	Argillaceous dolomudstone, light-green-gray, micro-crystalline, slightly to moderately-argillaceous, sparse whole ostracodes; stringers of chert-bearing intraclastic dolopack/grainstone at 1814' and 1818'; upper and lower contact gradational.
1820	C6	Mottled dolomudstone, light-brown-gray, microcrystalline, sparse to abundant quartz silt; locally pyritic; lower and upper contact gradational.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
	S2	Dolomitic quartz arenite, light-green-gray, fine- to medium grain, moderate- to poorly-sorted, well-rounded quartz.
	C17/C9	Bioclastic dolograinstone, medium-brown-gray, finely-crystalline, abundant fine- to medium-grain, subrounded intraclasts and subangular bioclasts; sparse, fine-grain, well-rounded, moderately-sorted quartz; lower contact gradational, upper contact sharp, irregular.
	C6	Mottled dolomudstone, light-brown-gray, microcrystalline, sparse to abundant quartz silt; locally pyritic; lower contact sharp, upper contact gradational.
1825		
	C12	Argillaceous dolomudstone, light-green-gray, micro-crystalline, slightly to moderately-argillaceous, sparse whole ostracodes; stringers of chert-bearing intraclastic dolopack/grainstone at base; upper contact gradational, lower contact sharp and irregular.
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, siliceous; lower contact gradational, upper contact sharp.
	C6	Mottled dolomudstone, light-brown-gray, microcrystalline, sparse to abundant quartz silt; stringer of siliceous intraclastic dolopack/wackestone 1829'6" to1830"; lower contact sharp, upper contact gradational
1830		
	C12	Argillaceous dolomudstone, light-green-gray to medium-brown-gray, microcrystalline, massive, fenestral and mottled and pyritic locally; green mudrock parting at 1830'8"; lower contact gradational, upper contact sharp.
	C8	Ostracodal dolowackestone, light-green-gray, micro-crystalline, slightly to moderately-argillaceous, sparse whole ostracodes; stringers of chert-bearing intraclastic dolopack/grainstone at 1831'7" and 1834'2"; upper contact gradational, lower contact sharp and irregular.

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
1835	S13	Lithic arenite, light-green-gray, fine- to medium-grain
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, siliceous; lower contact gradational, upper contact sharp.
	C8	Ostracodal dolowackestone, light-green-gray, micro-crystalline, slightly- to moderately-argillaceous, sparse whole ostracodes; upper contact gradational, lower contact sharp and irregular.
1840	C12	Argillaceous dolomudstone, light-green-gray to medium-brown-gray, microcrystalline, massive, fenestral and mottled locally.
	S2	Dolomitic quartz arenite, light-green-gray, fine- to medium grain, moderate- to poorly-sorted, well-rounded quartz; coarsely crystalline calcite infilling large, irregular voids (<0.2") in upper 3"; lower contact gradational, upper contact stylolitic.
1845	C17/C9	Bioclastic dolograinstone, medium-brown-gray, finely-crystalline, abundant fine- to medium-grain, subrounded intraclasts and subangular bioclasts; bioclasts include trilobite and echinoid debris; sparse, fine-grain, well-rounded, well-sorted quartz, mud-supported at base, grades upsection to overlying quartz arenite; lower and upper contacts gradational.
	C8	Ostracodal dolowackestone, light-green-gray, micro-crystalline, slightly to moderately-argillaceous, sparse whole ostracodes; upper contact gradational, lower contact sharp and irregular.
	C17/C9	Bioclastic dolopackstone, medium-brown-gray, finely-crystalline, abundant fine- to medium-grain, subrounded intraclasts and subangular bioclasts; bioclasts include trilobite and echinoid debris; upper contact brecciated and chert-bearing; chert is white, opaque and micro-crystalline.
	C12	Argillaceous dolomudstone, light-green-gray to medium-brown-gray, microcrystalline, massive, fenestral and mottled 1849'-1851'4", vertical burrows 1855'-1859',

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Cominco American CA-254, J. E. Willen 1, Cumberland Co., Ky. (cont.),

Depth (ft.),	Litho-facies	Description/Comments
1850		whole brachiopod at 1851'10", green mudrock parting with argillaceous quartz arenite stringer at 1855'3" and 1858'3"; upper contact stylolitic.
Bottom of described interval, TD at 2500 ft.		

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Cominco American CA-58, Ellis 1, Sec. 11-X-55, Henry Co., Ky., elev. 495 ft., IGS C508; BX core 63-1538 ft., described 623-726 ft.

Depth (ft.)	Litho-facies	Description/Comments
	M2	Green mudrock, fissle, pyritic.
	C15	Mottled calcimudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; upper contact sharp, lower contact gradational.
625		
	C10	Patterned calcimudstone, medium-brown-gray and medium-green-gray, microcrystalline, mottling decreases upsection; upper and lower contacts gradational.
630		
	C16	Stylolitic calciwackestone, light-brown-gray, micro-crystalline, micritic, locally peloidal; sharp lower contact, gradational upper contact.
635		
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, porous, calcareous; thin, planar to

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Cominco American CA-58, Ellis 1, Henry Co., Ky. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
		irregular laminae of brown mudrock; upper contact stylolitic.
	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; calcareous; upper contact gradational, lower contact sharp.
640		
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, porous, calcareous; thin, planar to irregular laminae of brown mudrock; upper contact stylolitic, lower contact gradational.
	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; calcareous; upper contact gradational, lower contact sharp.
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, porous, calcareous; thin, planar to irregular laminae of brown mudrock.
645	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; calcareous; upper contact gradational, lower contact sharp.
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, porous, calcareous; thin, planar to irregular laminae of brown mudrock; upper contact stylolitic.
	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; calcareous; upper contact gradational, lower contact sharp.
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, porous, calcareous; thin, planar to

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Cominco American CA-58, Ellis 1, Henry Co., Ky. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
650		irregular laminae of brown mudrock; upper contact stylolitic.
	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; calcareous; upper contact gradational, lower contact sharp.
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, porous, calcareous; thin, planar to irregular laminae of brown mudrock; upper contact stylolitic.
	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; calcareous; upper contact gradational, lower contact sharp.
655	M6	Argillaceous dolosiltstone, green-gray, quartzose.
	C11/C6	Dolomudstone, medium-brown-gray, microcrystalline, locally fenestral.
	C15	Mottled calcimudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; calcareous; upper contact gradational, lower contact sharp.
660		
	C16	Stylolitic calciwackestone, light-brown-gray, micro-crystalline, micritic, locally peloidal; sharp lower contact, gradational upper contact.
	C15	Mottled calcimudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally peloidal; calcareous; upper contact gradational, lower contact sharp.
	C4	Stromatolitic dolomudstone, light-brown-gray, micro-crystalline, porous, calcareous; thin, planar to

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Cominco American CA-58, Ellis 1, Henry Co., Ky. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
		irregular laminae of brown mudrock; upper contact stylolitic.
665	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally fenestral; calcareous; upper contact gradational, lower contact sharp.
	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline; increasingly argillaceous upsection, somewhat fissle at top.
670	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally fenestral; calcareous; upper contact gradational, lower contact sharp.
	C1	Quartzose dolowackestone, light-green-gray, silt-size to fine-grain, poorly-sorted, subrounded to rounded, mud-supported quartz; argillaceous; upper contact gradational, lower contact sharp.
675	C11	Fenestral dolomudstone, mottled medium-green-gray and medium-brown-gray, microcrystalline; abundant fenestrae infilled with sparry calcite; upper contact sharp and irregular, lower contact gradational.
	C6	Mottled dolomudstone, medium-green-gray and medium-brown-gray, microcrystalline, locally fenestral; calcareous; brown mudrock partings at 677'1", 678'7", 682'7", 684'6"; upper and lower contacts gradational.

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Cominco American CA-58, Ellis 1, Henry Co., Ky. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
680		
685		
	C15	Mottled calcimudstone, medium-brown-gray and light brown-gray, microcrystalline, locally fenestral; dolomitic; brown mudrock partings at 687'8", 688'9", and 689'; upper contact gradational, lower contact sharp.
	C12/M6	Argillaceous silty dolomudstone, medium-green-gray, microcrystalline; increasingly argillaceous upsection, somewhat fissle at top; abundant quartz silt throughout.
690		
	C12	Argillaceous dolomudstone, green-gray, microcrystalline, sparse to common quartz silt; mottled throughout, abundant green-gray clay-size fraction, somewhat fissle at 692' and 698'8".

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Cominco American CA-58, Ellis 1, Henry Co., Ky. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
695		
700		
	S13	Lithic quartz arenite, green-gray to light-yellowish-gray, fine-grain to pebble-size, poorly-sorted, sub-angular to subrounded intraclasts of dolostone; abundant fine- to medium-grain, moderately-sorted, well-rounded quartz; friable to moderately-indurated; increasingly mottled and argillaceous upsection; sharp lower contact, upper contact gradational
705	S8	*Skolithos*-bearing quartz arenite, light-green-gray, fine- to medium-grain, moderately- to poorly-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; burrow-infills are coarser-grain and pyritic; mottled at base, decreases upsection.

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Cominco American CA-58, Ellis 1, Henry Co., Ky. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-yellowish-gray to very-light-gray, fine-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; vague pyritic mottles locally.
710		
	S9	Mottled quartz arenite, light-yellowish-gray to light-green-gray, fine-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths and pore-filling calcite; sparse to common mottling; green mudrock partings at 714' and 717'.
715		
	S13	Lithic quartz arenite, green-gray to light-yellowish-gray, fine-grain to pebble-size, poorly-sorted, subangular to subrounded intraclasts of dolostone and chert; abundant fine- to medium-grain, moderately-sorted, subangular to well-rounded quartz; friable to

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Cominco American CA-58, Ellis 1, Henry Co., Ky. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
720		moderately-indurated; increasingly mottled and argillaceous upsection; lower contact sharp and irregular, upper contact gradational.
	C19	Vuggy cherty dolostone, finely-crystalline to micro-crystalline, sparse to abundant irregular vugs; chert and silicified ooids locally.
725		
730		
733		
Bottom of described interval, TD at 1538		

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E. I. Dupont, Inc., (Waste Disposal) Fee #1, Sec. 10-U-44, Jefferson Co., Ky., elev. 462 ft., KYGS Core 524, continuous 4" core 1678-1722 ft.

Depth (ft.)	Litho-facies	Description/Comments
1678	C10	Patterned dolomudstone, light- to medium-green-gray with dark-green-gray mottling, microcrystalline, argillaceous, mottled throughout; increasingly argillaceous upsection.
1680		
	M5	Brown mudrock, dark-brown, fissle, organic-bearing.
	C10	Patterned dolomudstone, light- to medium-green-gray with dark-green-gray mottling, microcrystalline argillaceous, mottled throughout.
	M2	Green mudrock, dark-green-gray, nonfissle, pyritic.
	C10	Patterned dolomudstone, light- to medium-green-gray with dark-green-gray mottling, microcrystalline, argillaceous, mottled throughout.
	M2	Green mudrock, dark-green-gray, nonfissle, pyritic.
1685	C10	Patterned dolomudstone, light- to medium-green-gray with dark-green-gray mottling, microcrystalline, argillaceous, mottled throughout; increasingly argillaceous upsection.
	C12	Argillaceous dolomudstone, medium-green-gray, silty, microcrystalline, argillaceous, massive.
1690		
	M2	Green mudrock, dark-green-gray, nonfissle, pyritic.
	C10	Patterned dolomudstone, light- to medium-green-gray with dark-green-gray mottling, microcrystalline, argillaceous, mottled throughout.

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E. I. Dupont, Inc., Fee #1, Jefferson Co., Ky. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	M2	Green mudrock, dark-green-gray, nonfissle, pyritic.
	C6	Mottled argillaceous dolomudstone, light- to medium-green-gray, dark-green-gray mottling locally; microcrystalline, argillaceous; increasingly argillaceous upsection.
1695		
	C6	Mottled argillaceous dolomudstone, light- to medium-green-gray, dark-green-gray mottling locally; microcrystalline, argillaceous; increasingly argillaceous upsection.
1700	S9	Mottled quartz arenite, light-yellow-gray with light-green-gray mottling locally, fine- to medium-grain, moderately to well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; coarse-grain to pebble-size, angular to subrounded dolomud-stone intraclasts, light-brown-gray in upper 1 ft.
1705	S15	Argillaceous quartz arenite, light-yellow-gray with anastomosing green-gray mudrock partings, fine- to medium-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by

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E. I. Dupont, Inc., Fee #1, Jefferson Co., Ky. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		quartz overgrowths, noncalcareous; 2" of green-gray siltstone at base; abundance of mudrock partings decreases upsection; lower contact sharp, upper contact gradational.
1710	S10	Massive quartz arenite, very light-yellow-gray, fine-grain, very well-sorted, well-rounded quartz; poorly- to moderately-indurated by calcite; thin-bedded, breaks along subhorizontal planes; very clean.
1715	M1	Conglomeratic mudrock, medium-green-gray, fissle to nonfissle, pyritic; sparse to abundant, fine- to pebble-size, angular to subrounded, poorly-sorted quartz; microcrystalline chert and dolomud-stone.
	C19	Dolomudstone, light-brown-gray to light-green-gray, finely- to microcrystalline, locally pyritic; sparse to abundant green-gray mudrock partings.

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E. I. Dupont, Inc., Fee #1, Jefferson Co., Ky. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1720		
1722		
Bottom of cored interval, TD at 5230 ft.		

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Louisville Gas & Electric Co., F. H. Wainscott (Wako) 1, Sec. 20-W-50, Oldham Co., Ky., elev. 852 ft., KYGS CA-123A, 4" core 1305-1384 ft., described 1305-1338.5 ft.

Depth (ft.)	Litho-facies	Description/Comments
1305	C15	Mottled calcimudstone, light-brown-gray, micro-crystalline, fenestral in upper 2 ft.
	M5	Brown mudrock, fissle, organic-bearing.
	C15/C11	Mottled calcimudstone, light-brown-gray, micro-crystalline, fenestral in upper 2 ft.
1310		
	C12	Argillaceous calcimudstone, medium-brown-gray with partings of medium-brown mudrock.
	M5	Argillaceous calcimudstone, medium-brown-gray,
	C12	abundant medium-brown, mudrock-partings; grades upsection to 3" bed of calcareous, brown mudrock.
	C10	Patterned dolomudstone, light-green-gray and light-brown-gray, microcrystalline, increasingly argillaceous upsection, abundant quartz silt in upper 6", mottled throughout.
1315		
	C16	Stylolaminated calciwackestone, light-brown-gray, microcrystalline, sparse ostracodes.
	C10	Patterned dolomudstone, light-green-gray and light-brown-gray, microcrystalline, increasingly argillaceous upsection, mottled throughout.

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Louisville Gas & Electric Co., F. H. Wainscott 1, Oldham Co., Ky. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1320	C10	Patterned dolomudstone, light-green-gray and light-brown-gray, microcrystalline; increasingly argillaceous upsection; sparse to abundant mottling that increases in abundance upsection.
	C12	Argillaceous dolomudstone, medium- to dark-green-gray, microcrystalline; moderately- to very-argillaceous, increasingly argillaceous upsection; mottled in lower 6".
1325	S9	*Mottled* quartz arenite, light-green-gray, fine-grain, moderately-sorted, well-rounded quartz; weakly- to moderately-indurated; sparse to abundant argillaceous mottles; grain-size decreases upsection; mottled throughout.
	S13	Lithic quartz arenite, light-greenish-gray, fine- to *medium-grain, poorly- to moderately-sorted*, well-rounded quartz and fine- to pebble-size, subround to subangular, poorly-sorted dolomudstone intraclasts upper contact gradational, lower is sharp.
1330	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray to light-green-gray, fine- to medium-grain, well-rounded quartz; poorly-indurated; matrix is finer-grain and argillaceous; *burrow infills are medium- to* coarse-grain and nonargillaceous.
	S10	Massive to mottled quartz arenite, light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated, calcareous; vaguely mottled locally.
	S8	*Skolithos* -bearing quartz arenite, light-green-gray to medium-green-gray, fine- to medium-grain, well-rounded quartz; poorly-indurated to friable.

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Louisville Gas & Electric Co., F. H. Wainscott 1, Oldham Co., Ky. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		calcareous; matrix is finer-grain and argillaceous, burrow infills are coarser-grain and slightly argillaceous.
1335	S9	Mottled quartz arenite, light-yellowish-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated, calcareous.
		Core 1335-1337 ft. reported lost by operator
	C12	Argillaceous dolomudstone, medium-brown-gray with green-gray mudrock partings; finely-crystalline; abundant microcrystalline, light-gray chert; core jumbled 1337-1338.5 ft.
Bottom of described interval, TD at 1468 ft.		

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Cities Services Minerals Corp., J. O'Donovan Tract BT-3, Sec. 7-Y-55, Owen Co., Ky., KYGS C103, BX (1") core, described 685-728 ft.

Depth (ft.)	Litho-facies	Description/Comments
685	C15	Mottled calcimudstone, medium-brown-gray, micro-crystalline, dolomitic in upper 1 ft., mottled through-out.
	C9	Intraclastic grainstone grading upsection to bio/intraclastic packstone, medium- to dark-brown-gray, microcrystalline, fine- to coarse-grain, subrounded to subangular intraclasts and ostracodal bioclasts; locally cherty, silicification associated with fracture.
690		
	C12	Argillaceous calcimudstone, medium-brown-gray, microcrystalline; sparse to abundant, brown mud-rock partings.
695	C10	Patterned calcimudstone, medium-brown-gray to medium-green-gray, sparsely dolomitic, argillaceous, pyritic; upper and lower contacts stylolitic.
	C12	Argillaceous calcimudstone, medium-brown-gray, microcrystalline, dolomitic in upper 1 ft., mottled locally.

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Cities Services Minerals Corp., J. O'Donovan Tract BT-3, Owen Co., Ky. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C9	Intraclastic grainstone grading upsection to bio/intraclastic packstone, medium- to light-green-gray, microcrystalline, fine- to coarse-grain, subrounded to subangular intraclasts.
700	C2	Dolomudstone, yellow-gray, microcrystalline, sparsely vuggy in upper 4".
	C9/C17	Intraclastic grainstone grading upsection to bio/intraclastic packstone, medium- to light-green-gray, microcrystalline, fine- to coarse-grain, subrounded to subangular intraclasts and well-rounded quartz; abundance of grains decreases upsection.
	C12	Argillaceous dolomudstone, light-brown-gray to light-green-gray, microcrystalline, increasingly argillaceous upsection; small, crystalline-calcite infilled vugs in upper 4".
705		
	C9	Intraclastic grain/packstone, medium-brown-gray.
	C10	Patterned calcimudstone, light- to medium-green-gray, microcrystalline, argillaceous, pyritic; mottled throughout, increasingly argillaceous upsection.
	C9/C1	Intraclastic grainstone grading upsection to bio/intraclastic packstone, medium- to light-green-gray, microcrystalline, fine- to coarse-grain, subrounded to subangular intraclasts and well-rounded quartz; abundance of grains decreases upsection.
710	C12	Argillaceous calcimudstone, medium-brown-gray, microcrystalline, sparse to abundant brown mud-rock partings.
	C10	Patterned dolomudstone, light- to medium-green-gray, microcrystalline, argillaceous, pyritic; sparse to abundant quartz silt; increasingly silty and argillaceous upsection; mottled throughout.
		Quartzose dolopack/wackestone, medium-green-

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Cities Services Minerals Corp., J. O'Donovan Tract B.T. 3, Owen Co., Ky. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C1	gray, microcrystalline, argillaceous; sparse to abundant, fine- to medium-grain, well-rounded quartz.
	C10	Patterned calcimudstone, light- to medium-green-gray, microcrystalline, argillaceous; increasingly argillaceous upsection, stylolaminated green-gray mudrock in upper 8"; sparse to abundant mottling, increases in abundance upsection.
715		
	C16	Stylolaminated calcimudstone, light-medium-brown gray, microcrystalline, 0.5" brown mudrock at base.
720		
	C12	Argillaceous calcimudstone, light- to medium-brown-gray, microcrystalline; sparse to abundant brown mudrock partings, mottled locally.
	C10	Patterned dolomudstone, light- to medium-green-gray, microcrystalline, argillaceous; increasingly argillaceous upsection; mottled throughout.
725		
	C9	Intraclastic dolograin/packestone, medium-green-gray, microcrystalline, argillaceous; abundant to sparse, fine- to medium-grain, well-rounded quartz and subrounded dolomudstone, light-brown-gray;

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Cities Services Minerals Corp., J. O'Donovan Tract B.T. 3, Owen Co., Ky. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		abundance of grains decreases upsection.
	C12	Argillaceous dolomudstone, medium-light-green, finely- to microcrystalline, sparse to abundant green-gray mudrock partings throughout, abundance and thickness of partings increases upsection; light-gray microcrystalline chert locally.
Bottom of described interval, TD at 2,900 ft.		

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Unimin Silica Corp., Pevely Quarry Boring 91-11, Jefferson Co., Mo.
elev. 600 ft., company core, NX core 5-35 ft.

Depth (ft.)	Litho-facies	Description/Comments
5	C2	Chalky dolomudstone, light-gray, deeply weathered.
	C7	Breccia, brecciated pale-yellow dolomudstone; voids infilled by coarsely-crystalline calcite.
	C10	Patterned dolomudstone, green-gray to pale-yellow-gray, 1" green mudrock parting, fissle, at top.
	C10	Patterned dolomudstone, green-gray to pale-yellow-gray, 1" fissle organic-rich mudrock-parting at top; 5" of dolomitic quartz arenite at base, medium- to fine-grain quartz; grain-size decreases upsection.
10	C10	Patterned dolomudstone, green-gray to pale-yellow-gray, 1" organic-rich mudrock parting, fissle at top; 6" of quartz arenite, fine-grain, well-sorted quartz, fines-upward.
	C4	Stromatolitic dolostone, pale-yellow-gray, clotted-fabric and breccia in upper 1 ft.
	C10	Patterned dolomudstone, medium-green-gray, abundant quartz silt; 1" of lithic arenite at base.
15	C4	Stromatolitic dolostone, pale-yellow-gray, clotted-fabric and vuggy; vugs are angular and irregular.
	C10	Patterned dolomudstone, medium-green-gray, abundant quartz silt; 4" of lithic arenite at base; contains abundant fine- to coarse-grain dolo-stone intraclasts and sparse phosphatic grains.

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Unimin Silica Corp., Pevely Quarry Boring 91-11, Jefferson Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C10	Patterned dolomudstone, pale-yellow-gray, abundant microporosity; lithic arenite at base.
20		
	C4	Quartzose stromatolitic dolostone, pale-yellow-gray, abundant fine- to medium-grain, well-rounded, quartz; vuggy, vugs are angular and irregular; planar laminae at base, increasingly convoluted upsection.
	C1	Quartzose dolopackstone, light-brown-gray, fine- to coarse-grain, well-rounded, mud-supported quartz; abundance of quartz grains increases upsection, grain-size decreases upsection.
	C4	Quartzose stromatolic dolostone, pale-yellow-gray, abundant fine- to medium-grain, well-rounded , quartz; vuggy, vugs are angular and irregular; planar laminae at base, increasingly convoluted upsection.
25	S2	Dolomitic quartz arenite, pale-yellow-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; well-indurated, abundant pore-filling calcite; green-gray clay throughout.
	S10	Massive quartz arenite, light-yellow-brown, medium-grain, well-sorted quartz; noncalcareous, limonite stain in upper 2"; weakly-indurated with quartz overgrowths.
	S8	*Skolithos*-bearing quartz arenite, green-gray to pale-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz matrix; burrows infilled with medium- to coarse-grain, well-rounded quartz; burrows absent in lower 1 ft., abundant at top; weakly- to moderately-indurated by quartz over-growths; upper and lower contacts are sharp.
30	S8	*Skolithos*-bearing quartz arenite, green-gray to pale-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz matrix; burrows infilled with medium- to coarse-grain, well-rounded quartz; burrows sparse near base, increase in abundance upsection; weakly-indurated by quartz over-overgrowths; upper and lower contacts are sharp.

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Unimin Silica Corp., Pevely Quarry Boring 91-11, Jefferson Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
35		
Bottom of preserved core, TD unknown.		

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Unimin Silica Corp., Pevely Quarry 91-12, Jefferson Co., Mo.
elev. 600 ft., company core, NX core 9-66 ft.

Depth (ft.)	Litho-facies	Description/Comments
9	C8	Ostracodal dolopackstone, medium-dark-brown and yellow-gray, microcrystalline, abundant ostracodes, limonite stain.
10	C3	Quartzose laminated dolowackestone, light-medium-brown-gray, microcrystalline, very silty, pyritic; fine- to medium-grain, well-rounded, well-sorted quartz, quartz content decreases in abundance upsection; moderately abundant planar and irregular laminae of brown mudrock.
15		
20	C1	Quartzose dolowackestone, light-medium-gray to brown-gray, microcrystalline, silty, pyritic; fine- to medium-grain, mostly medium-grain, well-rounded, well-sorted, quartz, quartz content decreases in abundance upsection.
	C8	Ostrocodal dolopackstone, medium-dark-brown microcrystalline, abundant biomolds after ostracodes, no quartz sand.

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Unimin Silica Corp., Pevely Quarry 91-12, Jefferson Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S15	Argillaceous quartz arenite, light-green-gray and reddish-brown-gray, fine- to coarse-grain, poorly-sorted to bimodal, well-indurated quartz; banded ferroan staining calcareous.
25	S8	*Skolithos* -bearing quartz arenite, light-gray to light-yellowish-gray, fine- to coarse-grain, mostly medium-grain, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant large diameter (0.25") *Skolithos* burrows at top, burrows decrease in abundance down-section; burrow infills are coarser-grain and more indurated.
30	S10	Massive quartz arenite, white to light-medium-gray, or light-greenish-gray, very fine- to fine-grain, very well-rounded quartz; poorly- to moderately-indurated by quartz overgrowths; locally friable and argillaceous at 33'6"-35'8", 36'6"-37', 38'1"-39'8"; sparse burrow mottles. No discernable lithologic breaks to 39'9".
35		

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Unimin Silica Corp., Pevely Quarry 91-12, Jefferson Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
40	S8	*Skolithos* -bearing quartz arenite, light-gray to light-yellowish-gray, fine- to coarse-grain, mostly medium-grain, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant large diameter (>0.25") *Skolithos* burrows at top, burrows decrease in abundance down-section; burrow infills are coarser-grain and more indurated; upper 6" contains ferroan stained, planar cross-stratified arenite; burrow cross-cuts cross-stratification. No discernable lithologic breaks to 47 ft.
45		
49	S8	*Skolithos* -bearing quartz arenite, light-gray to light-yellowish-gray, fine- to coarse-grain, mostly medium-grain, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant large diameter (>0.25:) *Skolithos* burrows, burrow infills are coarser-grain and more indurated.

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Unimin Silica Corp., Pevely Quarry 91-12, Jefferson Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		No core 49-59 ft.
59	S8	*Skolithos* -bearing quartz arenite, light-gray to light-yellowish-gray, fine- to coarse-grain, mostly medium-grain, well-rounded quartz; moderately-indurated by quartz overgrowths; sparse small diameter (<0.25") Skolithos burrows, burrow infills are coarser-grain and more indurated.
60		
	S8	*Skolithos* -bearing quartz arenite, light-gray to light-yellowish-gray, fine- to coarse-grain, mostly medium-grain, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant large diameter (>0.25") *Skolithos* burrows, some are greater than 10" in length; burrow infills are coarser-grain and more indurated, lower 2 ft. intensely ferroan stained, staining follows burrow margins; lower contact very sharp.
65		
	C1	Vuggy quartzose dolowackestone, yellow-gray to yellow-brown-gray, abundant medium- to coarse-grain, well-sorted, well-rounded, mud-supported quartz-grains; microcrystalline dolomicrite matrix; contains Middle Ordovician microfauna.
Bottom of core and TD.		

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Phillips Petroleum Co., Mineral Test Winge TP-W1, Sec. 20-T48N-R1E, Lincoln Co., Mo., elev. 505 ft., NX core described 423.5-609 ft.

Depth (ft.)	Litho-facies	Description/Comments
424	C8	Ostracodal wackestone interbedded with green mudrock, thin-bedded.
425	C18	Oolitic grain/packstone, medium-brown-gray, fine- to medium-grain, well-sorted ooids and sub-angular to subrounded intraclasts; medium-bedded, grain-size decreases upsection.
	C10	Patterned calcimudstone, medium-green-gray to medium-brown-gray, microcrystalline, very argillaceous throughout; sparse to abundant thin-laminae of brown mudrock, abundance of laminae increases upsection, 0.5" of brown mudrock at base; lower part of unit mottled, possibly stromatolitic in upper 6"; upper contact sharp, lower is gradational.
	C8	Ostracodal wackestone, medium-brown-gray, microcrystalline; abundant biomoldic porosity.
430	C12	Argillaceous calcimudstone, light-brown-gray, microcrystalline; sparse to abundant, anastomosing, brown mudrock partings.
	C8	Ostracodal wackestone, medium-brown-gray, microcrystalline; sparse to abundant complete ostracodes.
435	C12	Argillaceous calcimudstone, light-brown-gray, microcrystalline; sparse to abundant, anastomosing, brown mudrock partings.

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C16	Stylolaminated calcimudstone, light-brown-gray, microcrystalline; abundant subhorizontal, low-amplitude stylolites.
	C10	Patterned calcimudstone, light-green-gray to brown-gray.
440	C8	Ostracodal wackestone, medium-brown-gray, microcrystalline; sparse to abundant complete ostracodes; abundant biomoldic porosity upsection.
	C16	Stylolaminated calcimudstone, light-brown-gray, microcrystalline; abundant subhorizontal, low-amplitude stylolites; lower contact stylolitic, upper contact gradational.
	C10	Patterned calcimudstone, light-brown-gray to light-green-gray, microcrystalline, dense; intensely mottled.
	C8	Ostracodal wackestone, medium-brown-gray, microcrystalline; sparse to abundant complete ostracodes; abundant biomoldic porosity.
445	C12	Argillaceous calcimudstone, light-brown-gray, microcrystalline; sparse to abundant, anastomosing, brown mudrock partings.
	C16	Stylolaminated calcimudstone, light-brown-gray, microcrystalline; abundant subhorizontal, low-amplitude stylolites; lower contact stylolitic, upper contact gradational.
450	C8	Ostracodal wackestone, medium-brown-gray, microcrystalline; sparse to abundant complete ostracodes; abundant biomoldic porosity.

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C12	Argillaceous calcimudstone, light-brown-gray, microcrystalline; sparse to abundant, anastomosing, brown mudrock partings.
	C17	Bioclastic pack/wackestone, medium-brown-gray, sparse to abundant complete ostracodes and rare brachipods; laterally-discontinuous laminae of brown mudrock locally; mostly massive.
455		
	C12	Argillaceous calcimudstone, light-brown-gray, microcrystalline; sparse to abundant, anastomosing, brown mudrock partings.
	C17	Bioclastic pack/wackestone, medium-brown-gray, sparse to abundant complete ostracodes and rare brachipods; laterally-discontinuous laminae of brown mudrock; mostly massive.
	C9/C17	Argillaceous intraclastic packstone, brown-gray.
	C10	Patterned calcimudstone, light-brown-gray, micro-crystalline; very calcareous - calcite infills micro-porosity; mottling less well defined down-section.
460		
	C8	Ostracodal wackestone, medium-brown-gray, microcrystalline; sparse to abundant complete ostracodes; abundant biomoldic porosity.
465	C10	Patterned calcimudstone, light-brown-gray, micro-crystalline; very calcareous - calcite infills micro-

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		porosity; mottling less well defined down-section; abundant quartz and k-feldspar silt.
470		
475	C10	Patterned calcimudstone, light-brown-gray, micro-crystalline; very calcareous - calcite infills micro-porosity; mottling less well defined down-section; 1" brown mudrock at top.
	C3	Laminated dolomudstone, light-yellow-gray; micro-crystalline; high microporosity.
	M2	Green mudrock, fissle.
	C3/C2	Laminated dolomudstone, light-yellow-gray, micro-crystalline, porous; sparse laminae of brown mud-rock.
	C12	Argillaceous dolomudstone, medium-green-gray.
	C3	Laminated dolomudstone, light-yellow-gray, micro-crystalline, porous; sparse laminae of brown mud-rock.
	M2/M5	Interbedded green and brown mudrock, nonfissle.
	C10	Patterned dolomudstone, light-yellow- or light-green-

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		gray, microcrystalline, calcareous.
	M5	Brown mudrock, fissle, fine-grain quartz arenite laminae.
480	C10	Patterned dolomudstone, light-green-gray, microcrystalline.
	M2	Green mudrock, nonfissle, waxy.
	C3	Laminated dolomudstone, light-yellow-gray, microcrystalline, porous; sparse laminae of brown mudrock.
	M2	Green mudrock, nonfissle, waxy.
	C3	Laminated dolomudstone, light-yellow-gray, microcrystalline, porous; sparse laminae of brown mudrock.
		Argillaceous quartz arenite, light-yellow-green, fine- to medium-grain, well-sorted, well-rounded quartz;
	S15	friable; lower contact sharp, upper gradational.
485	C3	Laminated dolomudstone, light-yellow-gray, microcrystalline, porous; sparse laminae of brown mudrock.
		Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz;
	S15	friable; lower contact sharp, upper gradational.
	C3	Laminated dolomudstone, light-yellow-gray, microcrystalline, porous; sparse laminae of brown mudrock; sparse fine- to medium-grain, well-rounded, mud-supported quartz in lower 6".
		Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz;
	S15	friable; lower contact sharp, upper gradational.
	C3/C1	Laminated dolomudstone, light-yellow-gray, microcrystalline, porous; sparse laminae of brown mudrock; fine- to coarse-grain, bimoldal, well-rounded, mud-supported quartz throughout.
490	C8	Ostracodal dolowacke/packstone, medium-brown-gray, abundant ostracodes; high biomoldic porosity.
		Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz;
	S15	friable; lower contact sharp, upper gradational.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, poorly-sorted to bimodal; well-rounded quartz; friable; grades upsection to ostracodal dolowacke/packstone, medium-brown-gray with abundant ostracodes and high biomoldic porosity.
	S15/S8	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; possible *Skolithos* burrows in upper 1 ft.

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
494		
		Poor core recovery (<10%) **undescribed 494-508 ft.**
508	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; friable; possible *Skolithos* burrows locally.
510		
515	S4	Cross-stratified quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz arenite; friable, sparse quartz overgrowths; vague, poorly-defined cross-stratification throughout.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz arenite; friable, sparse quartz overgrowths; vague, poorly-defined cross-stratification throughout.

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		No discernable breaks to 534 ft.
520		
525		
530		

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
535	S6	Trough cross-stratified arenite, light-yellow-brown, medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; abundant concave cross-laminae.
	S4/S3	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, bimodal, well-rounded quartz; weakly-indurated; abundant planar and low-angle cross-laminae.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths; vague cross-stratification locally. No discernable breaks to 560' 5"".
540		
545		

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
550		
555		
560		

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		Planar cross-stratified quartz arenite, light-yellow-gray and light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; planar laminae well-defined by green-gray argillaceous laminae; green-gray laminae friable, light-yellow-gray laminae moderately-indurated by quartz overgrowths.
	S3	
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; sparse, vague cross-laminae locally; sulfide locally present as pore-filling cement.
565		
	S4	Cross-stratified quartz arenite, light-yellow-gray, fine- to medium-grain, well- to moderately-sorted, well-rounded quartz; upper 1 ft. has well-defined, low-angle cross-laminae; in lower 8" cross-laminae are laterally discontinuous and disrupted by mottling; upper contact is sharp, lower is irregular.
570		
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; sparse, vague cross-laminae locally; sulfide locally present as pore-filling cement.

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
575		
	S8	*Skolithos* -bearing quartz arenite, light-yellow-gray, massive, fine- to medium-grain, well-rounded quartz matrix crosscut by *Skolithos* burrows infilled by medium-grain, well-sorted, well-rounded quartz arenite.
580	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; sparse, vague cross-laminae locally; sulfide locally present as pore-filling cement.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable, pyritic; sparse, green-gray mudrock partings.
585		
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to weakly-indurated; sparse, vague cross-laminae locally; sulfide locally present as pore-filling cement.

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4/S3	Cross-stratified quartz arenite, very-light-gray, fine-grain, well-sorted, well-rounded quartz; friable to moderately-indurated by quartz overgrowths; sparse green-gray mudrock partings in lower 3 ft., decrease in abundance upsection; sparse to abundant, vague to well-defined, low-angle to planar cross-laminae.
590		
595		
600		
	M1	Conglomeratic mudrock, green-gray, waxy, mudrock matrix with laminae of fine- to medium-grain, well-

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Phillips Petroleum Co., Winge TP-W1, Lincoln Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		sorted, well-rounded quartz arenite locally; pebble-size intraclast of argillaceous dolomudstone at 602 ft.
	S15	Argillaceous quartz arenite, fine-grain, well-sorted, well-rounded quartz with abundant very-fine-grain, green-gray mudrock intraclasts; friable to weakly-indurated.
	M1	Conglomeratic mudrock, green-gray, waxy mudrock matrix with fine- to pebble-size, angular to subround, argillaceous dolomudstone and chert locally.
605		
	C19	Argillaceous dolomudstone, medium-brown-gray with laminae of green-gray mudrock; finely- to microcrystalline, vuggy.
608		
609		
Bottom of cored interval and TD.		

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Getty Oil Co., Mineral Test 1703-1, Sec. 12-T37N-R8E, St. Genevieve Co., Mo., elev. 600 ft., NX core 185-510 ft.

Depth (ft.)	Litho-facies	Description/Comments
185	C18	Oolitic grainstone, light-brown-gray, fine- to medium-grain, well-sorted, well-rounded ooids; fine- to coarse-grain, moderately-sorted, sub-angular to rounded intraclasts of peloidal calcimud-stone and bioclastic packstone; ooids are radial and tangental.
	C10	Patterned calcimudstone, light-green-gray to light-brown-gray, abundant irregular mottles defined by green-gray clay-size fraction.
190		
	C16	Stylolaminated wackestone, light-medium-gray, microcrystalline; sparse ostracodes; abundant subparallel, low-relief stylolites; contacts stylolitic.
	C10	Patterned calcimudstone, light-brown-gray to light-medium-gray, microcrystalline, locally pyritic; abundant mottling throughout.
195	C16	Stylolaminated wackestone, light-medium-gray, microcrystalline; sparse ostracodes; abundant subparallel, low-relief stylolites; contacts stylolitic.
	C10	Patterned calcimudstone, light-brown-gray to light-medium-gray, microcrystalline, locally pyritic; abundant mottling throughout.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C16	Stylolaminated wackestone, light-medium-gray, microcrystalline; sparse ostracodes; abundant subparallel, low-relief stylolites; contacts stylolitic.
200	C15	Mottled calcimudstone, light-brown-gray, micro-crystalline, intensely mottled throughout.
	C12	Argillaceous calcimudstone, light-brown-gray with medium-brown, anastomosing, organic-rich clay-stone partings throughout.
205	C8	Ostracodal wackestone, microcrystalline, sparse to abundant ostracodes; nonargillaceous; stylolitic in upper 1"; stylolitic contacts at base and top.
	C10	Patterned calcimudstone, light-brown-gray, micro-crystalline, intensely mottled throughout.
210	C16	Stylolaminated wackestone, light-medium-gray, microcrystalline; sparse ostracodes; abundant subparallel, low-relief stylolites; contacts stylolitic.
	C17	Bioclastic pack/wackestone, medium-brown-gray, microcrystalline, sparse to abundant ostracodes, rare brachiopods; abundant peloids.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
215		
	C15	Mottled calcimudstone, light-brown-gray to light-green-gray, microcrystalline, pyritic; intensely mottled throughout.
	C16	Stylolaminated calcimudstone, light-medium-gray, microcrystalline; abundant subparallel stylolites.
220	C12	Argillaceous wackestone, light-brown-gray with anastomising brown mudrock laminae, micro-crystalline, sparse ostracodes throughout; 2-inch bioclastic grainstone at base.
	C10	Patterned calcimudstone, light-brown-gray and light-green-gray, microcrystalline, intensely mottled.
225	C15/C8	Mottled calcimud/wackestone, light-brown-gray to light-green-gray, microcrystalline, pyritic; intensely mottled throughout; stringers of ostracodal calci-wackestone locally; stylolitic at base, lower contact stylolitic.
	C10	Patterned calcimudstone, light-green-gray, micro-crystalline, intensely mottled throughout.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C8	Ostracodal wacke/packstone, light-brown-gray, microcrystalline, sparse to abundant ostracodes throughout.
230	C15/C8	Mottled ostracodal packstone, medium-brown-gray, microcrystalline, abundant complete ostracodes; argillaceous and stylolitic at base.
	C10	Patterned calcimudstone, light-brown-gray and medium-brown-gray, microcrystalline, intensely mottled throughout; upper contact stylolitic, lower contact gradational.
235	C15/C8	Mottled ostracodal packstone, medium-brown-gray, microcrystalline, abundant complete ostracodes; argillaceous and stylolitic at base.
	C10	Patterned calcimudstone, light-brown-gray and medium-brown-gray, microcrystalline, intensely mottled throughout; upper and lower contacts stylolitic.
240	C10	Patterned calcimudstone, light-brown-gray and medium-brown-gray, microcrystalline, intensely mottled throughout; upper and lower contacts stylolitic.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C10	Patterned calcimudstone, light-brown-gray and medium-brown-gray, microcrystalline, intensely mottled throughout; locally argillaceous, two 1" interbeds of organic-bearing, brown mudrock at 249' and 249'6"; upper contact stylolitic, lower contact sharp and irregular.
245		
250	C10	Patterned calcimudstone, light-brown-gray and medium-brown-gray, microcrystalline, intensely mottled throughout; locally argillaceous; upper and lower contacts are sharp and irregular.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
255		
	C10	Patterned dolomudstone, light-yellowish-gray, chalky, high microporosity, calcite infilling of inter-crystalline voids.
260	C10	Patterned dolomudstone, light-yellowish-gray, chalky, microporous, calcite infilling of intercrystalline voids; laminae of organic-bearing, brown mudrock in upper 6"; 1" interbed of brown, fissle mudrock at base.
265	C10	Patterned dolomudstone, light-brown-gray, argil-laceous, microcrystalline, nonporous.
	C2/C10	Patterned dolomudstone, light-yellowish-gray, chalky, microporous.
	C7	Brecciated dolomudstone, light-yellowish-gray, micro- to finely-crystalline, clotted appearance; abundant

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		angular vugs throughout.
270		
	C10	Patterned dolomudstone, light-yellowish-gray, chalky, microporous.
275	C10	Patterned dolomudstone, light-yellowish-gray, micro-crystalline with light-green-gray mottled throughout; stylolaminated at base, lower contact sharp and irregular.
	C4	Stromatolitic dolomudstone, yellowish-gray, micro-crystalline, microporous, with irregular, thin laminae of brown mudrock.
	C10	Patterned dolomudstone, light-yellowish-gray to light-medium-gray, argillaceous, mottled throughtout; locally calcareous.
280		

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
285	C10	Patterned dolomudstone, light-yellowish-gray, chalky, microporous; angular vugs in lower 8-inches.
	C10	Patterned dolomudstone, light-yellowish-brown, micro-porous, microcrystalline; intensely mottled throughout.
	C10	Patterned dolomudstone, light-yellowish-gray, chalky, microporous.
	C10	Patterned dolomudstone, light-yellowish-brown, micro-porous, microcrystalline; intensely mottled throughout.
290		
	C3	Laminated dolomudstone, light-yellow-gray with thin to thick brown, organic-bearing mudrock laminae, chalky, microporous.
	C10	Patterned dolomudstone, light-yellowish-brown, micro-porous, microcrystalline; intensely mottled throughout.
295		

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
300		**Core missing 295-300 ft.**
	C10	Patterned dolomudstone, light-yellowish-brown, micro-porous, microcrystalline; intensely mottled throughout.
	C10/C11	Patterned dolomudstone grading upsection to fenestral dolomudstone, light-yellow-gray, micro-crystalline, vertical spar-filled fenestrae in upper 8"; upper and lower contacts stylolitic.
305	C10	Patterned dolomudstone, light-yellowish-brown, micro-porous, microcrystalline; intensely mottled throughout; 1" interbed of brown, organic-bearing mudrock at top.
	C2/C10	Patterned dolomudstone, light-yellowish-brown, micro-porous, microcrystalline; intensely mottled throughout; fenestral in upper 4".
	C3/C2	Laminated dolomudstone, light-yellow-gray with thin to thick, irregular, brown, organic-bearing mudrock laminae, chalky, microporous.
310	C2/C10	Patterned dolomudstone, light-yellowish-brown, micro-porous, microcrystalline; intensely mottled throughout.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C2	Microporous dolomudstone, light-yellowish-brown, chalky, high microporosity, locally vuggy.
	C2/C10	Patterned dolomudstone, light-yellowish-brown, micro-porous, microcrystalline; intensely mottled throughout.
315	C8	Ostracodal dolowackestone, medium-brown-gray, microcrystalline, abundant biomoldic porosity after complete ostracodes.
	C10/M5	Patterned dolomudstone, light-yellowish-gray, inter-bedded with brown, organic-bearing mudrock; patterned dolomudstone interbeds are 1-13" thick, organic-bearing mudrock interbeds are 0.25"-1.0" thick; patterned dolomudstone is microcrystalline, with sparse to abundant mottles; mudrock is fissle with thin, fine-grain quartz arenite laminae locally. Mud-rock interbeds present at 317'6", 318', 319'7", 320'5", 321'6", 322'4" and 324'.
320		

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
325	C3/M5	Laminated dolomudstone, light-yellow-gray with thin to thick lamine of brown, organic-bearing mudrock; chalky, microporous.
330	C10	Patterned dolomudstone, light-yellow-gray, micro-porous, microcrystalline; sparse to abundant mottling throughout, sparsely pyritic.
	C3	Laminated dolomudstone, light-yellowish-brown, chalky, high microporosity, locally vuggy; sparse, brown mudrock laminae; 1" of brown mudrock at base.
	C2/C10	Patterned dolomudstone, light-yellow-gray, micro-porous, microcrystalline; sparse to abundant mottling throughout, sparsely pyritic.
335	C2/C10	Patterned dolomudstone, light-yellow-gray, micro-porous, microcrystalline; sparse to abundant mottling throughout, sparsely pyritic; mudcracks on bedding plane at upper contact.

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Depth (ft.)	Litho-facies	Description/Comments
340	C2/C10	Patterned dolomudstone, light-yellowish-gray, micro-porous, microcrysalline; brown mudrock laminae in upper 4".
	C2/C3	Laminated dolomudstone, light-yellowish-brown, chalky, high microporosity, locally vuggy; sparse, brown mudrock laminae.
	C2/C10	Argillaceous patterned dolomudstone, light-green-gray, microporous, microcrystalline, intensely mottled throughout.
345	C8	Ostracodal dolowackestone, medium-brown-gray, dense, nonporous; sparse, thin (0.1-0.2"), anastomos-ing laminae of brown mudrock.
350	C2/C3	Medium- to thick-beds of argillaceous patterned dolomudstone, light-green-gray, grading upsection to stromatolitic or laminated dolomudstone, light-yellow-gray; laminated dolomudstone contains sparse to abundant, thin laminae of brown mudrock; all lithologies have high microporosity.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C10	Patterned dolomudstone, light-brown-gray, slightly calcareous, microcrystalline, dense, massive; sparse to moderate mottling throughout.
355		
	C3/C2	Laminated dolomudstone, light-yellowish-brown, chalky, high microporosity, locally vuggy; sparse, brown mudrock laminae; 1" green-gray mudrock interbed at base.
360	C1	Quartzose dolowackestone grading upsection to patterned dolomudstone, light-green-gray to light-yellowish-gray, microporous to dense; sparse to abundant fine-grain, well-rounded quartz in lower 1 ft.; ostracodal biomoldic porosity in upper 2".
	C2/C3	Medium- to thick-beds of argillaceous patterned dolomudstone, medium-green-gray, grading upsection to stromatolitic or laminated dolomudstone, light-yellow-gray; latter contains sparse to abundant, thin laminae of brown mudrock; patterned dolomudstones are slightly porous and have high argillaceous content, light-yellow-gray dolomudstones have high micro-porosity.
365		

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C2/C10	Patterned dolomudstone, light-green-gray to light-yellowish-gray, microporous to dense; sparse fine-grain, well-rounded quartz in lower 2 ft.
370		
	C1	Quartzose dolowackestone, light-green-gray, microcrystalline, porous; sparse to abundant, fine-grain, well-rounded, well-sorted quartz, abundance and grain-size decreases upsection; 1" of green-gray mudrock at top, 2" of lithic arenite at base.
	C3	Laminated dolomudstone, light-yellowish-brown, chalky, high microporosity, locally vuggy; sparse, brown mudrock laminae.
375	C2/C10	Patterned dolomudstone, light-green-gray to light-yellowish-gray, microporous to dense; sparse very fine-grain, well-rounded quartz in lower 2 ft.
380		

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C1	Quartzose dolowackestone, light-green-gray, microcrystalline, porous; sparse to abundant, fine-grain, well-rounded, well-sorted quartz, abundance and grain-size decreases upsection; 2" of green-gray mudrock at top, 3" of lithic arenite at base.
385	C10/C2	Patterned dolomudstone, light-green-gray to light-yellowish-gray, microporous to dense; sparse very fine-grain, well-rounded quartz.
	C15	Argillaceous dolomudstone, light- to medium-brown-gray, microcrystalline, locally calcareous; abundant, laterally-discontinuous, thin, brown mudrock laminae, somewhat shaly.
	S13	Lithic quartz arenite, light-yellow-gray, very-fine- to fine-grain, moderately- to poorly-sorted, well-rounded quartz and subangular to subrounded dolomudstone; dolomicrite increasingly abundant upsection.
390	C2/C7	Laminated and brecciated dolomudstone, light-yellow-gray, microcrystalline, microporous; sparse to abundant, thin-laminae of brown mudrock that increase in abundance upsection; brecciated and vuggy at 391'2" and 391'6".
	C10/M5	Patterned dolomudstone, light-brown-gray, microcrystalline, microporous, mottled; locally calcaroues due to crystalline calcite infilling of microporosity; bed bounded by mudrock partings.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
395	S13/S2	Lithic quartz arenite, light-yellow-gray, very-fine- to fine-grain, moderately- to poorly-sorted, well-rounded quartz and subangular to subrounded dolomudstone; dolomicrite increasingly abundant upsection.
	S13/S2	Lithic quartz arenite grading upsection to laminated dolomudstone; lithic quartz arenite, light-yellow-gray, fine-grain, moderately- to poorly-sorted, well-rounded quartz and subangular to subrounded dolomudstone; dolomicrite increasingly abundant upsection where it grades to laminated dolomudstone, light-yellow-gray, microcrystalline, microporous with rare, thin laminae of brown mudrock.
400	S13/S2	Lithic quartz arenite grading upsection to laminated dolomudstone; lithic quartz arenite, light-yellow-gray, fine-grain, moderately- to poorly-sorted, well-rounded quartz and subangular to subrounded dolomudstone; dolomicrite increasingly abundant upsection where it grades to laminated dolomudstone, light-yellow-gray, microcrystalline, microporous with rare, thin laminae of brown mudrock.
	C2	Chalky dolomudstone, light-yellow-gray, microcrystalline, very porous, featureless.
	S15	Argillaceous quartz arenite, light-yellowish-gray, fine-coarse-grain, moderately-sorted, well-rounded quartz; friable to weakly-indurated; locally calcareous; sparse to abundant partings of green-gray mudrock.
405	S10	Massive quartz arenite, medium-yellow-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; friable, abundant limonite staining; irregular, iron sulfide masses (<0.25") 406'-407'.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4	Cross-stratified quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately indurated by quartz overgrowths; abundant low-angle cross-laminae.
410	S9	Mottled quartz arenite, light-gray to light-green-gray, fine-grain, well-sorted, well-rounded quartz; friable, argillaceous throughout; mottling increases upsection; lower contact gradational, upper contact sharp.
	S10	Massive quartz arenite, light-gray to light-green-gray, fine-grain, well-sorted, well-rounded quartz; friable, argillaceous throughout.
415		
	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray, matrix is very-fine- to fine-grain, well-sorted, well-rounded quartz; sparse to abundant *Skolithos* burrows (0.2-0.5" diameter) are infilled by medium- to coarse-grain, poorly-sorted, well-rounded quartz; moderately-indurated throughtout by quartz overgrowths; abundance of burrows increases upsection.
420		
	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray, matrix is very-fine- to fine-grain, well-sorted, well-rounded quartz; sparse to abundant *Skolithos* burrows (0.2-0.5" diameter) are infilled by medium- to coarse-grain, poorly-sorted, well-rounded quartz; moderately- to weakly-indurated throughtout by quartz over-

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		growths; abundance of burrows increases upsection.
425	S10	Massive quartz arenite, light-medium-gray to light-yellow-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated to friable; ferroan nodules at 424'6"; no discernable breaks to 441 ft.
430		
435		

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
440		
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; friable; locally calcareous, massive.
445		
	S4	Cross-stratified quartz arenite, light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths, abundant low-angle cross-laminae.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
450	S10	Massive quartz arenite, light-medium-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; weakly-indurated by quartz over-growths, massive.
	S4	Cross-stratified quartz arenite, light-green-gray, fine-grain, well-sorted, well-rounded quartz; friable, argillaceous; abundant low angle cross-laminae; irregular ferroan masses (<0.25" diameter) near base.
455	S4	Cross-stratified quartz arenite, light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; abundant low-angle cross-laminae.
	S10	Massive quartz arenite, light-green-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; weakly indurated by quartz over-growths, massive.
460	S4	Cross-stratified quartz arenite, light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; abundant low-angle cross-laminae.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
465		
	S10	Massive quartz arenite, light-medium-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz over-growths, massive.
470	S14	Silty quartz arenite, light-gray, very-fine- to fine-grain, poorly-sorted, well-rounded quartz; friable; silty partings throughout.
	S4	Cross-stratified quartz arenite, light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; abundant low-angle cross-laminae.
475	S10	Massive quartz arenite, light-medium-gray, fine- to coarse-grain, poorly- to moderately-sorted, well-rounded quartz; moderately-indurated by quartz over-growths, massive.
	S4	Cross-stratified quartz arenite, yellow-gray to light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated, friable where

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		locally argillaceous; abundant ferroan staining, small nodules (<0.25") near base; well- to weakly-defined cross-laminae throughout.
480	S15	Argillaceous quartz arenite, light-green-gray, fine-grain, well-sorted, well-rounded quartz; friable, massive, lower contact is gradational, upper contact is sharp.
	S4	Cross-stratified quartz arenite, light-medium-gray grading to light-green-gray at top, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to weakly-indurated, less well-indurated upsection; abundant low-angle and planar cross-laminae, cross-laminae less well defined in upper 2 ft.
485		
	S10	Massive quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; moderately-indurated, massive.
490	S4/S3	Cross-stratified quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; abundant low-angle and sparse planar cross-laminae.
	S10	Massive quartz arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; well-indurated by quartz overgrowths; sparse to abundant sulfide nodules (0.25") at base.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S9	Mottled quartz arenite, light-green-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz; friable, argillaceous; mottled throughout.
	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz matrix with *Skolithos* burrows infilled by medium- to coarse-grain, well-rounded quartz; moderately- to weakly-indurated; sparsely argillaceous.
495	S10	Massive quartz arenite, very-light- to light-gray, fine- to medium-grain, poorly-sorted quartz; moderately- to well-indurated by quartz overgrowths; locally abundant sulfide nodules from 495-500 ft.
500		
	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz matrix with *Skolithos* burrows infilled by medium- to coarse-grain, well-rounded quartz; moderately- to weakly-indurated; sparsely argillaceous.
505	S10	Massive quartz arenite, light-green-gray, fine- to medium-grain, poorly-sorted quartz; friable, argillaceous; vague and discontinuous cross-stratification in lower 2 ft.

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Getty Oil Co., Mineral Test 1703-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		Skolithos -bearing quartz arenite, light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz matrix with *Skolithos* burrows infilled by medium- to coarse-grain, well-rounded quartz; moderately- to weakly-indurated; sparsely argillaceous.
	S8	
	S10	Massive quartz arenite, light-green-gray, fine- to medium-grain, well-sorted quartz; friable, argillaceous.
510	S8	*Skolithos* -bearing quartz arenite, light-yellowish-gray, fine-grain, well-sorted, well-rounded quartz matrix with *Skolithos* burrows infilled by medium- to coarse-grain, well-rounded quartz; moderately- to weakly-indurated; sparsely argillaceous.
Bottom of cored interval and TD		

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Getty Oil Co., Mineral Test 1701-1, Sec. 12-T37N-R8E, St. Genevieve Co., Mo., elev. 660 ft., NX core 65-265 ft.

Depth (ft.)	Litho-facies	Description/Comments
65	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, poorly- moderately-sorted, well-rounded quartz; weakly-indurated to friable; massive.
	S4	Cross-stratified quartz arenite, very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly-indurated by quartz overgrowths; abundant low-angle cross-laminae.
70		
75		
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated to friable; mostly massive, vague, laterally discontinuous cross-laminae locally.

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
80	S15	Argillaceous quartz arenite, light-green-gray, fine- to coarse-grain, poorly-sorted, well-rounded quartz; friable to weakly-indurated; upper contact gradational, lower contact sharp.
	S4/S3	Cross-stratified quartz arenite, very-light-yellow-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; friable; well-developed low-angle and planar cross-laminae.
85	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated, pore-filling sulfides locally.
	S4/S3	Cross-stratified quartz arenite, very-light-yellow-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; friable; well-developed low-angle and planar cross-laminae; green-gray clay drapes locally.
90		
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; weakly-indurated.

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4/S3	Cross-stratified quartz arenite, very-light-yellow-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; friable; well-developed low-angle and planar cross-laminae.
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated, pore-filling sulfides and ferroan nodules (0.25" diameter) locally.
95		
100		
	S14	Silty quartz arenite, light-yellow-gray, fine- to medium-grain, poorly- to moderately-sorted, well-rounded quartz; vague, laterally disrupted planar-laminae.
105		

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S4/S3	Cross-stratified quartz arenite, very-light-yellow-gray, very fine- to fine-grain, well-sorted, well-rounded quartz; friable; well-developed low-angle and planar cross-laminae.
110		
	S10	Massive quartz arenite, light-medium-gray to light-yellowish-gray, fine- to medium-grain, moderately- to poorly-sorted, well-rounded quartz; moderately-indurated by quartz overgrowths; pore-filling iron sulfide locally.
115		
	M2	Green mudrock, medium-green-gray, nonfissle.
	S15	Argillaceous quartz arenite, fine- to medium-gray, poorly-sorted, well-rounded quartz; weakly-

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
120		indurated, calcareous; vague, disrupted cross-laminae locally.
	M2	Green mudrock, medium-green-gray, nonfissle.
	S2	Dolomitic quartz arenite, yellow-gray grading up-section to quartz-bearing dolowackestone, green-gray to medium-brown-gray, finely-crystalline, abundant fine- to medium-grain, poorly-sorted, well-rounded mud-supported quartz.
	C4	Stromatolitic dolomudstone, light-medium-brown, microcrystalline, massive with planar to convex finely-crystalline dolomudstone laminae.
125	S13	Lithic quartz arenite, light-brown to light-yellowish gray, fine- to medium-grain, poorly-sorted, well-rounded quartz matrix and coarse-grain to cobble-size, angular to subrounded, poorly-sorted, matrix-supported stromatolitic dolomudstone; overall grain-size decreases upsection.
	C4	Stromatolitic dolomudstone, light-medium-brown, microcrystalline, massive with planar to convex finely-crystalline dolomudstone laminae, sparse to abundant, fine-grain, well-rounded, well-sorted quartz throughout.
130	S13	Lithic quartz arenite, light-green-gray to light-yellow-gray, fine- to medium-grain, poorly-sorted, well-rounded quartz matrix and coarse-grain to cobble-size, angular to subrounded, poorly-sorted, matrix-supported stromatolitic dolomudstone; overall grain-size decreases upsection.
	C4	Stromatolitic dolomudstone, light-medium-brown, microcrystalline, massive with planar to convex finely-crystalline dolomudstone laminae; sparse, fine-grain, well-rounded, well-sorted quartz.
	C1	Quartzose dolowackestone, medium-brown-gray, finely-crystalline; small, gypsum pseudomorph molds locally; sparse to abundant, medium- to coarse-grain, well-rounded, poorly-sorted, mud-supported quartz locally.

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
135	C4	Stromatolitic dolomudstone, light-medium-brown, microcrystalline, massive with planar to convex finely-crystalline dolomudstone laminae; sparse, fine-grain, well-rounded, well-sorted quartz.
	C1	Quartzose dolowackestone, medium-brown-gray; finely-crystalline; small, gypsum pseudomorph molds locally; medium- to coarse-grain, well-rounded, poorly-sorted, mud-supported quartz locally.
	C4	Stromatolitic quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted quartz; sparse planar, dolomicrite cemented laminae.
140	C1	Quartzose dolowackestone, medium-brown-gray; finely-crystalline; small, gypsum pseudomorph molds locally; abundant, medium- to coarse-grain, well-rounded, poorly-sorted quartz laminae through-out; 1" green-gray quartzose mudrock at top.
145		
	C1	Quartzose dolowackestone, medium-brown-gray; finely-crystalline; small, gypsum pseudomorph molds locally; sparse to abundant, medium- to coarse-grain, well-rounded, poorly-sorted; mud-supported quartz locally.
	C4	Stromatolitic quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted quartz; sparse planar, dolomicrite cemented laminae.

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C1	Quartzose dolowackestone, medium-brown-gray; finely-crystalline; small, gypsum pseudomorph molds locally; medium- to coarse-grain, well-rounded, poorly-sorted; mud-supported quartz locally.
150		
	C1	Argillaceous quartzose dolowackestone, green-gray, finely-crystalline; small, gypsum pseodomorph molds locally; sparse, medium- to coarse-grain, well-rounded, poorly-sorted, mud-supported quartz locally; sparse to abundant green-gray clay throughout.
	M1	Conglomeratic mudrock, green-gray, nonfissle, abundant quartz sand and calcimudstone intraclasts.
155	C12	Argillaceous calcimudstone with sparse laminae of quartz-bearing wackestone laminae, light- to medium-green-gray throughout; microcrystalline, possible stromatolitic in upper 6".
	S15	Argillaceous quartz arenite, light-brown-gray with green-gray claystone partings throughout; fine- to coarse-grain, moderately-sorted, well-rounded quartz; moderately-indurated, calcareous throughout.
160		
	M1	Conglomeratic mudrock, green-gray, nonfissle, abundant quartz sand and calcimudstone intraclasts.
		Argillaceous dolomudstone with sparse laminae

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		of quartz-bearing dolowackestone, light-to medium-green-gray; microcrystalline, calcareous.
		Mottled quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately-indurated; mottled throughout.
	S9	
	C12	Argillaceous dolomudstone with sparse laminae of quartzose dolowackestone laminae, light- to medium-green-gray; microcrystalline, calcareous.
165		
	C4	Stromatolitic quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted quartz; sparse planar, dolomicrite cemented laminae; abundant, angular dolomudstone intraclasts; rubbly.
	C2/C1	Dolomudstone, medium-brown, finely-crystalline with sparse quartzose dolowackestone laminae and mud-supported quartz grains.
170		
175		

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	M1	Conglomeratic mudrock, green-gray, nonfissle.
	S4	Stromatolitic quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted quartz; sparse planar, dolomicrite cemented laminae; abundant, angular dolomudstone intraclasts; rubbly.
	C12	Argillaceous calcimudstone with abundant to sparse laminae of quartzose wackestone laminae, light to medium-brown-gray throughout; micro-crystalline; abundance of quartz sand decreases upsection.
180	S7	Stromatolitic quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted quartz; sparse planar, microcrystalline calcite cemented laminae.
	C12/C2	Massive calcimudstone, light-brown-gray, micro-crystalline, sparse to abundant vugs (<0.3").
		Cross-stratified quartz arenite, very-light-gray, fine-grain, very well-sorted, well-rounded quartz; moder-ately indurated; abundant, vague low-angle cross-laminae.
	S4	
	S10/S7	Calcareous quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated; massive, possibly stromatolitic in upper 8".
185		
	S10	Massive quartz arenite, light-yellow-gray, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated, calcareous throughout; massive.

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
190		
	S10	Massive quartz arenite, light-yellow-gray to light-orange-red, fine- to medium-grain, moderately- to poorly-sorted, well-rounded quartz; moderately- to weakly-indurated, calcarous throughout, ferrigenous, massive.
195		
	C12	Calcimudstone, light-medium-gray, finely-crystalline, locally stylolitic; medium-grain, ferrigenous quartz arenite infills burrows at upper contact; massive; upper contact sharp, lower gradational.
	S10	Massive quartz arenite, light-yellow-gray to light-orange-red, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated, calcarous throughout, ferrigenous, massive.
200		
		No core 200-201 ft.
	C1	Quartzose packstone grading upsection to calcimudstone, light-brown-gray to light-medium-gray, sparse to abundant, medium-grain, ferroan-stained, well-rounded, grain- to mud-supported quartz.

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
205	S10	Massive quartz arenite, light-yellow-gray to light-orange-red, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated, calcarous throughout, ferrigenous, massive.
		No core 205-208 ft.
210	S10	Massive quartz arenite, light-yellow-gray to light-orange-red, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated, calcarous throughout, ferrigenous, massive.
	S4	Poor recovery (26.8%), 12'1" of core recovered 210-255 ft. Two core segments recovered, an upper segment 3'8" in length and a lower segment 4' in length. Upper core segment: cross-stratified quartz arenite, light-yellow-gray to orange red, fine- to medium-grain, well-sorted, well-rounded quartz; moderately-indurated, ferrigenous. Lower core segment: cross-stratified quarts arenite, light-medium-gray, fine-grain, well-sorted, well-rounded quartz; well-indurated by quartz over-growths, abundant low-angle cross-laminae.
255	S10	Massive quartz arenite, light-yellow-gray to light-orange-red, fine- to medium-grain, moderately-sorted, well-rounded quartz; moderately- to weakly-indurated, calcarous throughout, ferrigenous, massive; poor recovery (<35%).

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Getty Oil Co., Mineral Test 1701-1, St. Genevieve Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
260		
	S15	Argillaceous quartz arenite, light-medium-gray to light-red-brown, fine- to medium-grain, well-sorted, well-rounded quartz; abundant to sparse green-gray mudrock partings, decrease in abundance up-section; lower contact sharp and irregular, upper contact is gradational.
	C19	Vuggy dolomudstone, light-brown-gray, finely-crystalline; vuggy: sparse to abundant anastomosing green-gray mudrock laminae and mud-supported, fine-grain, well-sorted quartz; irregular vugs (<0.25").
265		
Bottom of cored interval and TD.		

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Lacleade Gas Storage, Hammer Lease 1, Sec. 12-T47N-R6E, St. Louis Co., Mo., ISGS Core 6108, 1" diameter plug samples each foot 1527-1675 ft.

Depth (ft.)	Litho-facies	Description/Comments
1528	C10	Patterned dolomudstone, light-yellowish-gray to light-brown-gray, microcrystalline; laminae of fenestral dolomudstone locally.
1530	C4	Stromatolitic dolomudstone, light-green-gray to light-yellowish-gray, microcrystalline, chalky; laminae of green-gray mudrock and fine-grain quartz arenite locally; high microporosity; locally vuggy.
1535		
1540	C10	Patterned dolomudstone, light-yellowish-gray to light-brown-gray, microcrystalline; laminae of fenestral dolomudstone locally.

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Lacleade Gas Storage, Hammer Lease 1, St. Louis Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C4	Stromatolitic dolomudstone, light-green-gray to light-yellowish-gray, microcrystalline, chalky; laminae of green-gray mudrock and fine-grain quartz arenite locally; high microporosity; locally vuggy.
1545	C1	Quartzose dolowackestone, light-brown-gray, microcrystalline dolomite matrix; sparse to abundant, medium-grain, poorly-sorted, well-rounded, mud-supported quartz; abundance of quartz decreases upsection.
	S9	Mottled quartz arenite, light-brown-gray and light-green-gray, medium- to fine-grain, poorly-sorted, well-rounded quartz; friable; mottling defined by distribution of light-green-gray argillaceous fraction.
1550		**Poor core recovery 1548-1552 ft.** **no samples**
	S15	Argillaceous quartz arenite, light-green-gray to medium-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable; pyritic, argillaceous throughout.
1555		

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Lacleade Gas Storage, Hammer Lease 1, St. Louis Co., Mo. (cont.)

Depth (ft.)	Litho-facies	Description/Comments
	S13	Lithic arenite, light-brown-gray and medium-green-gray; fine- to medium-grain, moderately-sorted, well-rounded quartz matrix with coarse-grain to pebble-size, angular green-gray argillaceous arenite clasts.
	S10	Massive quartz arenite, light-brown-gray, fine- to medium-grain, poorly- to moderately-sorted, well-rounded quartz; friable to weakly-indurated by quartz overgrowths.
1560		
1562		
		Poor recovery; no samples 1562-1588 ft.
1588	S10	Massive quartz arenite, light-yellow-brown, medium-grain, well-sorted, well-rounded quartz; friable, very silty throughout.
	S15	Argillaceous quartz arenite, light-green-gray, fine- to medium-grain, well-sorted, well-rounded; weakly-indurated by quartz overgrowths; sparsely pyritic; argillaceous throughout.
1590		

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Lacleade Gas Storage, Hammer Lease 1, St. Louis Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S3	Cross-stratified quartz arenite, light-yellowish-gray, fine- to coarse-grain, bimodal, well-rounded quartz; moderately- to well-indurated by quartz over-growths; thin (<0.2") planar laminae of fine- to medium-grain and medium- to coarse-grain quartz; abundance of latter increases upsection.
1595		
	S10	Massive quartz arenite, light-yellowish-gray to light-medium-gray, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths.
1600		
	S3	Cross-stratified quartz arenite, light-yellowish-gray, fine- to coarse-grain, bimodal, well-rounded quartz; moderately- to well-indurated by quartz over-growths; thin (<0.2") interlaminae of fine- to medium-grain and medium- to coarse-grain quartz; abundance of latter increases upsection.
1605		
	S10	Massive quartz arenite with thin interbeds of cross-stratified arenite, light-yellowish-gray to light-medium-gray, fine- to coarse-grain, moderately-sorted to bimodal, well-rounded quartz; massive arenite is

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Lacleade Gas Storage, Hammer Lease 1, St. Louis Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1610		moderately- to well-sorted and weakly- to moderately-indurated by quartz overgrowths; thin interbeds of cross-laminated arenite are medium- to coarse-grain, well-sorted, and well-indurated; abundance of cross-laminated arenite increases upsection.
1615	S10	Massive quartz arenite, light-yellowish-gray to light-medium-gray, fine- to medium-grain, moderately- to well-sorted, well-rounded quartz; weakly- to moderately-indurated by quartz overgrowths; silty.
1620	S5	Ripple cross-stratified quartz arenite, light-yellowish-gray, fine- to coarse-grain, bimodal, well-rounded quartz; moderately- to well-indurated by quartz over-growths; thin (<0.2") interlaminae of fine- to medium-grain and medium- to coarse-grain, abundance of latter increases upsection.

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Lacleade Gas Storage, Hammer Lease 1, St. Louis Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, very-light-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- well-indurated by quartz overgrowths.
1625		
	S10	Massive quartz arenite, light-yellowish-gray, medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz overgrowths; grain-size and degree of induration increases upsection.
1630		
	S10	Massive quartz arenite, light-medium-gray to medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; friable to moderately-indurated by quartz over-growths.
1635		

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Lacleade Gas Storage, Hammer Lease 1, St. Louis Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-yellow-brown, medium-grain, well-sorted, well-rounded quartz; very well-indurated by abundant quartz overgrowths.
	S10	Massive quartz arenite, light-medium-gray to medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to well-indurated by quartz over-growths; sparse, pore-filling sulfide.
1640		
1645	S10	Massive quartz arenite, light-yellowish-gray to light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz, weakly- to moderately-indurated by quartz overgrowths; increasingly indurated up-section; dead oil at 1648.5 ft.

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Lacleade Gas Storage, Hammer Lease 1, St. Louis Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1650	S5	Ripple cross-stratified quartz arenite, light-yellowish-gray, fine- to coarse-grain, bimodal, well-rounded quartz; moderately- to well-indurated by quartz over-growths; *thin* (<0.2") interlaminae of fine- to medium-grain and medium- to coarse-grain, abundance of latter increases upsection.
1655	S10	Massive quartz arenite, light-yellowish-gray, to light-green-gray, fine- to medium-grain, well-sorted, well-rounded quartz; weakly- to moderately-indurated by by quartz overgrowths; sparse to common, irregular masses of sulfide (<0.2") locally; argillaceous where sulfide is common.
1660	S10	Massive quartz arenite, light-medium-gray to medium-gray, fine to medium-grain, well-sorted, well-rounded quartz; well-indurated by quartz over-growths; locally sulfide cemented; abundant micro-crystalline dolomite; locally mud-supported.

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Lacleade Gas Storage, Hammer Lease 1, St. Louis Co., Mo. (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	S10	Massive quartz arenite, light-medium-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz over-growths.
1665		
	S5	Ripple cross-stratified quartz arenite, light-yellowish-gray, fine- to coarse-grain, bimodal, well-rounded quartz; moderately- to well-indurated by quartz over-growths; locally, irregular sulfide masses (<0.2"); abundant dolomicrite matrix, locally mud-supported.
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz over-growths; sparse, irregular sulfide masses (<0.2").
1670		
	S5	Ripple cross-stratified quartz arenite, light-yellowish-gray, fine- to coarse-grain, bimodal, well-rounded quartz; moderately indurated by quartz overgrowths; locally, irregular sulfide masses (<0.2").
	S10	Massive quartz arenite, light-yellowish-gray, fine- to medium-grain, well-sorted, well-rounded quartz; moderately- to weakly-indurated by quartz over-growths; sparse, irregular sulfide masses (<0.2").
1675		
Bottom of cored interval, TD at 1684 ft.		

Note: lithic contacts based, in part, on company core description.

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Ohio Dept. of Geological Survey, C. Beiser 1, Wayne Twp., Sec. 5, Butler Co., Ohio, elev. 935 ft., DGS C2537, NX core 0-1445 ft., described 1350-1420 ft.

Depth (ft.)	Litho-facies	Description/Comments
1350	C14	Peloidal wacke/packstone, medium-brown-gray, microcrystalline, massive.
1355	C12/C6	Argillaceous mottled calcimudstone, light-green-gray, microcrystalline; mottled throughout.
	C12	Argillaceous calcimudstone, medium-brown-gray to light-green-gray, microcrystalline; green-gray mudrock partings in lower 6" grading upsection to brown mudrock partings; abundance of partings decreases upsection; vague mottling in upper 1 ft.
1360	C11	Fenestral calcimudstone, light-green- to medium-brown-gray, microcrystalline, locally peloidal, calcite-infilled fenestrae increasingly abundant upsection; locally dolomitic.
	C12	Argillaceous dolomudstone, light-green-gray, microcrystalline, silty with sparse mottling; upper contact gradational.
	C15	Mottled calcimudstone, medium-brown-gray, microcrystalline; brown mudrock laminae in lower 1 ft.

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ODGS, C. Beiser 1, Butler Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1365	C12/C6	Argillaceous mottled calcimudstone, medium-green-gray, microcrystalline, dolomitic; abundant mottling.
	C15	Mottled calcimudstone, medium-brown-gray, micro-crystalline, mottled throughout, locally peloidal.
1370	C12/C6	Argillaceous mottled calcimudstone, medium-green-gray, microcrystalline, dolomitic; abundant mottling.
	C15/C14	Mottled calcimudstone, medium-brown-gray, micro-crystalline, mottled throughout, locally peloidal.
	C12	Argillaceous calcimudstone, medium-brown-gray, microcrystalline, abundant brown mudrock part-ings.
	C15/C14	Mottled calcimudstone, light-brown-gray, micro-crystalline, mottled throughout, locally peloidal.
1375	C3	Laminated dolomudstone, light-brown-gray, micro-crystalline, vuggy, bounded by thick brown-mud-rock laminae.
	C15	Mottled calcimudstone, light-brown-gray, micro-crystalline, mottled throughout, locally peloidal.
	C13	Laminated calcimudstone, medium-brown-gray, microcrystalline, abundant brown mudrock part-

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ODGS, C. Beiser 1, Butler Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		ings.
	C3/C2	Laminated dolomudstone, light-yellow-gray, micro-crystalline, porous; sparse to abundant planar laminae of brown mudrock.
1380	C6/C2	Mottled dolomudstone, light-yellow-brown, micro-crystalline, mottled to massive.
	C12/C2	Argillaceous dolomudstone, light-yellow-brown, microcrystalline, porous, sparse laminae of brown mudrock.
	C3/C2	Laminated dolomudstone, light-yellow-brown, microcrystalline, chalky, microporous, sparse to common, thin to thick, planar laminae of brown mudrock.
1385	C2/C12	Argillaceous dolomudstone, light-green-gray, grading to chalky dolomudstone, light-yellow-gray, microcrystalline, chalky, porous.
	C2/C12	Argillaceous dolomudstone, light-green-gray, grading to chalky dolomudstone, light-yellow-gray, microcrystalline, chalky, porous; green mudrock partings in lower 1 ft.
	C10	Patterned dolomudstone, light-brown-gray, micro-crystalline, mottled throughout.
1390	C4/C2 C7	Interbedded stromatolitic dolomudstone, light-yellow-gray with brown mudrock laminae, and brecciated dolomudstone, yellow-gray, vuggy; stringers of intraclastic dolograinstone with fine-grain quartz.

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ODGS, C. Beiser 1, Butler Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C12	Argillaceous dolomudstone, green-gray, micro-crystalline; sparse to abundant green-gray mud-rock partings, abundance increases upsection.
	C2	Chalky dolomudstone, light-yellow-brown, micro-crystalline, chalky, microporous.
1395	C10	Patterned dolomudstone, light-green-gray to green-gray, microcrystalline, abundant mottles, darker mottles are pyritic.
1400		
	M6	Argillaceous siltstone, light-green-gray, argillaceous, almost fissle; abundant microcrystalline dolomite and quartz silt.
	C6	Mottled dolomudstone, green-gray to light-green-gray, increasingly mottled upsection, clay content increases upsection; quartz silt locally, abundance decreases upsection.
1405	M6	Argillaceous dolomudstone, medium-green-gray, microcrystalline, abundant green-gray clay frac-

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ODGS, C. Beiser 1, Butler Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		tion, somewhat fissle upsection, 1" green mud-rock at top; abundant quartz silt at base.
	C6	Mottled dolomudstone, green-gray to light-green-gray, mottling and clay content increases upsection; quartz silt locally, abundance decreases upsection.
	C5/C3	Chalky dolomudstone, light-yellow-brown, micro-crystalline, porous, small vugs locally infilled by coarsely-crystalline dolomite; capped by 1" of brown mudrock.
1410	C6	Mottled dolomudstone, green-gray to light-green-gray, mottling and clay content increases upsection; quartz silt locally, abundance decreases upsection.
	C9	Intraclastic dolograinstone grading upsection to argillceous dolomudstone, light-green- to medium-green-gray, fine- coarse-grain, poorly-sorted, sub-angular to subrounded intraclasts of brown-gray and green-gray dolomudstone.
1415	M6/M2	Argillaceous siltstone, medium-green-gray, micro-crystalline dolomite, very argillaceous; sparse 1" green mudrock partings at base that decrease in abundance upsection.
	C19	Vuggy dolomudstone, light-brown-gray with light-green-gray mudrock partings; locally vuggy, vugs infilled by coarsely-crystalline dolomite and calcite; abundance of vugs decreases downsection; pyrite bands at 1415'7.5" and 1415'11".

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ODGS, C. Beiser 1, Butler Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
420		
Bottom of described interval, TD at 1445 ft.		

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Ohio Dept. of Geological Survey, Sky Valley Recreational Club 1, Pierce Twp., Clermont Co., Ohio, elev. 480 ft., DGS C2536, NX core 13-2080 ft., described 729-770 ft.

Depth (ft.)	Litho-facies	Description/Comments
730	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline, microporous, silty, locally pyritic.
	C15	Mottled calcimudstone, medium-brown-gray to light-green-gray, mottled throughout, increasingly argillaceous upsection.
735	C12/C11	Argillaceous calcimudstone, medium-brown-gray, microcrystalline, sparse to abundant partings of brown mudrock, increasingly argillaceous upsection, vertical burrows in upper 4".
	C15	Mottled calcimudstone, dark-brown-gray, microcrystalline, upper contact gradational, locally peloidal.
	C2/C3	Chalky dolomudstone, light-yellow-brown, microcrystalline, microporous, 1" brown mudrock interbed at base.
740	C12	Argillaceous dolomudstone, light-green-gray, microcrystalline, silty; very argillaceous at base; lower contact sharp, upper contact gradational.
	C3	Laminated dolomudstone, light-yellow-brown, microcrystalline, porous, sparse brown mudrock laminae.
	C12	Argillaceous dolomudstone, medium- to dark-green-gray, microcrystalline, silty; very argillaceous at base, lower contact sharp, upper contact gradational.

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ODGS, Sky Valley Recreational Club #1, Clermont Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
745		
	C3	Laminated dolomudstone, light-yellow-brown, microcrystalline, vuggy, irregular brown mudrock laminae; sparse, fine-grain quartz at top.
	C12	Argillaceous dolomudstone, light-green-gray, micro-crystalline, silty.
	C12/C11	Argillaceous dolomudstone, medium-green-gray, microcrystalline, sparse to abundant partings of green mudrock; increasingly argillaceous upsec-tion, vertical burrows in upper 4".
750		
	C12/M2	Argillaceous dolomudstone, medium-green-gray, microcrystalline, sparse to abundant partings of green mudrock, increasingly argillaceous upsec-tion; 1" interbed of green mudrock at top.
	C2/C7	Chalky dolomudstone, light-yellow-brown, micro-crystalline, microporous, locally brecciated.
755		
	C12/M2	Argillaceous dolomudstone, medium-green-gray, microcrystalline, sparse to abundant partings of green mudrock, 1" interbed of fissle green mudrock at top.

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ODGS, Sky Valley Recreational Club #1, Clermont Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C2/C7	Chalky dolomudstone, light-yellow-brown, micro-crystalline, microporous, locally brecciated.
	C12/M2	Argillaceous dolomudstone, medium-green-gray, microcrystalline, sparse to abundant partings of green mudrock.
	C2/C7	Chalky dolomudstone, light-green-gray, micro-crystalline, microporous, locally brecciated.
	C12/M2	Argillaceous dolomudstone, medium-green-gray, microcrystalline, sparse to abundant partings of green mudrock.
760	C12	Argillaceous dolomudstone, medium-brown-gray, microcrystalline, sparse to abundant partings of brown mudrock, 1" interbed of fissle brown mudrock at top.
	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline, sparse to abundant partings of green mudrock, sparse to abundant quartz silt; sharp lower contact, upper contact gradational.
	C9	Intraclastic dolograinstone grading upsection to argillaceous dolomudstone, light-green-gray to medium-green-gray, microcrystalline; argillaceous; intraclasts are fine- to coarse-grain, subangular; green mudrock partings at base; abundance of intraclasts decreases upsection.
765	C19	Dolomudstone, light-medium-brown with green-gray mudrock partings, microcrystalline to finely-crystalline, vuggy, stylolitic.
770		
Bottom of described interval, TD at 2080 ft.		

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Ohio Dept. of Geological Survey, American Aggregates Quarry 1, Wayne Twp., Sec. 14-T3N-R5E, Warren Co., Ohio, elev. 1005 ft., DGS 2627, NX core 0-5380 ft., described 1533-1620 ft.

Depth (ft.)	Litho-facies	Description/Comments
	C12	Argillaceous calcimudstone, medium-brown-gray, microcrystalline, dolomitic, abundant thin-laminae of brown mudrock.
1535	C15/C11	Mottled calcimudstone, medium-brown-gray and light-brown-gray, microcrystalline, mottled throughout; subhorizontal calcite-infilled fenestrae in upper 2 ft.
	C12	Argillaceous calcimudstone, medium-brown-gray, microcrystalline, dolomitic, abundant thin-laminae of brown mudrock; locally stylolitic.
1540	C15/C11	Mottled calcimudstone, medium-brown-gray and light-green-gray, microcrystalline, mottled throughout; subhorizontal calcite-infilled fenestrae in upper 1 ft.
	C12	Argillaceous calcimudstone, medium-green-gray, microcrystalline, dolomitic, abundant thin-laminae of brown mudrock, pyritic and argillaceous.
1545	C15/C11	Mottled calcimudstone, medium-brown-gray and light-green-gray, microcrystalline, mottled throughout; subhorizontal calcite-infilled fenestrae locally.
	C12	Argillaceous calcimudstone, medium-green-gray, microcrystalline, dolomitic, abundant thin-laminae of brown mudrock, pyritic and argillaceous.

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ODGS, American Aggregates Quarry 1, Warren Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C6	Mottled dolomudstone, medium-green-gray, micro-crystalline; sparse quartz silt, argillaceous; mottled throughout.
	C6/C15	Mottled calci/dolomudstone, medium-brown-gray, grading upsection to medium-green-gray, micro-crystalline, nonargillaceous grading upsection to argillaceous; increasingly dolomitic upsection; upper contact gradational, lower contact stylolitic.
1550		
	C15	Mottled calcimudstone, medium-brown-gray and light-brown-gray, microcrystalline, mottled through-out; subhorizontal calcite-infilled fenestrae locally.
	C12/C8	Argillaceous calcimudstone, medium-brown-gray, microcrystalline, dolomitic, abundant thin-laminae of brown mudrock; stylolites and stringers of ostra-codal packstone locally.
1555		
	C6/C11	Mottled dolo/calcimudstone, light-brown-gray, microcrystalline, increasingly dolomitic upsection, mottled throughout, vertical calcite-infilled burrows at upper contact.
	C1	Quartzose dolowacke/packstone, light-yellow-brown, microcrystalline dolomicrite matrix, sparse to abundant, fine-grain, well-rounded, well-sorted, grain- to mud-supported quartz that decreases in abundance upsection.
	C3	Laminated dolomudstone, light-yellow-brown, micro-crystalline, microporous, sparse laminae of brown mudrock; possible mudcracks at upper contact.
1560		
		Patterned dolomudstone, light-brown-gray, micro-

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ODGS, American Aggregates Quarry 1, Warren Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C10	crystalline, porous; mottled throughout.
	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline, massive, abundant green-gray clay-sized fraction.
	C3/C2	Laminated dolomudstone, light-yellow-brown, micro-crystalline, chalky, microporous, abundant laminae of brown mudrock; mudcracks at upper contact. contact.
1565	C10	Patterned dolomudstone, light- to medium-green-gray, microcrystalline, porous; mottled throughout; increasingly argillaceous upsection.
	C2	Chalky dolomudstone, light-yellow-brown, micro-crystalline, porous, vuggy, clotted appearance.
	C12/C8	Argillaceous ostracodal dolowackestone, medium-green-gray, very argillaceous, complete ostracodes, pyritic.
1570	C6	Mottled dolomudstone, light-brown-gray, micro-crystalline, abundant quartz silt.
	C2	Chalky dolomudstone, light-yellow-brown, micro-crystalline, porous, vuggy, clotted appearance.
	C12/C8	Argillaceous ostracodal dolowackestone, medium-brown-gray, very argillaceous, complete ostracodes.
	C6/C1	Mottled dolomudstone, light-brown-gray, micro-crystalline, mottled throughout; abundant fine-grain, well-rounded, well-sorted, mud-supported quartz in lower 1ft.; quartz decreases in abundance upsection.
	C6	Mottled dolomudstone, light- to medium-brown-gray, microcrystalline; argillaceous at base, argillaceous

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ODGS, American Aggregates Quarry 1, Warren Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1575		content decreases upsection.
	M5	Brown mudrock, fissle, organic-bearing.
	C6	Mottled dolomudstone, light- to medium-brown-gray, microcrystalline; argillaceous at base, argillaceous content decreases upsection.
	M5	Brown mudrock, fissle, organic-bearing.
	C12	Argillaceous dolomudstone, light-medium-green, microcrystalline, argillaceous.
	M2	Green mudrock, medium- to dark-green-gray, non-fissle, pyritic.
	C2	Chalky dolomudstone, light-green-gray to light-brown-gray, microcrystalline, microporous.
1580		
	C6/C12	Argillaceous mottled dolomudstone, light-green-gray to medium-green-gray, microcrystalline, micro-porous, *pyritic locally, sparse to abundant mottling*; argillaceous content increases upsection, becomes somewhat fissle in upper 4".
	C12	Argillaceous dolomudstone, medium-green-gray, microcrystalline, locally fenestral; dolomitic green-mudrock partings throughout that decrease in abundance upsection.
1585		
	C2	Chalky dolomudstone, light-green-gray to light-brown-gray, microcrystalline, microporous.
		Argillaceous mottled dolomudstone, light-green-

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ODGS, American Aggregates Quarry 1, Warren Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
	C12/C6	gray to medium-green-gray, microcrystalline, micro-porous, pyritic locally, sparse to abundant mottling; sparse to abundant quartz silt that decreases in abundance upsection; argillaceous content increases upsection, become somewhat fissle in upper 3".
1590		
	C12/C6	Argillaceous mottled dolomudstone, light-green-gray to medium-green-gray, microcrystalline, micro-porous, pyritic locally, sparse to abundant mottling; sparse to abundant quartz silt that decreases in abundance upsection; argillaceous content increases upsection, becomes somewhat fissle in upper 3".
1595		
	M6	Silty dolomudstone, light-green-gray, microcrystalline, abundant mud-supported quartz silt, locally pyritic.
	C12/C6	Argillaceous mottled dolomudstone, light-green-gray to medium-green-gray, microcrystalline, micro-porous, pyritic locally, sparse to abundant mottling; sparse to abundant quartz silt that decreases in abundance upsection; argillaceous content increases upsection.
1600		
	C12/C6	Argillaceous mottled dolomudstone, light-green-gray to medium-green-gray, microcrystalline, micro-porous, pyritic locally, sparse to abundant mottling; sparse to abundant quartz silt that decreases in

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ODGS, American Aggregates Quarry 1, Warren Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
		abundance upsection; argillaceous content increases upsection; fissle, green mudrock interbeds at 1601'6"-7" and 1602'3"-7".
1605		
	C12/C6	Argillaceous mottled dolomudstone, light-green-gray to medium-green-gray, microcrystalline, micro-porous, pyritic locally, sparse to abundant mottling; sparse to abundant quartz silt that decreases in abundance upsection; argillaceous content increases upsection; chert infilling of ostracod molds locally.
	C9	Intraclastic dolograinstone, very-light-green-gray, fine- to coarse-grain, subrounded, poorly-sorted dolomudstone and microcrystallline chert intraclasts.
1610	C12/C6	Argillaceous mottled dolomudstone, light-green-gray to medium-green-gray, microcrystalline, micro-porous, pyritic locally, sparse to abundant mottling; sparse to abundant quartz silt that decreases in abundance upsection; argillaceous content increases upsection.
	C9	Intraclastic dolograinstone grading upsection to argillaceous mottled dolomudstone, light-green-gray to green-gray; abundant fine- to coarse-grain to pebble-size, subangular to subrounded intraclasts of brown-gray dolomudstone and microcrystalline chert; abundance of intraclasts decreases upsection; medium-bedded.
1615	C19	Dolomudstone, brown-gray with green-gray mudrock partings, micro- to coarsely-crystalline; vuggy, vugs locally infilled by coarsely crystalline dolomite; sparse to abundant fine-grain quartz; stylolitic locally.

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ODGS, American Aggregates Quarry 1, Warren Co., Ohio (cont.).

Depth (ft.)	Litho-facies	Description/Comments
1620		
Bottom of cored interval, TD at 5380 ft.		

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APPENDIX III: WATER ANALYSIS FROM ANCELL GROUP AND REGIONAL EQUIVALANTS, ILLINOIS BASIN.

Well	County	Location	Depth	Fm.	TDS	Na	Ca	Mg	SiO2	SO4	Cl	SO4/Cl	pH	Reference/Source
ILLINOIS														
W. Schwartz #1	Adams	11-2S-6W	344-971	Osp	8210	2443	319	157	36	992	3876	0.2559	7.4	Meents et al, 1952
G. Fingerlin #1	Adams	26-2S-8W	666-675	Osp	12258	3715	456	266	22	987	6398	0.1543	7.2	Meents et al, 1952
Joe Kesl et al #1	Bond	12-6N-5W	2505-3154	Osp	12201	3563	583	260	6	1614	5973	0.2702		Meents et al, 1952
Not reported	Boone	24-44N-3E	1231	Osp	284			136		28	4	7.0000		Ill. State Water Survey
Scholfield #1	Clark	6-11N-11W	3945-3960	Osp	124550	37346	6778	2418	5	121	76000	0.0016	7	Meents et al, 1952
Spellbrig #34	Clark	8-11N-14W	2923-3009	Osp	124114	6941	1551	494	33	2618	12563	0.2084		Meents et al, 1952
Not reported	Cook	12-41N-11E	1934	Osp	540					180	18	10.0000		Ill. State Water Survey
Not reported	Cook	31-43N-12E	1055	Osp	644	77	104	26	9	243	36	6.7500		Ill. State Water Survey
Not reported	Cook	27-44N-11E	1000	Osp	552					142	28	5.0714		Ill. State Water Survey
Not reported	Cook	21-44N-12E	1900	Osp	580			5.6		182	16	11.3750		Ill. State Water Survey
Not reported	Cook	3-40N-9E	2001	Osp	263	44	50	14	8	39	25	1.5600	7.7	Ill. State Water Survey
Ducommon #1	Crawford	35-6N-13W	4650-4654	Osp	160730	44295	11260	2306	32	945	94257	0.0100	6.3	Meents et al, 1952
Not reported	De Kalb	20-40N-5E	690	Osp	351	17	62	32	8	10	1	10.0000	7.3	Ill. State Water Survey
J. Lamb #1	De Witt	1-20N-4E	2275-2295	Osp	3311		103	42	69	196	1650	0.1188	7.8	Graf et al, 1966
Walden #1	De Witt	29-21N-4E	2407-2427	Osp	3246		141	63	36	119	1740	0.0684	7.7	Graf et al, 1966
Cora Ryan #4	De Witt	21-21N-3E	2181-2219	Osp	1410	475	37	17		84	557	0.1508	7.4	Ill. State Geol. Survey
Shaw #1	Douglas	36-16N-8E	1644	Osp	25176	5306	1245	1037	26	1538	12106	0.1270		Meents et al, 1952
Not reported	Du Page	25-38N-11E	347	Osp	836					0	84			Ill. State Water Survey
Not reported	Henderson	17-9N-4W	934-1235	Osp	1623	386	105	46	7.5	659	269	2.4498		Meents et al, 1952
Not reported	Jo Davies	20-29N-2W	1502	Osp	702	52	115	58	22	70	30	2.3333	7.2	Ill. State Water Survey
Not reported	Jo Davies	9-26N-2E	1090	Osp	254	14	47	21	12	16	5	3.2000	7.5	Ill. State Water Survey
Not reported	Jo Davies	11-27N-4E	1277	Osp	384	7	84	39	15	13	1	13.0000	7.1	Ill. State Water Survey
Not reported	Jo Davies	24-29N-4E	963	Osp	451	6	83	51	18	65	18	3.6111	7.1	Ill. State Water Survey
Not reported	Jo Davies	13-28N-1W	1600	Osp	281	1	48	32	8	21	1	21.0000	7.7	Ill. State Water Survey
Not reported	Kane	27-40N-8E	850	Osp	369			96		27	5	5.4000		Ill. State Water Survey
Not reported	Kane	24-41N-8E	2000	Osp	318			60		33	24	1.3750		Ill. State Water Survey
Not reported	Kane	27-42N-8E	1200	Osp	323	19	64	25	7	26	2	13.0000	7.2	Ill. State Water Survey
Not reported	Kane	3-39N-8E	2300	Osp	315	16	65	25	7.2	11	2.6	4.2308	7.3	Ill. State Water Survey
Not reported	Kendall	17-37N-8E	720	Osp	472	82	52	26	14	125	24	5.2083	7.5	Ill. State Water Survey
Not reported	Kendall	35-37N-7E	642	Osp	413	57	51	25	7	75	19	3.9474	7.5	Ill. State Water Survey
Not reported	Knox	28-11N-2E	2525	Osp	1138	302	54	24	9	400	183	2.1858	7.7	Ill. State Water Survey
Not reported	La Salle	25-33N-5E	1447	Osp	607	96	71	37	7	113	95	1.1895		Ill. State Water Survey
Not reported	La Salle	19-36N-3E	125	Osp	234	31	41	17	13	10	1	10.0000	7.6	Ill. State Water Survey
Not reported	Lake	34-46N-12E	985	Osp	525	46	101	24		167	16	10.4375	7.3	Ill. State Water Survey
Not reported	Lee	36-22N-10E	345	Osp	337	5	62	35	12	25	3.4	7.3529	7.9	Ill. State Water Survey
Pearce #1	Jersey	27-8N-10W	1304-1802	Osp	9040	3256	97	101	4	254	5234	0.0485		Meents et al, 1952
Not reported	Mc Henry	5-44N-7E	1211	Osp	441			160		26	4	6.5000		Ill. State Water Survey
Not reported	Mc Henry	6-43N-8E	1295	Osp	274	10	44	22	8	1	1	1.0000	8.2	Ill. State Water Survey
Hyde Park Corp #1	Macon	34-16N-2E	3120-380	Osp	6682					523	3450	0.1516	7.8	Ill. State Geol. Survey
Powers #1	Macon	30-17N-2E	2937-2941	Osp	8118	2382	415	128	10	399	4245	0.0940		Meents et al, 1952
Robinson #1	Marion	4-2N-1E	4270-5023	Osp	110316	34183	6006	1450	38	1473	66418	0.0222		Meents et al, 1952
Shanafelt "A"	Marion	20-2N-2E	4556-5256	Osp	127050	39555	6862	1513	32	1393	76582	0.0182	6.4	Meents et al, 1952
Johnson Water Well	Menard	24-19N-5W	2156	Osp	5314					264	2900	0.0910		Ill. State Geol. Survey
Theobald #A-1	Monroe	35-1S-10W		Osp	15714					367	8164	0.0450		Ill. State Geol. Survey

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APPENDIX III (CONT.): WATER ANALYSIS FROM ANCELL GROUP AND REGIONAL EQUIVALANTS, ILLINOIS BASIN.

Well	County	Location	Depth	Fm.	TDS	Na	Ca	Mg	SiO2	SO4	Cl	SO4/Cl	pH	Reference/Source
ILLINOIS (cont.)														
Truitt #1	Montgomery	4-9N-3W		Osp	11622		640	214		600	5950	0.1008	7.6	Ill. State Geol. Survey
Brohammer #1	Montgomery	20-7N-2W	3758	Osp	13776					843	7781	0.1083		Ill. State Geol. Survey
Doolin 1-16	Morgan	15-13N-8W		Osp	3313	857	155	49	195	313	1288	0.2430		Ill. State Geol. Survey
Not reported	Morgan	28-15N-10W	3110	Osp		679	123	45	13	440	1000	0.4400		Ill. State Water Survey
Forrester #1	Perry	5-6S-1W	5143	Osp	82956	22060	4270	1289	5	1633	48525	0.0337		Meents et al, 1952
Mumford #1	Pike	21-5S-4W	764	Osp	4436		752			812	1875	0.4331		Ill. State Geol. Survey
M. Sueich #1	Pope	2-11S-6E	7300-7400	Osp	240200		30000	6100		650	152000	0.0043	5.5	Ill. State Geol. Survey
Not reported	Putnam	32-1W-1E	1800	Osp	1010	310	52	23	9	179	320	0.5594	7.6	Ill. State Water Survey
Nicholson #1	Randolph	12-5S-9W	1382-1840	Osp	29190	7950	1814	651	11	2104	15605	0.1348		Meents et al, 1952
Not reported	Rock Island	34-18N-2W	1450	Osp	1095	337	36	23	10	221	300	0.7367		Ill. State Water Survey
Dyroff #1	St. Clair	28-1N-10W	881-995	Osp	18326	5174	867	561	15	718	10589	0.0678		Ill. State Geol. Survey
Not reported	St. Clair	33-1S-8W	200	Osp	511	115	64	16	22	30	6	5.0000		Ill. State Water Survey
Not reported	Scott	2-15N-13W	1245	Osp	3324	1150	65.2	37.2	12	360	1481	0.2431		Ill. State Geol. Survey
Not reported	Stephenson	13-27N-7E	310	Osp	284	2	63	35	9	14	1.5	9.3333	7.6	Ill. State Water Survey
Not reported	Stephenson	36-29N-7E	304	Osp	281	2	62	35	11	17	1	17.0000	6.9	Ill. State Water Survey
Allied Chem. #1	Vermillion	12-19N-11W	DST	Osp	13630	3710	712	293	16.8	1124	7100	0.1583	7.1	Ill. State Geol. Survey
Ford et al C-17	White	27-4S-14W	7335-7407	Osp	199176	55362	13609	2294	341	923	115307	0.0080		Graf et al, 1966
Not reported	Whiteside	28-21N-7E	760	Osp	356	54	56	20.2	12	10	27	0.3704	7.2	Ill. State Water Survey
Not reported	Will	9-34N-9E	765	Osp	601	139	40	23	7	150	59	2.5424	7.7	Ill. State Water Survey
INDIANA														
Kistler #1	Cass	11-28N-1W	1358-1361	Chazy	14863	3740	1255	307		310	7200	0.0431		Walker, 1959
Not reported	Clark	Gr113-1S-7E	1499	Chazy		4165	1200	840		1200	10000	0.1200		IGS well file
Hutchinson #1	Jackson	11-5N-2E	2403-2410	Chazy	15387	4590	740	296		960	8200	0.1171		Walker, 1959
Nay #2	Jefferson	22-4N-8E	1475-1515	Chazy	11600	3430	476	213		746	6340	0.1177	7.54	Keller, 1983
Coy #1	Madison	1-19N-6E	1285-1325	Chazy	12817	3660	391	466		252	6880	0.0366		Walker, 1959
Mt. Jackson #1	Marion	9-15N-3E	1541	Chazy	16000	4351	777	730		16	9613	0.0017		Walker, 1959
Union Trust #1	Monroe	29-8N-1E	2373-2379	Chazy	17503	4591	901	405		1509	8812	0.1712		Walker, 1959
Baker #1-A	Orange	29-3N-2W	3222-3226	Chazy	27444	8260	1220	632		1900	15200	0.1250		Walker, 1959
Not reported	Porter	28-37N-6W	1297-1347	Chazy	9360	2330	2670	763		510	4360	0.1170		IGS well file
Vanderventer #1	Tipton	21-21N-3E	1512-1520	Chazy	6637	2025	182	185		25	3610	0.0069		Keller, 1983
KENTUCKY														
Roach #1	Adair		1442-1460	Om	30700	8500	1200	840		13	18000	0.0007	5.7	Faust et al, 1980
Brogden	Bourbon		792	Owk	531	82	47	40	8.3	38	166	0.2289	7.8	Faust et al, 1980
Melcher	Clark		1618	Owk	8880	2700	297	151	9.2	69	4380	0.0158	6.3	Faust et al, 1980
Jess Keen Lease	Clinton		1450	Om	64000	35400	3940	1900	12	385	34100	0.0113	7	Faust et al, 1980
Freida Roach	Clinton		1100	Owk	91200	27000	3400	1120	33	975	51700	0.0189	7.3	Faust et al, 1980
W. G. Reynolds	Clinton		1667	Om	22800	6990	956	492	13	2080	12500	0.1664	7.1	Faust et al, 1980
S. Masch	Cumberland			Om	59800	10000	2830	900	22	235	36400	0.0065	6.9	Faust et al, 1980
Walker Bag	Jefferson		2086	Owk		4490	721	281		1240	7970	0.1556		Faust et al, 1980
Beaver Dam Coal	Owen		785	Owk		968	60	42	4.8	304	1250	0.2432	7.5	Faust et al, 1980
Ky Drilling Co.	Pendleton		905-925	Owk	6760	2280	134	86	8.3	400	3380	0.1183	6.7	Faust et al, 1980
L. G. & E.	Oldham		1348-1354	?	8400	2480	343	162	11	615	4000	0.1538	7.3	Faust et al, 1980
L. G. & E.	Oldham		1383	?	7900	2490	236	115	11	730	3780	0.1931	6.7	Faust et al, 1980

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APPENDIX III (CONT.): WATER ANALYSIS FROM ANCELL GROUP AND REGIONAL EQUIVALANTS, ILLINOIS BASIN.

Well	County	Location	Depth	Fm.	TDS	Na	Ca	Mg	SiO2	SO4	Cl	SO4/Cl	pH	Reference/Source
MISSOURI														
Johnston #1	Jefferson	6-39N-7E	181	Osp/Oe	604	25	106	56	7.7	124	8.3	14.9398		Miller et al, 1974
Missouri R & R #1	Jefferson	27-40N-6E	240	Osp	343	2.4				26.3	3.6	7.3056		Mo. State Geol. Survey
Latzer #1	Jefferson	8-41N-6E	N/A	Osp	497	10.1				39.5	4	9.8750		Mo. State Geol. Survey
Eisenman #1	Jefferson	14-42N-5E	N/A	Osp	347	10.2				6	1.8	3.3333		Mo State Geol. Survey
L. Miller #1	Jefferson	30-42N-6E	562	Osp	3095	793				128	793	0.1614		Mo. State Geol. Survey
J. P. Fox #1	Jefferson	5-42N-5E	185	Osp/Oe	335	3.5	83	31	5.6	11	2.8	3.9286		Miller et al,1974
not reported	Jefferson	23-42N-5E	150	Osp/Oe	311	2.6	78	28	3.3	8	2	4.0000		Miller et al, 1974
Biltmore Club	Jefferson	4-43N-5E	N/A	Osp	402	11.3				28.2	2.8	10.0714		Mo. State Geol. Survey
Brookhaven #1	Jefferson	4-43N-5E	800	Osp/Oe	270	9.8	46	25	8	19	12	1.5833		Miller et al, 1974
Telle #1	Perry	28-34N-12E	593	Osp	483	32				22.2	6	3.7000		Mo. State Geol. Survey
Frohna Creamery	Perry	17-34N-13E	655	Osp	1351	42.6				534	62.4	8.5577		Mo. State Geol. Survey
not reported	St. Charles	7-45N-3E	535	Osp/Oe	420	17	85	35	6.8	17	13	1.3077		Miller et al, 1974
Forest Hills #1	St. Charles	19-47N-1E	770	Osp/Oe	478	40	35	68	8	70	8	8.7500		Miller et al, 1974
City of St. Peters #1	St. Charles	25-47N-3E	820	Osp/Oe	915	200	66	35	7	56	291	0.1924		Miller et al, 1974
McMenamy #1	St. Charles	35-48N-2E	810	Osp/Oe	777	290	6.5	3.4	8	150	28	5.3571		Miller et al, 1974
Peerless Lime Co.	St. Genevieve	30-38N-9E	1200	Osp	400	11				23.5	6.8	3.4559		Mo. State Geol. Survey
Clymer #1	St. Louis	1-44N-4E	798	Osp/Oe	7270	1810	325	149	8.8	442	3320	0.1331		Miller et al, 1974

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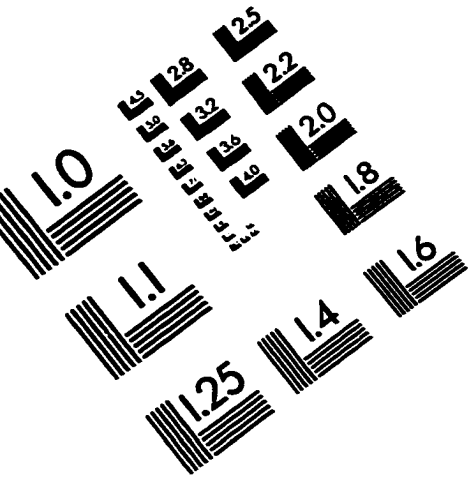

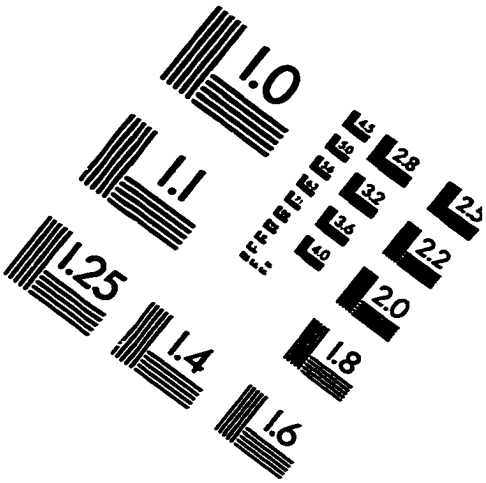

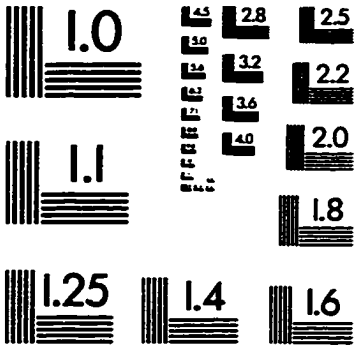

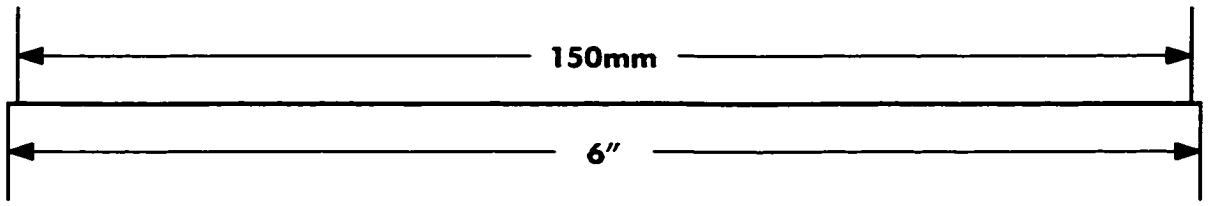

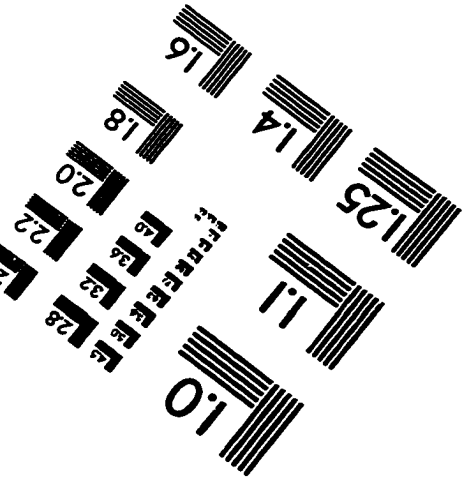

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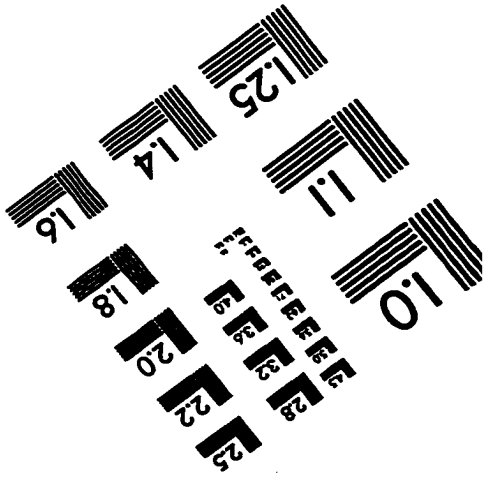

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