A LOG OF TEN CORES OF THE DEER CREEK LIMESTONE, CALHOUN SHALE, TOPEKA LIMESTONE, AND HAMILTON LAGERSTÄTTE (VIRGILLIAN, UPPER PENNSYLVANIAN) FROM THE HAMILTON AREA, GREENWOOD COUNTY, KANSAS

by

Karl W. Leonard

November 12, 1991

Kansas Geological Survey
Open-file Report 91-58

INTRODUCTION

PURPOSE OF INVESTIGATION

This report is a description of ten cores collected in the Hamilton area of Greenwood County, Kansas by the Kansas Geological Survey during the Summer of 1988. The purpose of collecting and describing the core was to provide additional data for an ongoing study (being conducted by the Kansas Geological Survey and other organizations) concerning the stratigraphy and depositional setting of the Hamilton Lagerstätte and associated units. The Hamilton Lagerstätte is an interval of dolomitic mudstones and shale which yields a well preserved fossil biota of primarily terrestrial plants, vertebrates, and invertebrates, and minor numbers of marine fossils (See Mapes and Mapes, eds., 1988). Fossil have been collected and described from this interval for nearly twenty years (Bridge and Mapes, 1988), but only recently has attention been paid to possible stratigraphic relationships and depositional setting of this unit.

STUDY AREA AND INTERVAL

The cores collected for this report are from sections 5, 8, 17, and 29 of the Janesville Township on the Virgil 7 1/2 Minute Quadrangle, 2.1 miles (3.38 km) east of Hamilton Kansas in Greenwood County. This is also the general location of the Hamilton quarry site (Bridge and Mapes, 1988), and is also in the vicinity of the Seeley-Wick and Virgil Oil Fields (Figure 1,and Table 1).

The stratigraphic interval of units recovered in the ten cores includes four members of the Deer Creek Limestone (Oskaloosa Shale, Rock Bluff Limestone, Larsh and Burroak Shale, and Ervine Creek Limestone), the Calhoun Shale, beds associated with the Hamilton Lagerstätte, and the Hartford Limestone Member, Iowa

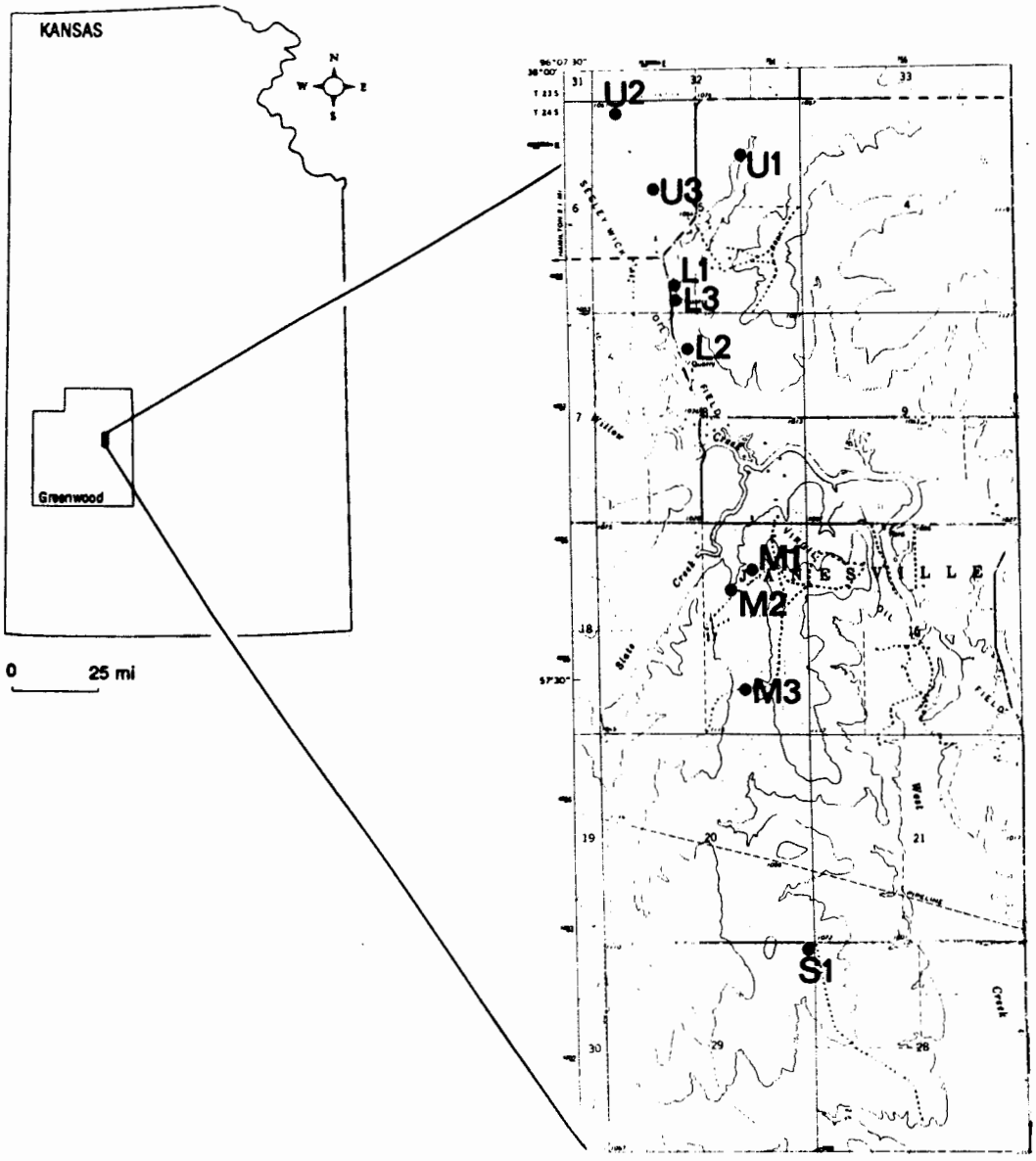


Figure 1. Map of the Hamilton area in Greenwood County, Kansas showing core locations.

LIST OF CORE LOCALITIES

CORE #	LOCATION
KGS #1 Ulrich	NE SW NE Sec. 5, T.24S. R.12E
KGS #2 Ulrich	NE NW NW Sec. 5, T.24S. R.12E.
KGS #3 Ulrich	SW SE NW Sec. 5, T.24S. R12E.
KGS #1 Lyke	SE SE SW Sec. 5,T.24S. R.12E.
KGS #2 Lyke	SE NE NW Sec. 8, T.24S. R.12E.
KGS #3 Lyke	SE SE SW Sec. 5, T.24S. R.12E.
KGS #1 Marlin	SE NW NE Sec. 17, T.24S. R.12E.
KGS #2 Marlin	NE SW NE Sec. 17, T.24S. R.12E.
KGS #3 Marlin	NE SW SE Sec. 17, T.24S. R.12E.
KGS #1 Short	NE NE NE Sec 29, T.24S. R.12E.

Table 1. Core names and locations on the Virgil Quadrangle, Greenwood County, Kansas.

Point Shale Member, and Curzon Limestone Member of the Topeka Limestone. These units (with the possible exception of the Hamilton beds) are in the upper part of the Shawnee Group (Virgillian, Upper Pennsylvanian) (Figure 2).

METHODS

Core samples were slabbed lengthwise, and carbonates were lightly etched with 10% hydrochloric acid. The slabbed samples were then examined wet with the aid of a binocular microscope. Detailed descriptions and graphic sections of the ten cores can be found in appendix 1 of this report.

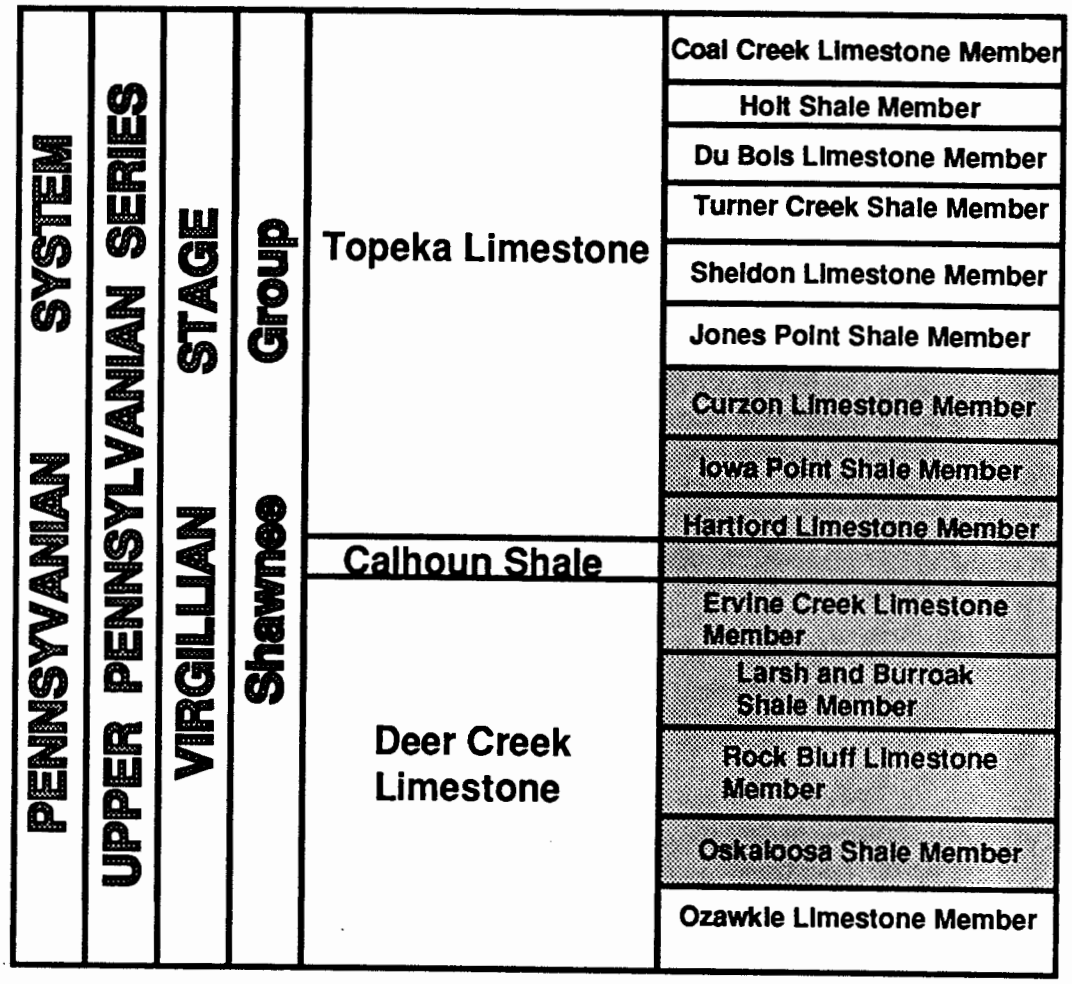


Figure 2. Stratigraphic position of units examined for this report (shaded) (modified from Zeller, 1968).

LITHOSTRATIGRAPHY

DESCRIPTION OF UNITS

Deer Creek Limestone

The Deer Creek Limestone is one of the uppermost limestone formations in the Shawnee Group (Virgillian, Upper Pennsylvanian). The Deer Creek is composed of five members, four of which were present in core examined for this report. They include (in ascending order): the Oskaloosa Shale Member; the Rock Bluff Limestone Member; the Larsh and Burroak Shale Member; and the Ervine Creek Limestone Member. The only member missing in recovered core is the lowermost member of the Deer Creek, the Ozawkie Limestone. The thickness of the Deer Creek Limestone recovered in the ten cores ranges from 4.46 ft. (1.36 m.) in KGS #2 Marlin to 13.34 ft. (4.06 m.) in KGS #1 Short (Table 2). Regionally, the Deer Creek ranges in thickness from 20 ft.. (6.1 m.) to 80 ft. (15.2 m.) (Zeller, 1968).

Oskaloosa Shale Member:

The Oskaloosa was recovered in only one core (KGS #1 Short), where it is a silty, olive gray to reddish brown, blocky mudstone. It contains few fossils except for plant fragments and root traces. The thickness of Oskaloosa recovered in S1 is 8.17 ft. (2.49 m.) (Table 2). Throughout its outcrop belt, the Oskaloosa Shale ranges in thickness from 3 ft. (0.91 m.) to 50 ft. (15.2 m.) (Zeller, 1968).

UNIT THICKNESS TABLE

UNIT NAME	CORE # (AND TOTAL THICKNESS-IN FEET)									
	U2	U1	U3	L1	L3	L2	M1	M2	M3	S1
Oskaloosa Sh.	--	--	--	--	--	--	--	--	--	8.17+ (2.49)
Rock Bluff Ls. Mbr.	--	--	--	--	--	--	--	--	1.92+ (0.58)	1.92 (0.58)
Larsh and Burroak Sh. Mbr.	2.66+ (0.81)	1.0+ (0.30)	--	3.83+ (1.17)	2.95+ (0.90)	0.16+ (0.05)	2.04+ (0.62)	--	3.17 (0.97)	0.42+ (0.12) 4.08 (1.24)
Ervine Creek Ls. Mbr.	6.16 (1.88)	6.33 (1.93)	--	3.0 (0.93)	4.54 (1.38)	6.08 (1.85)	6.20 (1.89)	4.46+ (1.36)	6.04 (1.84)	2.83 ((0.86)
Deer Creek Ls. (total)	8.82+ (2.69)	7.33+ (2.23)	--	6.83+ (2.08)	7.49+ (2.28)	6.24+ (1.90)	8.24+ (2.51)	4.46+ (1.36)	11.1+ (3.39)	13.3+ (4.06) 16.55 (5.04)
Calhoun Sh.	37.4 (11.4)	32.4+ (9.87) 36.3 (11.1)	5.33+ (1.62) 13.7 (4.17)	31.3+ (9.55) 35.3 (10.7)	23.5+ (7.16) 28.0 (8.53)	3.42+ (1.04) 3.83 (1.17)	29.3+ (8.92) 36.6 (11.2)	0.75- (0.23)	12.9+ (3.92) 14.8 (4.51)	1.58- (0.48)
Hamilton Beds	--	--	--	--	4.25+ (1.30)	19.9+ (6.07) 20.66 (6.30)	--	10.5+ (3.19) 13.2 (4.02)	15.3+ (4.65) 18.1 (5.51)	4.58+ (1.40)
Hartford Ls. Mbr.	16.9+ (5.14)	4.79+ (1.46) 4.95 (1.51)	15.71 (4.79)	--	--	--	5.0+ (1.52)	--	--	--
Iowa Point Sh. Mbr.	4.54+ (1.38) 5.13 (1.56)	--	4.45+ (1.36) 5.12 (1.56)	--	--	--	--	--	--	--
Curzon Ls. Mbr.	15.58 (4.75)	--	10.0 (3.05) 11.7 (3.56)	--	--	--	--	--	--	--
Topeka Ls. (total)	37.0+ (11.3) 37.6 (11.5)	4.79+ (1.46) 4.95 (1.51)	30.2+ (9.91) 32.5 (9.90)	--	--	--	5.0+ (1.52)	--	--	--

Table 2. The thicknesses of formations and members recovered in cores examined for this report. Recorded as feet (meters), and recovered (core) thickness / total encountered thickness in bore hole.

Rock Bluff Limestone Member:

The Rock Bluff Limestone is present in two of the ten cores (KGS #1 Short and KGS #3 Marlin), where it is a medium light gray, coarse grained, fusulinid and brachiopod wackestone. The Rock Bluff contains bryozoans, brachiopods, crinoids, and fusulinids, and directly overlies a sandy, fossiliferous, calcareous shale, and is directly overlain by carbonaceous clay shale. The thickness of the Rock Bluff in the two cores is 1.92 ft. (0.58 m.) (Table 2). The thickness along the outcrop belt of this member ranges from 1.0 ft. (0.30 m.) to 3.0 ft. (0.91 m.) (Zeller, 1968).

Larsh and Burroak Shale Member:

The Larsh and Burroak Shale was at least partially recovered in seven of the ten cores (KGS #2 Ulrich, KGS #1 Ulrich, KGS #1 Lyke, KGS #2 Lyke, KGS #3 Lyke, KGS #1 Marlin, and KGS #1 Short), and the entire member was recovered in one core(KGS #2 Marlin). The Larsh and Burroak Shale is a medium gray to black clay shale with alternation light and dark layers in the upper 2/3 of the unit, and with visible bioturbation only in the dark layers. The lower 1/3 of the member is commonly black, carbonaceous, and contains phosphate nodules. The basal 1 inch of the Larsh and Burroak is commonly calcareous. This member contains burrows, bivalves, plant fragments, and inarticulate brachiopods. The thickness of the Larsh and Burroak recovered in the eight cores ranges from 0.16 ft. (0.05 m.) to 3.83 ft. (1.17 m.) (Table 2). Regionally, the Larsh and Burroak ranges in thickness from 2.5 ft. (0.76 m.) to 7.0 ft. (2.13 m.) (Zeller, 1968).

Ervine Creek Limestone Member:

The Ervine Creek Limestone was completely recovered in eight cores (KGS #2 Ulrich, KGS #1 Ulrich, KGS #1 Lyke, KGS #3 Lyke, KGS #2 Lyke, KGS #1 Marlin, KGS #3 Marlin, and KGS #1 Short), and partially recovered in one core (KGS #2 Marlin).

The Ervine Creek commonly consists of two units, an upper slightly argillaceous to argillaceous, wavy bedded, brachiopod and fusulinid wackestone, and a lower brachiopod wackestone that is burrow mottled. The upper unit is typically over 3 ft. thick and the lower unit is generally less than 2 ft. thick . The upper unit contains a relatively diverse fossil assemblage, whereas the lower unit has a less diverse fossil biota, and contains algal coated grains. The contact between the two units is commonly a wavy, irregular surface. The two units are not present in two cores (KGS #1 Short, and KGS #1 Lyke) where there is only one lithology, a fusulinid and brachiopod wackestone. The thickness of Ervine Creek recovered in cores ranges from 2.83 ft. (0.86 m.) to 6.33 ft. (1.93 m.) (Table 2). Along the outcrop belt for the Ervine Creek, the thickness ranges from 5.0 ft. (1.52 m.) to 35 ft. (10.67 m.) (Zeller, 1968).

Calhoun Shale

The Calhoun Shale is in the upper part of the Shawnee Group (Virgillian, Upper Pennsylvanian) and directly overlies the Deer Creek Limestone, and is overlain by the Topeka Limestone. This formation was completely recovered in one core (KGS #2 Ulrich) ,was partially recovered in seven cores (KGS #1 Ulrich, KGS #3 Ulrich, KGS #1 Lyke, KGS #2 Lyke, KGS #3 Lyke, KGS #1 Marlin, and KGS #3 Marlin), and was encountered but not recovered while drilling two cores (KGS #2 Marlin, and KGS #1 Short). The Calhoun Shale is commonly composed of four distinct lithologic intervals including: a lower shale interval; a sandy interval in the middle part of the formation; a thin skeletal packstone to grainstone overlying the sandy interval; and an upper shale interval.

The lower shale interval is a medium gray, platy, clayey to silty shale. The shale is commonly fossiliferous in the lower 3 inches, directly over the Ervine Creek

Limestone, where it contains bryozoans, productid brachiopods, and crinoids. The remaining part of the lower shale interval is relatively unfossiliferous containing scattered plant fragments (small stem fragments) and pyrite nodules. This interval, where present, ranges in thickness from 9.0 ft. (2.74 m.) to 12.0 ft. (3.66 m.).

The sandy interval, directly overlying the lower shale interval, ranges in lithology from sandy shale to silty sandstone. This interval is medium light gray with flaser or lenticular bedding, and is sparsely fossiliferous containing plant fragments (stems and pinnules), Lingula, and scattered bivalves. The sandy interval in two cores (KGS #3 Lyke, and KGS #1 Lyke) is fossiliferous in a thin bed which ranges in thickness from 0.5 ft. (0.15 m.) to 2.0 ft. (0.61 m.). This fossiliferous zone contains large bivalves, brachiopods, gastropods, and plant fragments. The sandy interval ranges in thickness from 14.0 ft. (4.27 m.) to 28.0 ft. (8.53 m.).

A limestone interval commonly overlies the sandy interval. This interval is a thin bed of limestone and associated fossiliferous, calcareous sandstone and varies in lithology from coated grain and bivalve wackestone to skeletal grainstone. The limestone contains large bivalves (myalinids), coated grains, crinoids, sponges, productid brachiopods, encrusting foraminifera, bryozoans, and fusulinids. The limestone is sandy at the base and gradationally overlies a calcareous sandstone. The thickness of the limestone interval ranges from 1.08 ft. (0.33 m.) to 5.0 ft. (1.52 m.).

The upper lithologic interval in the Calhoun Shale is a silty to slightly sandy shale to mudstone. This interval directly overlies the limestone interval and is directly overlain by the Topeka Limestone. The upper shale interval is sparsely fossiliferous containing plant fragments, burrows, and Lingula. The thickness of the upper shale interval ranges from 8.0 ft. (2.44 m.) to 11.0 ft. (3.35 m.).

The thickness of the Calhoun shale recovered in cores examined for this report ranges from 12.9 ft. (3.92 m.) to 37.4 ft. (11.4 m.) (Table 2). The thickness of the Calhoun Shale in the study area is very much dependent on the presence or absence

of the beds associated with the Hamilton Lagerstatte. Where the Hamilton Beds are present, they have resulted in the erosion of much of the upper part of the Calhoun Shale. Regionally, the Calhoun Shale varies in thickness from 7 ft. (2.13 m.) to 50 ft. (15.24 m.) (Zeller, 1968).

Hamilton Lagerstätte and Associated Beds

The beds associated with the Hamilton Lagerstätte are present in five of the ten cores (KGS #3 Lyke, KGS #2 Lyke, KGS #2 Marlin, KGS #3 Marlin, and KGS #1 Short). In four of these cores (L3, L2, M2, and S1), the Hamilton beds consist of skeletal and intraclastic rudstone. In the remaining core (KGS #3 Marlin), the Hamilton beds consist of a number of lithologies including: silty to clay rich shale, intraclastic and skeletal rudstone, and laminated, dolomitic mudstone. The skeletal and intraclastic rudstone (as in L3, L2, and M2) contains intraclasts (up to five lithologies), productids and other brachiopods, bryozoans, bivalves, rugose corals, rhodoliths, and gastropods. The skeletal rudstone in KGS #1 Short contains only large skeletal grains and very few small intraclasts.

Where the Hamilton Beds include a number of different lithologies (as in KGS #3 Marlin), there is a thin (4 inches) intraclastic and skeletal rudstone at the base. This rudstone directly overlies the limestone interval in the Calhoun Shale, and is overlain by interbedded laminated, dolomitic mudstone and intraclastic and skeletal rudstone. The interbedded mudstone and rudstone is overlain by silty shale with thin (< 1 inch) layers of intraclastic and skeletal rudstone which grade upward into interbedded laminated, dolomitic mudstone, skeletal rudstone, and silty shale. The skeletal and intraclastic rudstones contain productid brachiopods, bryozoans and crinoids; the algal-laminated mudstones contain ostracodes and bivalves; and the shales contain Lingula, bivalves, and plant fragments. The thickness of the beds

associated with the Hamilton Lagerstatte recovered in core ranges from 4.25 ft. (1.30 m.) to 19.9 ft. (6.07 m.) (Table 2).

Topeka Limestone

In the normal stratigraphic sequence (i. e. Hamilton Beds are not present) for the upper part of the Shawnee Group in the study area, the Topeka Limestone directly overlies the Calhoun Shale (Moore, 1949). The Topeka Limestone consists of a wide variety of lithologies and a number of members (Moore, 1949), at least three of which were examined for this report. They include (in ascending order): the Hartford Limestone Member; the Iowa Point Shale Member, and the Curzon Limestone Member. Because of the highly variable nature of lithologies in the Topeka Limestone, delineating the members of this formation is rather difficult. The delineation of members for this report should therefore be considered tentative. The thickness of Topeka Limestone recovered in cores ranges from 5.0 ft. (1.52 m.) to 37.0 ft. (11.27 m.) (Table 2). Along the outcrop belt for the Topeka Limestone, the thickness ranges from 33 ft. (10.06 m.) to 55 ft. (16.76 m.) (Zeller, 1968).

Hartford Limestone Member:

The Hartford Limestone directly overlies the Calhoun Shale and is overlain by the Iowa Point Shale Member. The Hartford Limestone was completely recovered in one core (KGS #3 Ulrich), and partially recovered in three cores examined for this report (KGS #2 Ulrich, KGS #1 Ulrich, and KGS #1 Marlin). The Hartford consists of from two to four lithologies, including a thin (< 12 inches), sandy, crinoid and brachiopod wackestone to packstone at the base of the unit. The sandy wackestone to packstone is slightly argillaceous, and contains crinoids, brachiopods, bryozoans, fusulinids, encrusting foraminifera, and algal coated grains.

In three of the four cores in which the Hartford Limestone was recovered, a thin (< 12 inches) carbonaceous shale overlies the wackestone to packstone interval. The carbonaceous shale is black to dark gray, fissile, laminated, and contains Lingula, pectinid bivalves, brachiopods, Chondrites, and plant fragments. In KGS #1 Marlin, the carbonaceous shale is not present, but instead a skeletal wackestone overlies the sandy wackestone to packstone interval with a wavy, irregular surface between the two units.

The upper part of the Hartford consists of wavy bedded, argillaceous, fusulinid, crinoid and brachiopod wackestone. This interval becomes more argillaceous upwards and contains brachiopods, crinoids, gastropods, bryozoans, Amblysiphonella, and rugose corals. The upper part of the Hartford also has spar filled vugs and fractures, and many pressure solution features (styolites, microstyolites, and pressure solution seams). The thickness of the Hartford Limestone examined for this report ranges from 5.0 ft. (1.52 m.) to 16.9 ft. (5.14 m.) (Table 2). Regionally, the Hartford ranges in thickness from 3.0 ft. (0.91 m.) to 13.0 ft. (3.96 m.) (Zeller, 1968).

Iowa Point Shale Member:

The Iowa Point Shale directly overlies the Hartford Limestone and is overlain by the Curzon Limestone. The Iowa point was recovered in two of the ten cores (KGS #2 Ulrich, and KGS #3 Ulrich), and consists of silty to clay rich shale interbedded with several thin beds (< 12 inches) of limestone. The shale occurs at the base and the top of the member, with the limestones in the middle. The lower shale is sandy and calcareous with carbonaceous streaks, and contains pyrite, selenite, burrows, brachiopods, crinoids, and ostracodes. The limestone beds in the middle of the member are wackestones that contain brachiopods, crinoids, algal coated grains, intraclasts, fusulinids, encrusting foraminifera, and gastropods. The upper shale interval in this member is a sandy to silty , calcareous shale to mudstone with thin (< 1

inch) wackestone lenses. The upper shale contains bryozoans, crinoids, brachiopods, fusulinids, and ostracodes. The thickness of the Iowa Point Shale recovered in cores ranges from 4.45 ft. (1.36 m.) to 4.54 ft. (1.38 m.) (Table 2). Along the outcrop belt of the Iowa Point, the thickness ranges fro 0 ft. to 14.0 ft. (4.26 m.) (Zeller, 1968).

Curzon Limestone Member:

The Curzon Limestone directly overlies the Iowa Point Shale, and was recovered in two of the ten cores (KGS #2 Ulrich, and KGS #3 Ulrich). The Curzon consists of medium light gray to light gray, sandy to argillaceous, wavy-bedded wackestone. It contains fusulinids, brachiopods, bryozoans, crinoids, and echinoids. The Curzon is most argillaceous in the lower 3/4 of the member, becoming less argillaceous and slightly sandy towards the top. The thickness of the Curzon examined for this report ranges from 10.0 ft. (3.05 m.) to 15.58 ft. (4.75 m.) (Table 2). Regionally, the Curzon ranges in thickness from 5.0 ft. (1.52 m.) to 12.0 ft. (3.67 m.) (Zeller, 1968).

LOCAL CORRELATION

A north-south stratigraphic cross-section (A to A') was constructed using nine of the ten cores examined for this report (see Appendix II). The stratigraphic interval included in the cross section ranges from the upper part of the Larsh and Burroak Shale Member of the Deer Creek Limestone through the lower part of the Hartford Limestone Member of the Topeka Limestone. The datum for this cross-section is the top of the Ervine Creek Limestone.

Features illustrated by the cross-section include changes in the thickness of the Ervine Creek Limestone across the study area, and changes in the surface that

separates the two wackestone intervals within this member. In the northern part of the cross section, at the locality of KGS #1 Lyke, the Ervine Creek is relatively thin (3.0 ft), becoming much thicker to the north and south of this locality (5 to 6 feet). In the southern part of the cross-section, the thickness of the Ervine Creek remains relatively uniform (5 to 6 feet) until the southern-most locality (KGS #1 Short) where the member becomes thinner (< 3 feet). The surface that separates the upper and lower wackestone intervals in the Ervine Creek varies from a wavy irregular surface to a sharp planar surface. There does not appear to be any relationship between this surface and the thickness of the Ervine Creek Limestone.

The Calhoun Shale changes thickness and facies abruptly from core to core along the cross-section. The primary control of thickness in the Calhoun Shale is the presence or absence of the Hamilton Beds. Where present, the Hamilton Beds have incised down into the Calhoun Shale to varying degrees. In some cores (i.e. KGS #3 Lyke) the Hamilton Beds are only eroded down into the upper part of the Calhoun Shale and the Calhoun is still relatively thick (23.5 ft.), whereas in other cores (i.e. KGS #2 Lyke, KGS #2 Marlin, and KGS #1 Short), the Hamilton Beds overly less than 4 ft. of Calhoun Shale. Where the Calhoun Shale is thin, the overlying Hamilton Beds consist of a relatively thick (> 10 ft.) interval of intraclastic and skeletal rudstone. Also, where overlain by the rudstones of the Hamilton Beds, the Calhoun Shale appears to contain more sand.

KGS #3 Marlin is the only core examined for this report which contains the dolomitic mudstone associated with the Hamilton Lagerstatte. The basal part of the Hamilton Beds in this core consists of a thin (< 1 ft.) bed of intraclastic and skeletal rudstone which directly overlies the limestone interval of the Calhoun Shale which in turn overlies several feet of silty and sandy shale. KGS #2 Marlin, 0.47 miles (0.76 km.) to the north of KGS #3 Marlin, contains Hamilton Beds which consist of intraclastic

and skeletal rudstone, whereas KGS #1 Short, 1.3 miles (2.09 km.) to the south of KGS #3 Marlin, contains Hamilton Beds which consist entirely of skeletal rudstone.

REFERENCES

Bridge, T. E., and Mapes, R. H., 1988, Background history of the discovery and development of the Hamilton quarry site, in Mapes, G., and Mapes, R. H., eds., Regional Geology and Paleontology of Upper Paleozoic Hamilton Quarry Area in Southeastern Kansas: Kansas Geological Survey, Guidebook Series 6, p. 21-25.

Mapes, G., and Mapes, R. H., eds., 1988, Regional geology and paleontology of upper Paleozoic Hamilton quarry area in southeastern Kansas Kansas Geological Survey, Guidebook Series 6, 273 p.

Moore, R. C.,1949, Division of the Pennsylvanian System in Kansas: Kansas Geological Survey Bulletin 83, 203 p.

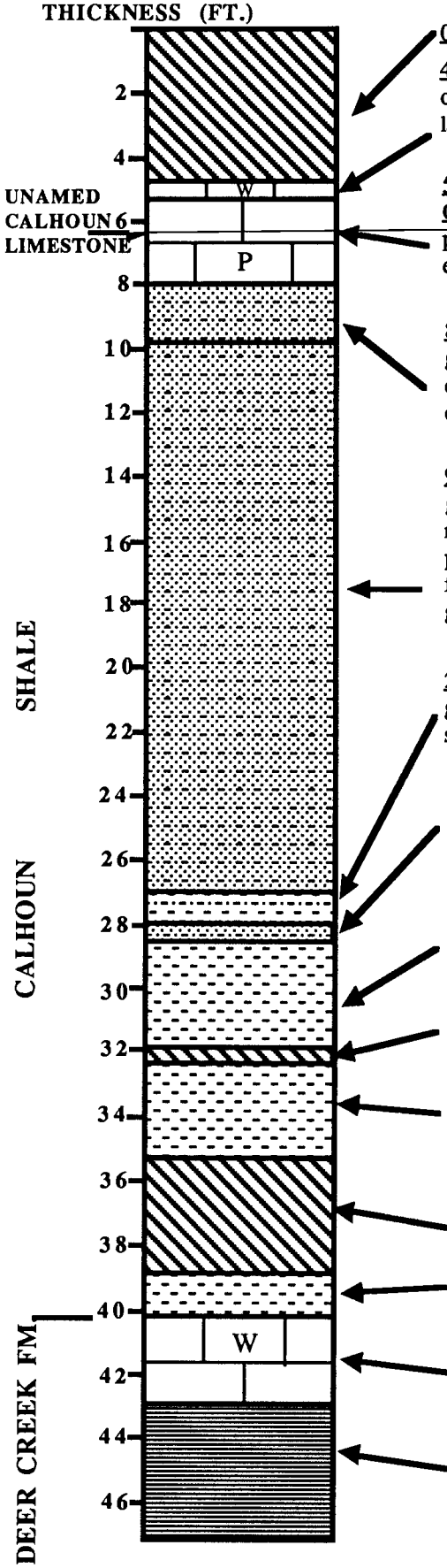
Zeller, D. E., 1968,The stratigraphic succession in Kansas: Kansas Geological Survey Bulletin 189, 81 p.

APPENDIX I

GRAPHIC SECTIONS

AND

CORE DESCRIPTIONS



DESCRIPTION

0-4'10" (58 inches) No recovery.

4'10"-5'5" (7 inches) Limestone: med. lt. gray (N6) fresh, weathered pale yel. or. (10YR8/6), med. to crs. grnd., coated grain and brachiopod wackestone; laminated; brachiopods, ostracodes, carbonaceous material.

5'5"-8'0" (31 inches) Limestone: lt. gray (N7) to med. lt. gray (N6), crs. grnd., Osagia and brachiopod wackestone; abundant pyrite, coated grains, Composita, productid brachiopods, pectinid bivalves, crinoids, fenestrate bryozoans, encrusting forams; becomes sandy basally; gradational lower contact.

8'0"-9'10" (22 inches) Silty Calcareous Sandstone: med. lt. gray (N6), fn. grnd., silty, micaceous; flaser bedding; quartz, plant fragmentts, very thin, discontinous coal layers, bivlaves, crinoids , gastropods, small brachiopods, coated grains; gradational upper and lower contacts.

9'10"-26'11" (205 inches) Silty Calcareous Sandstone: lt. gray (N7) to med. gray (N5), fn. grnd., subangular, moderately sorted, calcareous cement, micaceous, lenticular bedding,soft sediment deformation; quartz, mud clasts, plant fragments (carbonaceous), bivalves, small brachiopods, crinoids, fenestrate bryozoans, the most fossiliferous interval being 25'10"-26'3"; gradational upper and lower contacts.

26'11"- 27'10.5" (11.5 inches) Sandy Shale; lt. gray (N7), sandy, pebbles and granules at base, platy; pyrite (as small nodules), plant fragments (mostly stems); sharp lower contact.

27'10.5"-28'5.5" (7 inches) Silty Sandstone: yel. gray (5Y8/1) to lt. gray (N7), fn. grnd., micaceous, flaser bedding; quartz, nuculoid bivalves, small productid brachiopods, carbonaceous plant fragments; sharp upper and lower contacts.

28'5.5"-31'11" (41.5 inches) Silty Shale: med. lt. gray (N6), silty, platy, micaceous; pyrite, plant fragments (stems and Alethopteris pinnules), Lingula, bone fragments (fish?); sharp upper contact.

31'11"-32'3" (4 inches) No Recovery.

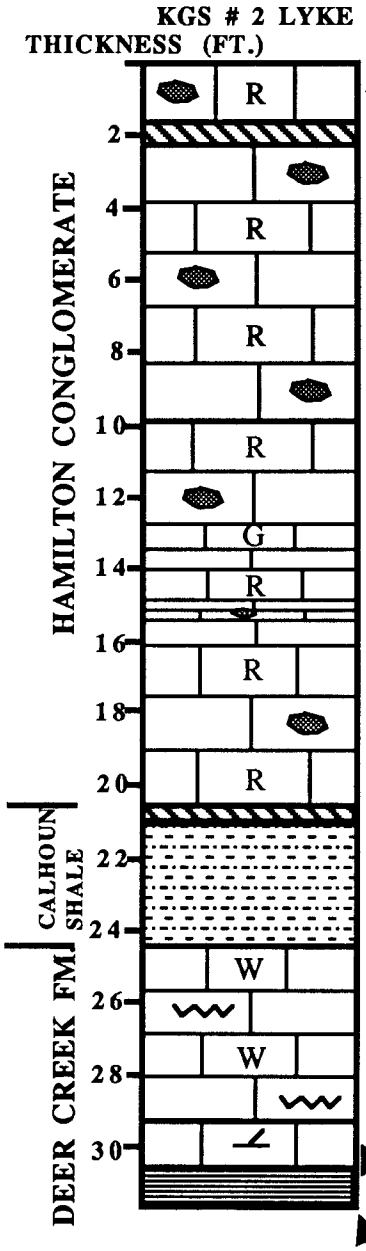
32'3"-35'4" (37 inches) Silty Shale: med. lt. gray (N6), silty, micaceous, platy to flaggy; small pyrite nodules, plant fragments (large and small stems, pinnules of Neuropteris, and Alethopteris), Lingula, Spirorbis (occuring on large stem fragments); plant fragments are commonly pyritized.

35'4"-38'11" (43 inches) No Recovery.

38'11"-40'1" (14 inches) Silty Shale: med. gray (N5), silty, micaceous, platy to flaggy; plant fragments; described from rubble.

40'1"-43'1" (36 inches) Limestone: lt. gray (N7), med. to very crs. grnd., brachiopod and fusulinid wackestone; pyrite, productid and other brachiopods, fusulinids, crinoids, bryozoans, coated grains, rhodoliths in upper 6", encrusting foraminifera; sharp lower contact.

43'1"-46'11" (46 inches) Clay Shale: med. gray (N5) to gray black (N2), fissile to papery; pyrite, mica, Planolites, Chondrites, and Zoophycus, Orbiculoidea, small brachiopods, nuculoid and pectinid bivalves, conodonts, phosphate nodules (in basal 11"); sharp upper contact.



DESCRIPTION

0-1'7" (19 inches) Conglomeratic Limestone: very lt. gray (N8) to weather dk. yel. or. (10YR6/6), very crs. to pebble size clasts, sparry matrix, intraclast and skeletal rudstone: intraclasts (2 lithologies - mudstone and brachiopod wackestone), fusulinids, productid brachiopods, bryozoans, rugose corals, bivalves; intraclasts may be bioturbated.

1'7"-2'4" (9 inches) No Recovery.

2'4"-9'11" (91 inches) Conglomeratic Limestone: very lt. gray (N8) to med. lt. gray (N6), to weathered dk. yel. or. (10YR6/6), very crs. to pebble size clasts, sparry matrix, weathered intraclast and skeletal rudstone: pyrite, intraclasts (at least 3 lithologies), fusulinids, productids and other brachiopods, crinoids, echinoids, bryozoans, bivalves, coated grains; skeletal grains with only moderate abrasion and fragmentation; lower contact based on weathering.

9'11"-20'8" (129 inches) Conglomeratic Limestone: very lt. (N8) to med. gray (N6), crs. grnd. to pebble size clasts, sparry matrix (becomes more micritic towards base), intraclast and skeletal rudstone to floatstone; pyrite, intraclasts (6 lithologies), fusulinids, crinoids, bryozoans, productid and other brachiopods, rugose corals, echinoids, bivalves, gastropods, ostracodes, small foraminfera, coated grains, rhodoliths; moderate fragmentation and abrasion of skeletal grains; several intervals with primarily skeletal grains and few intraclasts, pressure solution features (seams and styolites).

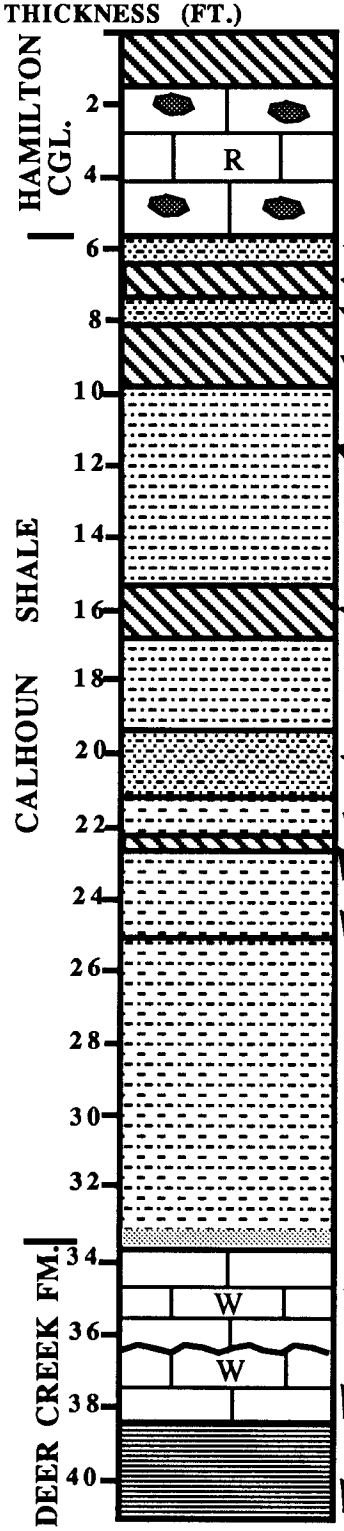
20'8"-21'1" (5 inches) No Recovery.

21'1"-24'6" (41 inches) Sandy Shale: med. lt. gray (N6), silt to very fn. sand, flaggy to platy, micaceous, sandy near top; pyrite (as nodules and replacing fragments), plant fragments (small stems); gradational lower contact.

24'6"-29'4" (58 inches) Limestone: lt. gray (N7) to med. gray (N 5), med to very crs. grnd., argillaceous, bryozoan, fusulinid and coated grain wackestone; pyrite, spar filled vugs and fractures, pressure solution features (styolites and shaley partings), plant fragments (in upper 3"), fusulinids, bryozoans, small brachiopods, Osagia, ostracodes, gastropods, smaller and encrusting foraminfera, rugose corals, small bivalves, rhodoliths; gradational lower contact.

29'4"-30'7" (15 inches) Limestone: lt. gray (N7) to med. lt. gray (N6), med. to crs. grnd., dolomitic (fn. crystalline), burrow mottled, Osagia and brachiopod wackestone; burrows, pyrite, Osagia, small brachiopods, crinoids, gastropods, fusulinids, smaller foraminifera, bryozoans; sharp lower contact.

30'7"-30'9" (2 inches) Clay Shale: med. gray (N5), fissile, finely laminated, burrow mottled; Chondrites, Planolites, small brachiopods; sharp upper contact.



DESCRIPTION

0-1'6" (18 inches) No Recovery.

1'6"-5'9" (51 inches) Conglomeratic Limestone: very lt. gray (N8) to med. gray (N5) to weatherd pl. tel. or. (10YR8/6), crs. grnd to pebble size clasts, sparry matrix, intraclast and skeletal rudstone; pyrite, intraclasts (at least 6 different lithologies), fuslinids, productid and other brachiopods, crinoids, echinoids, bryozoans, gastropods, bivalves, rhodoliths, coated grains, smaller foraminifera; sharp lower contact.

5'9"-6'6.5" (9.5 inches) Silty Sandstone: med. lt. gray (N6), fn. grnd., calcareous cement, micaceous, silty, soft sediment deformation, laminated, flaser bedding; quartz, plant fragments.

6'6.5"-7'7.5" (13 inches) No Recovery.

7'7.5"-8'2" (6.5 inches) Silty Sandstone: med. lt. gray (N6), fn. grnd., silty, micaceous, calcareous cemnt, flaser bedding, soft sediment deformation; plant fragments, fish teeth and bones.

8'2"-9'10" (20 inches) No Recovery.

9'10"-15'5" (67 inches) Sandy Shale: med. lt. gray (N6), silty to fn. grnd., micaceous, calcareous, soft sediment deformation, lenticular bedding; quartz, plant fragments, burrows (Planolites?), bivalves.

15'5"-16'9" (16 inches) No Recovery.

16'9"-19'5" (32 inches) Sandy Shale: very lt. gray (N8) to med. lt. gray (N6), silty to fn. grnd., laminated, micaceous, soft sediment deformation; quartz, pyrite, plant fragments (small stems), burrows (Planolites); gradational lower contact.

19'5"-21'4.5" (23.5 inches) Very Silty Sandstone: very lt. gray (N8) to med. lt. gray (N6), silty to fn. grnd., calcareous, micaceous, laminated, soft sediment deformation; quartz, pyrite, selenite, myalinid and pectinid bivalves, productid and other brachiopods, bryozoans, gastropods, plant fragments (large and small stems), Spirorbis; skeletal grains broken and abraded; sharp lower contact.

21'4.5"-22'2.5" (10 inches) Sandy Shale: med. lt. gray. (N6), clay to very fn. sand, laminated, platy; plant fragments (pinnules of Alethopteris, and small and large stems; plant fragments are pyritized.

22'2.5"-22'2.7" (5 inches) No Recovery.

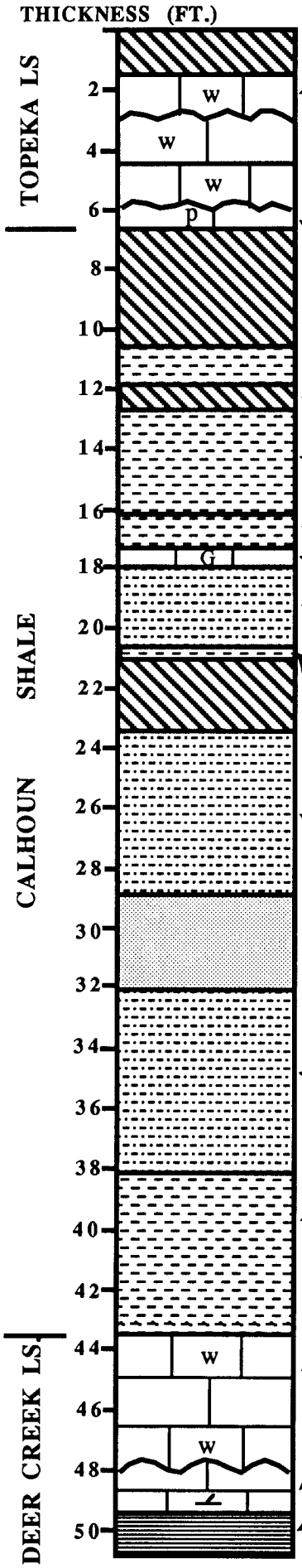
22'7.5"-25'3" (31.5 inches) Sandy Shale: med. lt. gray (N6), clay to very fn. grnd. sand, laminated, platy, micaceous; pyrite, plant fragments (pinnules of Alethopteris, Pecopteris, and Neuropteris, and large and small stems), ostracodes (smooth tests), Spirorbis; gradational lower contact.

25'3"-33'9" (102 inches) Sandy Shale: lt. gray (N7) to med. lt. gray (N6), silty to fn. grnd., platy to flaggy, low angle cross-bedding in upper part of unit, laminated, micaceous; pyrite, selenite, quartz, plant fragments (pinnules of Neuropteris, and small and large stems), burrows (Planolites); sharp basal contact.

33'9"-36'6" (33 inches) Limestone: lt. gray (N7) to lt. br. gray (5YR6/1), crs. to very crs. grnd., rhodolith and brachiopod wackestone; pressure solution features (seams, styolites, and thin shale breaks) spar filled fractures; rhodoliths, productid and other brachiopods, bryozoans, gastropods, smaller and encrusting foraminifera, fusulinids, phylloid algae, ostracodes, rugose corals, sponges, coated grains; abundant skeletal debris at base; wavy lower contact.

36'6"-38'3.5" (21.5 inches) Limestone: med. lt. gray (N6) to lt. gray (N7), med. to very crs. grnd., Osagia and brachiopod wackestone.

38'3.5"-41'3" (35.5 inches) Clay Shale: med. gray (N5) to grayish black (N2), laminated, papery to fissile; sharp upper contact.



DESCRIPTION

0-1'6" (18 inches) No Recovery.

1'6"-3'0" (15 inches) Limestone: weathered grayish orange (10YR7/4), med. to crs. grnd., fusulinid and brachiopod wackestone; fusulinids, crinoids, small brachiopods, gastropods, bryozoans; sharp and wavy lower contact (ommission surface ?).

3'0"-4'3" (15 inches) Limestone: very lt. gray (N8) to weathered pl. yel. or. (10YR8/6), crs. to very crs. grnd., brachiopod and crinoid wackestone; brachiopods, crinoids, bivalves, phylloid algae, gastropods, bryozoans, smaller foraminifera, rugose corals; spar filled vugs and fractures; skeletal grains fragmented; wavy lower contact.

4'3"-5'11.5" (20.5 inches) Limestone: lt. gray (N7) to lt brn. gray (5Y6/1), med. to crs. grnd., Osagia and crinoid wackestone; pyrite, Osagia, brachiopods, crinoids, ostracodes, small formainifera, bryozoans, gastropods, rhodoliths, Amblysiphonella; skeletal grains fragmented; wavey lower contact.

5'11.5"-6'6" (6.5 inches) Limestone: weathered grayish orange (10YR7/4), med, to crs. grnd., brachiopod and crinoid packstone; crinoids, brachiopods, bryozoans, bivalves, abundant skeletal debris.

6'6"-10'6" (48 inches) No Recovery.

10'6"-11'10" (16 inches) Silty Shale: med. lt. gray (N6), some very fn. grnd. sand, flaggy to platy, micaceous, soft sediment deformation; plant fragments (small stems) Lingula.

11'10"-12'8" (10 inches) No Recovery.

12'8"- 16'1" (41 inches) Silty Shale: med. lt. gray (N6), silty, flaggy to platy, micaceous; pyrite (as small nodules and replacing plant fragments), plant fragments (large and small stems), nuculoid bivalves, Lingula; gradational lower contact.

16'1"-17'4" (15 inches) Silty Shale: med. gray (N5) to med. lt. grya (N6), silty, platy; pyrite (as small nodules), small productid brachiopods, Phestia and other bivalves, gastropods, bryozoans, ostracodes, Derbyia, Lingula; sharp lower contact.

17'4"-18'0" (8 inches) Limestone: med. gray (N5), med. to very crs. grnd., sparry matrix, Osagia packstone to grainstone; replacement pyrite, Osagia, gastropods, productids and other brachiopods, crinoids, bivalves, bryozoans, echinoids, fusulinids, encrusting foraminifera, small rhodoliths; skeletal grains bored and fragmented; sharp upper and lower contacts.

18'0"-20'7" (31 inches) Sandy Shale: med. lt. gray (N6), silt to very fn. grnd. sand, flaggy to platy, micaceous, calcareous; pyrite, plant fragments (small and large stems), Lingula, small productid brachiopods, Crurithyris, crinoids, echinoids, bivalves, ostracodes; most fossiliferous in basal 1.5"

20'7"-21'0" (5 inches) Silty Shale: med. gray (N5), silty, platy: pyrite, plant fragments (large and small stems), Lingula; described from rubble.

21'0"-23'6" (30 inches) No Recovery.

23'6"-28'10" (64 inches) Sandy Shale: med. lt. gray (N6) to med. gray (N5), silt to very fn. qtz. sand, flaggy to platy, micaceous, laminated, interbedded with thin lenses and layers of sand, lenticular bedding in basal 3", increasing sand basally; pyrite, plant fragments (small and large stems), Lingula, burrows (Planolites?), calcareous nodules with pyrite rims; sharp lower contact.

28'10"-32'1.5" (39.5 inches) Sandstone: dk. yel or. (10YR6/6), very fn. to fn. grnd., micaceous, subrounded, moderately well sorted, friable, submature, quartz sublitharenite; shale partings, ripple laminations, low angle cross-bedding, some flaser bedding, silica cement with minor hematite, calcareous cement in basal 6"; plant fragments (small and large plant fragments, and pinnules of Neuropteris); sharp upper and lower contacts.

32'1.5"-38'2" (72.5 inches) Sandy Shale: med. lt. gray (N6), silt to very fn. sand, flaggy to platy, laminated, sandy; pyrite, plant fragments (small and large stems), Lingula, Aviculapectin, burrows (Planolites?); sharp upper contact, gradational lower contact.

38'2"-43'6" (57 inches) Silty Shale: med. lt. gray (N6) to med. gray (N5), clay to silt, platy, basal 2" calcareous; pyrite, plant fragments (large and small stms), Lingula, bivalves, basal 1" fossiliferous with small brachiopods, crinoids, and bryozoans; sharp basal contact.

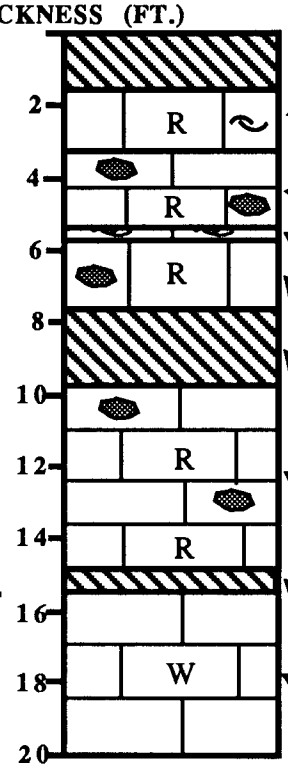
43'6"-48-0" (57 inches) Limestone: lt.brn. gray (5YR6/1), med. to very crs. grnd., micritic matrix, fusulinid, brachiopod, and bryozoan wackestone; fusulinids, brachiopods, bryozoans, gastropods, small foraminifera, coated grains, crinoids, rhodoliths, ostracodes, rugose corals, bivalves; skeletal grains fragmented; spar filled vugs and fractures; pressure solution features (styolites and seams); wavy lower contact.

48'0"-49'5.5" (17.5 inches) Limestone: lt. gray (N7) to lt.brn. gray (5YR6/1), med. to crs. grnd., slightly dodmitic, burrow mottled, Osagia and brachiopod wackestone; pyrite, Osagia, brachipods, bivalves, ostracodes, burrows, gastropods, encrusting foraminifera; skeletal grains fragmented; sharp lower contact.

49'5.5"-51'6" (24.5 inches) Clay Shale: med. gray (N5) to dk. gray (N3), fissile, finely laminated, burrow mottled, alternating med. gray and dk. gray intervals; pyrite, Planolites, Chondrites, Orbiculoidea, Crurithyris,scolecodonts, bivalves, conodonts, cephalopods; darker intervals appear to be more bioturbated.

KGS # 2 MARLIN

THICKNESS (FT.)



DESCRIPTION

0-1'7" (19 inches) No Recovery

1'7"-3'5" (22 inches) Limestone: very lt. gray (N8) to weathered dk. yel. or. (10YR6/6), crs. to very crs. grnd., skeletal rudstone; few intraclasts, fusulinids, brachiopods, bryozoans, crinoids, rugose corals, bivalves; gradational basal contact.

3'5"-5'3" (22 inches) Conglomeratic Limestone: very lt. gray (N8), very crs. grnd to pebbles, intraclast and skeletal rudstone; intraclasts (at least 3 lithologies), productid and other brachiopods, bryozoans, fusulinids, crinoids, rugose corals; intraclasts may be bored; gradational basal contact.

5'3"-5'8" (5 inches) Limestone: very lt. gray (N8), crs. to very crs. grnd., skeletal rudstone; bryozoans, productids and other brachiopods, fusulinids, bivalves; skeletal grains eleongate parallel to bedding.

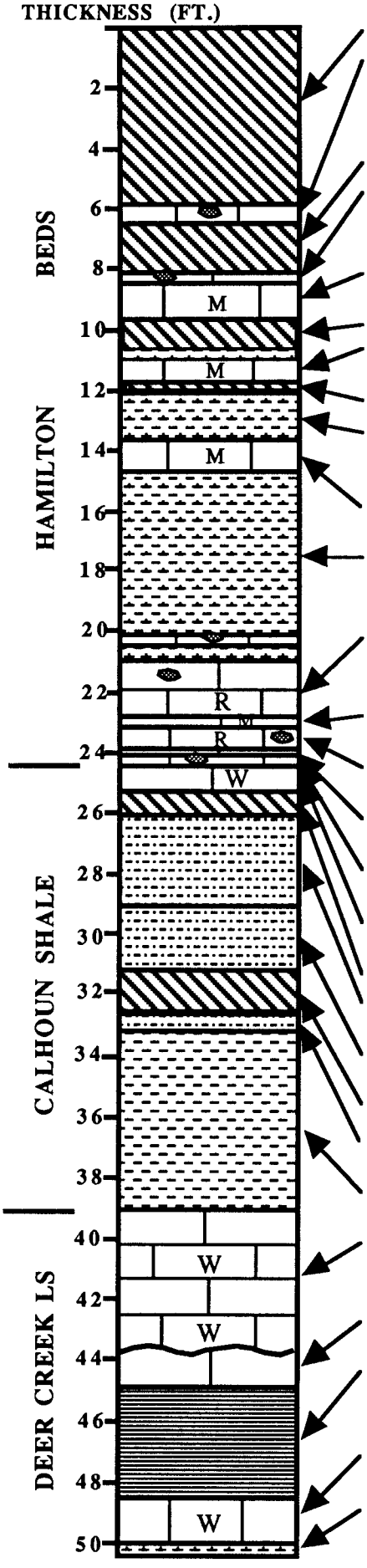
5'8"-7'9" (25 inches) Conglomeratic Limestone: vry lt. gray (N8), crs. grnd. to pebbles, spar matrix, weathered, intraclast and skeletal rudstone; large intraclasts (up to 6 cm. in diameter), productid brachiopods, bryozoans, fusulinids.

7'9"-9'9" (24 inches) No Recovery.

9'9"-14'9.5" (60.5 inches) Conglomeratic Limestone: very lt. gray (N8) to weathered mottled dk. yel. or. (10YR6/6), crs. grnd. to cobble size, weathered, spar matrix, intraclast and skeletal rudstone; intraclasts (at least 5 lithologies), productid and other brachiopods, fusulinids, bryozoans, coated grains, bivalves, gastropods; very few clasts in upper 1".

14'9.5"-15'6.5" (9 inches) No Recovery.

15'6.5"-20'0" (53.5 inches) Limestone: lt. gray (N7) to med. lt. gray (N6), crs. to very crs. grnd., micritic, fusulinid and brachipod wackestone; fusulinids, brachiopods, coated grains, rhodoliths, bryozoans, ostracodes, crinoids, gastropods, pylloid algae, smaller foraminifera, rugose coral; skeletal grains fragmented and concentrated in irregular shaped pockets.



DESCRIPTION

0-5'11" (71 inches) No Recovery.

5'11"-6'6" (7 inches) Conglomeratic Limestone: lt. gray (N7) to weathered mottled dk. yel. or. (10YR6/6), crs. grnd. to pebbles, spar matrix, weathered, intraclast and skeletal rudstone; intraclasts (weathered and small - < 1cm.), fusulinids, brachiopods, small gastropods, smaller foraminifera, bryozoans.

6'6"-8'1" (19 inches) No Recovery.

8'1"-8'4" (3 inches) Conglomeratic Limestone: lt. gray (N7), very crs. grnd to pebbles, spar matrix, intraclast and skeletal rudstone; algal laminite intraclasts (up to 3 cm.), brachiopods, bryozoans, pyrite; sharp lower contact.

8'4"-9'8" (16 inches) Micritic Limestone: lt. gray (N7), to med. lt. gray (N6), very fn. grnd., algal laminated mudstone; algal laminations, ostracodes, carbonaceous streaks.

9'8"-10'8" (12 inches) No Recovery.

10'8"-11'8" (12 inches) Micritic Limestone: lt. gray (N7) to med. lt. gray (N6), very fn. grnd., algal laminated mudstone; 1" calcareous mudstone at top of unit with plant fragments.

11'8"-11'11" (3 inches) No Recovery.

11'11"-13'8" (21 inches) Silty Shale: med. lt. gray (N6) to lt. yel gray (10YR8/6), silty, platy, micaceous, calcareous, thin calcareous layers (<1cm); plant fragments (large and small stems); sharp lower contact.

13'8"-14'8" (12 inches) Micritic Limestone: lt. gray (N7), very fn. grnd., algal laminated mudstone; ostracodes, parallel and wavey algal laminations; sharp lower contact.

14'8"-20'10" (74 inches) Silty Shale with calcareous layers; med. lt. gray (N6), clay to fn. sand, calcareous lenses and layers; plant fragments (small stems), thin (<1") conglomeratic limestone layer (20'2.5"-20'3.5"); sharp basal contact.

20'10"-22'10" (24 inches) Conglomeratic Limestone: lt. gray (N7), crs. grnd. to pebbles, intraclast and skeletal rudstone; intraclasts, fusulinids, crinoids, brachiopods; fines upward; sharp lower contact.

22'10"-23'3" (5 inches) Micritic Limestone: lt. gray (N7), very fn. grnd., algal laminated mudstone; ostracodes and algal laminations; sharp lower contact.

23'3"-23'9" (6 inches) Conglomeratic Limestone: lt. gray (N7), very crs. grnd., intraclast and skeletal rudstone; intraclasts, fusulinids, brachiopods, bryozoans; sharp lower contact.

23'9"-23'11" (2 inches) Micritic Limestone; lt. gray (N7), very fn. grnd., algal laminated mudstone; sharp lower contact.

23'11"-24'3" (4 inches) Conglomeratic Limestone: lt. gray (N7), very crs. grnd, spar and micritic matrix, intraclast and skeletal grainstone.

24'3"-25'3.5" (12.5 inches) Limestone; med. lt. gray (N6), med. to crs grnd., Osagia, crinoid and brachiopod wackestone to packstone; pyrite.

25'3"-26'0.5" (9 inches) No Recovery.

26'0.5"-29'2" (37.5 inches) Sandy Shale: med. lt. gray (N6), silt to very fn. grnd. sand, platy, micaceous; plant fragments (small stems); gradational lower contact.

29'2"31'3" (25 inches) Sandy Shale: med. lt. gray (N6), laminated, lenticular bedding, soft sediment deformation (slump); carbonaceous plant fragments (small stems).

31'3"-32'5" (14 inches) No Recovery.

32'5"-32'11.5" (6.5 inches) Sandy Shale: med. lt. gray (N6), laminated, lenticular bedding, slump; carbonaceous plant fragments (stems); gradational lower contact.

32'11.5"-39'0.5" (73 inches) Silty Shale: med. gray (N5), silty, platy, micaceous; plant fragments (small stems), Lingula; sharp lower contact.

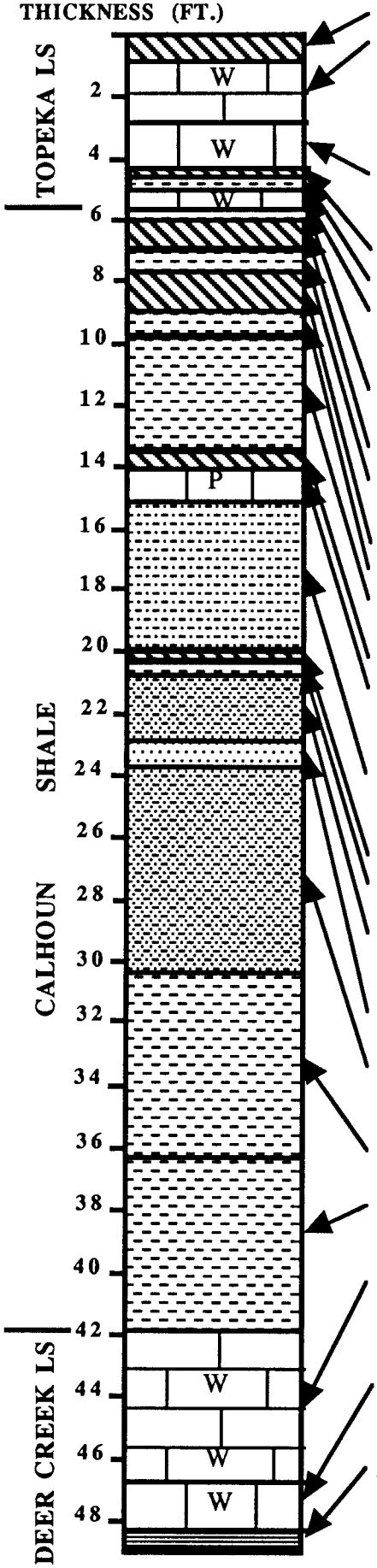
39'0.5"-43'10" (57.5 inches) Limestone: lt. gray (N7), med. to crs. grnd., fusulinid and brachiopod wackestone; fusulinids, brachiopods, bryozoans, coated grains, rhodoliths, rugose corals; wispy pressure solution features; spar filled fractures and vugs; wavey lower contact.

43'10"-45'1" (15 inches) Limestone: lt. gray (N7), burrow mottled, Osagia and brachiopod wackestone; sharp lower contact.

45'1"-48'3" (38 inches) Clay Shale: med. gray (N5) to black (N1), fissile to papery, phosphatic in lower 1/3 of unit, alternating lt. and dk. laminations, calcareous in basal 1", dark layers with more bioturbation; Chondrites, Planolites, Orbiculoidea; sharp lower contact.

48'3"49'11" (20 inches) Limestone: med. lt. gray (N6), med. to crs. grnd., fusulinid, coated grain and brachiopod wackestone; sharp basal contact.

49'11"-50'2" (3 inches) Calcareous Shale: med. lt. gray (N6), platy, calcareous, sandy; brachiopods, fusulinids, bryozoans; abraded skeletal grains.



DESCRIPTION

0-8" (8 inches) No Recovery.

8"-2'10" (26 inches) Limestone: lt. brn. gray (5YR6/1) to weathered very lt. gray (N8) and mottled dk. yel. or. (10YR6/6), med. to very crs. grnd., vuggy, brachiopod and crinoid wackestone; Composita and other brachiopods, crinoids, ostracodes, phylloid algae, fusulinids, gastropods; spar filled vugs and fractures; lower boudary is a sharp change in the amount of weathering and fossil content.

2'10"-4'2" (16 inches) Limestone: lt. gray (N7) to weatherd mottled gr. or. (10YR7/4), crs. to very crs. grnd., sandy, vuggy, crinoid and brachiopod wackestone; pyrite, crinoids, small productids and other bachiopods, coated grains, encrusting foraminifera, sponges.

4'2"-4'4" (2 inches) No Recovery.

4'4"-5'1" (9 inches) Shale: Drilled.

5'1"-5'7.5" (6.5 inches) Limestone: lt. gray (N7), crs. to very crs. grnd., crinoid and brachiopod wackestone to packstone; crinoids, brachiopods, coated grains, encrusting foraminifera, sponges; sharp basal contact.

5'7.5"-5'10.5" (3 inches) Silty Shale: med. lt. gray (N6), silty, micaceous, platy, sandy; plant fragments (small stems).

5'10.5"-6'11.5" (13 inches) No Recovery.

6'11.5"-7'9.5" (10 inches) Silty Shale: med. lt. gray (N6), silt to very fine sand, micaceous, platy; plant fragments (small stems).

7'9.5"-9'0.5" (15 inches) No Recovery.

9'0.5"-9'9.5" (9 inches) Shale: Drilled.

9'9.5"-13'6" (44.5 inches) Silty Shale: med. lt. gray (N6), sandy, platy, micaceous; plant fragments (small stems), burrows (Planolites).

13'6"-14'1" (7 inches) No Recovery.

14'1"-15'2" (13 inches) Limestone: med. lt. gray (N6), crs. to very crs. grnd., coated grain and bivalve packstone; coated grains, large, robust bivalves, crinoids, productid brachiopods, encrusting foraminifera, sponges; sharp lower contact.

15'2"-19'11.5" (57.5 inches) Sandy Shale: med. lt. gray (N6) to very lt. gray (N8), clay to very fn. sand, platy, micaceous, laminated, lenticular bedding, ripple cross-stratification and slump; pyrite nodules, quartz sand, plant fragments (often pyritized), Lingula.

19'11.5"-20'2.5" (3 inches) No Recovery.

20'2.5"-20'7.5" (5 inches) Silty Shale: med. lt. gray (N6), sandy, platy, micaceous; plant fragments.

20'7.5"-22'10.5" (27 inches) Sandy Shale: med. lt. gray (N6) to very lt. gray (N8), clay to very fn. sand, micaceous, platy, sandy lenses, laminated, lenticular bedding; pyrite, qurtz, plant fragments; gradational lower contact.

22'10.5"-23'9.5" (11 inches) Silty Sandstone: lt. gray (N7) to very lt. gray (N8), fn. grnd., minor carbonate cement; quartz, mica, plant fragments.

23'9.5"-30'5.75" (80.25 inches) Interbedded Shale and Sandstone: med. lt. gray (N6) to very lt. gray (N8), silty shale, very fn. grnd. sand, flaser anmd lenticular bedding, soft sediment deformation; plant fragments; sharp upper and lower contact.

30'5.75"-36'4" (70.25 inches) Silty Shale: med. gray (N5) to lt. gray (N7), platy, slightly micaceous, laminated; plant fragments, burrows, Lingula; gradational lower contact.

36'4"-41'11" (67 inches) Clay Shale: med. dk. gray (N4) to dk. gray (N3), platy to fissile, silty; pyrite nodules, plant fragments, becomes more fossiliferous basally with bryozoans, small productid brachiopods, and crinoids; sharp lower contact.

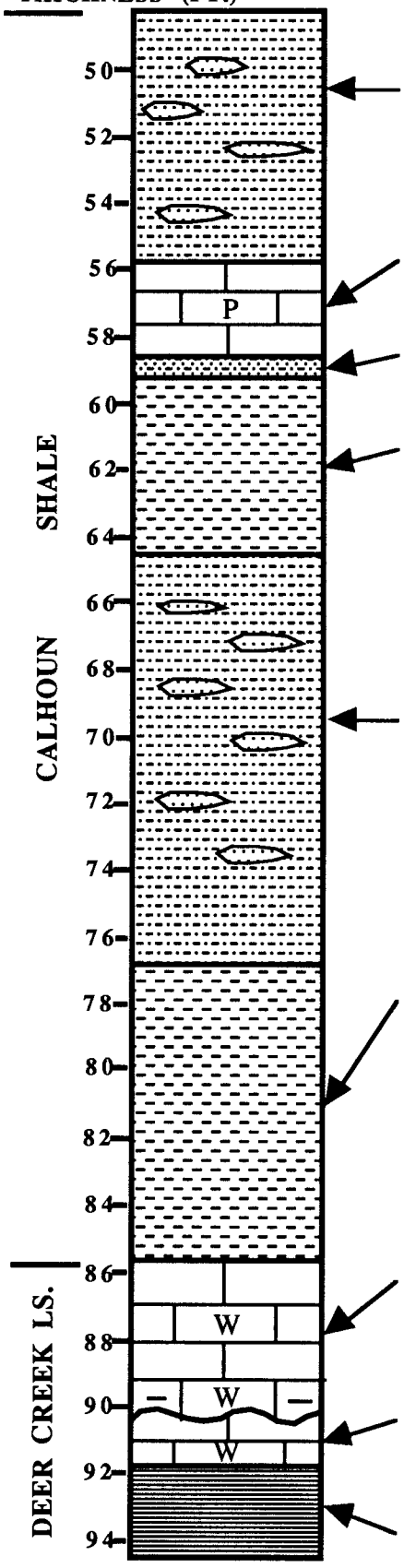
41'11"-46'8" (57 inches) Limestone: lt. gray (N7), to med. gray (N5), med. to crs. grnd., wavy bedded, brachiopod and fusulinid wackestone; Composita, Hustedia, small productid brachiopods, fusulinids, Astartella, bryozoans, crinoids, ostracodes, coated grains, sponges; gradational lower contact.

46'8"-48'3" (19 inches) Limestone: med. lt. gray (N6) to brn. gray (5YR4/1), med. to crs. grnd., brachiopod and crinoid wackestone; small brachiopods, crinoids, encrusting foraminifera, coated grains; sharp lower contact.

48'3"-49'3" (12 inches) Clay Shale: med. dk. gray (N4) to gray blk. (N2), platy to fissile, finely laminated; burrow mottled (Chondrites and Planolites), small bivalves, Orbiculoidea, plant fragments.

KGS # 2 ULRICH (LOWER)

THICKNESS (FT.)



DESCRIPTION

48'2"-55'9" (91 inches) Sandy Mudstone: very lt. gray (N8) to med. gray (N5), clay to very fn. sand, lenticular bedding, micaceous; quartz, pyrite, brachiopods in upper 3", bryozoans, brachiopods, and bivalves in basal 6", Lingula, plant fragments, sand filled burrows; gradational lower contact.

55'9"-58'6" (32 inches) Limestone: med. lt. gray, (N6), med. to very crs. grnd., coated grain, crinoid and brachiopod wackestone; coated grains, oncolitic near base, crinoids, brachiopods, bryozoans, fusulinids, encrusting foraminifera, bivalves, sponges; sharp lower contact.

58'6"-59'3.5" (9.5 inches) Fossiliferous Silty Sandstone: med. lt. gray (N6) to med. gray (N5), very fn. grnd., poorly sorted, micaceous, calcareous, flaser bedding; mica, quartz, productid brachiopods, crinoids, bryozoans, plant fragments (stems); sharp lower contact.

59'3.5"-64'7" (63.5 inches) Silty Shale: med. lt. gray (N6), to med. gray (N5), silty, platy , micaceous, laminated; pyrite, plant fragments (stems, and pinnules of Neuropteris and Alethopteris), bivalves, spirorbid worm tubes; gradational lower contact.

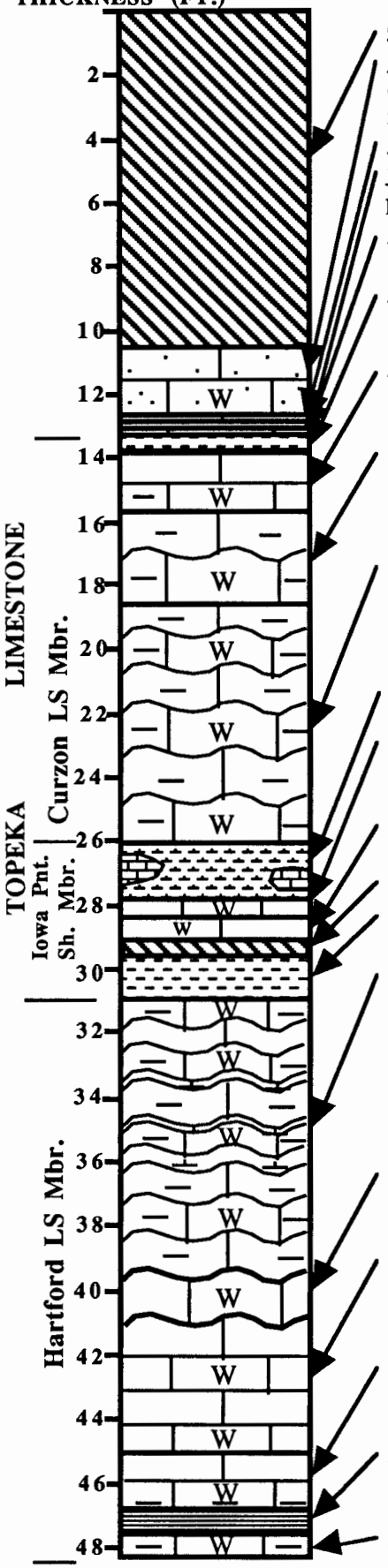
64'7"-76'10" (147 inches) Sandy Shale: very lt. gray (N8) to med. gray (N5), clay to very fn. sand, micaceous, laminated, ripple cross-stratification, sandy lenses, slump; pyrite nodules, plant fragments (stems and pinnules), spirorbid worm tubes; gradational lower contact.

76'10"-85'8" (106 inches) Shale: med. gray (N5) to med. dk. gray (N4), silty, platy, slightly micaceous; siderite and pyrite nodules, plant fragments, root traces?, ostracodes, gastropods, basal 2" more fossiliferous with brachiopods, bryozoans, and crinoids; sharp lower contact.

85'8"-90'4" (56 inches) Limestone: lt. gray (N7), to lt. brn. gray (5YR6/1), med. to very crs. grnd., wavey bedded, slightly argillaceous, fusulinid and brachiopod wackestone; pressure solution features (carbonaceous microstyolites); fusulinids, brachiopods, crinoids, bryozoans, echinoids, coated grains, pellets, ostracodes; wavy lower contact.

90'4"-91'10" (18 inches) Limestone: lt. gray (N7), med. to very crs. grnd., sandy, brachiopod and crinoid wackestone; small brachiopods, crinoids, coated grains, encrusting foraminifera, bryozoans, pellets, fusulinids; sharp lower contact.

91' 10"- 94'6" (32 inches) Clay Shale: dk. gray (N3) to gray black (N2), fissile, laminated; pyritized skeletal grains and burrows, Chondrites, Planolites, Orbiculoidea, Crurithyris, Herbertella, plant fragments, fish bones and dermal denticles, conodonts (idiognathodid Pa elements), cephalopods, ostracodes.



DESCRIPTION

0-10'7" (127 inches) No Recovery.

10'7"-12'7.5" (24.5 inches) Limestone: yel. gray (5Y7/2), med. to crs. grnd.. sandy, dolomitic, ostracode and bivalve wackestone to packstone; ostracodes, small bivalves, gastropods; spar filled fractures and vugs; sharp lower boundary.

12'7.5"-12'9" (1.5 inches) Limestone: med. lt. gray (N6), med. grnd., ostracode mudstone.

12'9"-12'10.25" (1.25 inches) Calcareous Shale: med. lt. gray (N6), slightly micaceous; productid spines.

12'10.25"-13'0" (1.75 inches) Argillaceous Limestone: med. lt. gray (N6) productid and other brachiopod wackestone.

13'0"-13'9" (9.5 inches) Shale: med. lt. gray (N6), micaceous, platy, calcareous, poorly indurated; small brachiopods, Hustedia; increasingly fossiliferous basally; gradational upper and lower conatact.

13'9.5"-15'8.5" (23 inches) Limestone: lt. gray (N7), to med. lt. gray (N6), very crs. grnd., slightly argillaceous, fusulinid and brachiopod wackestone; fusulinids, bryozoans, crinoids, echinoids, brachiopods; gradational lower contact.

15'8.5"-18'8" (35.5 inches) Argillaceous Limestone: lt. gray (N7) to med. gray (N5), wavy bedded, argillaceous, fusulinid and bryozoan wackestone to packstone; fusulinids, bryozoans, brachiopods, crinoids, echinoids; pressure solution features (microstyolites and shale breaks); preferential alignment of skeletal grains in argillaceous interbeds; gradational lower contact.

18'8"-26'2" (90 inches) Argillaceous Limestone: lt. gray (N7) to med. gray (N5), very crs. grnd., wavy bedded, fusulinid and bryozoan wackestone; fusulinids, bryozoans, crinoids, brachiopods, echinoids; pressure solution features (styolites, microstyolites, and shale breaks), preferential alignment of skeletal grains in argillaceous interbeds; gradational lower contact.

26'2"-27'9" (19 inches) Calcareous Shale: med. gray (N5), platy, micaceous, thin (<1") wackestone lenses; bryozoans, crinoids, brachiopods, fusulinids; sharp lower contact.

27'9"-28'5.5" (8.5 inches) Limestone: lt. gray (N7), crs. to very crs. grnd, coated grain wackestone; coated grains, brachiopods, encrusting foraminifera, fusulinids, echinoids, gastropods; gradational lower contact.

28'5.5"-29'2.5" (9 inches) Limestone: lt. gray (N7), crs. to very crs. grnd., brachiopod and gastropod wackestone; algal coated grains, productid and other brachiopods, gastropods.

29'2.5"-29'9.5" (7 inches) No Recovery.

29'9.5"-31'3.5" (18 inches) Shale: med. gray (N5), platy, micaceous, calcareous; carbonaceous streaks, pyrite, selenite, burrows, brachiopods and crinoids in basal 3"; sharp lower contact.

31'3.5"-39'8.5" (101 inches) Limestone Interbedded with Very Argillaceous Nodular Limestone and Calcareous Shale: lt. gray (N7) to med. gray (N5), crs. to very crs. grnd., wavy bedded, argillaceous fusulinid wackestone with interbeds of very argillaceous fusulinid and bryozoan wackestone to packstone, and calcareous shale; spar filled vugs and fractures; pressure solution features (seams, styolites, and shale breaks); minor mica and pyrite, fusulinids, bryozoans, brachiopods, crinoids, echinoids, algal coated grains, large skeletal grains in basal 18"; gradational basal contact.

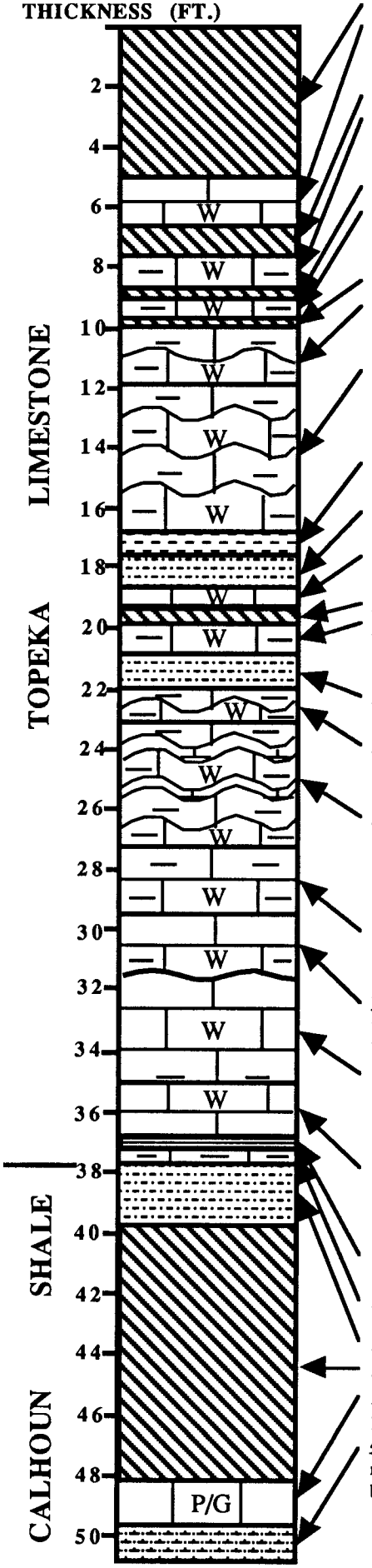
39'8.5"-41'1" (16.5 inches) Limestone: med. lt. gray (N6), med. to crs. grnd., wavy bedded, pelletal, fusulinid, bryozoan and brachiopod wackestone; fusulinids, bryozoans, brachiopods, crinoids, pellets, algal coated grains; wavy, sharp lower contact.

41'1"-45'2.5" (49.5 inches) Limestone: very lt. gray (N8), med. to crs. grnd., ostracode and brachiopod wackestone; spar filled vugs and fractures; styolites and microstyolites; minor pyrite, smooth shelled ostracodes, Composita, productids and other brachiopods, crinoids, echinoids, gastropods; sharp lower contact with thin black shale parting (<5mm).

45'2.5"-46'10.75" (20.25 inches) Limestone: lt. gray (N7), med. to very crs. grnd., rhodolith, brachiopod and crinoid wackestone; spar filled vugs and fractures; crinoids, productids and other brachiopods, rhodoliths, pellets; sharp lower contact.

46'10.75"-47'7" (8 inches) Shale: dk. gray (N3) to gry. black (N2), laminated, fissile, carbonaceous; pyrite, Lingula, burrows (Chondrites?), pectinid bivalves, brachiopods, plant fragments; sharp lower contact.

47'7"-48'2" (7 inches) Limestone: med. lt. gray (N6) to med. gray (N5), crs. to very crs grnd., wavy bedded, argillaceous, crinoid and brachiopod wackestone to packstone; microstyolites; crinoids, brachiopods, fusulinids, bryozoans; gradational lower contact.



DESCRIPTION

0-5'2" (62 inches) No Recovery.

5'2"-6'8" (18 inches) Limestone: weathered gry. orange ((10YR7/4) to dk. yel orange ((10YR6/6), crs. to very crs. grnd., fusulinid and brachiopod wackestone; fusulinids, small brachiopods, crinoids; described from rubble.

6'8"-7'8" (12 inches) No Recovery.

7'8"-8'7.5" (11.5 inches) Limestone: weathered very pl. orange (10YR8/2) to dk. yel. orange (10YR6/6), crs. to very crs. grnd., fusulinid, brachiopod and bryozoan wackestone; spar filled vugs; fusulinids, productids and other brachiopods, crinoids, bryozoans.

8'7.5"-9'1.5" (6 inches) No Recovery.

9'1.5"-9'9" (7.5 inches) Limestone: lt. gray (N7) to med. lt. gray (N6), argillaceous, crs. grnd., brachiopod and fusulinid wackestone; productid and other brachiopods, fusulinids, crinoids, bryozoans.

9'9"-9'11" (2 inches) No Recovery.

9'11"-11'11" (24 inches) Limestone: lt. gray (N7) to med. lt. fray (N6), crs. to very crs. grnd., wavy bedded, brachiopod, crinoid and fusulinid wackestone; pressure solution features (microsyolites); productids and other brachiopods, crinoids, fusulinids, bryozoans; sharp basal contact.

11'11"-16'10" (59 inches) Limestone: very lt. gray (N8) to med. lt. gray (N6), crs. to very crs. grnd., wavy bedded, argillaceous, fusulinid and brachiopod wackestone to packstone; pressure solution features (microstyolites and wavey bedding?); fusulinids, productid and other brachipods, crinoids, echinoids, ostracodes, phylloid algae; more argillaceous basally; sharp basal contact.

16'10"-17'9.5" (11.5 inches) Calcareous Mudstone: med. gray (N5), silty to slightly sandy, micaceous, blocky; bryozoans, crinoids, brachiopods; described from rubble.

17'9.5"-18'8" (10.5 inches) Sandy Shale: med. lt. gray (N6), sandy, platy, micaceous; fenestrate bryozoans, small productid brachiopods, ostracodes; sharp lower contact.

18'8"-19'3" (7 inches) Limestone: med. lt. gray (N6), crs. to very crs. grnd., bivalve and foraminifera wackestone; pectinid bivalves, encrusting foraminifera, crinoids, small brachiopods, gastropods.

19'3"-19'11" (8 inches) No Recovery.

19'11"-20'9" (10 inches) Limestone: lt. gray (N7), med. to crs. grnd., argillaceous, intraclastic, ostracode and brachiopod mudstone to wckestone; spar filled vugs; intraclasts, ostracodes, Hustedia and other brachiopods, bivalves, crinoids; sharp lower contact.

20'9"-21'11.5" (14.5 inches) Sandy Shale: med. lt. gray (N6), sandy, palty, micaceous; small brachiopods, ostracodes; sharp lower contact.

21'11.5"-23'1" (13.5 inches) Limestone: lt. gray (N7) to med. lt. gray (N6), crs. to very crs. grnd., wavy bedded, argillaceous, fusulinid and brachiopod wackestone; pressure solution features (microstyolites); fusulinids, brachiopods, crinoids, bryozoans; sharp lower contact.

23'1"-27'4.5" (51.5 inches) Interbedded Calcareous Shale and Nodular Limestone: lt. gray (N7) to med. gray (N6), shale is calcareous, platy, micaceous and sandy, limestone is crs. to very crs. grnd., wavy bedded, argillaceous, fusulinid and brachiopod wackestone; fusulinids, Composita, productid and other brachiopods, bryozoans, crinoids, ostracodes, smaller foraminifera, bivalves, plant fragments; gradational lower contact.

27'4.5"-29'6" (25.5 inches) Very Argillaceous Limestone: med. lt. gray (N6), med. to crs. grnd., argillaceous, fusulinid and productid brachiopod wackestone; pellets, fusulinids, large productids and other brachiopods, bryozoans,crinoids, echinoids; gradational lower contact.

29'6"-31'6" (24 inches) Limestone: lt. gray (N7), med. to very crs. grnd., slightly argillaceous, fusulinid and brachiopod wackestone; styolites; pellets, fusulinids, productid and other brachiopods, bryozoans, crinoids, rugose corals, coated grains; wavy lower contact.

31'6"-35'1" (43 inches) Limestone: very lt. gray (N8) to white (N9), med. to crs. grnd., vuggy, ostracode and brachiopod wackestone; spar filled vugs and fractures; styolites; ostracodes, Mesolobus, Hustedia, fusulinids, bryozoans, phylloid algae; sharp lower contact with 1" shale parting.

35'1"-36'9" (20 inches) Limestone: lt. gray (N7), med. to very crs. grnd., algal coated grains and brachiopod wackestone; coated grains, Mesolobus, Composita, other brachiopods, sponges, crinoids, encrusting foraminifera, echinoids, bryozoans, bivalves, oncolitic near base; sharp lower contact.

36'9" -37'1" (4 inches) Clay Shale: med. gray (N5), fissile, laminated, burrow mottled, carbonaceous and slightly calcareous; small brachiopods, Lingula; sharp lower contact.

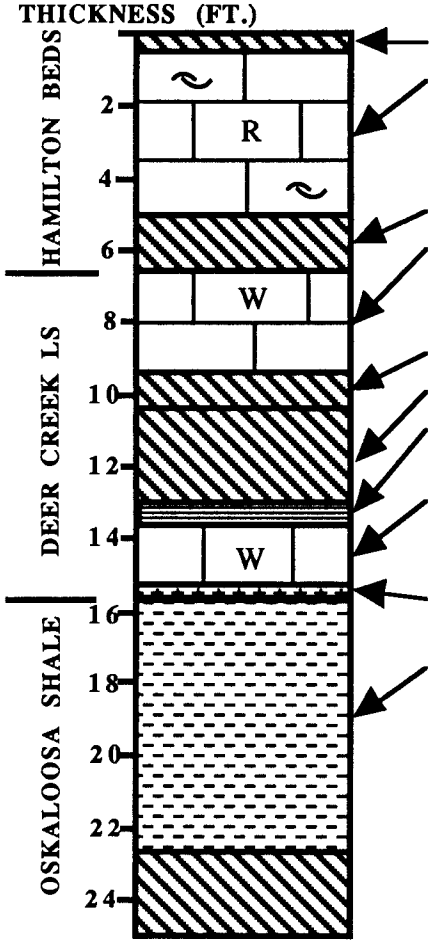
37'1"-37'8" (7 inches) Argillaceous Limestone: med. lt. gray (N6), crs. to very crs. grnd., crinoid and brachiopod wackestone to packstone; sharp lower contact.

37'8"-39'9" (25 inches) Burrowed Sandy Shale: med. lt. gray (N6), platy, micaceous calcareous.

39'9"-48'1" (100 inches) No recovery: Shale ; drilled.

48'1"-49'8" (19 inches) Limestone: med. lt. gray (N6), med. to crs. grnd., coated grain and crinoid packstone to grainstone; becomes sandy basally; gradational lower contact.

49'8"-51'4" (20 inches) Calcareous Sandstone to Sandy Limestone: med. lt. gray (N6), very fn. grnd., micaceous; quartz sand, bivalves, productid brachiopods, bryozoans, crinoids; becomes silty towards base.



DESCRIPTION

0-6" (6 inches) No Recovery.

6"-5'1" (55 inches) Limestone: very lt. gray (N8) to weathered dk. yel or. (10YR6/6), crs. grnd. to pebbles, spar matrix, skeletal rudstone; fusulinids, brachiopods, coated grains, bryozoans, small intraclasts (< 1cm in diameter); some fragmentation and abrasion of skeletal grains, skeletal grains elongate parallel to bedding.

5'1"-6'8" (19 inches) No Recovery.

6'8"-9'6" (34 inches) Limestone: lt. gray (N7), crs. to very crs. grnd., coated grain, brachiopod and fusulinid wackestone: coated grains, brachiopods, fusulinids, rhodoliths, encrusting foraminifera, crinoids, fenestrate bryozoans.

9'6"-10'2" (8 inches) No Recovery.

10'2"-13'2" (36 inches) Shale: Drilled.

13'2"-13'7" (5 inches) Clay Shale: grayish black (N2), fissile, papery, laminated, calcareous in basal 1"; phosphate nodules; sharp basal contact.

13'7"15'3" (20 inches) Limestone: med. lt. gray (N6), med. to crs. grnd., brachiopod and fusulinid wackestone; fusulinids, brachiopods, coated grains, crinoids, fenestrate bryozoans, encrusting foraminifera; sharp lower contact.

15'3"-15'6" (3 inches) Calcareous Shale: med. lt. gray (N6), med. to crs. grnd., platy, sandy; brachiopods, fusulinids, crinoids; abraded skeltal grains; gradational basal contact.

15'6"-23'8" (98 inches) Silty Mudstone: varicolored, olive gray to reddish brown, silty, blocky; plant fragments (stems) and root traces.

A

A'

KGS # 2 ULRICH (LOWER)

KGS # 1 ULRICH

KGS #1 LYKE

KGS # 3 LYKE

KGS # 2 LYKE

KGS #1 MARLIN

KGS # 2 MARLIN

KGS # 3 MARLIN

KGS # 1 SHORT

0.64 mi 1.01 km

0.70 mi 1.13 km

0.06 mi 0.10 km

0.25 mi 0.39 km

1.09 mi 1.75 km

0.13 mi 0.19 km

0.47 mi 0.76 km

1.3 mi 2.09 km

Hartford Ls. Mbr.

Calhoun Shale

Calhoun Ls. Mbr.

Calhoun Shale (sandy)

Calhoun Shale (silty)

Hamilton Beds

Fossiliferous zone

DATUM

Ervine Creek Ls. Mbr.

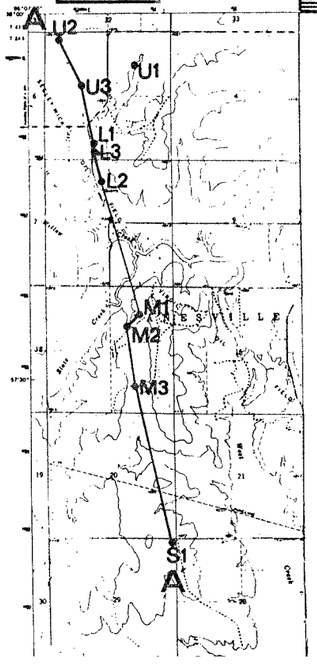
Larsh and Burroak Sh. Mbr.

Larsh and Burroak Shale Mbr.

Rock Bluff Ls

M. FT.

NO HORIZONTAL SCALE



LEGEND

- SHALE
- CALCAREOUS SHALE
- SANDY SHALE
- SANDSTONE
- SHALEY SANDSTONE
- CARBONACEOUS SHALE
- RUDSTONE
- GRAINSTONE
- PACKSTONE
- WACKESTONE
- MUDSTONE
- WAVY BEDDED LIMESTONE
- ARGILLACEOUS LIMESTONE
- DOLOMITIC LIMESTONE
- SANDY LIMESTONE
- MISSING INTERVAL
- SANDY LENSE
- INTRACLAST
- STYOLITES
- SKELETAL GRAINS