UNITED STATES GEOLOGICAL SURVEY
MIDCONTINENT STRATEGIC AND CRITICAL MINERALS PROGRAM

CLASTIC ROCKS ASSOCIATED WITH THE MIDCONTINENT RIFT SYSTEM NORTH-CENTRAL U.S.A.

Progress Report for F.Y. 1986
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Abstract

The Midcontinent Rift (MCR) Study is one of several studies sponsored by the U.S. Geological Survey and state geological surveys through the Midcontinent Strategic and Critical Minerals Program. The study has several parts, including an examination of clastic rocks associated with the MCR, both from surface exposures in the Lake Superior region and from cores and cutting samples from the subcrop belt to the southwest of Lake Superior. In the fall of 1985 and Spring of 1986 geologists from the Minnesota, Iowa, Nebraska, and Kansas geological surveys examined the exposures and subsurface samples in the respective state repositories. This is a first attempts to correlate the stratigraphic positions of the Middle to Upper Proterozoic Keweenawan supergroup clastic units observed in exposure with clastic rocks from the subsurface in other areas of the rift. The small number of subsurface sample sets, the generally shallow penetrations of these clastics, and the often poor quality of the samples (primarily cuttings) make this task difficult. Nevertheless, some preliminary correlations, were suggested based on hand-specimen examination. No rock units similar to the Oronto group (or Solor Church formation) were recognized in the subsurface south of the Twin City basin. Units similar to the lower part of the Bayfield group of Wisconsin were observed in Minnesota (Fond du Lac formation), Iowa ("red clastics"), Nebraska (in the Schroeder #1 well) and in Kansas (in the Finn 1-1 well). Rocks similar to the quartz arenites of the Devils Island sandstone (Bayfield group) were seen in Minnesota (Hinkley sandstone) and possibly Nebraska ("red clastics"), and Kansas (Rice formation). Another rock unit recognized appears to be most similar to the non-marine, basal units in the Cambrian Mt. Simon formation as defined in northern Illinois, also called Mt. Simon in Iowa, and very similar to part of the "red clastic" sequence in Nebraska and the Rice

formation in Kansas. The lack of fossils or presently recognizable marker beds make time correlations very of these clastic rock very difficult, but one of the goals of this study is to identify such markers.

Major copper and minor silver, lead, and zinc mineralization is associated with MCR-related clastics rocks of the Lake Superior region. Chalcopyrite and bornite(?) observed in a core from Iowa was the only such mineralization observed during our cursory examination of subsurface samples. More definitive statements about mineralization in these rocks will follow detailed studies of available samples.

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Introduction

This study of the Midcontinent rift system was initiated in F.Y. 1985 as a component of the U.S.G.S. Midcontinent Strategic and Critical Minerals Program. The study was organized to investigate the Midcontinent rift system, a failed rift which developed about a billion years ago and extends for 1600 km (1000 mi) from central Lake Superior to northern Oklahoma. The goals of the multi-year study are to examine and evaluate all extant data, to determine what additional data would be most useful to refine interpretations of the rift and evaluate its mineral potential, and to obtain and analyze these new data within the financial and time constraints of the larger program.

The first year of the study was dedicated to describing and sampling surface exposures and materials collected from subsurface penetrations of Keweenawan clastic rocks from Michigan, Wisconsin, Minnesota, Iowa, Nebraska, and Kansas. The study was divided into two stages, the first an examination of exposures in Minnesota, Wisconsin, and Michigan; the second a two-phase examination of subsurface materials in Kansas and Nebraska (Phase 1) and in Iowa and Minnesota (Phase 2). Future years of this study, as they are presently envisioned, include standardization of subsurface data, production of thin-sections from key samples, petrologic studies, x-ray determinations of clay mineralogy, chemical analyses, and an attempt to extend clastic stratigraphic nomenclature from surface exposures into the subsurface. A similar study of igneous rocks associated with the rift may follow. If the results of the study warrent it, and if funding is available, some dedicated drilling may be employed in special problem areas.

This report will describe activities during the first year of the study, including descriptions of each exposure and the rocks collected, followed by a proposal for continuing work in the following year.

PART I: EXAMINATION AND SAMPLING OF EXPOSURES

Exposures of clastic rocks assigned to the Keweenawan supergroup in east-central Minnesota, northern Wisconsin, and the northern penninsula of Michigan were examined on September 27 through October 1, 1985. Table I lists the exposures examined and their locations, and Figure 1 shows the rock units examined at each locality. Participants in this part of the study included Peter McSwiggen (Minnesota Geological Survey), Pieter Berendsen and Andrzej Barczuk (Kansas Geological Survey), and Ray Anderson and Robert McKay (Iowa Geological Survey Bureau). Special assistance in locating and interpreting exposures in Wisconsin and northern Michigan was provided by Mike Mudrey (Wisconsin Geological and Natural History Survey) and Albert Dickas (University of Wisconsin-Superior). The goal of the exposure study was to locate, describe, and sample as many of the Keweenawan clastic type sections as possible or the best available representative sections, sections that best displayed the stratigraphic relationships of these units, and other clastic and nonclastic sections that would aid in understanding the structure, stratigraphy, lithology, or depositional environment of the Keweenawan clastic rocks. This information will be used to help understand the geology of similar units encountered in the subsurface south of the outcrop belt.

Exposure Descriptions

Stop 1: Chengwatana Volcanic Group at Cross Lake Dam, Pine City, MN

Stop 1 was the Cross Lake Dam, on the Snake River at the southeast end of Cross Lake about 1 mile northeast of Pine City, Minnesota. This area represents the type locality of the Keweenawan age Chengwatana volcanic group, a sequence of mafic flows displaying a regular sequence of textures ranging from

TABLE I. Exposures Examined.

Date	Stop	Exposure	Location	Unit(s) Exposed
9/27	1	Cross Lake Dam, Snake River, Pine City, MN	T42N R20W	Chengwatana volcanic group (type area)
9/27	2	Quarries at Robinson Park Sandstone, MN	T42N R20W	Hinkley sandstone (type section)
9/27	3	Hwy 123, Kettle River, Sandstone, MN	T42N R20W	Hinkley sandstone
9/27	4	Hwy 23, Askov, MN	T43N R19W	Hinkley sandstone
9/27	5	Town Park, Holyoke, MN	T46N R16W	Hinkley sandstone
9/28	6	I-35, exit 246, Duluth, MN	T49N R15W	Nopeming sandstone (type section), Ely's Peak basalt
9/28	7	Mission Creek, Duluth, MN	T49N R15W	Fond du Lac formation (type area)
9/28	8	Fond du Lac Park, Duluth, MN	T49N R15W	Fond du Lac formation (type area)
9/28	9	Jay Cooke Park, Duluth, MN	T49N R15W	Fond du Lac formation (type area), Thompson formation
9/28	9a	Town Park, Two Harbors, MN	T52N R11W	North Shore volcanic group
9/29	10	Washburn, WI	T48N R4W	Cheguamegon sandstone (type area)
9/29	11	Siskiwit River Cornucopia, WI	T51N R6W	Devils Island sandstone
9/29	12	Iron River, Port Wing, WI	T49N R9W	Orienta sandstone (type area)
9/29	13	Big Rock Park, Washburn, WI	T48N R4W	Cheguamegon sandstone
9/29	14	White River Dam, Ashland, WI	T47N R4W	Freda sandstone
9/29	15	Radio Tower Hill, Mellen, WI		Puritan granite
9/29	16	Potato River Park, Gurney, WI	T46N R1W	Oronto group
9/30	17	Freda, MI		Freda formation (type section)
9/30	18	Phoenix, MI	T58N R31W	Portage Lake volcanic group
9/30	19	Eagle River, MI	T58N R31W	Portage Lake volcanic group, Copper Harbor conglomerate
9/30	19a	Copper Harbor, MI		Copper Harbor conglomerate (type area)
9/30	20	Lac La Belle, MI	T58N R29W	Portage Lake volcanic group
9/30	21	Haven Park, Lac La Belle, MI	T58N R29W	Portage Lake volcanic group
9/30	22	Gay, MI	T56N R30W	Jacobsville sandstone
9/30	23	Baraga, MI	T50N R33W	Jacobsville sandstone
9/30	24	Silver City, MI	T51N R42W	Nonesuch shale (type area)
9/30	25	White Pine, MI	T50N R45W	Unnamed (rhyolite) formation
10/1	26	Porcupine Mountain Park, MI	T50N R45W	Freda sandstone, Nonesuch shale
10/1	27	Saxon, WI	T48N R49W	Portage Lake volcanic group and interflow clastics
10/1	28	Copper Falls Park, Mellen, WI	T45N R3W	Portage Lake volcanic group, Oronto group
10/1	29	Amnicon Falls Park, Superior, WI	T48N R12W	Portage Lake volcanic group, Orienta sandstone
10/1	30	Pattison Falls Park, Superior, WI	T46N R14W	Portage Lake volcanic group, Orienta sandstone

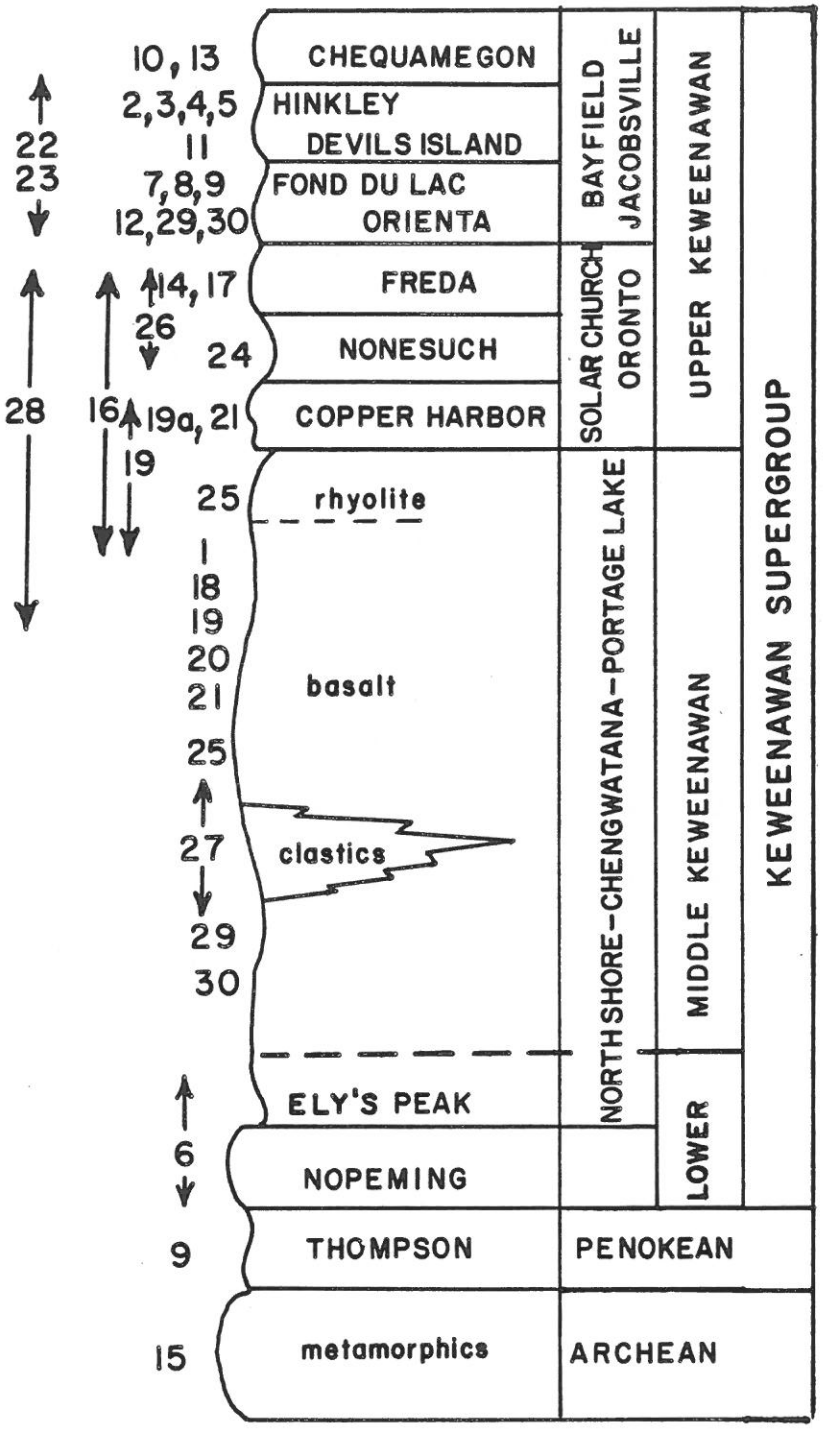


Figure 1. Keweenawan and associated rock units examined in exposures in Part I of the Keweenawan study. The numbers to the left of the stratigraphic column are stop numbers and indicate which units were examined at each stop.

a basal aphanitic unit into an ophitic diabase or porpyritic unit and an uppermost vesicular unit. Vesicles in the upper unit are variably filled with zeolites, calcite, epidote, and other secondary minerals.

High water levels obscured most exposures at our visit to the area, however three samples were collected. These samples are described in Appendix I. Two samples were collected by Berendsen and Barczuk. See Appendix I.

Stop 2: Hinkley sandstone at quarries in Robinson Park, Hinkley, MN

The abandoned quarries along the west bank of the Kettle River, just east of Sandstone, MN, on Minnesota highway 123, form the type section of the Upper Keweenawan Hinkley sandstone, Stop 2. The rocks at location are beige to orange-red, fine-to coarse-grained, angular to well rounded, quartz arenites. Large scale cross-bedding was observed and ripple marks are present. Morey (1979) described the cement as weak to strong including post-depositional silica and iron oxide. Tryhorn and Ojakangas (1972) suggested a probable stable, shallow water depositional environment. Five samples were collected at this stop. Descriptions are reproduced in Appendix I.

Stop 3: Hinkley sandstone at the east bank of Kettle River at hwy. 123, Hinkley, MN

The third stop was a road cut on the east bank of the Kettle River along Minnesota highway 123, just across the river from Stop 2. The rocks in the road cut are correlated to those observed at the Robinson Quarry (Stop 2), are considerably less-well cemented suggested a greater degree of weathering. One sample was collected at this stop by Beredsen and Barozuk.

Stop 4: Hinkley sandstone in roadcut along hwy. 23, near Askov, MN

The fourth exposure examined was in a roadcut along the Minnesota

highway 23 northeast of Askov, Minnesota. This exposure is about seven miles (11 km) northeast of Stops 2 and 3, and the rocks exposed are similar. Bedding at this exposure is generally thinner (cms) with iron oxide cement much more abundant. Individual beds can be traced for several hundred feet, and some contain abundant heavy minerals. One samples of a heavy mineral rich bed was collected by Pieter Berendsen and Andrzej Barczuk.

Stop 5: Lower Hinkley sandstone, city park, Holyoke, MN

The basal Hinkley sandstone crops out at the city park in Holyoke, Minnesota, about 10 miles (16 km) southeast of Duluth. At this location, about 8 feet (2.5 m) of the Hinkley is exposed along a creek. The rock is reddish orange, fine to medium-grained rounded to angular quartz arenite. Rock fragments and feldspar grains are more abundant at this location. One sample was collected.

Stop 6: Nopeming sandstone near Nopeming, MN

The type section of the Nopeming sandstone is located northeast of I-35 interchange number 246, 2 miles (3 km) west of Duluth. The exposure is on a dirt road, south of a paved road paralleling I-35 and about 1/4 mile (400 m) east of its intersection with Midway Road at the interchange. At this exposure the Lower Keweenawan Nopeming sandstone and its contact with the overlying Ely's Peak basalt are visible. About 25 feet (7.5 m) of Nopeming is exposed ranging upward from a light gray quartz cemented conglomerate to buff to gray mottled silica cemented quartz arenite with thin interbeds of very dark gray, tan, rust and green colored metasiltstone near its upper contact. The conglomerate is about 8 feet (2.5 m) thick and contains about 10% coarse clasts (sub-rounded, generally 3 to 5 cm diameter) and dominantly milky quartz. The clasts are enclosed in a in a quartz sand well sorted, medium-

grained quart sand matrix that is is well cemented with silica cement.

Overlying the conglomerate is a fine to medium grained quartz arenite that contains scattered rock fragments. Near the its upper contact with overlying basalt the quartz arenite beds become silty and are interbedded with thin beds of siltstone with zones containing small (to 2 cms) rip-up clasts. Cross-bedding is observable in these beds which display an overall gentle eastward dip. Morey (1978, p. 13) divided the exposure into two lithotopes; the upper a fine-grained laminated to thin-bedded metasiltstone, and the lower a cross-bedded medium to coarse-grained quartzite.

Rocks of the overlying Ely's Peak basalt are black to dark gray fine-grained augite basalt porphyries and are associated with the lowermost part (Lower) Keweenawan of the North Shore volcanic group (Green, 1973). Phenocrysts are about .5 mm in diameter. Small-scale load structures in the upper 15 cm of the quartzite and pillow structures in the overlying basal were interpreted by Mattis (1972) as suggesting that the flows were extruded into the same body of water in which the sediment (still unconsolidated at the time) was deposited. Samples of Nopeming conglomerate, sandstone and siltstone and Ely's Peak basalt were collected (including - 4 samples by Berendsen and Barczuk).

Stop 6a: Thompson formation west of Duluth

This stop was a quick look at one exposure of the Penokean (Early Proterozoic) Thompson formation about 1/4 mile (.5 km) east of Stop 6. The Thompson formation at this exposure is a light to dark gray graywacke with local quartz veins (probable source materials for the coarse clasts in the overlying Nopeming sandstone conglomerates) and graded bedding. Bedding at this exposure is nearly vertical, in sharp contrast to the nearly horizontal bedding in the overlying Nopeming sandstone. Two samples of the Thompson formation were collected by P. Berendsen and A. Barczuk.

Stop 7: Fond du Lac formation along Mission Creek, Duluth, MN

Stop 7 is in the type area of the Upper Keweenawan Fond du Lac formation and is located about .5 mi (1 km) north of Minnesota highway 23, along Mission Creek, at the western most end of Duluth. Approximately 25 feet (7.5 m) of section is exposed at this stop including gray, buff, green, and red sandstone, siltstone, and mudstone. The lower 12 feet (3.5 m) of the section is dominated by red siltstones and mudstones having abundant subrounded gray mottles. Thin interbeds of sandstone are locally present as are abundant clay intraclasts, asymmetric ripple-marks, and related current structures.

Overlying the basal sequence, is about 8 feet (2.5 m) of red, fine-to medium-grained, crossbedded silty sandstone containing interbeds of gray to buff sandstone with green clay partings. A typical composition of the sand-size component includes quartz (50%), feldspar (30%), and volcanic rock fragments. Other beds are dominated by pebbles of volcanic rock fragments. The upper 5 feet (2 m) of the section is composed of thin-bedded red silty sandstone. Samples of all rock types were collected.

Stop 8: Fond du Lac formation, Fond du Lac Park, Duluth, MN

Fond du Lac Park is located west of Minnesota highway 23 on the north bank of the St. Louis River in south Duluth. There are several exposures of Fond du Lac Formation in the forested area in the northwest corner of the park. Units observed include, red, medium-to coarse-grained, crossbedded sandstones intercalated with beds of shale as much as 5 feet (2 m) thick and characterized by spherical areas of better-cemented sandstone with a concretionary appearance. Fine-to medium-grained, white-mottled units are present, as well as pebble conglomerates containing clay rip-up and quartz clasts in a medium-grained quartz and feldspar sand matrix. Representative examples of all major rock types were collected.

Stop 9: Basal Fond du Lac Formation, Jay Cooke State Park, MN

Stop 9 includes a conglomerate unit at the base of the Fond du Lac formation and its angularly unconformable contact with the underlying Thompson formation (Penokean). The section is exposed along the Little River, about .4 miles (.6 km) north of Minnesota highway 210 (Oldenberg Road) in Jay Cooke State Park west of Duluth. At this locality the 60 feet (18 m) of basal conglomerate is dominated by clasts of milky-white vein quartz as much as 6 inches (15 cm) in diameter, but also include clasts of chert, quartzite, graywacke, and slate (apparently derived from the underlying Thompson formation). Matrix materials are dominated by fine-to coarse-grained milky quartz sand, with some coarse grained slate and graywacke sand. Cements include calcite, clay and pyrite. The conglomerate grades upward into arkosic sandstone similar to that observed at Stop 8 (Morey, 1979, p. 12). Samples of the basal Fond du Lac conglomerate and underlying Thompson formation were collected.

Stop 9a. North Shore volcanic group, city park, Two Harbors, MN

Exposures of two Middle Keweenowan basalt flows were examined at Stop 9a, a city park along Lake Superior in Two Harbors, Minnesota. The rock is a red-weathering dark to medium gray porphyritic basalt. Phenocrysts are pink feldspar crystals to 1 cm in length. Basal flow units are massive, becoming increasingly vesicular toward the flowtop. Most vesicles are filled with zeolite minerals, epidote, quartz, chlorite, and calcite. Fragments of red mudstone to 5 inches (12 cm) in lengths were also seen. One sample was collected at Stop 9a by Berendsen and Barczuk.

Stop 10: Chequamegon sandstone, Washburn, WI

The type section of the Upper Keweenawan Chequamegan sandstone, the upper-most unit in the Bayfield group, is exposed a few hundred yards north of

the marina on Chequamegon Bay in Washburn, Wisconsin, on the eastern shore of the Bayfield Penninsula. The unit is a white mottled, red to pinkish gray, poorly-sorted, fine-to medium-grained, rounded to angular arkosic sandstone. Grains are dominantly quartz, with minor feldspar grains and rock fragments present. The rock is poorly cemented, dominantly by iron oxide. Bedding is uneven and generally thick to massive, however some thin-bedded intervals are present, often associated with thin siltstone partings. Cross-bedding was observed and burrow-like structures (possibly load casts) are present in thin-bedded intervals. Locally abundant clay chips and other intraclasts up to several centimeters in diameter were also observed. Samples were collected.

Stop 11: Devils Island sandstone, Siskiwit Falls, Conucopia, WI

The Devils Island sandstonee (Upper Keweenawan), the middle formation of the Bayfield group is exposed at Siskiwit Falls, on the Siskiwit River about 1 mile (1.6 km) south of Wisconsin highway 13, and 1 mile (1.6 km) east of Conucopia, Wisconsin. The unit is a pink to orange colored, well sorted, fine-to medium-grained well rounded quartz arenite. Bedding ranges up to about .5 feet (15 cm) with local cross-bedding. Samples were collected.

Stop 12: Orienta sandstone, Iron River, Port Wing, WI

Stop 12 was at the Orienta Dam on the Iron River, about 1 mile (1.6 km) south of Wisconsin highway 13, about 7 miles (11 km) west of Port Wing, Wisconsin. This location is in the type area of the Orienta sandstone, and exposures of the unit were examined on the east bank of the river, just north of the dam. The rocks exposed include about 50 feet (15 m) of massive red, fairly well sorted, angular to well rounded, arkosic sandstone with a few interbeds of red siltstone to mudstone. Sandstone bedding, where present, is 10 to 15 feet, 3 to 5 m) in thickness, displaying cross-bedding and also dis-

playing local beds of pebble to cobble conglomerate with some clasts in excess of 4 inches (10 cm) in diameter. Sand grains are dominantly quartz but also include dark gray volcanic rock fragments and feldspar. Rocks are moderately well cemented with iron oxide and white clay (kaolinite?) cement apparently the most common cement. In exposure this unit is very similar in appearance to the Chequamegon sandstone. Samples were collected.

Stop 13: Chequamegon sandstone, Big Rock Wayside Park, near Washburn, WI

Big Rock Wayside Park is located about 3 miles northwest of Washburn, Wisconsin, on Bayfield County road C. Exposures of Chequamegon sandstone were examined along the Sioux River and were dominated by massive to thick bedded (10-15 feet - 3 to 5 m), medium-to very coarse-grained, moderately well sorted red sandstone. Sand grains are primarily quartz but also include rock fragments and chert. Some thin (4-8 inches - 10-20 cm) interbedded red shale beds were observed as were thin conglomerate discontinuous bands. The conglomerate included coarse clasts (up to 2 cm) of white quartz, quartzite, red chert, and red clay some displaying original laminations. Cross-bedding included very large-scale cross sets. Samples were collected.

Stop 14: Freda sandstone, White River Dam south of Ashland, WI

Stop 14 exposes an 8 foot (3 m) section of Freda sandstone, the uppermost unit of the Upper Keweenawan Oronto Group. The exposure, about 6 miles south of Ashland, Wisconsin, on Wisconsin highway 112 at the White River, includes two sandstone units separated by a siltstone. The basal sandstone is about 4.5 feet (1.5 m) of grayish red to brown, fine-to very-coarse grained, poorly sorted argillaceous sandstone, with sand grains dominated by volcanic rock fragments, but also including feldspar, clay clasts, and quartz. Siltstone interbeds were observed and some mudcracks are present. The overlying

siltstone unit is about 2 feet (.5 m) thick, grayish-red in color with light gray mottles. The upper 1.5 feet (9.5 m) of the exposure is a poorly sorted, pebbly to fine-grained, angular to fairly well rounded, silty, dirty red sandstone. Coarse grains are primarily volcanic rock fragments, with white clay (kaolinite?), feldspar, black chert, and minor quartz grains also observed. The silty component of the rock is micaceous. Rock samples were collected.

Stop 15: Puriton quartz-monzonite, Radio Tower Hill, Mellen, WI

Stop 15 allowed examination of Archean granites and gneisses at Radio Tower Hill, about 4 miles south of Mellen, Wisconsin, on Wisconsin highway 13. At this location the northwest-trending Mineral Creek fault zone separates Archean greenstone to the north from the Archean quartz-monzonite of the Puritan batholith to the south. Mike Mudrey (Wisconsin Geological Survey) reported Keweenawan-age deformation at this location. No Keweenawan samples were collected.

Stop 16: Copper Harbor conglomerate, Nonesuch shale, and Freda sandstone, Potato River Falls County Park, near Gurney, WI

Stop 16 is an excellent exposure of the three component formations of the Oronto group and the underlying basalts of the Portage Lake volcanic group, along the Potato River at Potato River Falls County Park about 1.5 mile (2.5 km) southwest of Gurney, Wisconsin. The exposure is in a deep canyon where for a distance of about 1 mile (1.5 km) the Potato River cuts through a steeply-dipping (~80° to the N.W.) sequence of sediments and volcanic rocks (Figure 2). The stratigraphic column in Figure 3 was examined. One of the most significant observations was the interbedded and apparently conformable nature of all observed contacts, including the Portage Lake volcanic group/ Copper Harbor conglomerate contact. The exposure is located along the Douglas Fault Zone on the northern margin of the St. Croix horst. Mike Mudrey de-

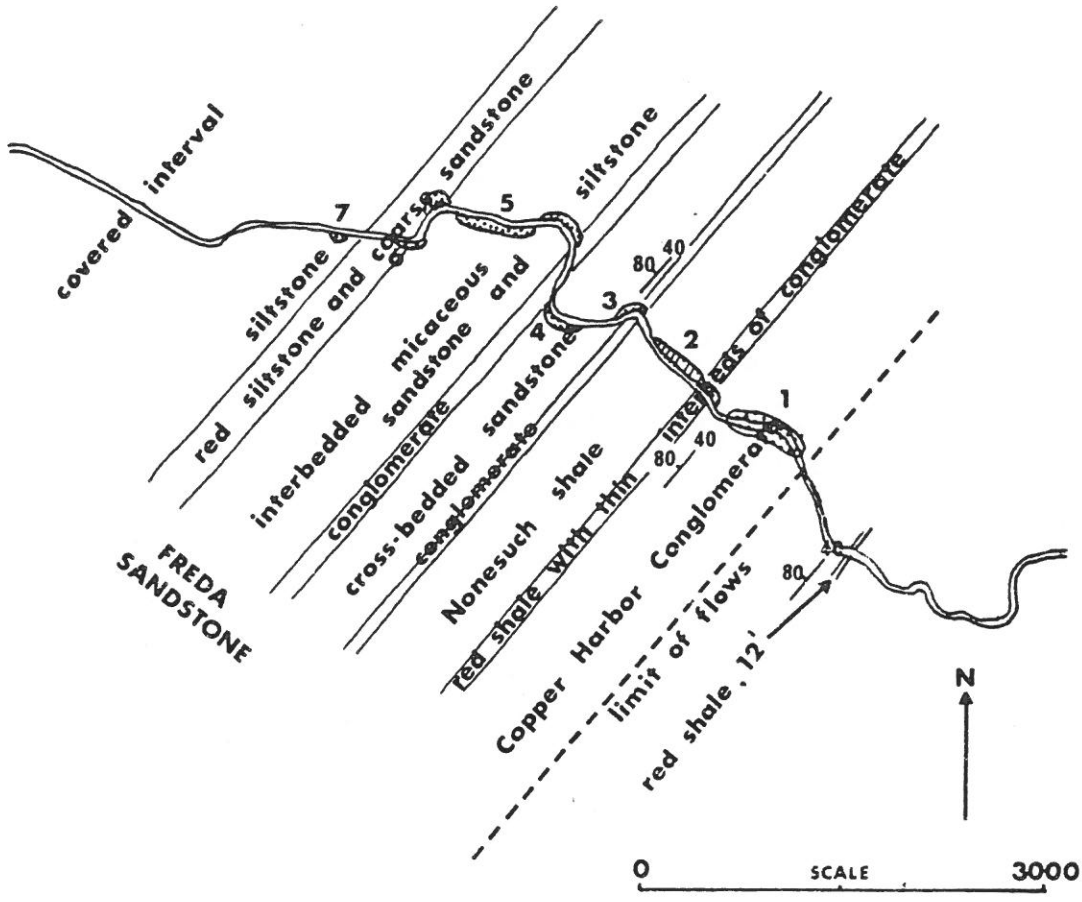
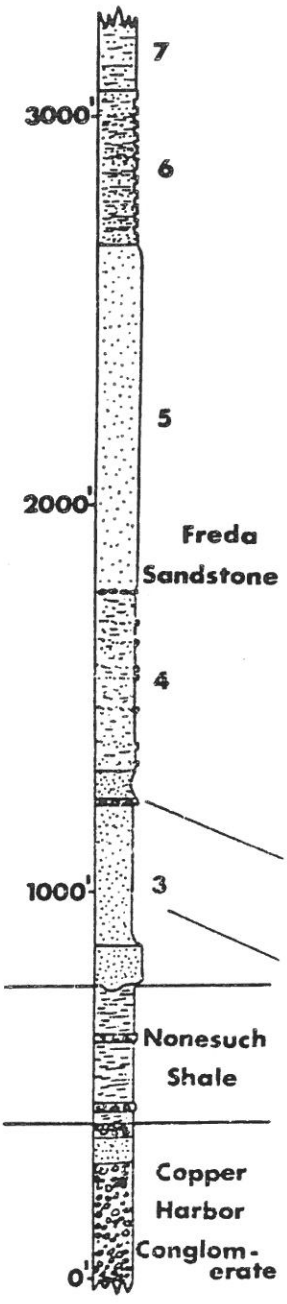


Figure 2. Index map showing the location of exposures of Oronto group rocks, Potato River, E 1/2, Sec. 18, T46N., R1W, Wisconsin. Outcrop numbers correspond to numbers on stratigraphic column. Section from Wisconsin Geological Survey.



Covered Interval. Thickness of covered interval estimated to be over 4000 feet.

Grayish red and grayish red purple siltstone with minor soft thin sandstone. Poorly exposed.

Interbedded grayish red fine- to medium-grained sandstone and siltstone. Beds typically 10' in thickness, but 50' zone of sandstone present at base. This sand is coarse, grayish red purple. Near top of this zone is 8' grayish brown siltstone. Cut-and fill; birdseye leaching.
Tectonic Attitude: Strike N40 E, Dip 80 NW

Very uniform, resistant sandstone; medium to coarse grained; grayish red purple and very micaceous. Cut and fill (1) present; occasional cross-bedding, current ripple marks. Isolated pebbles up to 1" in diameter (quartz). Increasingly conglomeratic toward base. Minor siltstone beds (1') scattered throughout section.

Soft grayish red purple micaceous siltstone with occasional layers of hard grayish red sandstone. One thin layer of conglomerate near top. Sandstone is medium grained; abundant clay shale pebbles randomly distributed. Birdseye leaching and leaching along bedding planes and joints.

Soft, grayish red purple sandstone; micaceous. Underlain by conglomerate with pebbles up to 6" Calcite cement prominent in hand specimen and under microscope.

Zone of interbedded sandstone and siltstone (minor). Siltstone units 3-6" thick; leaching and minor copper staming. Basal 20' consists of hard grayish red sandstone and siltstone. Some evidence of cut and fill; contact with Nonesuch may be minor diastem

Interbedded fine-grained sandstone, siltstone and silty shale. Sedimentary structures identified included parting lineation and cut-and-fill. In general, section is composed of thin-bedded (2-5"), well sorted, and highly indurated silty shale.

Conglomerate; clasts up to 8"; estimate 75-80% vol. R. F.; quartz + quartzite 20-25%. Some epidotized volcanic R. F.s. Pebbles rounded, rare percussion marks; faint suggestion of cross-bedding.

Figure 3. Stratigraphic column of exposures on the Potato River, E 1/2, sec. 18, T46N., R1W., Wisconsin. Section from Wisconsin Geological Survey.

scribed the high angles of the sedimentary bedding as the product of block rotation associated with reverse faulting and horst formation. Samples of all units were collected.

Stop 17: Freda sandstone, Freda, MI

The type section of the Freda sandstone is at Stop 17, Freda, Michigan, along Lake Superior on the western shore of the Keweenaw Penninsula. Heavy rain and high winds prevented location of the rocks on this day.

Stop 18: Portage Lake volcanic group, Eagle River, Phoenix, WI

The basalts of the Portage Lake volcanic group are exposed along Michigan highway 26 (U.S. Highway 41), at the Eagle River, about .5 mi (1 km) north of Phoenix, Michigan, on the Keweenaw Penninsula. The exposure is along the northeast trending Keweenawan fault zone. The rocks exposed range from aphanitic black basalt to basalt prophyry. Hornblende phenocrysts range to .5 cm. Also exposed is a black ophilitc basalt containing augite(?) phenocrysts about .5 cm in diameter. Samples were collected.

Stop 19: Basal Copper Harbor conglomerate, Eagle City, MI

The Copper Harbor conglomerate and underlying Portage Lake volcanic group is exposed along Michigan Highway 26 at the Eagle River in Eagle City, Michigan. The Eagle River falls over the volcanic rocks and cuts deeply into the steeply-dipping, overlying Copper Harbor conglomerate. The Copper Harbor conglomerate is a rusty brown, extremely poorly sorted conglomerate with a coarse clast component dominated by fairly well rounded volcanic rock fragments. Coarse sand grains of volcanic rocks are angular. The matrix of the conglomerate is composed of fine sand to silt-size volcanic rocks. Cements include calcite and iron oxide with some white to light green mottling due to alteration.

Also exposed at this stop are several beds of sandstone, up to 15 feet (5 m) thick. The sandstone is a dirty brown colored, very poorly sorted, angular to well rounded litharenite, with grain size ranging from silt to pebbles that are dominantly composed of volcanic rock fragments with some feldspar and minor quartz grains. Calcite-filled veins in these units were probably the cemented product of tectonic activity along the nearby Keweenawan fault zone. Samples of the Copper Harbor conglomerate and sandstone were collected.

Stop 19a: Copper Harbor conglomerate south of Copper Harbor, MI

The type area of the Copper Harbor conglomerate includes exposures along Michigan highway 26, about 4 miles (6.5 km) west of Copper Harbor, Michigan. These exposures, along Lake Superior on the north shore of the Keweenaw Peninsula, include conglomerates, conglomeratic sandstones, and sandstones. Clasts observed range to 1.5 feet (.5 m) in diameter, and all clasts, from sand to boulder size, are predominantly volcanic rock fragments, but smaller grains include sparse feldspar and quartz grains. One sample was collected.

Stop 20: Portage Lake volcanic group, Lac La Belle, MI

Stop 20 is located along the road between U.S. highway 41 north of Lac La Belle, Michigan, on the northern end of the Keweenaw Penninsula, about 1 mile northwest of Lac La Belle. A section of the Portage Lake volcanic group, exposed on the north side of the road, consists of approximately 35 feet (10.5 m) of dark to medium gray, vesicular basalt, with vesicules comprising about 30% of the rock. The vesicles are filled with chlorite, calcite, and epidote and greenish-blue copper oxide (malachite?) is present. Samples were collected.

Stop 21: Copper Harbor conglomerate, Haven Park, Loc La Belle, MI

At Stop 21, Haven Park in Lac La Belle, Michigan, along a small waterfall

a conglomerate and breccia are exposed in contact with the Portage Lake volcanic group, on the northern, upthrown block of the Keweenaw fault zone. The Portage Lake is a dark basalt, and the conglomerates and breccias are red with fragment of reddish-brown, well sorted, micaceous, arkosic sandstone (similar to the Freda) up to 8 inches (20 cm) in diameter. No rocks are exposed south of the waterfall, where Jacobsville sandstone would be expected. One sample was collected by Berendsen and Barczug.

Stop 22. Jacobsville group, Keweenaw Bay, Gay, WI

A series of Jacobsville sandstone sections are exposed along Keweenaw Bay, about 5 miles (8 km) northeast of Gay, Michigan. The rocks are buff to red, very fine-to coarse-grained sandstone. Coarse clasts are dominated by quartz, but the finer grains appear to be an equal mixture of quartz and rock fragments. Some clay clasts to 1 inch (3 cm) are present as are thin rust-colored clay laminae and green clay drapes. Bedding is nearly horizontal, dipping slightly to the southeast. Samples were collected.

Stop 23: Jacobsville group, Keweenaw Bay, Baraga, MI

A section of Jacobsville group rocks up to about 50 feet (15 m) high is exposed for about 1000 feet (300 yards) along U.S. highway 61, 1 mile (1.5 km) southeast of Baraga, Michigan. This exposure includes a variety of lithologies (see Appendix I) the most common of which were dark gray to brown to light gray and pale green, poorly sorted litharenite to conglomerates. Rock fragments and milky quartz comprise the dominant coarse clastic lithology. Rock fragments are more predominant in the micaceous fine clastic components. Cross bedding is common, with bedding variable in thickness, commonly about 3 feet (1 m). Samples were collected.

Stop 24: Nonesuch shale, Silver City, MI

The type area of the Nonesuch formation, the middle formation in the Oronto group, is near Stop 24, on the east bank of the Iron River on Michigan highway 107, just east of Silver City, Michigan. The Nonesuch is a very dark gray to dark grayish green, silty shale to argillaceous siltstone exhibiting conchoidal-fracturing. Slumping of the exposure precluded determination of the attitude of the beds. Samples were collected.

Stop 25: "Unnamed (rhyolite) formation" near Bergland, MI

Stop 25 was one of a series of exposures along Michigan highway 64 about 1.5 miles (2.5 km) north of Bergland, Michigan. The rocks exposed are informally known as the "unnamed formation," a brick red rhyolite porphyry with phenocrysts of pink feldspar and clear quartz averaging about 1 cm in diameter. The "unnamed formation" is reported to be a Keweenawan age extrusive. Samples were collected.

Stop 26: Freda sandstone and Nonesuch shale, Presque Isle Unit, Porcupine Mountain State Park, MI

In the Presque Isle Unit at the western end of Porcupine Mountain State Park, the Freda sandstone and underlying Nonesuch shale (Oronto group) are exposed along the Presque Isle River near its mouth in Lake Superior. The Freda sandstone is a gray to dark grayish brown, fine grained, well rounded, silty litharenite. Fine grains of mica are concentrated on bedding planes. Graded bedding, ripple marks, horizontal laminations to ripple cross-lamination, thin clay drapes, and clay clasts were observed. The Freda sandstone grades into the Nonesuch shale, which at this location ranges from red to gray-green to dark brown to black argillaceous siltstone to fine-grained litharenites. The unit is micaceous, with ripple cross laminations, mud cracks, and possible trace fossils. Fracture is conchoidal with diamond-shape fracture patterns on

bedding plains commonly observed. Manganese coatings on bedding plains are also common. Samples were collected.

Stop 27: Portage Lake volcanic group and interflow clastics, Montreal River Power Station near Saxon, WI

Stop 27 was located on the Montreal River on Iron County road B, about 3 miles (5 km) north of U.S. highway 2, about 2 miles (3 km) east of Saxon, Wisconsin. At this location, just downstream from Saxon Falls, the Montreal River cuts deeply through the lavas of the Portage Lake volcanic group and associated interflow sediments. Construction work on a hydroelectric facility at this location allowed access to a section of interflow clastics. The clastics are dark reddish-brown, poorly sorted, fine-to coarse-grained silty litharenites with minor mudstones. Mafic volcanic rock fragments are the dominant clasts, with some feldspar and quartz grains, limited to the medium to fine size grains. Clay clasts are common on bedding plains. The clastic beds dip steeply to the northwest, and zones of breciation and slickensides were observed. Samples were collected.

Stop 28: Portage Lake volcanic group and Oronto group, Copper Falls State Park near Mellen, WI

Copper Falls State Park is located on Ashland County road J, about 2 miles (3 km) north of Wisconsin highway 169, 3 miles (5 km) northeast of Mellen, Wisconsin. In the park, the Bad River cuts deeply through the nearly vertically-dipping upper portion of Portage Lake volcanic group and overlying Copper Harbor conglomerate, Nonesuch shale, and Freda sandstone (Oronto group), near the Keweenaw fault zone. The Wisconsin Park Service has constructed a trail with multiple overlooks along the edges of the canyon with footbridges across the river at each end of the exposure. Figure 4 is an illustration of the stratigraphic relationships observed, and Figure 5 is a

stratigraphic column estimated from overlook observation. The canyon cut by the Bad River narrows to a thin notch called the "Devil's Gateway" as it passes from the Portage Lake volcanic group into the more resistant Copper Harbor conglomerate and then widens again as it cuts through the Nonesuch shale and Freda sandstone. Interbeddng of all units was observed. One sample was collected.

Stop 29. Portage Lake volcanic group and Orienta sandstone, Amnicon Falls State Park, near Superior, WI

Amnicon Falls State Park is located on the Douglas fault (northern bounding fault zone of the St. Croix horst) just north on U.S. highway 2, 5 miles (8 km) southeast of Superior Wisconsin. At the park, the north-flowing Amnicon River cuts the lavas of the Portage Lake volcanic group, and with a series of rapids and waterfalls crosses the Douglas fault and falls into a

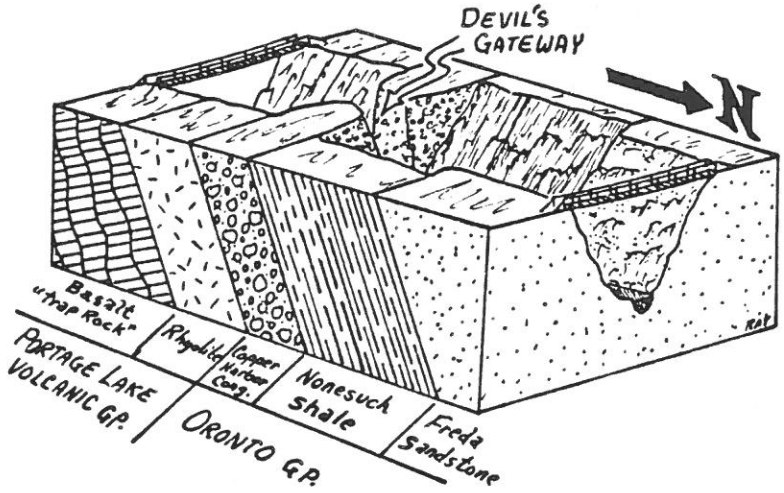


Figure 4. Block Diagram of stratigraphic relationships observed at Copper Harbor State Park, WI.

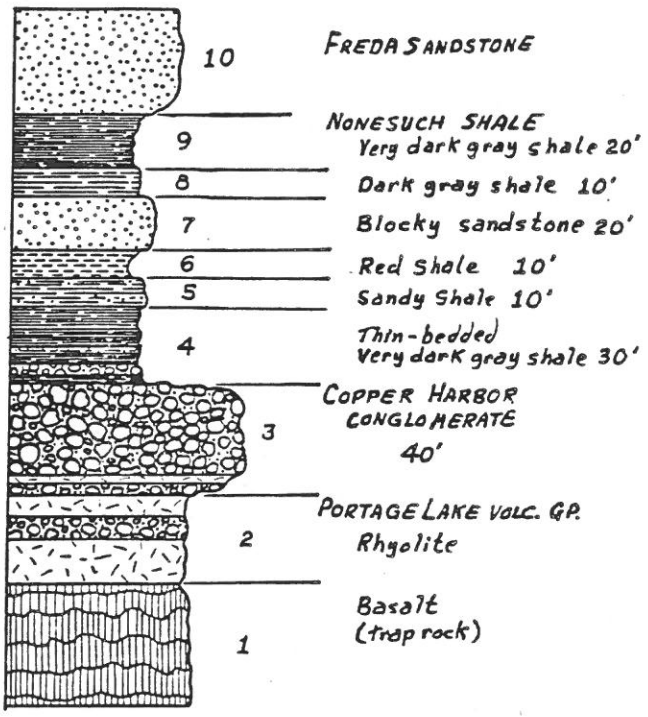


Figure 5. Approximate stratigraphic column at Copper Harbor State Park, WI.

canyon incised into the more easily eroded Orienta sandstone (Bayfield group). The southeast-dipping Douglas fault shows a reverse sense of movement at this location. A fault breccia and gouge developed in the Orienta sandstone at the contact indicates post-Orienta movements. The Portage Lake lavas at the park are red-weathering black aphanitic basalts, and some inclusions of red metasandstones were observed. The Orienta sandstone is a buff to brick red, fine-to very coarse-grained, angular to rounded, fairly well sorted litharenite, with subordinate rock fragments. A conglomeratic unit that lies along the fault against the volcanic rocks of the up-thrown block is dominated by angular to sub-rounded sand-to pebble-size clasts of mafic volcanics with sand sized quartz grains abundant. Downstream from the fault zone, the Orienta displays nearly horizontal bedding. Samples were collected.

Stop 30: Portage Lake volcanic group and Orienta sandstone, Pattison Falls State Park south of Superior, WI

Stop 30 was at Pattison Falls State Park, east of Wisconsin highway 35, 7 miles (11 km) south of Superior, Wisconsin. At the park, the Black River flows over a high escarpment formed by the Portage Lake volcanic group, uplifted on the St. Croix horst along the Douglas fault zone, and onto rocks of the Orienta sandstone (Bayfield group). The geologic setting at Pattison Falls Park is similar to the setting at Amnicon Falls Park, 11 miles (18 km) to the northeast. The rocks of the Portage Lake volcanic group and the Douglas fault zone were not closely examined at this site, however, the more accessible Orienta sandstone was examined. The rock is a buff to light brick red, fine to coarse-grained, well sorted, angular to well rounded quartz arenite, with some rock fragments and feldspar grains observed. Clay appears to be the dominant cement. The rock is finely laminated and displays some liesegang iron staining. Samples of the Orienta sandstone were collected.

Part II. EXAMINATION OF SUBSURFACE SAMPLES

The second part of the Midcontinent Strategic and Critical Minerals Program study of Midcontinent rift zone sedimentary rocks was the examination of subsurface samples in Minnesota, Iowa, Nebraska, and Kansas where these Proterozoic rocks subcrop beneath Phanerozoic units. The object of this part of the study was to examine the best subsurface samples available, compare these samples to Keweenawan rocks observed in the outcrop belt (Part I of this study), attempt to identify physical or geochemical properties that would allow definition and correlation of subsurface units with exposed rocks, to identify metalic mineralization in subsurface samples, and to identify specific intervals for sampling and analysis in future years of the study. To expedite these examinations geologists from each survey identified the best available sample sets in their state, produced copies of any existing logs or scout tickets for these wells, and provided a work area and microscopes for examination of the samples.

Participants in this part of the study included Pieter Berendsen and Andrzej Barczuk (Kansas Geological Survey), Marvin Carlson (Nebraska Conservation and Survey Division), and Ray Anderson and Robert McKay (Iowa Geological Survey Bureau). Glen Morey (Minnesota Geological Survey) also participated in examination of Minnesota samples.

To expedite the logistics of the subsurface sample examination part of the study, it was divided into two phases. Phase I included examination of sample materials in Kansas and Nebraksa from March 3 through March 7, 1986. Phase II included examination of sample materials in Iowa and Minnesota from March 30 through April 4, 1986.

Summary of Subsurface Keweenawan Clastic Sediment Examined

I. Kansas Subsurface

Keweenawan clastics from the subsurface of Kansas (Table II) fall into two primary categories. The first is best seen in the #1 Finn well, where the interval from 2245 to about 2800 feet can be characterized as a red-colored, fine-to-coarse-grained, fairly well sorted, arkosic sandstone. Sand grains are about 50% potassium feldspar, with the remaining grains composed of quartz, rock fragments, and opaques (magnetite?). The sand is well cemented, in part by angular quartz overgrowths. Chips of green-mottled red mudstones suggest finer-grained intervals. Some iron staining is evident.

The second lithology is known locally as "standard Rice formation." It is an orange to red, fine-to medium-grained, subangular to subrounded sandstone. Sand grains are dominantly quartz but include some pink to orange potassium feldspar grains. The grain-supported sandstone is poorly cemented by a white, earthy cement (kaolinite?). Shaley and silty interbeds are apparently present.

II. Nebraska Subsurface

In the subsurface of Nebraska, samples considered to be of Keweenawan age (Table III) appear to fall into three primary lithologic units. The first includes pink, fine-to very coarse-grained, subangular to subrounded, argillaceous (micaceous) sandstone, typified by samples examined in the basal 300 feet (90 m) of the #1 Ihde well. This unit has been informally referred to as the "cornhusker clastics," and is similar to the "standard Rice formation" in Kansas, and like the "standard Rice" may be cemented with white clay.

The second primary lithology was observed in the #3 Lonergan Lake well, from 1950 to 2355 feet (585-707 m). It is dominated by maroon mottled gray-

TABLE II. Kansas subsurface cutting samples examined

Well No.	Name	Location	County	Units Examined	Intervals Examined
1	#1 Russell Frey	T11S, R10E, S11	Wabaunsee		
2	#1 Hartter	T1S, R14E, S34	Nemaha	Reagan fm. and Rice fm.	3950-3980
3	#1 Llewellyn	T9S, R4E, S11	Riley	Simpson fm. and Granite	2750-2815
4	#1 Reilly	T11S, R3E, S20	Dickinson	diabase	3960-3175
5	#1 Beach	T4S, R8E, S20	Marshall	Simpson fm. and Rice fm.	1435-2168
6	#1 Sedlacek	T4S, R8E, S31	Marshall	Rice fm.	1920-2264
7	#1 Seematter	T3S, R8E, S24	Marshall	Rice fm.	1466-1627
8	#1 W.E. Neal	T4S, R8E, S5	Marshall	granite wash	1624-1715
9	#1 Beck "A"	T5S, R12E, S14	Nemaha	granite	2708-2755
10	#1 Steele Griffe "A"	T5S, R12E, S14	Nemaha	and granite	3473-3522
11	#1 Kratchovil	T5S, R7E, S30	Marshall	and schist	2469-2526
12	#1 Weakley	T5S, R7E, S26	Marshall	clastics	2014-2030
13	#1 Kunze	T7S, R5E, S3	Riley	Simpson sand and weathered granite	2425-2503
14	#1 Fagerberg	T6S, R8E, S31	Pottowatomie	arkosic sand	2114-2150
15	#1 Wood	T7S, R3E, S1	Clay	quartzite	3162-3255
16	#1 Blaney	T5S, R7E, S3	Marshall	Rice fm. and granite	2420-2570
17	#1 Winkler	T6S R6E, S8	Riley	amphibolite	2584-2735
18	#1 Finchan	T4S, R8E, S20	Marshall	arkosic sand	1791-2500
19	#1 Henley	T4S, R8E, S34	Marshall	Rice fm.	1629-1680
20	#1 Sherman	T5S, R3E, S13	Washington	granite wash	3140-3264
21	#1 Gravenstine	T8S, R6E, S21	Riley	Simpson fm. and weathered granite	2600-2702
22	#1 Finn (Cathrine)	T4S, R7E S4	Marshall	arkosic sandstone and metamorphics	2245-3935
23	#1 Lumingood	T13S, R2E, S13	Dickinson	Lamotte fm. and arkosic sandstone	3250-4900
24	#1 Sugget	T2S, R8E, S34	Marshall	Simpson fm. and arkosic sandstone	1680-2373
25	#1 Ireland	T5S, R7E, S8	Marshall	granite wash	2295-3266
26	#1 Thierer	T10S, R7E, S20	Riley	Simpson fm. and granite	2295-2496
27	#1 (Seneca) Meyers	T3S, R11E, S19	Nemaha	granite wash and granite	707-3256

TABLE III. Nebraska subsurface core adn cutting samples examined

Well No.	Name	Location	County	Units Examined	Intervals Examined
1	#1 Smith	T16N, R9E, S25	Douglas	clastics	1870-2345
2	#1 Ihde	T10N, R4E, S14	Seward	clastics	2605-2830
3	#11 Schutz	T9N, R12E, S7	Otoe	clastics and granite	1570-
4	#3 Longergan Lake	T16N, R12E, S11	Douglas	clastics and basalt	1950-2355
5	#21 Stral	T13N, R10E, S6	Saunders	clastics	1170-1190
6	#1 Sullivan	19N, R5E, S36	Lancaster	clastics and granite	2270-2319
7	#1 Nygven	T15N, R8E, S33	Saunders	clastics	1790-1835
8	#1 Forster	T16N, R8E, S5	Saunders	clastics	2145-2204
9	#1 Cameron	T7N, R10E, S11	Otoe	?	1795-2378
10	#1 Ruffner	T11N, R13E, S5	Cass	?	1565-1570
11	Peterson	T8N, R6E, S14	Lancaster	?	1990-2008
12	N.N.G. #1 Strat	T10N, R12E, S28	Cass	?	1480-1497
13	Brick Plant #1	T8N, R14E, S10	Otoe	?	2783-2950
14	Shroeder #1 *core*	T11N, R12E, S26	Cass	arkose	1567-1828

green shale and siltstone, associated with weathered basic igneous rocks and minor fine to very fine arkosic sandstone.

The third lithology is a well-cemented grayish buff to pink, fine to coarse-grained, subangular to subrounded arkosic sandstone. Quartz grains appear to dominate, with feldspar grains and rock fragments also present. This lithology was observed in the Amerada Schroeder #1 well at a depth of about 1800 feet (540 m).

III. Iowa Subsurface

In the Iowa subsurface three primary lithologies, possibly of Keweenawan age, were examined (Table IV). The first of these is presently called "lower" (barren) Mt. Simon formation and can be best characterized as a buff to orange colored fine-to coarse-grained, subangular to rounded quartz sandstone with

TABLE IV. Iowa subsurface core and cutting samples examined.

Well No.	Name	Location	County	Units Examined	Intervals Examined
1	McCallum A-1 *core*	T79N, R27W, S5	Dallas	Mt. Simon fm. and PC clastics	2950-3030
2	Birdie Lehman #1 *core*	T79N, R27W, S18	Dallas	Mt. Simon fm. and PC clastics	2850-2967
3	Reinhart A-1 *core*	T80N, R27W, S28	Dallas	Mt. Simon fm. and PC clastics	3000-3082
4	Hummell #1 *core*	T79N, R28W, S18	Dallas	Mt. Simon fm. and diabase	2650-2790
5	Friis M1 *core*	T75N, R5W, S12	Louisa	Mt. Simon fm.	2228-2563
6	#1 Huntley	T90N, R15W, S15	Butler	Mt. Simon fm.	2150-3595
7	Wilson #1	T68N, R37W, S25	Page	Mt. Simon fm. and PC clastics	4500-5305
8	Fitzgerrald #1	T71N, R41W, S21	Mills	Mt. Simon fm. and basalt	2450-2605
9	Mason City #12	T96N, R20W, S10	Cerro Gordo	Mt. Simon fm. and diabase	1400-1575
10	Nevada City #3	R83N, R22W, S6	Story	Mt. Simon fm.	3000-3342
11	Green Island *core*	T85N, R6E, S29	Jackson	Mt. Simon fm. and granite	2450-2673 2450-2673
12	New Jersy Zinc	T96N, R5W, S8	Clayton	Mt. Simon fm. and norite	1650-1850

interbeds of light brownish-red to greenish gray, sandy, silty, micaceous shale. Some inarticulate brachiopod shell material is found associated with this lithology in chip samples from the Wilson #1 well, from 3600 to 4700 feet (1080 to 1410 m).

The second lithology is also observed in the Wilson #1 well, from 4700 to 5305 feet (1410 to 1592 m). This unit includes a red to orange colored, very fine-to medium-grained, angular to subrounded sandstone. Quartz is the dominant clast lithology, however feldspar, biotite, and muscovite is abundant and iron cement is evident. This sandstone is interbedded, with reddish-brown micaceous sandy, silty, shale and siltstone. Also noted were several

intervals of what appeared to be fine-grained magnetite sands.

The third lithology was observed in cores from Birdie Lehman #1, Reinhart A-1, and McCallum A-1. This lithology includes interlayered maroon and green mottled sandy, shaley, siltstone and tan colored, very-fine-to coarse-grained feldspathic sandstone. An angular unconformity was observed in these cores between the flat-lying Mt. Simon formation and the underlying Precambrian clastics, which dip at about 60° from horizontal.

IV. Minnesota Subsurface

Diamond drill cores of Keweenawan materials from the subsurface of Minnesota include samples of the Hinkley sandstone, Fond du Lac formation, and Solar Church formation (Table V). The Hinkley sandstone was examined in the Kingstrom #1 well, from 1342 to 1380 feet (403 to 414 m), the Londsdale 65-1 well from 918 to 945 feet (275 to 284 m), and the Hollandale #1 well from 1619 to 1905 feet (486 to 572 m). The unit is a grayish-brown to orange to white and pale purple-red, fine- to coarse-grained, angular to subrounded, moderately well sorted, quartz arenite. Clay seams and a thin basal conglomerate are also present. Cement includes quartz overgrowths, iron oxide and a white clay (kaolinite?). A detailed study of the Hinkley and underlying Solor Church formation was published by Morey (1977).

The Fond du Lac formation was examined in the Schvette #1 well where it is a gray to maroon mottled medium-to coarse-grained, angular to subrounded, micaceous, feldspathic sandstone. Although quartz dominates the sand-size grains, feldspar and various rock fragments are also common. Cement appears to include iron oxide and white clay (kaolinite?).

The Lonsdale 65-1 core includes almost 2000 feet (600 m) of the Solor Church formation, penetrating the unit from a depth of 945 to 2844 feet (284 to 853 m). Rocks of several compositions and textures were encountered, in-

TABLE V. Minnesota subsurface samples examined

Well No.	Name	Location	County	Units Examined	Intervals Examined
1	Kingstrom #1 *core*	T101N, R24W, S6	Faribault	Mt. Simon and Hinkley ss.	1200-1335
2	Lonsdale 65-1 *core*	T112N, R21W, S14	Rice	Hinkley and Solar Church fms.	945-2844
3	Schvette #1 *core*		Waseca	Fond du Lac fm.	1750-2300
4	Hollandale #1 *core*	T103N, R19W, S7	Freeborn	Fond du Lac fm.	1619-1905
5	Osseo 75-1 *core*	T119N, R22W, S24	Hennepin	Solar Church fm. and Chengwatana volcanic group	730-3988

cluding interlaminated, very fine-to fine-grained micaceous sandstone, red to gray-green laminated, mudcracked, mudstone, a well induarated, dusky brown, fine-to medium-grained, micaceous sandstone with abundant feldspar and rock fragment grains, and a finely-laminated, medium to very dark gray shale to mudstone displaying slickensides.

Interpretations and Correlations

The correlation of individual sedimentary stratigraphic units over the 1000 mile (1600 Km) length of the Midcontinent rift system is complicated by a number of factors. Over about 600 miles (960 km) of its length the rocks of the MCR are completely buried by Paleozoic rocks, and in as much as they offer no known mineral resources, and serve as an aquifer only very near their outcrop belt, there has been little incentive to obtain drill samples of the units. Consequently, there are only 50 known drill penetrations of Keweenawan sediments over the 40,500 square mile (65,000 km^2) area where Keweenawan

sedimentary rocks are mapped in the subsurface. Even if better subsurface control existed, the problem of correlating units within a terrestrial clastic sediment package, without fossils, known extensive marker beds, or other internal datums is formidable. To further complicate the task the possible period of time over which clastic deposition may have occurred is great, the package being constrained only by the 1050 Ma age of the most recent Keweenawan volcanism and the 550 Ma age of the initial Phanerozoic marine transgression into the region. This suggests that clastic sedimentation could have extended over a time interval of about 500 million years, a length of time comparable with the entire Phanerozoic Era.

I. Lower Clastic Sequence

The lower most clastic package in the Keweenawan supergroup (Oronto group, Solar Church formation, and equivalent units) was apparently deposited in response to the initial subsidence following volcanism along the MRS trend and is probably restricted to a few 10's of millions of years (at most) after cessation of volcanism. A second and younger sedimentary package (Bayfield group, Fond du Lac formation, Hinkley sandstone, Rice formation, and equivalent units) is generally flat-lying and could have been deposited at anytime between 500 Ma and the onset of Late Cambrian (Croixan) sedimentation. Inasmuchas few unique attributes are known that can be used to differentiate fluvial systems in a given region, it is difficult to correlate the several clastic packages over large areas in the subsurface. Even where the units are exposed in the Lake Superior region it is impossible to correlate with certainty similar appear in rocks such as the Bayfield group and the Jacobsville sandstone.

In future years of this study we will attempt to identify the sedimentary attributes that might be used to more precisely compare the various rock pack-

ages. These might include detailed petrographic characteristics, heavy mineral content, clay and/or cement chemistry, diagenetic features, or other distinguishing characteristics.

Although this detailed characterization of the subsurface samples of clastic rocks associated with the Midcontinent rift has not yet begun, our reconnaissance observation of available samples has allowed us to make preliminary observations.

II. Upper Clastic Sequence

The similarities between the Late Proterozoic and Early Paleozoic terrestrial clastic sequences in the Midcontinent and the sparcity or absence of fossils or other age indicators make their identification and correlation over the study area very difficult. In the subsurface of northern Illinois the Illinois Geological Survey recognizes seven members (Table VI) within a 2600 feet (780 m) section of the Mt. Simon formation (Buschbach, 1975, p. 39-41). These members are differentiated primarily on the basis of their grain size. The interval is dominated by a fine-to coarse-grained, pebbly, friable sandstone, most commonly a coarse-grained, poorly sorted, and subangular quartz arenite. The lower part of the formation has been correlated with other Cambrian units as well as the Proterozoic Bayfield group and Jacobsville sandstone and the Fond du Lac formation (Buschbach, 1975).

III. Minnesota Subsurface

The Mt. Simon sandstone of Minnesota was characterized by Austin (1972) as a white, gray, pink, or yellow, fine-to coarse-grained quartzose sandstone, with some thin shale beds, and inarticulate brachiopod fragments, that are especially abundant higher in the unit. The formation, however, generally contains a limited fauna, and Morey (1977) used three other criteria to dif-

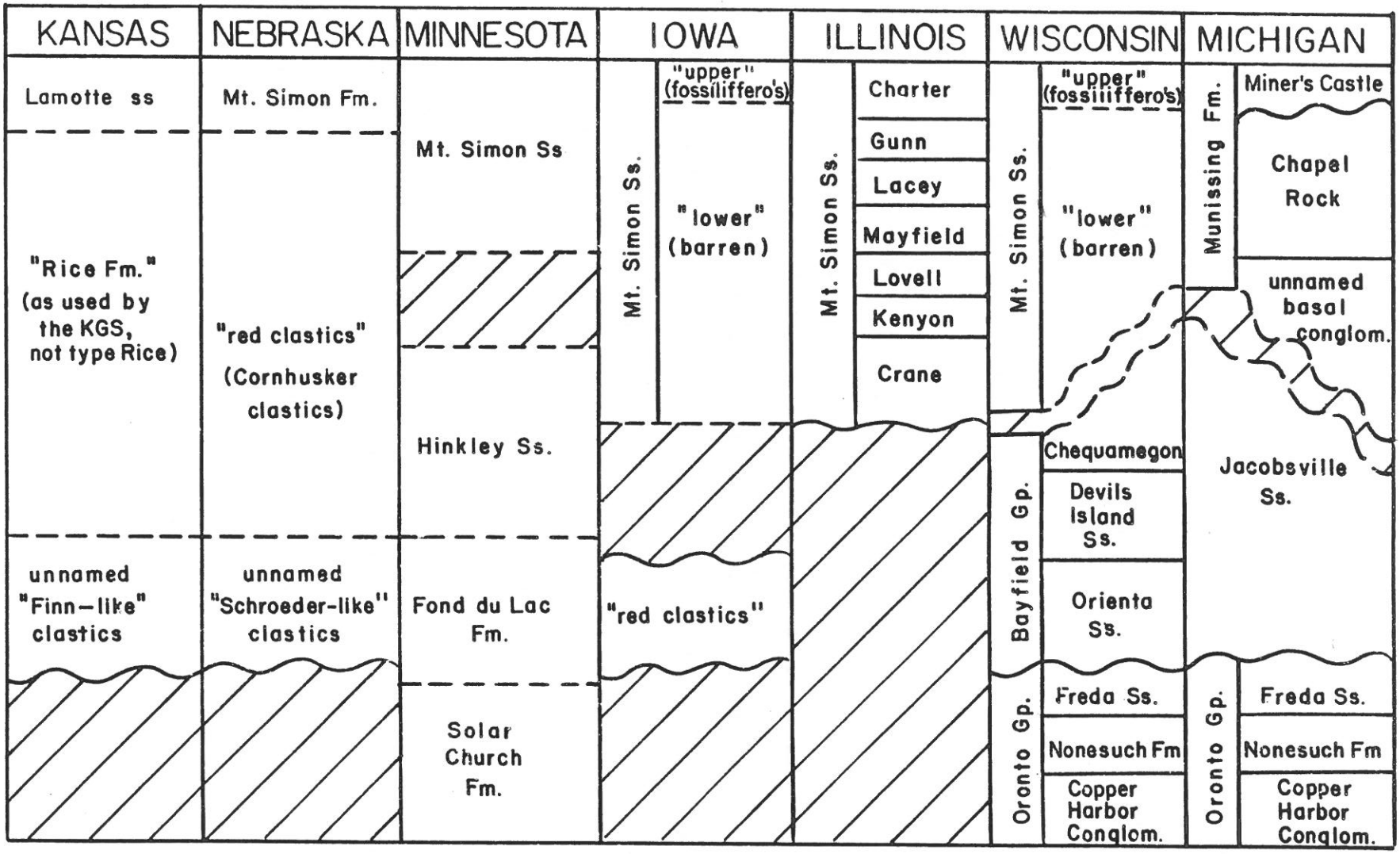


TABLE VI. Preliminary correlation of surface and subsurface early Phanerozoic and Upper Keweenawan clastic units along the trend of the Midcontinent rift system.

ferentiate the Mt. Simon sandstone from the similar appearing, underlying Hinkley sandstone. These criteria include; 1) the presence of red and green laminated shale and mudstone beds in the Mt. Simon sandstone, 2) the presence of abundant quartz overgrowths in the Hinkley sandstone, and 3) the presence of kaolinite and minor illite in the clay fraction of the Hinkley sandstone, in contrast to the illite and montmorillonite that dominate the clay fraction in the Mt. Simon sandstone. The Mt. Simon sandstone, as the term is used in Minnesota, can probably be correlated with the upper part of the Mt. Simon of Illinois (Table II).

Modern discrimination of Keweenawan sedimentary sequences in Minnesota began with the work of Kirwin (1963), who demonstrated, using variations in mineralogic composition, that the "red clastics" (an informal term used to describe these units since the early part of the century) could be subdivided into five lithostratigraphic units. These include (unit 1) a quartz arenite with minor K-spar and no rock fragments correlated with the Hinkley formation by Morey (1977), a feldspathic sandstone (unit 2) grading into an arkose composed of 60-85% quartz, with minor K-spar, plagioclase, and rock fragments equated by Morey (1977) with the Fond du Lac formation, and an arkose (unit 3) with 50% quartz, plagioclase, and subordinate rock fragments, a litharentite (unit 4) with 30% quartz, 40% volcanic rock fragments, and plagioclase, and a litharenite (unit 5) with 5-10% quartz and the remainder of the framework grains volcanic rock fragments and plagioclase. Units 3, 4, and 5 were considered a single unit named the Solor Church formation by Morey (1977).

Exposures of the Hinkley formation were correlated with the Devils Island sandstone (middle Bayfield group of Wisconsin) and the Fond du Lac formation with the Orienta sandstone (lower Bayfield group of Wisconsin) by Tyler and others (1940). Morey (1977) suggested that the Solor Church was probably

equivalent to the Oronto group in Wisconsin. These correlations have been continued by a number of subsequent workers (e.g., Morey and Ojakangas, 1982; Dickas, 1985).

IV. Iowa Subsurface

The Iowa Geological Survey Bureau recognizes a thick Mt. Simon formation (maximum penetration of 1220 feet--366 m) but does not use the member subdivisions identified in Illinois. Rather an informal two-fold subdivision consisting of an "upper" fossiliferous marine unit and a lower generally non-fossiliferous, nonmarine unit (although rare fossiliferous marine interbeds may be present). Where no fossils are present the age of the rocks are uncertain.

The Mt. Simon formation in Iowa can be characterized as a tan to orange-pink colored, very fine-to very coarse-grained, subangular to round, poorly sorted, quartz arenite with some feldspathic sandstone beds. Inarticulate brachiopods and trace fossils are present only in the upper-most 20 feet (6 m) of the formation except in the Wilson #1 well (Page County) and #1 Huntley (Butler County) where inarticulate brachiopods have been identified in rare beds as much as 1375 feet (413 m) below the top of the formation. The thickness of the Mt. Simon formation in Iowa varies considerably across the state. The thickest interval encountered in Iowa occurs in the #1 Huntley oil test (Butler County) where 1445 feet (434 m) of Mt. Simon strata was penetrated. The USGS-RASA Green Island test in Jackson County penetrated 1195 feet (359 m) of Mt. Simon material, and the Wilson #1 oil test in Page County penetrated 1100 feet (330 m) of the unit. The Mt. Simon formation is generally thickest in east-central Iowa, on the western margins of the northeastern Illinois Mt. Simon basin. It thins into western Iowa where it averages 150 to 300 feet (45-90 m) in thickness. The unit may be locally absent due to non-deposition

or erosion. The Mt. Simon formation also thickens into a half-graben which developed over the Keweenawan clastic basins on the eastern flank of the Iowa horst (the central uplifted portion of the Midcontinent rift system in Iowa). The #1 Huntley and Wilson #1 wells were drilled into the half-graben, informally called the "Ancestral Iowa basin."

Keweenawan clastics in Iowa, informally called "red clastics," have been encountered in 5 wells in Iowa. Three Iowa penetrations are cores, but they total only 75 feet (23 m) and are within 5 miles (8 km) of one another. Maximum penetration of the "red clastics" is 43 feet (13 m) in the Berdie Lehman #1 where the unit includes interlayered green and red shale and mudstone and tan sandstone. The sandstone is very fine-to medium-grained, angular to subangular arkose with roughly equal proportions of quartz and feldspar and some black rock fragments. The sand is well cemented, including white clay cement. The deepest penetrations of the "red clastics" was in the Crawford County Martin Augustine #1 oil test. A total of 1355 feet (407 m) of the unit was drilled, but the cuttings collected were extremely poor due to a loss of circulation.

The "red clastics" in Iowa appear to correlate most closely (Table VI) to the Fond du Lac formation/Bayfield group clastics in exposures in Minnesota and Wisconsin. No rocks correlative with Solar Church formation/Oronto group rocks have been encountered in Iowa. The "lower" Mt. Simon formation in Iowa may be correlative with the Hinkley sandstone in Minnesota. More work is necessary to improve the confidence of these correlations. This future work is described later in this report.

V. Nebraska Subsurface

The basal Paleozoic sandstone unit in Nebraska has traditionally been called the Dresbach sandstone but is referred to as Mt. Simon formation by

Carlson in the recently completed COSUNA correlation charts (Adler, 1987). The unit was described by Condra and Reed (1943) as a light gray, subangular to rounded, medium-to coarse-grained, frosted sandstone. The greater degree of rounding and frosting of the quartz grains and scarcity of grains of other mineralogy are the key characteristics that are used to differentiate the Mt. Simon formation from underlying clastic units. This criteria suggests that the Mt. Simon formation of Nebraska probably equates with the "upper" (fossiliferous) and the upper part of the "lower" (barren) Mt. Simon sandstone of Iowa, and approximately the upper half of the Mt. Simon sandstone as recognized in Minnesota (see Table VI).

Clastics associated with the Midcontinent rift system beneath the Mt. Simon formation in Nebraska are not differentiated, in the correlation chart, but are collectively referred to as "red clastics." The three primary rock types described on pages of this report can be tentatively related to depositional packages observed in other areas. The first type, a pink, fine-to very coarse-grained argillaceous sandstone informally called "cornhusker clastics," is similar to the "standard Rice" formation of Kansas. This is similar to the lower Mt. Simon sandstone of Iowa and Minnesota and is tentatively correlated lithologically with them.

The second type, a maroon mottled gray-green shale and siltstone, is similar to Iowa "red clastics" seen in Birdie Lehman #1 and related cores. This unit apparently correlates with the Fond du Lac formation of Minnesota, derived by the weathering of nearby mafic igneous rocks. The third type, a well cemented grayish buff to pink, fine-to coarse-grained arkosic sandstone is also most similar to the "red clastic" of Iowa, specifically the sandstone in the McCallum A-1 core. This rock type is also similar to the Fond du Lac formation of Minnesota, in the Schvette #1 core and in exposures. In the Schroeder core

in Nebraska this unit is, however, much better indurated than other occurrences, proably because of epitaxial quartz cement produced by local diagenetic processes. No samples from the subsurface of Nebraska are similar to the Solor Church formation of Minnesota.

VI. Kansas Subsurface

The basal Paleozoic sandstone in Kansas is called the Lamotte sandstone. It was characterized by Goebel (1969) as a poorly sorted, rounded to angular, fine-to coarse-grained, quartzose sandstone, dolomitic sandstone, quartz-glauconite sandstone, feldspathic sandstone, or arkose. The Lamott sandstone probably correlates directly with the Mt. Simon formation of Nebraska, the "upper" (fossiliferous) and upper "lower" (barren) subdivisions of the Mt. Simon sandstone of Iowa, and the upper part of the Mt. Simon sandstone in Minnesota.

Beneath the Lamotte sandstone, clastic rocks associated with the MRS have been traditionally called the Rice formation. As originally defined by Scott (1966), the Rice formation is a grayish red to grayish orange-pink, poorly sorted, medium-to coarse-grained, subangular to rounded, frosted, feldspathic sandstone. Accessory grains include rock fragments (schist, quartzite, felsite, granite, argillite) and pyrite. Cement includes dolomite and a white illitic clay. Greenish gray and dark reddish brown shale or mudstone interbeds are also reported. No type well was designated; rather four "typical" drill holes, in Ellsworth and Rice counties, were described. Pieter Berendsen (Kansas Geological Survey) suggested (personal communication, 1986) that the Rice formation, as described by Scott, was not uniquely the product of Mid-continent rift development, but also includes detritus shed from an ancestral Central Kansas uplift. The composition of the rock fragment component of the Rice formation as described by Scott is consistent with Berenden's idea. Scott

described rock fragments of various igneous and metamorphic lithologies, but no mafic volcanic clasts. Such mafic volcanic clasts are the dominant rock fragment component in the Solor Church formation, and equivalent rocks, and are not uncommon in the Fond du Lac formation, and its equivalents. The term Rice formation, however, used by most workers to identify Keweenawan clastic rocks associated with the MRS in Kansas.

The name Rice formation (or informally "standard Rice formation") is presently applied by the Kansas Geological Survey to a sequence of pink to orange colored, fine-to medium-grained, subangular to subrounded, poorly-cemented feldspathic sandstones to quartz arenites and intercalated reddish siltstones and shale. The sand clasts are commonly iron stained and are cemented by iron oxide and white clay (kaolinite?). This composition is best observed in #1 Sedlacek and #1 Seematter wells. We have tentatively lithologically correlated this sequence with the upper "red clastics" ("cornhusker clastics") in Nebraska (Table VI), the "lower" (barren) Mt. Simon sandstone in Iowa, and the lower Mt. Simon sandstone and possible Hinkley sandstone in Minnesota.

The other major clastic rock types associated with the Midcontinent rift system in the subsurface of Kansas is a red to pink colored, well sorted, fine-to coarse-grained, angular (overgrowths), well-cemented feldspathic sandstone. Feldspar constitutes about 50% of this rock, and detrital opaques (magnetite?) are common. Thin, green-mottled red mudstone unit is apparently interbedded with the coarser clastic unit. This sequence, best observed in the #1 Cathrine Finn well, differs from the other sub-Mt. Simon clastic rocks, most notably by much more abundant clastic feldspar component, an abundance of quartz overgrowths, and the absence of white clay (kaolinite?) cement. This rock unit is tentatively equated with the unnamed clastic unit observed in the Schroeder #1

well in Nebraska and the "red clastics" observed in the Birdie Lehman #1 well in Iowa, and the Fond du Lac formation in Minnesota. As was the case in Iowa and Nebraska, no samples observed in the subsurface of Kansas are presently correlated with the Solor Church formation of Minnesota.

Conclusions

Our preliminary examination of surface exposures and subsurface samples of clastic rocks associated with the Keweenawan age Midcontinent rift system has led to a number of tentative conclusions.

1. We concur with most recent workers that exposures of Oronto group and equivalent rocks represent generally first-cycle fanglomerates, lacustrine, and fluvial deposits associated with the formation of grabens during rifting. Also, that Bayfield group and equivalent rocks generally represent second-cycle fluvial channel sands and overbank deposits, apparently separate from the underlying Oronto group sediments by an angular unconformity. Oronto group sediments reworked as a result of tectonism associated with the MRS as well as extra-rift rocks make up the Bayfield group.
2. It appears to us that some of the rocks of the Bayfield group and equivalents and the fluvial rocks presently assigned to the lower Mt. Simon sandstone and equivalents are very similar and may be related.
3. We are in agreement with Morey (1977) that the Lonsdale 65-1 core, from the Twin City basin just south of Minneapolis, penetrates rocks (the Solor Church formation) that are probably correlative with rocks of the Oronto group (Freda and Nonesuch formations) rocks. No rocks lithologically similar to the Solor Church formation were observed in the subsurface south of Minnesota.

4. Two primary lithologic sequences were observed stratigraphically below the demonstrably marine, rounded, frosted quartz arenites of the Upper Cambrian Mt. Simon (Lamotte) sandstone in the subsurface of Iowa, Nebraska, and Kansas. The uppermost of these sequences is a pink to orange colored, fine-to coarse-grained, subangular to subrounded, poorly cemented, feldspathic sandstone to quartz arenite and intercalated reddish siltstones and mudstones, commonly displaying iron oxide and white clay (kaolinite?) cements. This unit is called "lower" Mt. Simon sandstone by the Iowa Geological Survey, "red clastics" by the Nebraska Conservation and National History Survey, and Rice formation by the Kansas Geological Survey. These units lithologically correlate with the lower Mt. Simon or Hinkley sandstones of Minnesota, the lower Mt. Simon sandstone and upper Bayfield group of Wisconsin, and the lower Munissing, upper Jacobsville formations of Michigan.

   The lower sequence is a red to pink colored, well sorted, fine- to coarse-grained, angular (overgrowths), well cemented feldspathic sandstone, with feldspar content approaching 50%, abundant opaque detrital grains, and green to red mottled siltstone and mudstone interbeds. This unit was identified in the Finn well in Kansas, the Schroeder well in Nebraska, and the Berdie Lehman well in Iowa. It probably correlates with the Fond du Lac formation in Minnesota, the Orienta sandstone (Bayfield group) of Wisconsin, and the lower Jacobsville sandstone in Wisconsin.

5. A more detailed and accurate comparison of the Precambrian sands associated with the MRS in the subsurface and in surface exposures will require additional sample analyses. These analyses, proposed

for future years of the Keweenawan Study, will include examinations of depositional environments, source terranes, transport directions, and diagenesis. Procedures used will include detailed petrographic descriptions of samples, heavy mineral analyses, x-ray determination of clay minerals, microprobe elemental analyses of clays, silts, and some sand grains and cements, scanning electron microscopic examination of selected samples, and other analytic techniques.

6. Metalic mineralization in the Lake Superior Keweenawan clastic exposure region includes the famous stratbound native copper deposits, found in amygdules and fractures in basalts, and in the Copper Harbor conglomerate, described by White (1968) and stratiform copper deposits in the Nonesuch shale at White Pine, Wisconsin (Ensign and others, 1968). Other mineralization associated with these rocks include chalcocite, silver, lead, and zinc (Berendsen, 1986). Although similar conditions were apparently present along the entire length of the MRS, the only mineralization observed in the subsurface was in the McCallum A-1 well in Iowa where calcopyrite and possibly bornite were observed by us. The darth of observable mineralization is probably a product of the small number of Keweenawan wells, the shallow penetrations of these units, and the poor quality of the samples available for examination. As an increasing number of better subsurface Keweenawan samples become available, more examples of mineralization should be observed.

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Proposal for Continued Work in 1987

The examination of Keweenawan clastic rocks in exposure and subsurface samples in late 1985 and early 1986 provided valuable insight into the nature of these sedimentary rock units, the problems involved in understanding their depositional environment, diagenetic history, mineralization potential, and in correlating them, given the nature and quantity of the samples available. In the next year of this study we would like to sample selected intervals of many of the cores and cutting sets that we examined, and prepare thin sections of many of these samples and selected exposure samples for detailed petrographic analyses. Associated with these petrographic studies we would determine the mineralogy of the clays in many of the fine-grained intervals and cements in some of the sandstones. After examination of the result of this study we will identify specific samples for continued analyses in the following years. These additional analyses will include, but not be limited to, heavy mineral and trace mineral analysis, elemental analysis of clays and selected grains using SEM or XRF techniques, SEM examination of selected grain surfaces, grain boundaries, and other features. These studies will help us to better understand the geological histories of these units, and their strategic and critical minerals potential.

APPENDIX

APPENDIX I

A. Description of Exposure Samples Collected by Raymond Anderson

Stop 1 Type area Chengwatana volcanic group, northeast end of Cross Lake at the dam on the Snake River near Pine City, Minnesota. September 27, 1985

Sample ME1/1 - Chengwatana volcanics. A dark reddish brown, vesicular basalt porphyry, vesicles are filled of gray-green clay, a black mineral, and minor thomsonite? Porphyroblast are small pink feldspar crystals. Vesicles make up about 25% of the rock. Sample size 6 x 6 x 5 cm.

Sample ME1/2 - Chengwatana volcanics. A gray, slightly reddish brown basalt, few epidote filled vesicles. Sample size 6 x 6 x 3 cm.

Sample ME1/3 - Chengwatana volcanics. Reddish-brown vesicular basalt porphyry. Vesicles constitute 15% of the rock, dominantly thomsonite and epidote. Porphyroblast are small pink feldspar crystals. Sample size is 5 x 5 x 5 cm.

Stop 2 Type area of Hinkley sandstone. Quarries at Robinson Park, Hwy 123 east of Sandstone, MN., west bank of the Kettle River. September 27, 1985.

Sample ME2/1 - Hinkley sandstone. Orange to red, fine-to coarse-grained, well-rounded to angular, fairley well cemented quartz arenite, some rock fragments and feldspar grains. Thin bedded with alternating fine and medium beds ranging from about .5 to .2 mm in thickness. Sample size is 11 x 3 x 4 cm.

Sample ME2/2 - Hinkley sandstone. Light pink to peach colored, fine-to medium-grained, coarse to angular, quartz arenite. Some rock fragments and feldspar grains. Thin, cross-beds, to about 3 mm. Sample size is 8 x 10 x 2 cm.

Sample ME2/3 - Hinkley sandstone. Beige colored, fine-to medium-grained, rounded to angular, quartz arenite. Some rock fragments and feldspar. Bedding is difficult to discern. Sample size is 6 x 5 x 5 cm.

Stop 3 East bank of Kettle River Hwy 123. Exposures of Hinkley sandstone. September 27, 1985. One sample collected by Berendsen and Barczuk.

Stop 4 East bank of Kettle River, Hwy 23. Exposure of Hinkley sandstone. September 27, 1985. One sample collected by Berendsen and Barczuk.

Stop 5 Lower Hinkley sandstone, City Park, Holyoke, MN. September 27, 1985

Sample ME 5/1 - Hinkley sandstone. Reddish orange, fine-to medium-grained, rounded to angular quartz arenite. Iron staining on some grains. Some rock fragments and feldspar grains. Sample size is 4 x 7 x 7 cm.

Stop 6 Type area of the Nopeming sandstone, just off I-35 about 1 mile NE of the Nopeming exit of I-35 south of Duluth. September 28, 1985.

Sample ME6/1. Nopeming quartzite. Gray quartzite. Some rock fragments, grayish-green color. This sample shows a layer of sandstone about 3.5 cm thick overlain and underlain by beds of metasiltstone 1-.5 5 cm in thickness. Sample size is 6 x 9 x 4 cm.

Sample ME6/2. Nopeming quartzite. Gray quartzite. A greenish to pinkish mottled fine-to medium-grained quartzite. Horizontal laminations. Some rock fragments. Oriented sample. Sample size 10 x 12 x 6 cm.

Sample ME6/3. Nopeming quartzite. Buff and dark gray mottled quartzite. Dark gray metashale clasts in fine sand follow apparent bedding. Sample size is 8 x 6 x 4 cm.

Sample ME6/4. Nopeming quartzite. Upper contact with overlying basalts. Sample is a very dark gray and tan, banded silt stone. Bands are disrupted and measure 1 to 2 mm in thickness. Oriented sample. Sample size is 18 x 6 x 3 cm.

Sample ME6/5. Nopeming quartzite. A silty, sandy metaconglomerate. Pinkishto rust to green mottled with siltstone and mudstone clasts, sand size to several cms. Sample size is 15 x 7 x 4 cm.

Sample ME6/6. Nopeming conglomerate. Basal conglomerate. Light gray, quartz cemented conglomerate. Clasts making up approximately 50% of the rock and range in size from coarse sand to 5 cm in diameter. Sub-rounded to sub-angular and dominated by milky quartz, with some volcanic rock or metagraywacke clasts. Matrix is medium grained quartz sand. Sample size is 10 x 10 x 10 cm.

Sample ME6/7. Ely's Peak basalt. A black basalt porphyry. Porphyroblast are augite grains. About .5 mm in length. Sample size is 9 x 5 x 9 cm.

Sample ME6/8. Ely's Peak basalt. A black basalt porphyry. Porphyroblast are augite grains. About .5 mm in length. Sample size is 12 x 7 x 4 cm.

Stop 7 Type area of the Fond du Lac formation, along Mission Creek, Fond du Lac Park, Duluth, MN. Behind park just north of Hwy 23 on 131 Ave West. September 28, 1985

Sample ME7/1. Fond du Lac formation. Pinkish gray, fine-to medium-grained, well sorted, rounded to angular, immature sandstone. Horizontally bedded and laminated. Approximately 50% of the grains are quartz sand. Approximately 30% feldspar. Remaining grains are rock fragments and others. Top and bottom of this samples consist of green and brick red mottled sandy siltstone The sand bed is 5 cm thick with the silty areas being about .5 mm. Sample size is 12 x 7 x 5 cm.

Sample ME 7/2. Fond du Lac formation. Dark grayish brown, sandy silt-

stone. Thin bedded, beds range to about 1 -2 mm in thickness. Horizontally laminated. Some grayish bleaching in individual beds and mottles. Sand is dominantly rock fragments, probably volcanic, some quartz grains. Sample size is 13 x 6 x 3 cm.

Sample ME7/3 Fond du Lac formation. Dark grayish brown, sandstone. Some lighter beds are approximately .5 mm thick. Most sand grains range from medium to fine and are rock fragments. Sample size is 7 x 8 x 5 cm.

Sample ME7/4 Fond du Lac formation. Dark grayish brown, micaceous, sandstone with circular buff mottles. Bedding ranges from about .25 mm to 2 mm. Sample size is 4 x 5 x 2 cm.

Sample ME7/5 Fond du Lac formation. Light green to buff mottled, silty sandstone. Many feldspar grains, fine-to medium-grained. Sample size is 8 x 6 x 1 cm.

Sample ME7/6 Fond du Lac formation. Light green to buff mottled, sandy siltstone. Many feldspar grains in this rock. Some rock fragments. Little bit of mica. Sample size is 10 x 7 x 1 cm.

Sample ME7/7 Fond du Lac formation. Light green to buff mottled sandy siltstone. Many feldspar grains in this rock. Some rock fragments. Little bit of mica. Sample size is 10 x 5 x 1 cm.

Sample ME7/8 Fond du Lac formation. Green to brick red mottled sandy siltstone to claystone. Ripple cross-laminated Quite a bit of mica in like ripples. Sample size 7 x 8 x 1 cm.

Sample ME7/9 Fond du Lac formation. Brick red micaceous silty shale. Very thin irregular beddings. Rock breaks along micaceous silty partings.

Sample ME7/10 Fond du Lac formation. Dark brownish gray micaceous silt stone. Thin bedded but rather compact. Sample size 5 x 7 x 4 cm.

Stop 8 Type area of Fond du Lac formation, Fond du Lac Park, Duluth, MN on the north bank of the St. Louis River, south along the river about 1/2 mile from Hwy 23. September 28, 1985

Sample ME8/1 Fond du Lac formation. Pink, medium-grained, angular to rounded, immature sandstone, abundant feldspar, some quartz, some rock fragments, no bedding evident. Sample size is 10 x 9 x 5 cm.

Sample ME 8/2 Fond du Lac formation. A very light gray, medium-grained, immature sandstone, no bedding evident. Grains are dominantly feldspars and clay. Some thin clay laminae are present, few quartz grains. Oriented sample. Sample size is 11 x 8 x 7 cm.

Sample ME 8/3 Fond du Lac formation. Light gray to brick red mottled conglomerate. Clasts are dominantly brick red, some light green, clay and silt, and are rounded to very flat. The rock matrix is pink to light gray in color. It is dominated by medium-to coarse-grained sand.

Large sand grains are dominantly quartz, the medium grains are dominantly rock fragments and feldspar with 20% quartz. Some bedding is evident as is some degree of sorting. Sample size is 10 x 10 x 8 cm.

Sample ME 8/4. Fond du Lac formation. A light gray, very poorly sorted sandstone. Coarse grains range to about 2 mm in diameter and are dominantly quartz with some feldspar and rock fragments. Matrix is dominantly medium-grained sand, 50% quartz, 50% feldspar, clay, and rock fragments. Sample size is 8 x 10 x 6 cm.

Sample ME 8/5. Fond du Lac formation. Dark reddish-brown sandy siltstone with gray mottles. Sand fragments are dominantly volcanic. Mica is present. Deformed bedding is also present. Sample size is 9 x 12 x 7 cm.

Sample ME 8/6. Fond du Lac formation. A light brown, very poorly sorted conglomeratic sandstone. Large clasts range to 1 cm in diameter. Larger grains are dominantly quartz with some feldspar rock fragments. The bulk of the rock is medium-grained sandstone, roughly 50% quartz, the remainder feldspar, clay, and rock fragments. Some bedding is evident as beds of coarser grain class ranging to about 3 mm in thickness. Sample size is 8 x 12 x 5 cm.

Stop 9 Exposure of basal Fond du Lac formation Jay Cooke State Park, Duluth, MN. Enter from the north, and continue for about 1/2 mile south of the entrance where a small lake lies north of the road. Walk north past the lake for about a quarter mile along the Little River. September 28, 1985.

Sample ME 9/1. Fond du Lac formation. A light green colored, conglomeratic, containing coarse clasts that range up to 5 cm in diameter. 90% of the clasts consist of milky quartz, but some slate clasts of Thompson formation are also present as coarse clasts. Matrix is fine-to coarse-grained sand with some pyrite cement. Sample size is 12 x 8 x 4 cm.

Sample ME 9/2. Fond du Lac formation. Basal conglomerate. A light green colored, clay cemented conglomerate. Coarse clasts. Range up to 5 cm in diameter and are 90% milky quartz. Some pieces slate clasts of Thompson Formation are also present as coarse clasts. Matrix is fine-to coarse-grained sandstone consisting dominantly of milky quartz. Sample size is 16 x 16 x 4 cm.

Sample ME 9/3. Thompson formation. Banded milky quartz and green slates. Sample size 8 x 5 x 3 cm.

Stop 10 Exposures of Chequamegon sandstone, Washburn, Wisconsin. Just north of the marina along Lake Superior. September 29, 1985.

Sample ME 10/1. Chequamegon sandstone. Brick red, thin-bedded, fine-to medium-grained, rounded to angular sandstone. Grains are dominantly quartz. The rock is poorly cemented, and the cement appears to be iron. Sample size is 10 x 8 x 1 cm.

Sample ME 10/2. Chequamegon sandstone. Pinkish-grey and brick red banded, medium-to coarse-grained, rounded to subrounded, poorly cemented quartz arenite. Sample size is 8 x 6 x 4 cm.

Sample ME 10/3. Chequamegon sandstone. Brick red colored thin-bedded, fine-to medium-grained, sandstone with thin silty partings. Very poorly cemented. Horizontally laminated. Two samples in ziploc bag. Size of each approximately 7 x 6 x 1 cm.

Sample ME 10/4. Chequamegon sandstone. Buff to light orange, fine- to medium-grained, rounded to subrounded, very poorly cemented, quartz arenite, some rock fragements. Two samples in ziploc bag, each approximately 8 x 4 x 3 cm.

Sample ME 10/5. Not found.

Sample ME 10/6. Chequamegon sandstone. Pinkish-orange colored fine-to coarse-grained, rounded to subrounded, very poorly cemented, quartz arenite. Sample size approximately 8 x 6 x 4 cm.

Stop 11 Exposure of Devils Island sandstone. Siskiwit Falls on the Siskiwit River. One mile south of Cornucopia, Wisconsin. September 29, 1985.

Sample ME 11/1. Devils Island sandstone. Pink to orange, fine-grained, well sorted, medium-to well-rounded quartz arenite with some rock fragments. Size is 8 x 10 x 11 cm.

Sample ME 11/2. Devils Island sandstone. Pink to orange colored, fine-to medium-grained, well-rounded, well sorted, quartz arenite with some rock fragements. Sample size is 2 x 8 x 10 cm.

Sample ME 11/3. Devils Island sandstone. Pink to orange colored, well rounded, fine-to-medium grained. well sorted, quartz arenite with some rock fragements. Sample size is 3 x 3 x 8 cm.

Sample ME 11/4. Devils Island sandstone. Pink to orange colored, medium-grained, well sorted, well rounded quartz arenite. Sample size is 3 x 5 x 8 cm.

Stop 12 This is a type area of the Orienta sandstone just east of the Iron River about 7 miles west of Port Wing and about one mile south of Highway 13. September 29, 1985.

Sample ME 12/1. Orienta sandstone. A rust to brown colored, medium-to very coarse-grained, but fairly well sorted, angular to well rounded, quartz dominated sandstone. Other clasts include feldspars, black volcanic fragments, some large clay clasts, up to 2 cm. Coarse sand fraction forms beds up to 1 cm thick. Sample size is 6 x 5 x 10 cm. The kaolinite cement gives the rock a white speckled appearance.

Sample ME 12/2. Orienta sandstone. Brown to rust colored, fine-to medium-grained, well sorted, angular to well rounded, quartz dominated sandstone. Also includes black volcanic rock fragment. Two samples, both with feldspar clasts. One sample has a red speckled appearance.

Both samples are oriented. The sample sizes are 15 x 6 x 2 cm and 3 x 7 x 6 cm.

Sample ME 12/3. Orienta sandstone. Light brick red to dark brick red banded, very fine-to medium-grained, angular, horizontally laminated, quartz dominated sandstone. Sample size 2 x 7 x 10 cm.

Sample ME 12/4. Same as 12/3. Sample size is 2 x 6 x 6 cm.

Sample ME 12/5. Same as 12/3. Sample size is 2 x 4 x 6 cm.

Sample ME 12/6. Orienta sandstone. Brick red to brown colored, fine-to medium-grained, fairly well sorted, angular to well rounded quartz dominated sandstone. It also includes black volcanic rock and feldspar clasts. White speckled from kaolinite cement. Sample size is 3 x 3 x 6 cm.

Sample ME 12/7. Orienta sandstone. White speckled from kaolinite cement. Dark rust to buff banded, fine-grained, well sorted, medium-to well-rounded quartz dominated sandstone with feldspar and black volcanic clasts. The bedding is thin with the dark brick colored bands approximately 1 mm thick and apparently including more finer grained clasts. The buff colored bands range up to about 5 mm in thickness and appear to derive their color from kaolonite cements and less iron. The rock sample is 2 x 4 x 5 mm.

Sample ME 12/8. Orienta sandstone. Red-colored, medium-to very coarse-grained, poorly sorted, angular to well rounded quartz dominated sandstone, but also including more feldspar then the previous rocks and more rock fragments dominated by black volcanics. Large clasts include well rounded quartz grains to 5 mm in diameter, and volcanic fragments to 1 cm in diameter. This rock is approximately 2 x 5 5 cm.

Stop 13 Exposure of Chequamegon sandstone. Big Rock Wayside Park. Approximately 3 miles northwest of Washburn, Wisconsin on County Road C. September 29, 1985.

Sample ME 13/1. Chequamegon sandstone. Brick red, medium-to very coarse-grained, quartz rich, moderately well-rounded, quartz sandstone, with some chert and rock fragments. Sample size 2 x 8 x 10 cm.

Sample ME 13/2. Chequamegon sandstone. This sample is the same as ME 13/1. More thin clay clasts. Conglomerate bands. This sample is oriented. Sample size is 5 x 12 x 15 cm.

Stop 14 Exposure of the Freda sandstone. White River Dam about 5 miles south of Ashland on Wisconsin Highway 112.

Sample ME 14/1. Freda sandstone. Dirty brick red colored, very fine-to coarse-grained, poorly sorted, litharenite. Some beds of coarse class up to 5 mm thick include about 20% quartz clasts ranging in size up to 2 cm in diameter. Dominantly clastlithologies include rock fragments, feldspar, kaolonite, black chert and some quartz grains. Fine and coarse beds appear to alternate through much of the rock. The fine sand component is micaceous. Seven samples in a ziploc bag.

Sample ME 14/2. Freda sandstone. Dirty brick red colored, fine-to pebbly, poorly sorted very silty litharenite. The coarse clasts are angular to faily well rounded and dominated by volcanic rock fragments with some kaolonite, feldspar, and minor quartz. The finer component of this rock is micaceous. Sample size is 1 x 8 x 12 cm.

Sample ME 14/3. Freda sandstone. Brown colored, fine-to very coarse-grained litharenite. The coarse-grain components range up to .5 cm in diameter and are dominantly volcanic rock fragments but include some feldspar, kaolonite, and quartz. Poorly sorted, coarse beds range up to about .5 cm. Sample size is 2 x 4 x 10 cm.

Stop 15 Radio Tower Hill, 4 miles south of Mellen, Wisconsin on Highway 13. This is an exposure of Archean granites and gneisses. No Keweenawan samples are collected here. September 29, 1985

Stop 16 Exposures of Portage Lake volcanic group, Copper Harbor Conglomerate, Nonesuch formation, and Freda sandstone. Potato River at County Park 1.5 miles southwest of Gurney, Wisconsin. September 29, 1985.

Sample ME 16/1. Freda sandstone. Dark gray, well sorted, fine-to coarse-grained micaceous litharenite. Clasts are dominantly volcanic rock with secondary feldspar and minor quartz. Micas include muscovite and phlogopite. Mica grains range up to 3 mm in diameter. Rock fragments are angular to moderately well-rounded. Bedding is relatively thin ranging from about 1/2 cm to 1 cm. This sample is 2 x 7 x 11 cm.

Sample ME 16/2. Freda sandstone. Dark gray, well sorted, fine-grained micaceous silty litharenite. Clasts appear to be dominantly volcanic rock with feldspar and minor quartz. Micas include muscovite and phlogopite. Mica grains range up to 3 mm in diameter. Rock fragments are angular to moderately well-rounded. This rock sample is 2 x 9 x 14 cm.

Sample ME 16/3. Freda sandstone. Dark gray, well sorted, fine-grained silty micaceous litharenite. Clasts appear to be dominantely volcanic rock with feldspar and minor quartz. Micas include muskovite and phlogopite. Mica grains range up to 3 mm in diameter. Rock fragments are angular to moderately well-rounded. This rock sample is 4 x 14 x 15 cm.

Sample ME 16/4. Nonesuch shale. Shaley siltstone, dark gray to dark brown with very fine dark buff bands. Bedding is generally thin, less then .5 mm, ranging up to 2 cm. Lighter color bands appear to be siltier. The rock has a concoidal fracture. This rock is 4 x 5 x 9 cm.

Sample ME 16/5. Nonesuch shale. Shaley silstone, dark gray to dark brown with very fine dark buff bands. Bedding is generally thin, less then .5 mm, ranging up to 2 cm. Lighter color bands appear to be siltier. The rock has a sort of concoidal fracture. This rock is 4 x 6 x 6 cm.

Sample ME 16/6. Nonesuch shale. Shaley siltstone, dark gray to dark brown with very fine dark buff bands. Bedding is generally thin, less then .5 mm, ranging up to 2 cm. Lighter color bands appear to be siltier. The rock has a concoidal fracture. This rock is 2 x 5 x 6 cm.

Stop 17 September 30, 1985

Type Freda sandstone at Freda, Michigan. Due to extremely inclement weather we are unable to find the exposure.

Stop 18 Exposure of Portage Lake volcanic group at Keweenawan Fault Zone, 1/2 mile north of Phoenix, Michigan on Highway 26 at its crossing of the Eagle River. September 30, 1985.

Sample ME 18/1. Portage Lake volcanic group. Black basalt displaying ophitic texture. Spherical weathering of ophitic texture yields a rough surface exposing sphericals approximately .5 cm in diameter. This sample is 1 x 13 x 17 cm.

Sample ME 18/2. Portage Lake volcanic group. Black basalt, massive. Sample size is 7 x 8 x 6 cm.

Sample ME 18/3. Portage Lake volcanic group. Black porphyritic basalt, porphyry. Phenocrysts are hornblende crystals, ranging up to .5 cm in length. Sample size is 5 x 5 x 13 cm.

Stop 19 Exposure of Copper Harbor Conglomerate and Portage Lake volcanic group. Eagle City, Michigan just north of the Eagle River on Highway 26. September 30, 1985

Sample ME 19/1. Copper Harbor sandstone. Dirty brown, very poorly-sorted, well-rounded to angular, litharenite. Grain sizes range from silt to pebble that are dominantly rock fragments with some feldspar and minor quartz. Calcite with veins are present in this rock. Sample size is 2 x 7 x 12 cm.

Sample ME 19/2. Copper Harbor sandstone. Dirty brown, very poorly sorted, well-rounded to angular, litharenite. Grain sizes range from silt to pebble that are predominantly rock fragments with some feldspar and minor quartz. Calcite with veins are present in this rock. Sample size is 3 x 8 x 9 cm.

Sample ME 19/3. Calcite from a fracture fill in Copper Harbor Conglomerate. Calcite is white to pink, very coarse-grained with individual crystals reaching up to 2 cm. Kaolonite intermixed with the calcite grains. This rock does not fluoresce. Sample size is 5 x 5 x 8 cm.

Sample ME 19/4. Calcite from a fracture fill in Copper Harbor Conglomerate. Calcilte is white to pink, very coarse grain with individual cyrstals reaching up to 2 cm. Kaolonite intermixed with the calcite grains. This rock does not fluoresce. Sample size is 4 x 4 x 7 cm.

Sample ME 19/5. Copper Harbor Conglomerate. A rusty brown, poorly

sorted conglomerate with a matrix of fine sand and silt composed primarily of rock fragments with some feldspar. Clasts ranging up to 10 cm. in diameter are dominated by well-to medium-rounded volcanic rock fragments. Coarse sand fragments are commonly angular. Some calcite cement. Sample size is 5 x 15 x 15.

Sample ME 19/6. Copper Harbor conglomerate. A rusty brown, poorly sorted conglomerate clasts with a matrix of fine sand and silt composed primarily of rock fragments with some feldspar. Clasts ranging up to 10 cm in diameter are dominated by well-to medium-rounded volcanic rock fragments. Coarse sand fragments are commonly angular. Also includes a medium to fine silty sand layer. This rock has some white to light-green mottled areas and also includes calcite cement in some area. Rock size is 5 x 15 x 20 cm.

Sample ME 19/7. Copper Harbor conglomerate. A rusty brown, poorly sorted conglomerate with a matrix of fine sand and silt composed primarily of rock fragments with some feldspar. Clasts range up to 10 cm. in diameter are dominated by well-to medium-rounded volcanic rock fragments. Coarse sand fragments are commonly angular areas of white to light-green mottling, appears to be secondary alteration with many of the mafic rock fragments chloritized or bleached to a pinkish-orange color. The size of this rock is 4 x 12 x 20 cm.

Sample ME 19/8. Copper Harbor conglomerate. A rusty brown, extremely poorly sorted conglomerate composed dominantly of coarse clasts with a matrix of fine sand and silt composed primarily of rock fragments with some feldspar. Clasts ranging up to 10 cm. in diamter are dominated by well-to medium-rounded volcanic rock fragments. Coarse sand fragments are commonly angular. This conglomerate is calcite cemented and includes some light-pinkish-orange mottling and kaolinitic clay layers. The sample size is 7 x 6 x 7 cm.

Stop 20 Exposure of Portage Lake volcanics group. Three miles east of Michigan Highway 41 on the road to Lac La Belle. September 30, 1985.

Sample ME 20/1. Portage Lake volcanics group. A medium gray vesicular basalt, It has about 30% vesicules ranging up to 5 mm in diameter. Vesicules are filled with chlorite, calcite and epidote. Sample size is 4 x 7 x 12 cm.

Sample ME 20/2. Portage Lake volcanics group. medium gray vesicular basalt, It has about 30% vesicules ranging up to 5 mm in diameter. Vesicules are filled with chlorite, calcite and epidote. Sample size is 3 x 6 x 11 cm.

Sample ME 20/3. Portage Lake volcanics group. A dark gray basalt with greenish-blue copper mineralization apparently malachite with light brick red colored iron staining. Sample size is 3 x 4 x 6 cm.

Stop 21 Haven Park and Waterfalls at Lac La Belle. At this location waterfall over the Keweenawan fault zone from Portage Lake volcanics on

to Jacobsville sandstone. One sample was collected by Berendsen and Barczuk. September 30, 1986.

Stop 22 Along the shore of Lake Superior five miles north of Gay, Michigan. The exposures of Jacobsville sandstone. September 30, 1986.

Sample ME 22/1. Jacobsville sandstone. This is a brick red, very fine to fine grained well sorted sandstone consisting of quartz and nearly equal amounts of fine red rock fragments. The unit has fine horizontal laminate less then 1 mm thick of dark red iron stained finer grained, probably silty, in between 3 mm thick beds that are brick red and composed dominantly of fine sand. Some mottling is present with individual mottles being buff to cream in color and being of two sizes, one about 1 mm in diameter, the other is larger ranging from from about 6 mm to 1 cm in diameter. This rock is also micaceous. Sample size is 2 x 6 x 16 cm.

Sample ME 22/2. Jacobsville sandstone. This is a cream to buff colored very fine to coarse grained sandstone sand that includes clay clasts up to 3 cm in diameter and thin clay drapes. The coarser components are dominantly quartz but the finer components seem to be about an equal mixture of quartz and rock fragments. This sample is 2 x 9 x 16 cm. in size.

Sample ME 22/3. Jacobsville sandstone. This is a cream to buff colored very fine to coarse grained sandstone that includes clay clasts up to 3 cm in diameter and thin clay drapes. The coarser components are dominantly quartz but the finer components seem to be about an equal mixture of quartz and rock fragments. Sample size is 3 x 13 x 20 cm.

Stop 23 Jacobsville sandstone section, along Highway 41 southeast of Baraga. This is September 30, 1985.

Sample ME 23/1. Jacobsville sandstone. Dark purplish gray, medium-to very coarse-grained, moderately well sorted, quartz dominated litharenite, with relatively abundant mica flakes in some of the bedding planes ranging in size up to 1 1/2 mm in diameter; calcite and kaolinite cement. Sample size is 4 x 5 x 9 cm.

Sample ME 23/2. Jacobsville sandstone. This is a dirty earthy rust colored iron and calcite cemented conglomeritic sandstone. Clasts range in size from fine sand to small pebble up to 4 cm in diameter. Clasts include dominantly chert, volcanics, and some granite, quartz, and clay. The rock is dominated by medium sand fraction. It includes mud class and individual grains may range from angular to rounded. Sample size is 6 x 9 x 12 cm.

Sample ME 23/3. Ziploc bag with three rocks.

Sample ME 23/3-A. Jacobsville sandstone. Earthy brownish to white mottled, very poorly-sorted quartz litharenite. Grains are fine to pebbly, large clasts range up to approximately 2 cm in diameter. Rock fragments and quartz dominate large clasts, black micas present in bedding planes. Sample size is 2 x 2 x 4 cm.

Sample ME 23/3-B. Jacobsville sandstone. Light pale green, with dark green speckles, angular to fairly well-rounded, fine to very coarse quartz litharenite, with abundant dark green mica in bedding planes.

Sample ME 23/3-C. Jacobsville sandstone. Earthy brownish to white mottled, very poorly-sorted quartz litharenite. Grains are fine to pebbly, large clasts range up to approximately 2 cm in diameter. Rock fragments and quartz dominate large clasts, black micas present in bedding planes. Sample size is 4 x 4 x 3 cm.

Sample ME 23/3-D. Jacobsville sandstone. Dark grayish brown, silty, fine-grained litharenite with minor quartz and white to dark green speckled bleached circular spots ranging from 1 mm to 1 cm in diameter. The rock size is 1 x 5 x 5 cm.

Sample ME 23/3-E. Jacobsville sandstone. Dark grayish brown, silty, fine-grained litharenite with minor quartz and white to dark green speckled bleached circular spots ranging from 1 mm to 1 cm in diameter. The rock size is 1 x 6 x 5 cm.

Sample ME 23/4. Jacobsville sandstone. Light gray, fine-to medium-grained, subangular to well rounded quartz litharenite. The rock is generally well sorted but individual layers include very coarse clasts up to 9 cm in diameter of milky quartz, mafic igneous rocks and cherty banded iron formation. Other clasts include ferruginous clay rip-up clasts. Sample size is 8 x 12 x 20 cm.

Sample ME 23/5. Jacobsville sandstone. Light gray, medium-to coarse-grained, angular to well-rounded quartz arenite. Sample size is 2 x 4 x 6 cm.

Sample ME 23/6. Jacobsville sandstone. Light gray medium to coarse grained angular to well rounded quartz arenite, well sorted with a few larger clasts to 3 mm in diameter. Sample size is 4 x 5 x 9 cm.

Sample ME 23/7. Jacobsville sandstone. Light gray, medium-to coarse-grained quartz litharenite. Poorly sorted, individual clasts are angular to well rounded. Greenish weathering mica is prevalent in bedding planes.

Sample ME 23/8. Jacobsville sandstone. Light brown red to light gray mottled, fine-to coarse-grained quartz litharenite. Poorly sorted, individual clasts are angular to well rounded. Greenish weathering mica is common in bedding plains. Sample size is 6 x 8 x 10 cm.

Stop 24 Type area of the Nonesuch shale. East of a bridge over the Iron River on Michigan Highway 107 at Silver City, Michigan. September 30, 1985.

Sample ME 24/1. Nonesuch shale. Very dark gray, muddy siltstone having a conchoidal fracture. Approximately 25 pieces in a ziploc bag.

Sample ME 24/2. Nonesuch shale. Very dark gray, muddy siltstone having a conchoidal fracture.

Sample ME 24/3. Nonesuch shale. Very dark gray, muddy siltstone. Conchoidal fracture.

Sample ME 24/4. Nonesuch shale. Very dark gray, muddy siltstone. Conchoidal fracture.

Sample ME 24/5. Nonesuch shale. Very dark gray, muddy siltstone. Conchoidal fracture.

Sample ME 24/6. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal to bedding planes. Sample size is 5 x 9 x 17 cm.

Sample ME 24/7. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal across bedding planes. Sample size is 3 x 6 x 14 cm.

Sample ME 24/8. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal across bedding planes. Sample size is 3 x 6 x 12 cm.

Sample ME 24/9. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal across bedding planes. Sample size is 2 x 10 x 6 cm.

Sample ME 24/10. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal across bedding planes. Sample size is 2 x 12 x 18 cm.

Sample ME 24/11. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal across bedding planes. Sample size is 2 x 8 x 12 cm.

Sample ME 24/12. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal across bedding planes. Sample size is 1 x 5 x 16 cm.

Sample ME 24/13. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal across bedding planes. Sample size is 1 x 5 x 14 cm.

Sample ME 24/14. Nonesuch shale. Dark gray to black to dark grayish green, argillaceous siltstone. Fracturing conchoidal across to bedding planes. Sample size is 3 x 6 x 11 cm.

Stop 25 Exposure of "unnamed (rhyolite) formation". Eight miles south of White Pine, Michigan on Highway 64. September 30, 1985

Sample ME 25/1. "unnamed (rhyolite) formation". Brick red colored, rhyolite porphyry. Phenocrysts include pink feldspars and clear quartz. Sample size is 4 x 8 x 10 cm.

Stop 26 exposure of Freda sandstone and Nonesuch shale Porcupine Mountain State Park on the west side of the park the Presque Isle Unit. October 1, 1985.

Sample ME 26/1. Freda sandstone. Dark grayish brown, silty litharenite. Fine grained. Micas are obvious on the bedding plane. Sample size is 3 x 9 x 11 cm.

Sample ME 26/2. Freda sandstone. Gray, silty litharenite. Mica on the bedding planes and some apparent ripple marks present on the upper and lower surfaces. Sample size is 2 x 10 x 18 cm.

Sample ME 26/3. Freda sandstone. Gray, silty litharenite Mica on the bedding planes and some apparent ripple marks present on the upper and lower surfaces. Sample size is 2 x 10 x 10 cm.

Sample ME 26/4. Freda sandstone. Gray, silty litharenite. Mica on the bedding planes and some apparent ripple marks present on the upper and lower surface. This sample is oriented and appears to be graded with finer siltier beds at the top and the bottom, only a couple of mm thick. Sample size is 3 x 9 x 12 cm.

Sample ME 26/5. Freda sandstone. Gray, silty litharenite. Mica on the bedding planes and some apparent ripple marks present on the upper and lower surface. This sample is oriented and appears to be graded with fine sediments at the top and bottom. Sample size is 3 x 6 x 10 cm.

Sample ME 26/6. Freda sandstone. Medium brown, silty, well rounded, fine grained sandstone. Horizontally laminated to ripple cross-laminated with thin clay drapes and thin clay clasts. Thin beds, generally 1-2 mm maximum thickness. Clays and silt beds range from 1-3 mm in thickness and are often brownish or greenish in color. Sample size is 6 x 7 x 8 cm.

Sample ME 26/7. Nonesuch shale. Medium-green gray, argillaceous to silty sandstone. Micaceous, no bedding apparent. Sample size is 3 x 7 x 11 cm.

Sample ME 26/8. Nonesuch shale. Medium brown to iridescent black, argillaceous, sandy siltstone. Micaceous with pyrolusite coatings on many of the fracture surfaces. Ziploc bag with 3 samples.

Sample ME 26/9. Nonesuch shale. Dark brown to a very dark brown, fine grained litharenite. Micaceous, with ripple cross-laminated silty layers. One of the surfaces is fractured with a diamond shape fracture pattern (by desication?). Pyrolucite coatings on this surface are very abundant. Sample size is 1 x 8 x 20 cm.

Sample ME 26/10. Nonesuch shale. Medium gray to green, shaly micaceous, siltstone. Fracture along bedding planes is irregular to conchoidal, evidence of mud cracks is present in upper surface. Sample size is 2 x 20 x 25 cm.

Sample ME 26/11. Nonesuch shale. Dark gray micaceous siltstone. Horizontally laminated with conchoidal fracture and shale interlaminae, This piece is very irregular in shape and includes some iron staining along fractures. Sample size is 5 x 8 x 14 cm.

Stop 27 Exposure of Portage Lake volcanic group and interflow clastics. The Montreal River Hydro Project, on the Montreal River on Iron County, Wisconsin Road B, 2 miles north of Hwy 2 just east of Saxon, Wisconsin. October 1, 1985.

Sample ME 27/1. Portage Lake volcanic group interflow clastic. Dark reddish brown, poorly sorted, fine- to coarse-immature litharenite. The rock is dominantly composed of lithic fragments some up to .5 cm in diameter. Minor components include fine to medium feldspar and quartz grains. Sample size is 4 x 6 x 6 cm.

Sample ME 27/2. Portage Lake volcanic group interflow clastic. Dark reddish brown, fine to medium grained, silty litharenite. Sample size is 1 x 8 x 9 cm.

Sample ME 27/3. Portage Lake volcanic group interflow clastic. A dark reddish brown, very silty, litharenite. Sand grains are dominantly fine- to very coarse-grained. The rock is cross-laminated. Lithic rock fragments are the major component with some feldspar and quartz. Clay clasts ranging up to 1 cm in diameter and are distributed along bedding planes. One side of the speciment displays slickensides. Sample size is

Stop 28 Exposures of the "unnamed (rhyolite) formation," Portage Lake volcanic group, Copper Harbor conglomerate, Nonesuch shale and Freda sandstone. Copper Falls State Park located on the Bad River 2 miles north of Mellen, Wisconsin. One sample was collected at this site by Berendesen and Barczuk. October 1, 1985.

Stop 29 Exposures of Portage Lake volcanic group and Orienta sandstone. Amnicon State Park located on U.S. Highway 2, five miles south of Superior, Wisconsin. October 1, 1985.

Sample ME 29/1. Orienta sandstone. An iron red to buff banded fine-to medium-grained, moderately well-rounded to well rounded quartz arenite. Horizontally laminated, cement is white clay. Sample size is 2 x 8 x 9 cm.

Sample ME 29/2. Orienta sandstone. An iron red to buff banded, fine-to medium-grained, moderately well-rounded to well rounded quartz arenite. Cement is white clay. Sample size is 2 x 6 x 8 cm.

Sample ME 29/3. Orienta sandstone. An iron red to buff banded, fine-to medium-grained, moderately well-rounded to well rounded quartz arenite. Cement is white clay. Sample size is 2 x 5 x 5 cm.

Sample ME 29/4. Orienta sandstone. Rusty red, white mottled conglomerate from near the fault zone. The matrix is fine-to coarse-grained fairly well sorted sandstone, dominantly quartz and rock fragments. Coarse clasts range in size from 1/2 cm to 6 cm and are dominantly volcanic rock fragments but also include some chert, rhyolite, and quartz. The conglomerate is matrix supported. Sample size is 5 x 9 x 15 cm.

Sample ME 29/5. Orienta sandstone. Rusty red, white mottled conglomerate from near the fault zone. The matrix is fine to granular, fairly

well-sorted sandstone. Dominantly quartz and rock fragments. Coarse clasts range in size from 1/2 cm to 6 cm, and are dominantly volcanic rock fragments, but also include some chert and quartz. The conglomerate is matrix supported. Sample size is 6 x 10 x 15 cm.

Sample ME 29/6. Orienta sandstone. Rusty red, white mottled conglomerate from near the fault zone. The matrix is composed of fine to granular sandstone, composed dominantly of quartz and rock fragments. Coarse clasts range in size from 1/2 cm to 6 cm, and are dominantly volcanic rock fragments, but also include some chert, possibly sandstone, and quartz. Clasts are angular to subrounded. The conglomerate is matrix supported. Sample size 5 x 8 x 18 cm.

Sample ME 29/7. Orienta sandstone. Buff to iron-red mottled, fine to coarse grained , subangular to subrounded sandstone. Coarse clasts form beds approximately 1 cm thick. Sample size is 5 x 12 x 17 cm.

Sample ME 29/8. Orienta sandstone. Light brick red, white mottled, fine- to medium-grained, angular to well-rounded litharenite. Oriented sample from fault zone with vertical beds. The sample size is 6 x 8 x 18 cm.

Sample ME 29/9. Douglas Fault gouge. Brecciated basalt with zeolite and calcite vein filings. Two samples in zip-lock bag.

Stop 30 Exposures of Portage Lake volcanic group and Orienta sandstone. Pattison State Park. Eight miles south of Superior on Wisconsin Highway 35 and the Black River.

Sample ME 30/1. Orienta sandstone. Buff colored, medium to coarse grained, subround to subangular, well sorted quartz arenite with liesegang banding. Some feldspar and rock fragments, cement appears to be clay. This is an oriented sample. Sample size is 9 x 12 x 16 cm.

Sample ME 30/2. Orienta sandstone. A light brick red, well-sorted, angular to well-rounded, quartz arenite, with some rock fragments and feldspar grains. The sample size is 6 x 7 x 8 cm.

B. Description of Exposure Samples Collected by Pieter Berendsen and Andrzej Barczuk

Stop 1

Samples 1a and 1b - Chengwatana volcanic group. A dark reddish brown, vesicular basalt (diabase ?) with white calcite veins up to 1.5 cm thick. The rock contains numerous, small (up to 1.0 cm in diameters) vesicles, which are filled with pink zeolites and/or green chlorites. Vesicles make about 20% of the rocks. Samples size 5x4x4 cm and 6x6x4 cm.

No conglomerate beds were observed as reported by C. Craddock (1972, Geology of Minnesota).

Stop 2

Samples 2a and 2b - Hinkley sandstone. Bedding massive in lower 40-60 ft., upper part beds 4-6 ft thick. A pink to beige, fine grained, well rounded to angular sandstone. Locally - yellowish brown laminae. Few intraclasts of light pink shales up to 3x5 cm. The rock often contains brown cementation zones. Samples size 10x10x8 cm and 9x7x5 cm.

Stop 3

Sample 3a - Hinkley sandstone. A yellowish brown, fine grained, with abundant of dark brown, ferruginous, irregular veins and spots, up to 0.5 cm thick. Very poor cemented (soft). Sample size 4x3x3 cm.

Stop 4

Sample 3b - Hinkley sandstone. A yellowish brown, fine grained, poorly cemented sandstone with few dark brown laminae up to 1 cm thick, that are much better cemented and coarser grained then the rest part of the rock. Samples sizes 4x4x2 cm.

Stop 5

Hinkley formation. No samples were collected by P. Berendsen and A. Barczuk.

Stop 6

Sample 4a - Nopeming sandstone ("Quartzite"), close to the contact with the overlying Ely Peak basalt. Laminated siltstone. Alternating laminae are very dark gray to light tan. They are irregular, often disrupted and from 0.1 to 2.0 cm thick. A single laminae, about 2 mm thick, in contact with the overlying Ely Peak basalt, is black, as the basalt itself. Away from the contact the laminae become gradually lighter colored. Sample size 10x8x5 cm.

Sample 4b - Nopeming sandstone. Gray quartzite (formerly - sandstone), medium to coarse grained, contains some small (up to 0.5 cm) pebbles of

white quartz and grayish green, brownish black metamorphosed rocks. Locally - round shaped, pinkish gray structures (load structures?, concretions ?), up to 1.0 cm in diameter, which sometimes formed single layers. Sample size 8x8x6 cm.

Sample 4c - Nopeming sandstone. Light grayish, very coarse grained quartzite (formerly - conglomerate), with abundant of white and milky quartz pebbles up to 5.0 cm in diameter. The pebbles are pretty well rounded. Matrix is gray sand with several greenish, small spots, about 1 mm in diameter, which are probably chlorites. Sample size 10x7x7 cm.

Sample 4d - Ely's Peak basalt. Black, aphanitic, featureless, very hard basalt. Sample size 4x4x3 cm.

Stop 6a

Samples 5a and 5b - Thompson formation. Black, slightly laminated, very well cemented metasiltstone, which includes locally very dark gray, lense shaped, carbonate concretions up to 10.0 cm in diameter. The lamination wihin the concretions is much coarser then in surrounding rock. Samples size 6x5x3 cm and 5x4x4 cm.

Stop 7

Sample 6a - Fond du Lac formation. Dark reddish, fine grained, slightly laminated, not very well cemented sandstone. Alternating darker and lighter laminae are up to 0.1 cm thick. Sample size 9x8x7 cm.

Sample 6b - Fond du Lac formation. Greenish gray, fine grained sandstone with abundant reddish brown, clayey intraclasts, which are up to 0.4 cm thick and up to 2.0 cm long. The rock includes locally lenses, bands and intercalations of dark reddish brown mudstones. Sample size 6x5x5 cm.

Sample 6c - Fond du Lac formation. Gray, fine to medium grained sandstone with abundant green, clayey intraclasts. Locally the rock is interbedded with thin (up to 1.0 cm) laminae of green claystones, similar to those that form intraclasts (intraformational erosion). Sample size 5x5x4 cm.

Stop 8

Sample 7a - Fond du Lac formation. Light reddish brown, medium to coarse grained, slightly laminated sandstone. Locally - graded beds with a few very coarse grained laminae up to 1.5 cm thick. The white spots visible on the surface of the rock are probably altered feldspars. Sample size 6x5x5 cm.

Sample 7b - Fond du Lac formation. Reddish brown, medium grained sandstone with several white and beige, irregular spots up to 12.0 cm in diameter. The boundaries of these spots are sharp. Sample size 8x7x5 cm.

Sample 7c and 7d - Fond du Lac formation. Intraformational conglomerates - yellowish gray, very poor sorted, sandy, with an abundance of gray,

brown and white, medium to well rounded pebbles up to 5.0 cm in diameter and with several reddish brown clayey intraclasts up to 10.0 cm long. Samples size 10x8x8 cm and 7x6x4 cm.

Stop 9

Sample 8 - Thompson formation. Gray blueish green shales (slates) with few milky quartz veins up to 1.5 cm thick. Sample size 4x4x2 cm.

Sample 8a - Thompson formation. Greenish blueish gray, discoidal, carbonate concretion. The size of the concretions in the exposure varies between 2.0 cm and 50.0 cm. Sample size 9x9x4 cm.

Sample 8b - Fond du Lac formation; Basal Conglomerate. Gray blueish gray and/or greenish gray (on the fresh, wet surface - light green), very poorly sorted conglomerate. Locally - the surface has the yellowish stains. Matrix is a poor sorted sandstone. There are a few pyrite concretions within the conglomerate. The pebbles are differentiated: mainly milky quartz and gray cherts(?) fragments, but also a lot of other rock fragments, including a few greenish shale clasts, probably derived from the underlying Thompson formation. The pebbles are medium to well rounded, up to 20.0 cm in diameter. Sample size 12x10x9 cm.

Sample 8c - Fond du Lac formation; Basal Conglomerate. As above, but with small pyritic concretions. About 5 small pieces in plastic ziplock bag.

Sample 8d - Fond du Lac formation; Basal Conglomerate. Blueish gray, medium grained, poorly cemented, sandy conglomerate. The pebbles are up to 2.0 cm in diameter. Sample size 8x7x7 cm.

Stop 9a

Sample 9 - North Shore volcanic group. A dark reddish brown, vesicular basalt porphyry. Vesicles make up more the 30% of the rock. They are filled with pink minerals (zeolites? clay minerals?). The rock includes few intraclasts of dark reddish brown, slightly laminated mudstones. These intraclasts reach up to 15.0 cm in length. Sample size 8x8x87 cm.

Stop 10

Sample 10a - Chequamegon sandstone. White to buff, fine to medium grained, poorly cemented, laminated sandstone with reddish spots (relicts of former color). Sample size 6x5x5 cm.

Sample 10b - Chequamegon sandstone. Typical for this exposure, reddish to brick red, slightly laminated sandstone. Fine to medium grained, rounded to angular, rather poor cemented. Sample size 8x6x5 cm.

Stop 11

Sample 11 - Devils Island sandstone. Reddish orange, fine grained, well sorted, very slightly laminated, poor cemented sandstone. Sample size 15x12x10 cm.

Stop 12

Sample 12a - Orienta sandstone (Bayfield group). White gray medium grained, well sorted, delicate laminated sandstone with few laminae of reddish brown claystone. Poor cemented. Sample size 6x5x3 cm.

Sample 12a - Orienta sandstone. Red, fine grained sandstone with abundant of dark reddish brown, clayey intraclasts up to 10.0 cm long. The rock is locally interbedded with few, dark red mudstone and/or yellowish brown, medium grained sandstone laminae up to 1.0 cm thick. Sample size 8x7x5 cm.

Sample 12c - Orienta sandstone. Purple reddish brown, fine grained, well sorted, slightly laminated, well cemented sandstone. The rock includes locally few laminae of medium grained sandstone. Sample size 5x4x4 cm.

Stop 13

Sample 13 - Chequamegon sandstone. Dark reddish to dark reddish brown, medium to very coarse grained, very poor sorted sandstone with some beds rich with well rounded pebbles up to 2.0 cm in diameter. The pebbles are represented mainly by white grayish and milky quartz and brown chert fragments. The rock includes locally relatively large (up to 3.0 cm long), sharp edged intraclasts of dark reddish, fresh looking, soft and sticky clay. Sample size 12x10x9 cm.

Sample 13a - Chequamegon sandstone. Same as 13, but much poorer sorted, with several pebbles and granules of differentiated size, shape and color. Sample size 9x8x6 cm.

Stop 14

Sample 14a - Freda sandstone. Very dark reddish brown, fine to coarse grained, poorly sorted and friable sandstone, with some thin conglomerate layers. Locally - graded bedding is present. Grains, granules and pebbles are angular. Some beds include abundant dark brown, clayey intraclasts. The rock contains a variety of rock fragments and feldspars; quartz is minor component. Sample size: two pieces 8x7x3 cm.

Sample 14b - Freda sandstone. Dark brown, brecciated, fine grained, friable and poorly cemented conglomerate. The pebbles up to 0.5 cm (max. - 1.0 cm) are represented by dark brown fragments of volcanic rocks, feldspars and other types of rocks. Quartz and cherts are minor components. Sample size: four pieces about 4x4x3 cm in plastic, ziplock bag.

Sample 14 c - Freda sandstone. Red to reddish brown, very poorly sorted, locally brecciated, coarse to very coarse grained, friable, conglomeratic sandstone. Granules and pebbles up to 1.0 cm are represented by brownish volcanic rock fragments, claystones, feldspars an quartz. Matrix is sandy, locally with white spots of secondary calcite cement. Sample size 8x6x4 cm.

Stop 15

Sample not found.

Stop 16

Sample 16a - Freda sandstone. Dark red, medium to coarse grained, poorly sorted, well cemented sandstones with a few sharp edged, dark reddish brown, clayey intraclasts up to 3.0 cm. Samples size 8x7x7x cm.

Sample 16b - Nonesuch shale. Dark gray, fine grained, delicate laminated, very well cemented, micaceous sandstone (litharenite). Sample size 5x5x4 cm.

Sample 16c - Nonesuch shale. Dark gray, very fined grained, shaly, very well cemented sandstone (litharenite). The rock includes variable rock fragments, micas, feldspars, and minor quartz. Sample size 4x4x2 cm.

Stop 17

No samples were taken.

Stop 18

Sample 17 - Portage Lake volcanic group. Black, massive, very hard basalt. Locally - fault structures. Sample size 5x4x4 cm.

Stop 19

Sample 18a - Copper Harbor conglomerate. Dark reddish brown, sandy, calcite cemented, poorly sorted. Locally - graded bedding is present. Pebbles up to 15.0 cm in diameter are medium to well rounded. They are represented mainly by very dark reddish and brown volcanic rock fragments, feldspars and by milky quartz. The rock includes locally mud-clayey layers, lenses and laminae as well as clayey intraclasts up to 6.0 cm. Sample size 15x12x10 cm.

Sample 18b - Copper Harbor conglomerate. Dark reddish brown, poorly sorted, conglomeratic sandstone, which includes scattered pebbles of volcanic rocks up to 5.0 cm in diameter. Locally conglomerate layers. Sample size 7x7x5 cm.

Stop 19a

Sample 19 - Copper Harbor conglomerate. Very dark reddish, poorly sorted conglomerate, with a sandy, locally calcite cemented matrix. Pebbles up to 8.0 cm in diameter are represented by volcanic rock fragments, quartzites, cherts and quartz. Sample size 11x10x8 cm.

Stop 20

Sample 20 - Portage Lake volcanics. Purple brown vesicular basalt. Vesicles up to 0.3 cm in diameter make about 25% of the rock and are filled with greenish chlorite and white calcite. Small, up to 0.2 mm

thick, veins are filled with calcite and/or epidote. Sample size 4x4x3 cm.

Stop 21

Sample 21 - Jacobsville sandstone. Brecciated, dark brown, fine grained, massive sandstone. Sample size 5x4x2 cm.

Stop 22

Sample 22a - Jacobsville sandstone. Cream white, medium to coarse grained, poorly sorted sandstone. The rock includes few, greenish, clayey intraclasts up to 3.0 cm long and one brown black, triangle shaped fragment of phosphatic (?) rock, about 0.5 cm long. Sample size 12x12x10 cm.

Sample 22b - Jacobsville sandstone. Dark reddish, very fine grained, laminated sandstone with an abundance of scattered, small (about 1.0 cm) spots, probably weathered feldspars. Sample size 8x6x5 cm.

Stop 23

Sample 23a - Jacobsville sandstone. White gray, medium to coarse grained, poorly sorted (locally - conglomeratic) sandstone. The rock includes a few medium to poorly rounded pebbles of quartz up to 5.0 cm in diameter. Sample size 7x7x6 cm.

Sample 23b - Jacobsville sandstone. Grayish white, medium to coarse grained sandstone, with reddish, irregular spots and layers. The rock includes a few medium to well rounded pebbles of milky quartz. Sample size 6x5x5 cm.

Sample 23c - Jacobsville sandstone. Dark reddish to gray, mottled, medium grained, poorly sorted sandstone, with a few quartz pebbles up to 1.0 cm in diameter. The rock includes also some flat clayey intraclasts up to 5.0 cm long. Locally - the pebbles reach 10.0 cm in diameter. Sample size 10x8x7 cm.

Sample 23d - Jacobsville sandstone. This sample consists of a number (about 20) of the pebbles collected along the entire exposure, which is at least 300 m long. The pebbles are medium to well rounded fragments of white to gray quartz, quartzites and cherts, up to 15.0 cm in diameter. Locally such pebbles form individual layers.

Stop 24

Sample 24a - Nonesuch shale. Dark blueish greenish gray, muddy, very slightly laminated siltstone. Locally - intersecting sedimentary structures, like very small (about 1x2 cm) erosional channel, filled with fine grained sand. Sample size 7x6x4 cm.

Sample 24b - Nonesuch shale. Dark blueish greenish gray siltstone, interbedded with beige creamy mudstone. The mudstone layers and laminae are irregular, often lense shaped, up to 0.5 cm thick. They often inter-

finger with siltstones laminae. Sample sizs 8x8x5 cm.

Stop 25

Sample 25 - "Unnamed rhyolite volcanic formation." Pinkish red rhyolite porphyry with small (up to 0.2 cm) phenocrysts of pink feldspars, black mafin minerals and clear quartz. Sample size 5x4x4 cm.

Stop 26

Sample 26a - Freda sandstone. Dark reddish brown, massive, well cemented mudstone, which locally includes lenses and spots of grayish, fine grained sandstone. Sample sizes 7x7x6 cm.

Sample 26b - Nonesuch shale. Reddish gray, slightly ripplecross laminated, muddy siltstone with greenish, irregular spots. Sample size 10x6x2 cm.

Stop 27

Sample 27a - Portage Lake volcanic group. Dark brown, vesicular basalt. The vesicles make up to 20% of the rock. They are filled with white calcite, greenish chlorite and pinkish ziolite (?) and they are up to 1.5 cm in diameter. Sample size 9x8x6 cm.

Sample 27b - Portage Lake volcanic group with interflow clastics. Very dark gray, almost black, massive basalt, in contact with dark reddish, very fine grained, slighly cross laminated sandstone. Sandstone includes several small (up to 0.2 cm in diameter), irregular, white spots and veins. The basalt includes irregular xenoliths of reddish mudstones up to 1.5 cm in diameter. Sample size 12x10x10 cm.

Stop 28

Sample 28 - the transition zone between Copper Harbor sandstone and Nonesuch shale. Dark brownish red, medium grained, pretty well sorted sandstone with an abundance of very dark reddish, clayey intraclasts up to 2.0 cm long, having sharp edged, irregular shapes. They are probably fragments of broken clayey laminae. Sample size 8x8x7 cm.

Stop 29

Stop 29a - Orienta sandstone. Pink reddish, medium to coarse grained, poorly sorted, well cemented sandstone with a few white spots and a few dark reddish, clayey intraclasts. Sample sizse 8x8x7 cm.

Stop 29b - Orienta sandstone. White grayish, coarse grained, poorly cemented, conglomeratic sandstone with sandy matrix. Locally - graded bedding is present. Coarse clasts range up to 1.0 cm in diameter and consist of volcanic rocks, cherts, and quartz fragments. Sample size 9x7x6 cm.

Stop 29c - Portage Lake volcanic group; Douglas Fault Gouge. Reddish black, massive basalt with xenoliths of very dark reddish, slightly

metamorphosed mudstones. Sample size 8x6x5 cm.

Stop 30

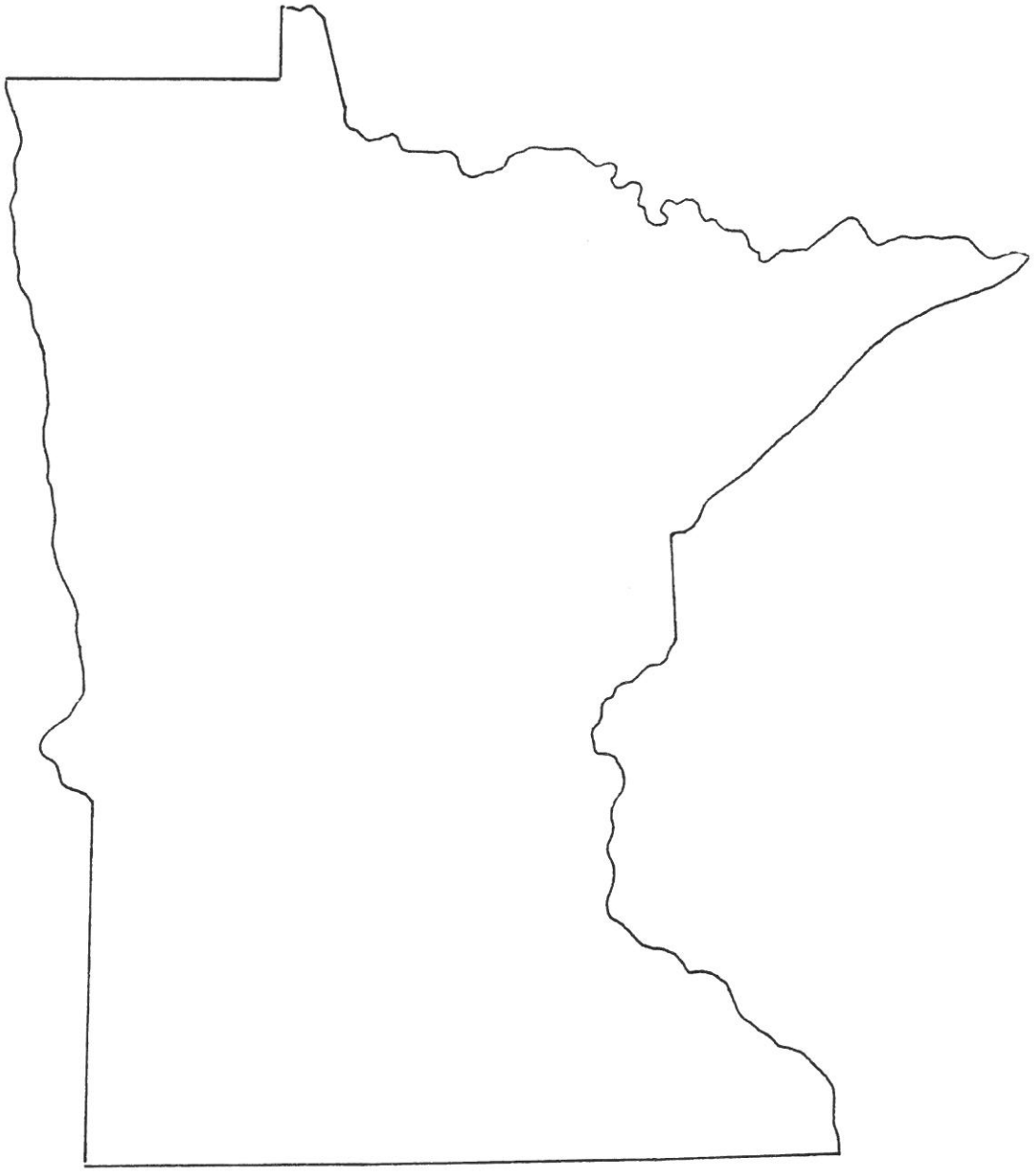
Stop 30a - Orienta sandstone. Pink reddish, fine grained, well sorted, laminated sandstone. Laminae are from 0.1 to 1.2 cm thick and differ in colors and grain size (the darker ones are finer grained). Locally - a few white grayish, medium grained, sandy laminae. The rock is rather poorly cemented. Sample size 10x9x7 cm.

Stop 30b - Orienta sandstone. Light pinkish, medium grained, well sorted, delicately laminated sandstone with a few, dark reddish, clayey intraclasts up to 0.3 cm long. The rock is poorly cemented. Sample size 8x8x6 cm.

APPENDIX II

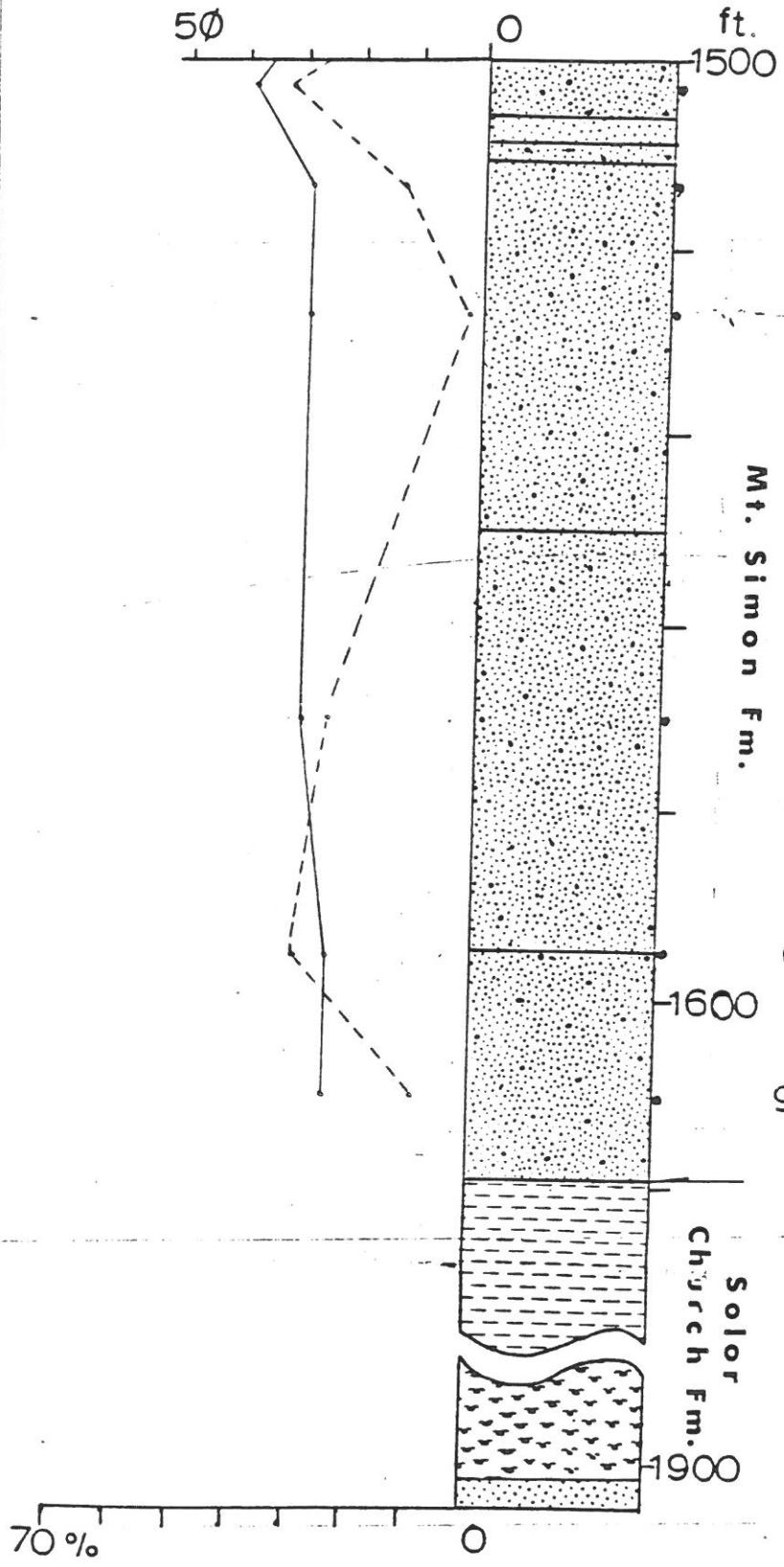
Well Logs, Sample Descriptions, and Scout Tickets from selected wells in the subsurface of Minnesota, Iowa, Nebraska, and Kansas

Minnesota Information



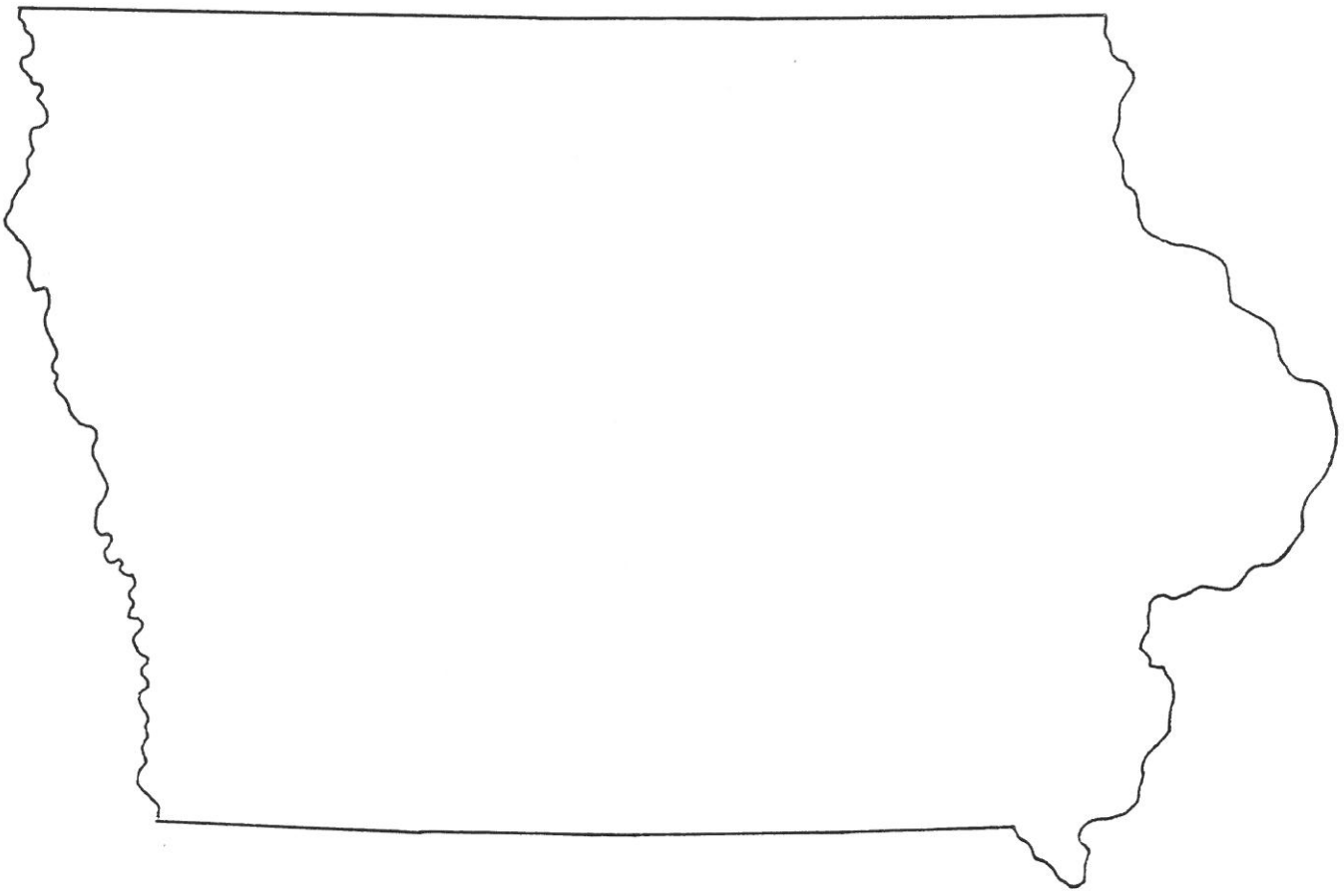
Hollandale #1

Freeborn Co.



Q	F	C	G	M
58	28	1	—	2
81	12	1	—	5
94	2	2	—	—
60	20	—	—	—
68	28	—	—	4
91	9	—	—	—

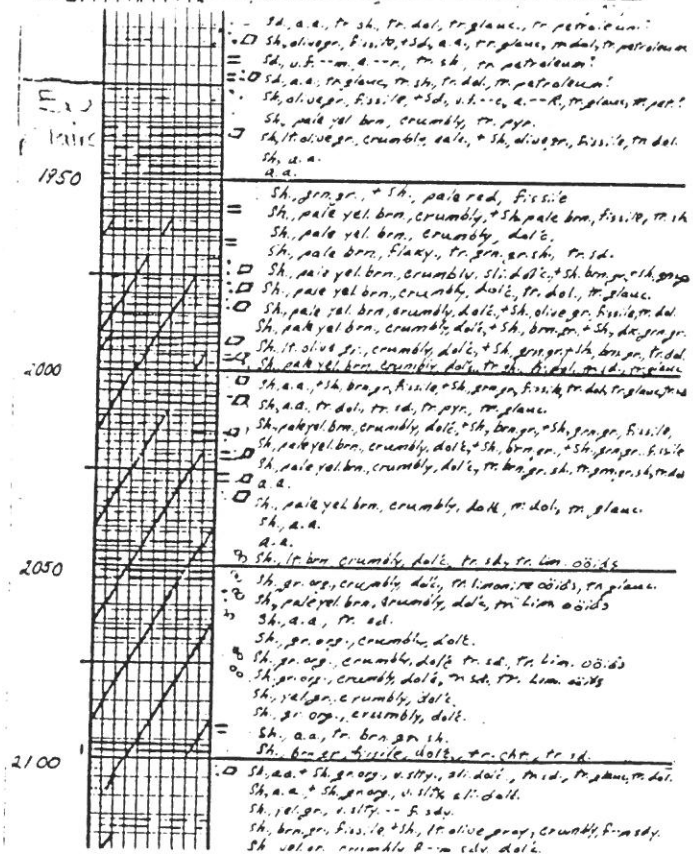
Iowa Information

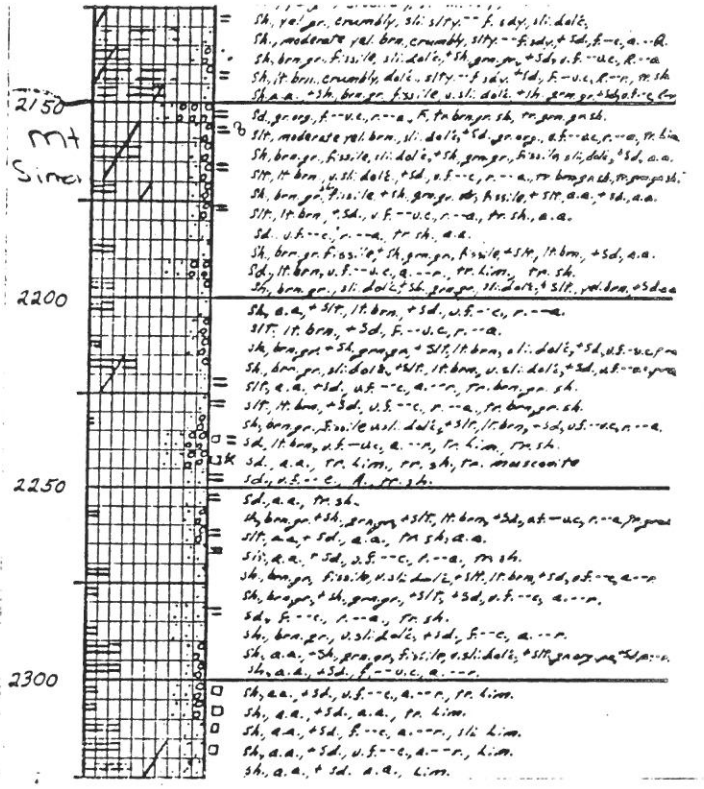


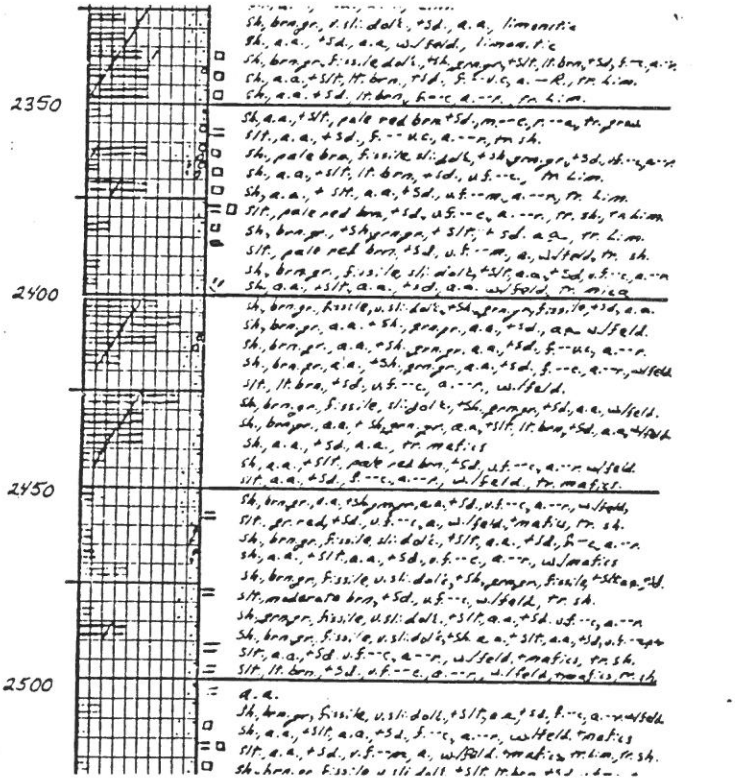
W-14428

FORM NO. 79—In stock and for sale by Ross-Martin Co., Tulsa.

STATE Iowa	New Hartford (Butler)
SW, NE NE	W. C. Schaper #1 Huntley Oil Test
SEC. 15	
TWP. 90N, RGE. 15W	COMMENCED 5-7-63 COMPLETED
X 15	CASING RECORD 137'7" of 8" I.D, 425' of 6" I.D (recovered) 1561' of 5" I.D (358' recovered) 2110' of 4" (2046' recovered)
	LOGGED 3-8-82 BY Curtis R. Klug
El. 896' (Alt.) T.D.: 3595'	REMARKS Relog of E section
	relog from 1400' to T.D.

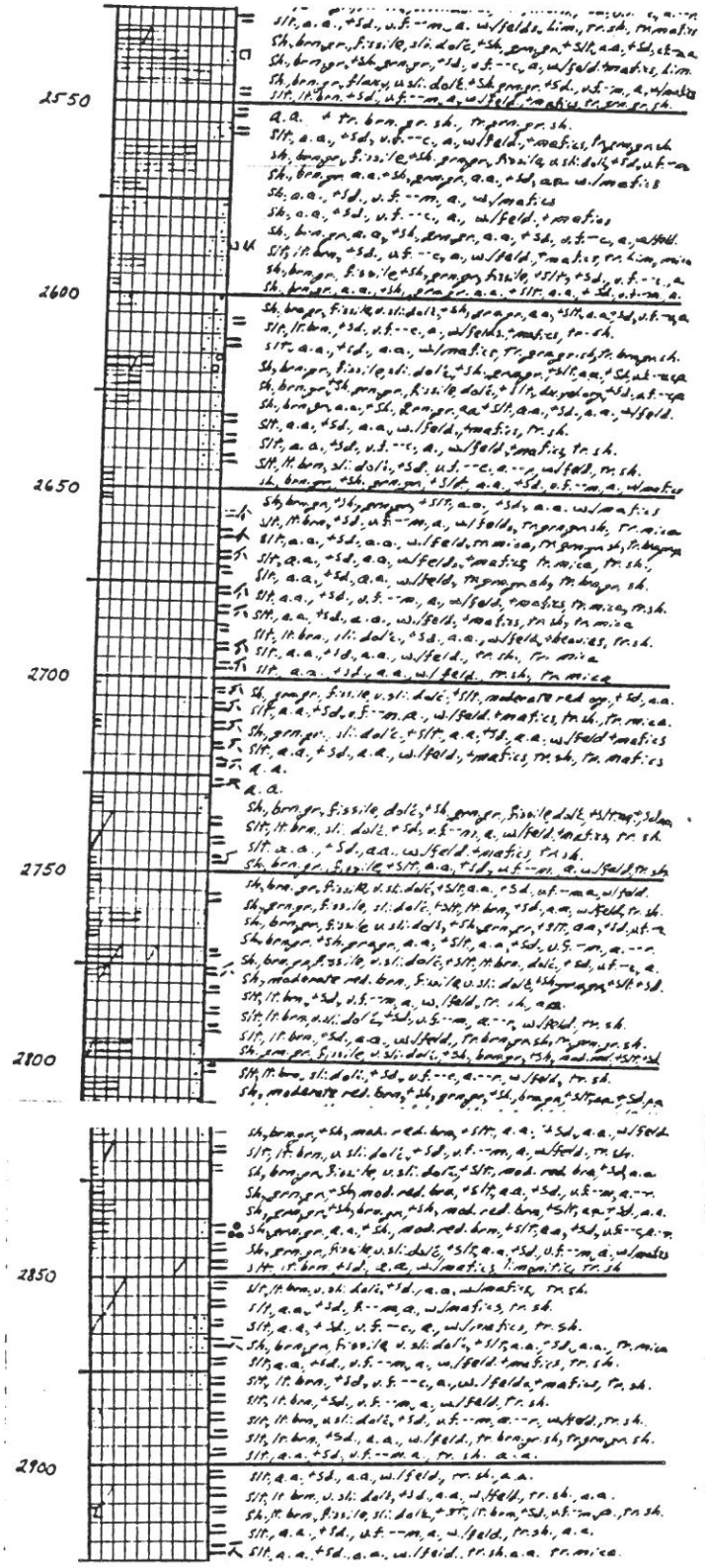


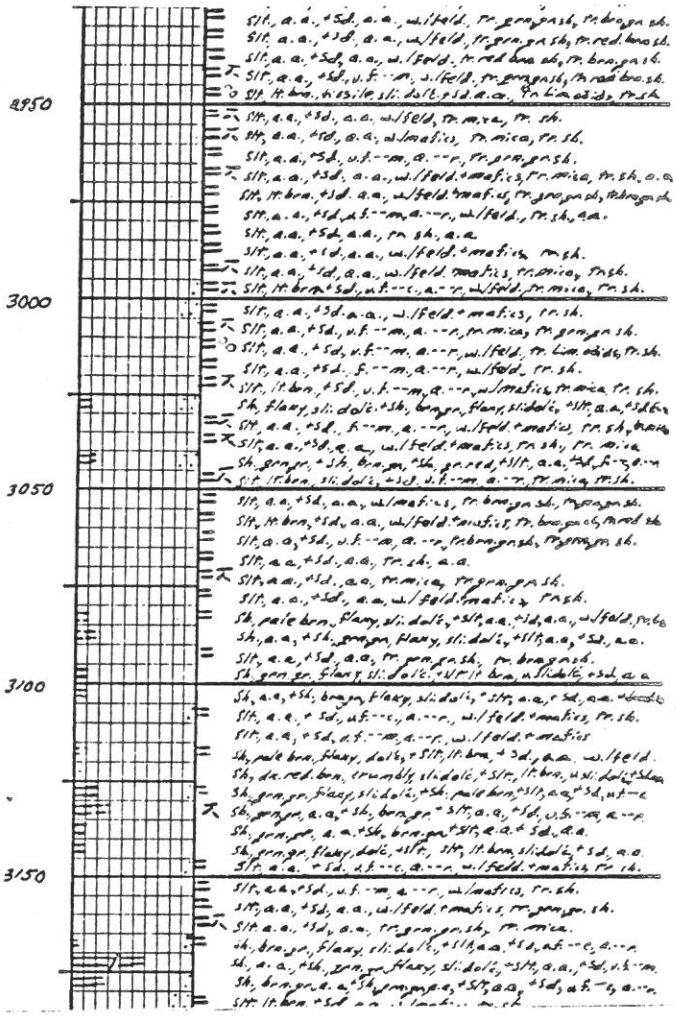


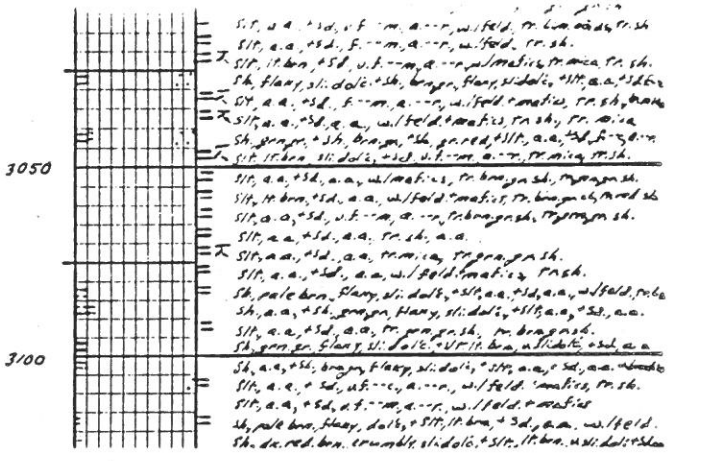


#1 Hunley

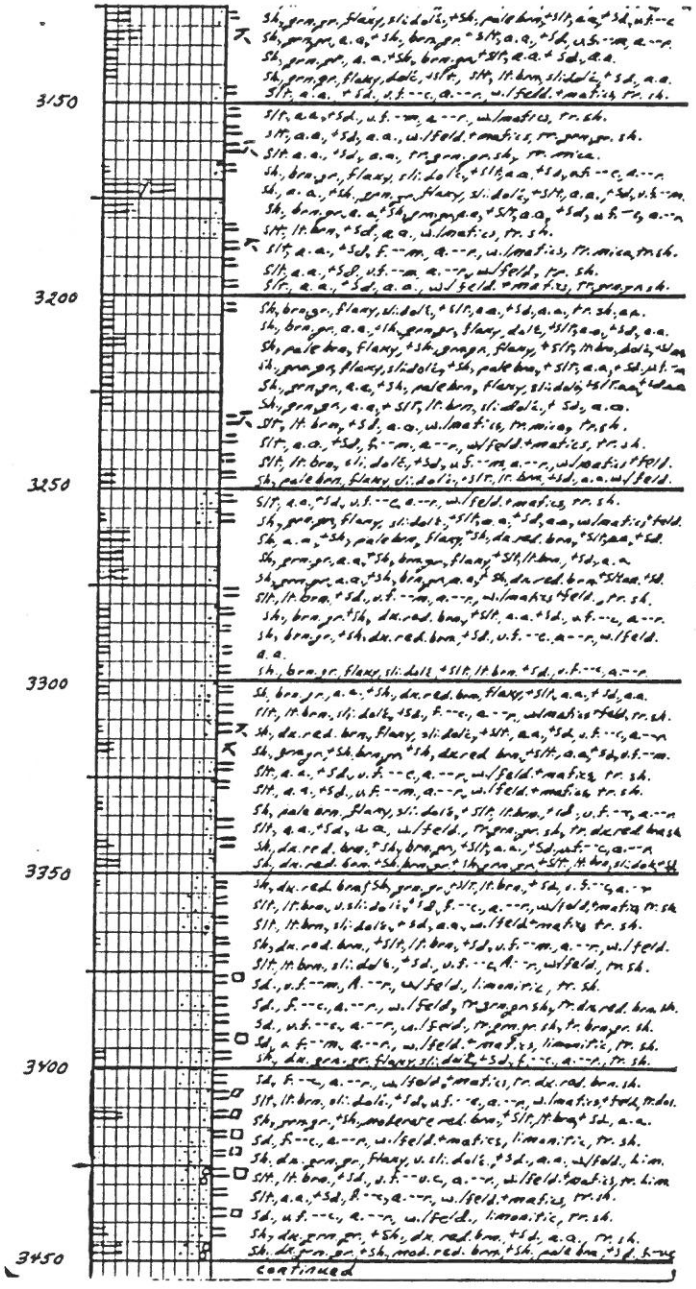
p. 2

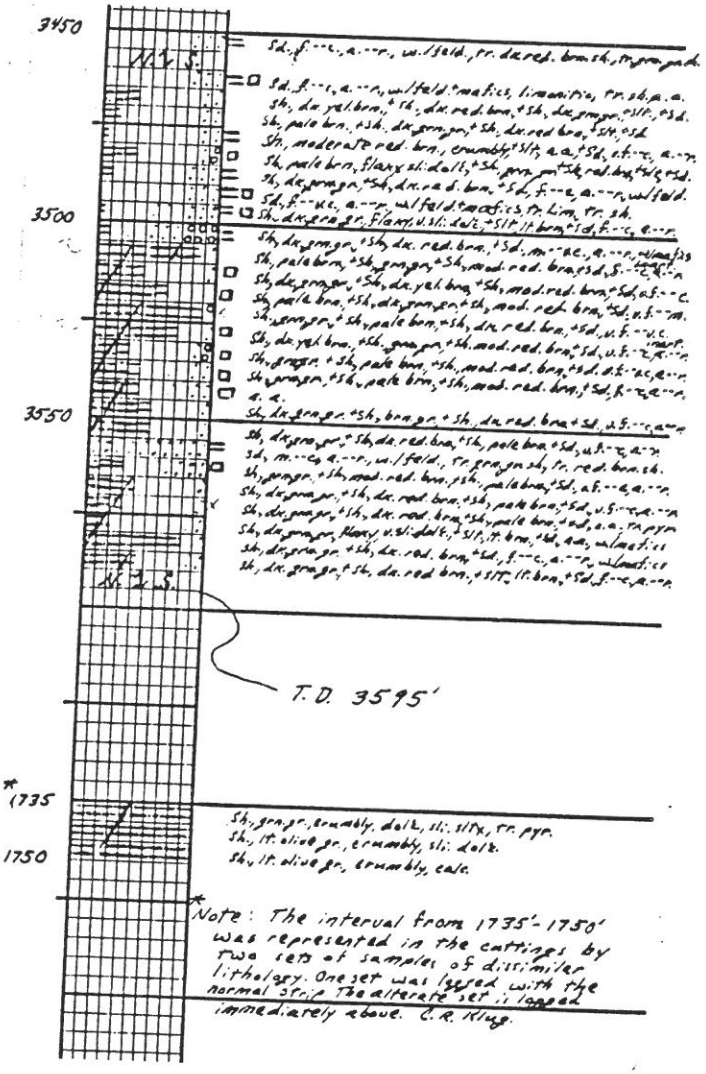

2550
2600
2650
2700
2750
2800
2850
2900


2950
3000
3050
3100
3150


3050
3100

#1 Huntley
p 3.





Note: The interval from 1735'-1750' was represented in the cuttings by two sets of samples of dissimilar lithology. One set was logged with the normal strip. The alternate set, logged immediately above. C.R. Klug.

FORM NO. 79—In stock and for sale by Ross-Martin Co., Tulsa. W-26115

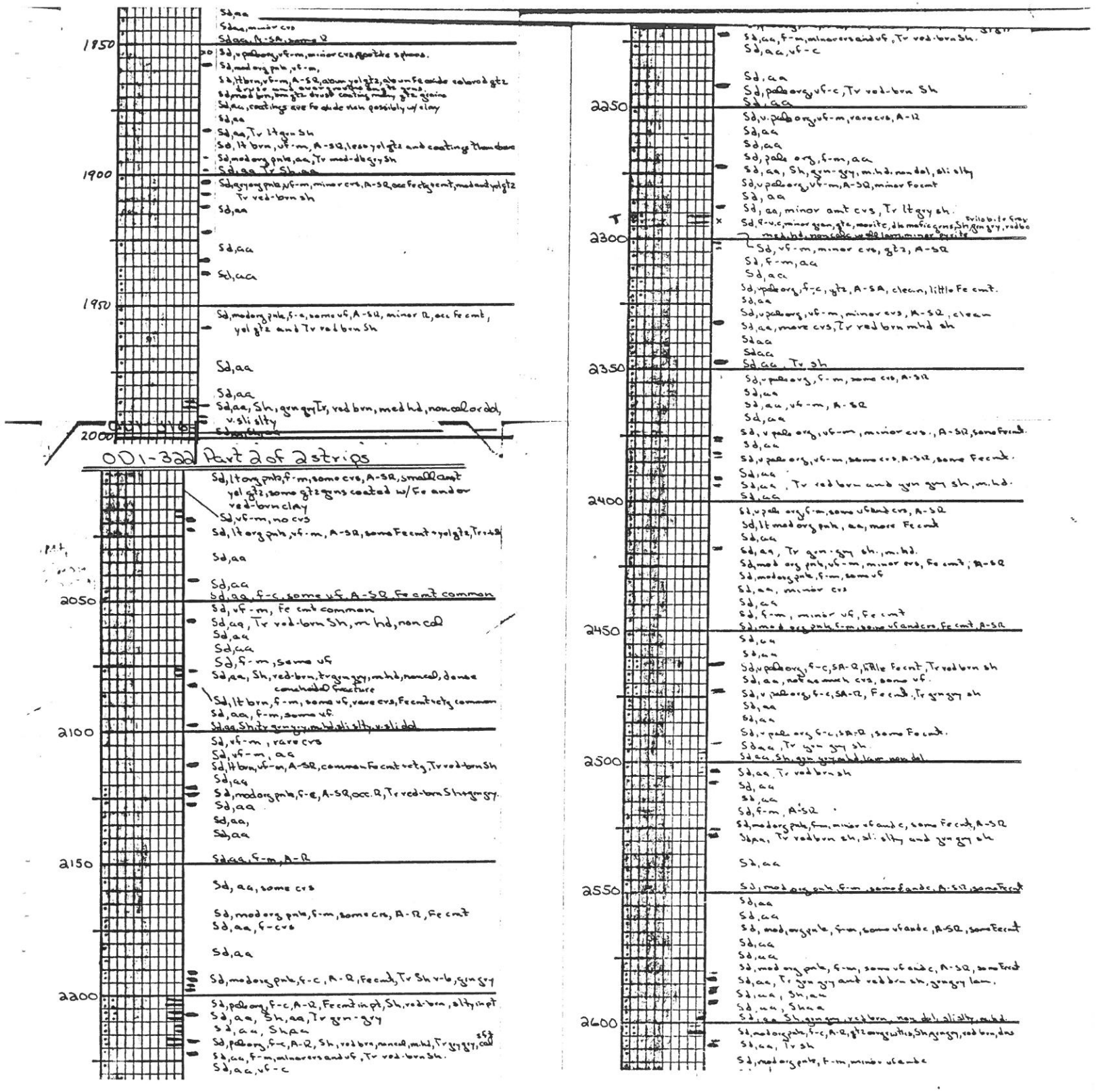
STATE IOWA	Green Island (Jackson)
SE, NE, SW, NE	USGS - RASA
SEC. 29	
TWP. 85N RGE. 6E	COMMENCED 12/ /1980 COMPLETED 1/ /1981
	Layne-Western
	CASING RECORD
	LOGGED Jan 1981 BY B. J. Witzke and R.M. McKay
EL--610'	REMARKS
T.D. 2672.8'	Cuttings 0'-2667', Core 2667'-2672.8'

Geophysics Run

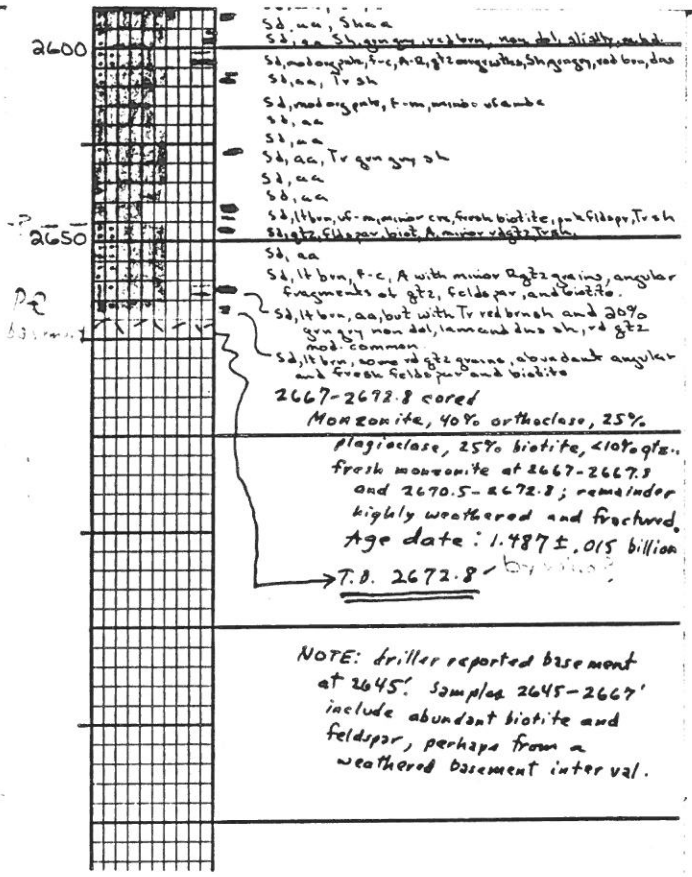
Sd, f-m, some vf, SR-R, frstd, Tr red brn and lt grn sh
Sd, aa, Sh, aa
Sd, vf-m, aa, Sh, aa
Sd, vf-m, aa, Sh, aa
Sh, dk grn gry, sli dol, m hd, dns, lam, sli slty in pt, Tr r b sh
SS, v lt gry, vf-f, sli slty, dol, glau, Sh, aa, Tr red brn sh
SS, aa, Sltst, v lt gry, sli sdy, dol, glau, Sh, aa, inart brach
SS, aa, Sltst, aa, Sh, aa
1300 SS, v lt gry, dol, glau, vf-m, sltst, v lt gry, f sdy, dol, glau, inart brach
SS, f-c, aa interlam w/ sh, Sh, aa, Tr Dol and pyrite
SS, v lt gry, f-c, mostly m, SR-R, dol, glau, also loose sand, Sltst, Sh, aa
Sd, qtz, f-c, SR-R, frosted, glau, Sh, med lt gry and red brn, dolo
Sd, SS and Sh, aa, dol
Sd, v lt gry, qtz, vf-m, some crs, Tr gry and red brn Sh.
Sd, aa, Tr Sh, aa, sli glau
Eau Claire Sd, aa, Sh, aa
Sd, v lt gry, qtz, vf-m, some crs, SR-R, Sh, red brn gry grn, gry
Sd, aa, Tr Sh
Sd, aa, some vf & crs, Sh, micaceous
1350 SS and Sd, lt brn gry, f-c, mostly m., sli glau, v dol, Sh, aa
Sd, and SS, aa
SS, and Sd, v. lt gry, vf, glau, dol, and vf-c, loose qtz, Sh, lt grn gry
Sltst, pale yel brn, f sdy, glau, dol, interlam w/ Sh, med dk gry, SS, vf-m
Sltst, pale yel brn, f sdy, dol, interlam w/ Sh, gray red, sli dol, SS vf-m micaceous
Sltst, aa, Sh, aa
Sd, qtz, vf-m, Sltst, aa, Sh, grey red, med gry, dol, lam.
Sd, qtz, vf-m, SR-R, frstd, glau, Sh, varicolored, dol, lam.
Sd, aa, Sh, aa, Sd has common FeO cement
Sd, vf-m, qtz, SR-R, frstd, glau, Tr Sh, aa
1400 Sd, aa, Tr Sh, aa
Sd, aa, Fe oxide stng, coating and cement, Tr Sh, aa
Sd, qtz, loose, vf-m, SR-R, frstd, Fe coatings, Sh, aa
Sd, aa
Sd, aa, gry org pnk
Sd, aa
Sd, gry org pnk, qtz and feldspar?, abundant Fe coating
Sd, aa, some feldspar grns, unidentifiable fos fragments
Sd, aa
Sd, aa, Tr abraded fossil debris, noncalcareous, prob. shell ...
1450 Sd, v lt pale gry, vf-m, SR-R, frosted, loose qtz, Tr red brn sh
Mt Simon Sd, aa
Sd, aa, minor amount crs.
Sd, aa, iron stng and partial cmt.
Sd, aa
Sd, aa, sli dol where cmt., Tr Sh, red brn
Sd, aa, Tr lt grn and red brn Sh
Sd, aa
Sd, v lt tan, vf-m, minor crs, SR-R, frstd, v sli dol where cmtd
Sd, aa
1500 Sd, v pale org, vf-m, sli dol, SA-R, frstd, Tr Sh and Dol
Sd, aa, less vf, some crs.
Sd, aa, more vf
Sd, v pl org, vf-m, SA-R, frstd in pt, Tr red brn Sh
Sd, aa, iron stng and partial cement
Sd, aa

Sd, aa
1500 Sd, v pale org, vf-m, sli dol, SA-R, frstd, Tr Sh and Dol
Sd, aa, less vf, some crs.
Sd, aa, more vf
Sd, v pl org, vf-m, SA-R, frstd in pt, Tr red brn Sh
Sd, aa, iron stng and partial cement
Sd, aa
Sd, aa
Sd, aa, some crs, Tr Sh, red brn, [illegible], Sltst, tan
Sd, aa
Sd, aa
1550 Sd, aa
Sd, v pale org, vf-m, some crs, SA-R, frosted in pt, Tr Sh
Sd, aa, Sh, gry grn to med gry, lam, sft, nondol, v sli slty
aa, tr dol sltst, lt tan
Sh, lt grn gry, sli glau, Sd, aa.
Sd and Sh, aa
Sd, aa, Tr red brn and gry sh
Sd, aa
Sd, aa, Tr Sh
Sd, aa
1600 Sd, v pale org, vf-m, SA-R, frosted in pt, Fe stng & cmt in pt.
Sd, aa, some crs
Sd, aa
Sd, aa
Sd, aa, Sh, red-brn, med gry, hd & sft, nondol.
Sd, aa, Tr Sh
Sd, aa, Sh, med gry, Tr red-brn Sh.
Sd, v pale org, vf-m, some crs, SA-R, frstd, Fe cmt in pt, Sh, r-b, gry grn
Sd, aa, Sh med lt gry, r-b, v sli dol, gry is micaceous
1650 Sd, aa, Tr Sh
Sd, aa, Tr Sh
Sd, aa, minor amt crs, scattered Fe cmt
Sd, aa, Sh, aa
Sd, aa, minor amt crs, scattered Fe cmt
Sd, aa
Sd, aa, Sh, gry grn, dense, mod hd. nondol.
Sd, aa, Sh, aa, sli slty in part
1700 Sd, aa, minor crs, Fe stng & cement, Sh, aa
Sd, aa, Sh, red brn & gry grn, m. hd, interlam to mottled, slty lam. in pt non dol
SS & Sd, v pale org, vf-c, v sli dol, SA-R, Fe stng & cmt, Dol, tr, v lt brn gry, arg., Sh, aa, Sltst, v. dol, v pale gry
Sd, aa, mostly loose, Dol, v. arg & slty, lt gry grn, Sh, r-b, dk gry
Sd, vf-c, v lt pale org, some Fe stng & cmt, SA-R, Sh-red-brn, Tr silty dol.
Sd, v pale org, vf-m, Sh red-brn, Tr, silty Dol, v lt brn gry
Sd, aa, Sh, red-brn, med gry, lam, m.hd-sft, non dol.
1750 Sd, mod org pnk, f-c, mostly m, A-R, frstd in pt, some Fe stng
Sd, aa, Tr red brn and med gry sh.
Sd, aa, little crs, some Fe stng as grain coatings
Sd, aa, Sh, lt grn gry, fissile, dol, sft
Sd, mod org pnk, vf-m, some crs, blk pyrite spheres, Sh, lt ol gry, hd, sli glau
Sd, aa, Sh, red-brn, sli grn mott, v sli dol
Sd, aa, A-SR
Sd, aa
Sd, v pale org, vf-c, m. dom., [illegible]
Sd, aa, goethite spheres common
1800 Sd, v pale org, vf-c, A-R, Fe stng, Tr red brn sh
Sd, aa
Sd, aa
Sd, v pale org, f-m, A-SR, Fe stng & cmt, Tr Sh
Sd, vf-m
Sd, aa
Sd, v pale org, vf-m, A-SA, Fe stng & cmt
Sd, aa
Sd, aa
Sd, aa, minor crs
Sd, aa, Tr SR, some R
1850 Sd, v pale org, vf-m, minor crs, goethite spheres.
Sd and org pnk, vf-m,
Sd, lt brn, vf-m, A-SR, abun yel qtz, abun Fe oxide colored qtz & rose and overgrowths on qtz grns.
Sd, pink brn, [illegible] qtz. drusy coating many qtz grains
Sd, aa, coatings are Fe oxide rich possibly w/ clay
Sd, aa
Sd, aa, Tr lt grn Sh
Sd, lt brn, [illegible]

USGS - RASA
Green Island
p. 2



USGS - RASA
Green Island
p. 3



In stock and for sale by Mid-West Prtg. Co., Tulsa W-2971

STATE: Iowa	Mason City (Cerro Gordo)
N.E. 1/4 SE 1/4 NE 1/4 SE 1/4	Mason City Well #12
SEC. 16	
TWP. 96 N RGE. 20W	COMMENCED July 7, 1947 COMPLETED
	Layne-Western Co., Inc.
	CASING RECORD 10' of 30" curbing 0'-10'; 145' of 20" pipe 0'-145' cem. in 26" hole; 22' of 18" pipe 793'-815' 147.5' of 14" pipe 732'-879.5'; Open 12 1/2" hole 879'-1377
	LOGGED February 9, 1948 BY R.W.
Elev. 1165.4 DC 1163.9 L.S.	REMARKS SWL 175
1577	PDL 207 @ 1356 gpm
	rec'd cut & chart
CT-1	[illegible]

1400

Dol, crm, aa.

Ls, crm, gr mot, f-m, w glauc.; Sh, gr-gn w mica specks

Dol, crm, f; Ls, gr & brn mot w glauc.

Tr. L, Ls.

Ls, a.a., little wh. chlky.

Sh, some soft calc.

Dol, gr, brn gran, silty w abun. glauc; Sh, gr w mica + cinne. specks

Sd, gr. brn, mot. w abun. glauc.

Ls, bf. wh. L + bf silty w glauc.; Sh, bf w glauc

Ls, wh. chlky + brn. mot. m. w glauc.

€E Dol + Ls wh-brn, f-m, w glauc.; Sd. fst. sR.

Dol, bf, m, w glauc.

Dol, bf, brn mot, c.

1500

Sd, clr. + frst. + yel, A-R.

Mt. Simon

Sd, clr, frst, gr, yel., s A-sR.

€

Ss. w dol. cem., gr.

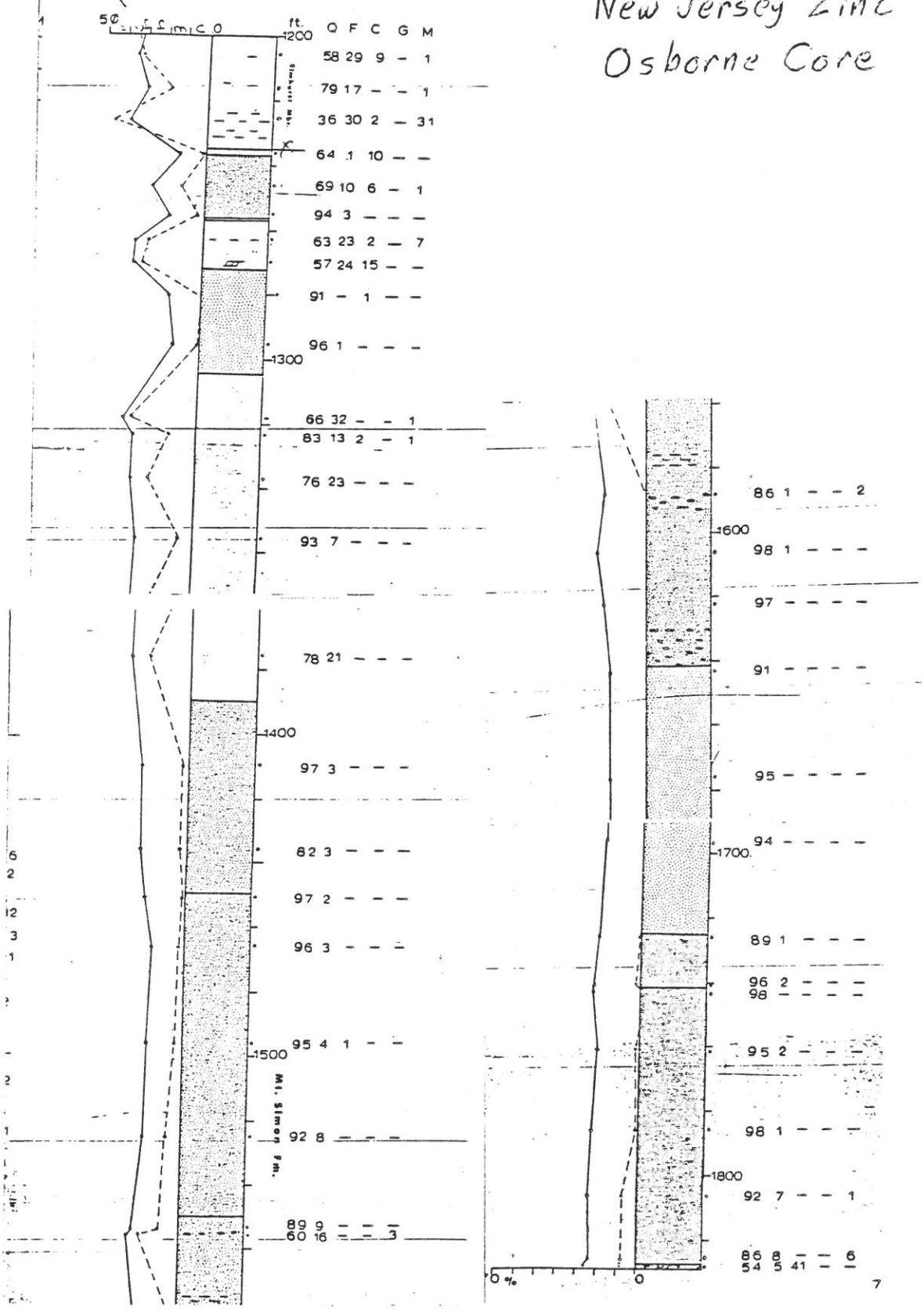
Ign., red ngrn.

P€ Ign., dk, basic.

1600

Clayton Co

New Jersey Zinc
Osborne Core



LOUISA COUNTY, IOWA

NATURAL GAS PIPELINE COMPANY, T. FRIIS, M,-1, T75N, R5W, SECTION 12, SE¼, NE¼, SW¼, 3½ INCH CORE. DESCRIPTION SUPPLEMENTED WITH DESCRIPTIONS FROM ANDREW FLURKEY'S THESIS (1976). CORED INTERVAL FROM 2142.0 to 2563.0' T.D.

EAU CLAIRE FORMATION

2142.0-2228.0' Sandstone, pink to gray, very fine grained, subangular, moderately well sorted, sparsely fossiliferous (brachiopods), micaceous, with interbedded shale, gray-green to dark-gray, very thinly to thinly bedded, planar to wavy bioturbation absent to moderate. T.S. at 2227 and 2226.

MT. SIMON FORMATION

2228.0-2240.0' Sandstone, buff to tan, medium to coarse grained, subrounded, poorly sorted, with interbedded shale, gray-green, thin, wavy. Contact gradational. T.S. at 2236.

2240.0-2245.5' Sandstone, pink to red, medium to coarse grained, subrounded, poorly sorted with interbedded shale, red, very thin, planar. Contact gradational. T.S. at 2241.

2245.5-2248.5' Sandstone, white, medium to coarse grained, subrounded, moderately well sorted, with interbedded shale, red, thin, wavy. Contact gradational.

2248.5-2270.0' Sandstone, white to red, medium to coarse grained, subrounded, poor to moderate sorting, locally cross-bedded, zones of small scale faulting, with interbedded shale, red, thin, planar to wavy. Contact gradational.

2270.0-2278.0' Sandstone, white to pink, fine grained, subrounded, moderate sorting, cross-bedded at base. Contact gradational. T.S. at 2275.

2278.0-2279.0' Sandstone, white to pink, medium to coarse grained, subrounded, poorly sorted. Contact gradational.

2279.0-2299.0' Sandstone, white to pink, very fine to fine grained, subrounded, moderately well sorted, with interbedded siltstone and shale, red. Contact sharp.

2299.0-2300.0' Shale, red brown to green, micaceous. Contact sharp.

2300.0-2306.0' Sandstone, buff, fine to medium grained, subrounded, moderately well sorted, cross-bedded. Contact gradational. T.S. at 2300.

2306.0-2354.5' Sandstone, buff, fine to medium grained, locally coarse grained, subrounded, moderately well sorted, coarser fractions more poorly sorted, cross-bedded, some shaley zones, gray green, very thin, wavy. Contact gradational. T.S. at 2340, 2330, 2321 and 2310.

2354.5-2355.0' Sandstone, buff, coarse grained, subrounded, moderate to poor sorting. Contact sharp.

2355.0-2359.5' Sandstone, tan, very fine grained, subrounded, moderately well sorted, with interbedded shale, gray, thin to medium (±1"), planar to wavy. Contact gradational. T.S. at 2359 and 2355.

2359.5-2376.5' Sandstone, buff, medium to coarse grained, subrounded, poor to very poor sorting, large scale cross-beds. Contact gradational. T.S. at 2367.

2376.5-2385.3' Sandstone, buff, fine to medium grained, locally coarse grained, subrounded, moderate to poor sorting with interbedded shale, dark gray, thin to medium (±3"), planar to wavy. Contact gradational. T.S. at 2379.

2385.3-2402.0' Sandstone, buff, fine to medium grained, locally coarse to very coarse grained, subrounded, moderately well sorted, coarser fraction poorly sorted, large scale cross-beds. Contact gradational. T.S. at 2397.

2402.0-2405.0' Sandstone, buff, fine to medium grained, subrounded, moderately well sorted, locally interbedded with shale, gray to dark gray, thin, planar to slightly wavy. Contact gradational.

2405.0-2407.5' Sandstone, buff, fine, subrounded, moderately well sorted, cross-bedded. Contact sharp.

2407.5-2413.0' Shale, gray, micaceous, very sandy near top. Contact sharp.

2413.0-2450.0' Sandstone, buff to pink, fine to coarse grained, locally very coarse grained, subrounded to subangular, poorly sorted, coarser fraction more poorly sorted, large scale cross-beds. Contact gradational. T.S. at 2443 and 2415.

2450.0-2453.0' Sandstone, gray, very coarse grained, subangular, moderately well sorted. Contact gradational.

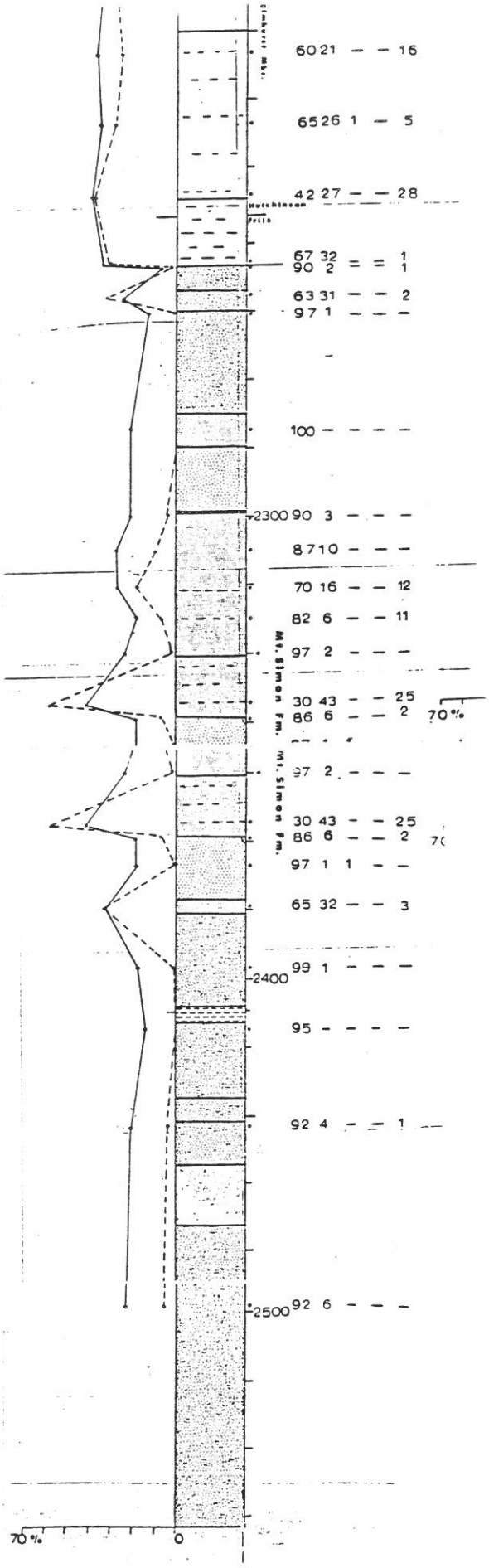
2453.0-2454.5' Sandstone, white to pink, fine to very fine grained, subrounded, moderately well sorted, contact gradational.

2454.5-2455.0' Sandstone, gray, very coarse, subangular, moderately well sorted. Contact gradational.

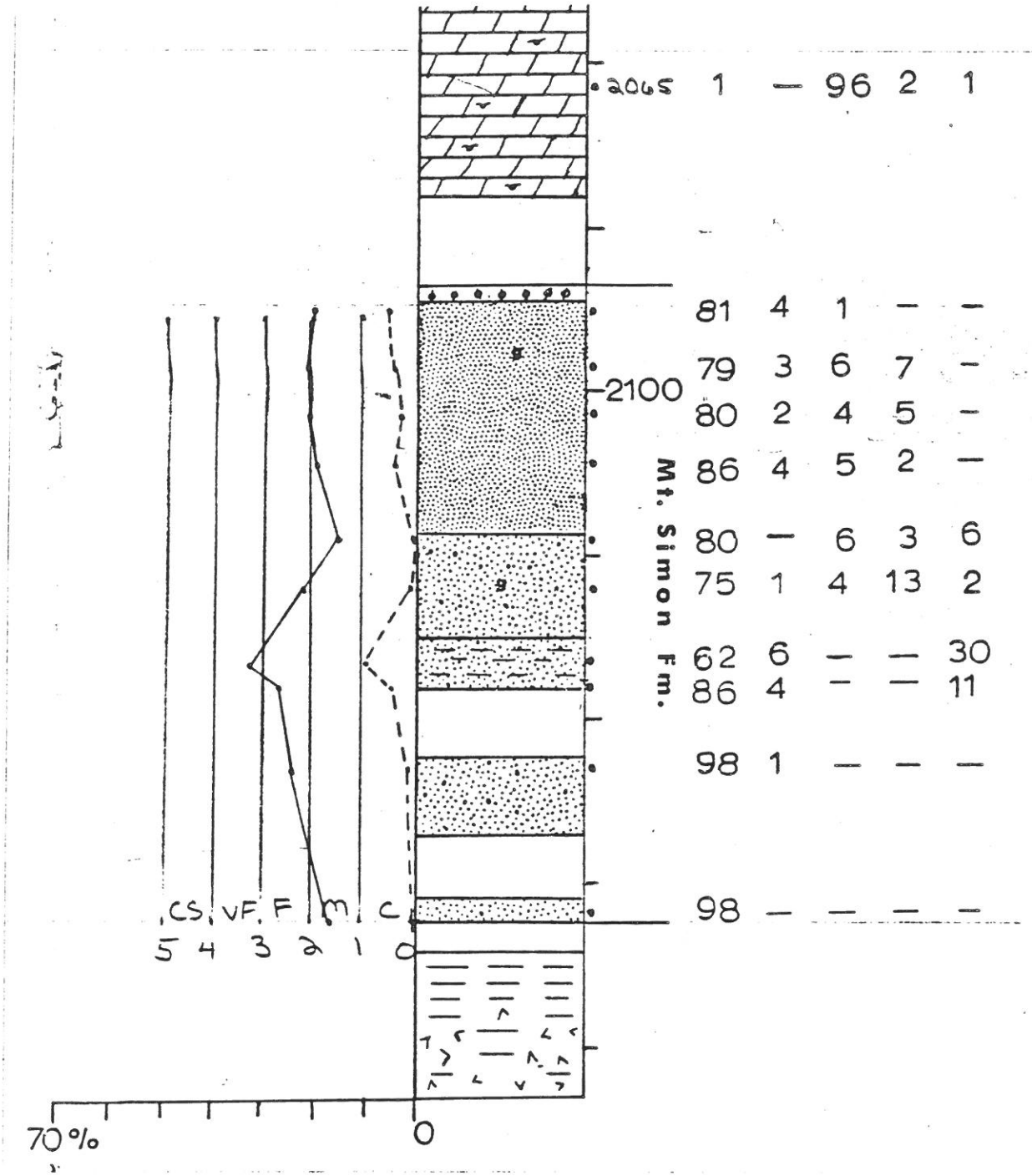
2455.0-2563 Sandstone, white to pink, fine to very fine grained, subrounded, moderately well sorted, medium to large scale cross-bedding, liesegang banding. T.S. at 2498.

End of core.

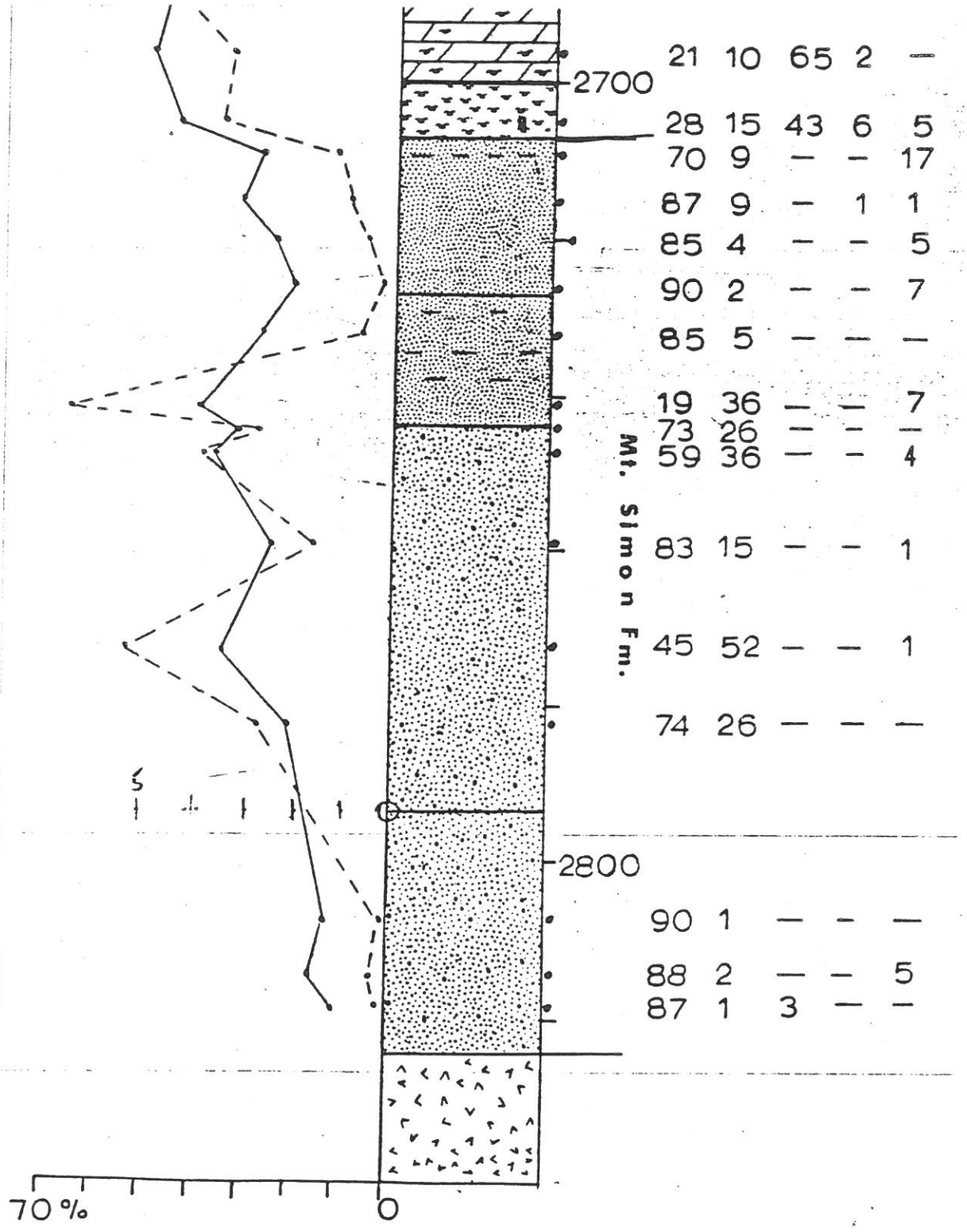
Friis M-1


Upper Mt. Simon Fm.
Middle Mt. Simon Fm.
Lower Mt. Simon Fm.
Eau Claire Fm.
Hutchinson
Friis
2300
2400
2500
70%
0

Peterson #1


2065
2100
Mt. Simon Fm.
1 — 96 2 1
81 4 1 — —
79 3 6 7 —
80 2 4 5 —
86 4 5 2 —
80 — 6 3 6
75 1 4 13 2
62 6 — — 30
86 4 — — 11
98 1 — — —
98 — — — —
CS VF F m C
5 4 3 2 1 0
70%
0

Nelson #1 (very similar to Hummel #1)



NORTHERN NATURAL GAS COMPANY, B. LEHMAN #1, DALLAS CO., IOWA 1971, SW NW NW SEC. 18 T79N R27W. ELEVATION: 900' K.B., 890' G.L. CORED INTERVAL DESCRIPTION 2567'-2964' T.D., DEPTHS IN FEET. DESCRIBED BY RANDY PARKINSON, AUGUST 1981.

BONNETERRE FORMATION

Upper Member

2567.5-2583.7' Interlayered dolostone and shale: dolostone, gray-green, finely crystalline, thinly laminated to medium bedded, parallel to wavy, very silty, slightly glauconitic; shale, dark gray, thinly laminated to medium bedded, parallel to wavy, fissile; horizontal burrows, with dolostone in fill (as above) within shale. 0.3' of dolomitic limestone at 2583.0'. Trough cross-bedding from 2575.0' to 2576.0'. T.S. at 2567.5'. Contact gradational.

2583.7-2589.0' Shale, dark green to dark gray, silty at top, dolomitic. Abundant trilobite fragments, sparse brachiopods. Contact gradational.

2589.0-2590.0' Intraclastic conglomerate; intraclasts light gray, glauconitic limestone, cobble size, randomly orientated; matrix light gray limestone, shaley, glauconitic. Contact gradational.

2590.0-2594.0' Shale, light green to dark green, calcareous. Mottled light gray dolostone, glauconitic, from 2591.0' to 2592.0'. Intraclasts, dolomitic, glauconitic, cobble size at 2592.0'. Contact gradational.

2594.0-2115.0' Interlayered limestone intraclastic conglomerate and shale: limestone conglomerate gray to gray-green; medium laminated to medium bedded; intraclasts are limestone, fine to very finely crystalline, cobble size, very sparsely fossiliferous (brachiopods), slightly glauconitic, silty; matrix, microsparite, fossiliferous (brachiopods, trilobites), glauconitic, dolomitic, slightly silty; shale, dark gray, thinly laminated to medium bedded, dense, fossiliferous (brachiopods). Intraclasts randomly oriented in greater than thin beds, horizontal within less than thin beds. Stylolites between 2604.5'. Limestone conglomerate appears mottled due to variance in carbonate grain size. T.S. at 2601.0' and 2604.0'. Contact gradational.

2615.0-2623.5' Shale, gray-green dense, with 0.3' of interlaminated limestone, light gray-green, glauconitic, medium, wavy at 2616.7'. 0.1' limestone intraclastic conglomerate within shale at 2617.0'. Shale surrounding the conglomeratic zone is calcitic. Contact gradational.

2623.5-2628.0' Limestone, light gray, very fine grained to coarse grained interbeds, thin to medium; coarser layers very fossiliferous (trilobites, echinoderms), silty, with micrite pellets; finer fraction sparsely fossiliferous (brachiopods), both are glauconitic. Interlaminated shale, dark green, very thin to medium, parallel to wavy, silty, scattered throughout. T.S. at 2627.0'. Contact gradational.

2628.0-2629.0' Shale, dark green, dense, with interlayered limestone lenses, light gray, fine grained. Contact gradational.
2629.0-2641.0' Limestone, light gray, mottled and stylolitic. Mottled appearance due to presence of micrite, microsparite and coarsely crystalline dolomite, all glauconitic. Micrite and microsparite silty and fossiliferous (trilobites, echinoderms). Interlayered shale present, medium to thickly laminated, wavy, shale also present as: 0.5' at 2636.5', 0.5' at 2638.6' and 0.4' at 2639.6'. T.S. at 2634.0'. Contact gradational.
2641.0-2642.2' Shale, dark green, dense, with scattered very thin limestone lenses at base, grading upwards into chocolate brown, fissile, fossilierous (brachiopods). Contact gradational.
2642.4-2644.5' Limestone, light gray, fine to medium crystalline, glauconitic, mottled (as above), with some limestone intraclastic cobbles. Shale interlaminae, very thin to medium, dark green, wavy, also present within limestone. Contact gradational.

Brown Shale Member

2644.5-2667.9' Interbedded dark green and chocolate brown shale, medium to thick: Dark green shale dense, containing very thin, light gray limestone nodules from 2649.0' to 2652.5'. Chocolate brown shale fissile. Also present are medium interbeds of limestone, light gray, consisting of fine to coarse grained interlaminae, thin, very fossiliferous (trilobites, echinoderms), glauconitic, coarser interlayers silty: 0.2' at 2648.0', 0.4' at 2650.0', 0.5' at 2652.5', 0.2' at 2654.0', 1.0' at 2657.5', 0.6' at 2660.0', 0.8' at 2661.0', 0.3' at 2663.0', 0.1' at 2664.0', 0.1' at 2665.0', 0.3' at 2666.0', 0.2' at 2668.0'. 0.2' of limestone, cobble intraclastic conglomerate at 2652.5'. T.S. at 2657.5'. Contact gradational.

Lower Member

2667.9-2670.0' Interlayered limestone and shale: limestone light gray, thickly laminated to parallel to lense-like, medium crystalline, fossiliferous (trilobites), glauconitic; shale, dark green, thick laminae, dense. Contact gradational.
2670.0-2674.4' Limestone, light gray, extremely fossiliferous (trilobites) and glauconitic, coarsely crystalline, with shale interlaminae, dark green, thin to medium, wavy. Contact gradational.
2674.4-2678.0' Interlayered limestone and shale: Limestone light gray, thickly laminated to parallel to lense-like, medium crystalline, fossiliferous (trilobites), glauconitic; shale, dark green, thick laminae, dense. Contact gradational.
2678.0-2698.0' Limestone, light gray, extremely fossiliferous (trilobites, echinoderms, brachiopods) and glauconitic, coarsely crystalline, slightly dolomitic, with dark green shale interlaminae, thin to medium, wavy. Shale interbeds are also present, medium, gray-green, dense, glauconitic: 0.1' at 2686.0', 0.2' at 2687.2', 0.4' at 2688.5' and 0.4' at 2690.0'. T.S. at 2681.0'. Contact gradational.

2698.0-2704.0' Interlayered limestone and shale: limestone light gray, thickly laminated to medium bedded, parallel to lense-like, fine to coarsely crystalline, glauconitic, fossiliferous (trilobites, echinoderms, brachiopods), silty, stylolitic; shale, dark gray-green, thinly laminated to medium bedded, parallel to wavy, glauconitic, silty. T.S. at 2702.5'. Contact gradational.

2704.0-2712.5' Limestone, light gray, coarsely crystalline, fossiliferous (trilobites), glauconitic, with interlaminated shale, green, very thin to thin, wavy. Limestone extremely glauconitic from 2704.0' to 2706.0'. Crosbedded at 2705.0'. Contact gradational.

2712.5-2714.0' Shale, dark gray, dense. Contact gradational.

2714.0'2717.0' Limestone, light gray, coarsely crystalline, fossiliferous (trilobites), glaucinitic, with interlaminated shale, gray, thin, wavy. 0.4' shale, brown, fissil at 2716.6'. Contact gradational.

2717.0-2718.0' Limestone, red brown, coarsely crystalline, fossiliferous (trilobites), glauconitic, hemititic. Contact gradational.

2718.0-2722.9' Interlaminated limestone and shale; limestone, thin to medium bedded, wavy to lense-like, light gray, coarsely crystalline, very fossiliferous (trilobites) and glauconitic, with limestone intraclasts, light gray, without skeletal grains or glauconite, scattered throughout (these clasts have a red-brown rind); shale, dark green, medium laminae to medium bedded, wavy, glauconitic. 0.4' dark gray shales at 2721.5'. Contact gradational.

2722.9-2788±2' Interlayered carbonate and shale: carbonate is a very silty dolostone at base, light gray to buff, fine to coarsely crystalline, medium bedded to nodular, glauconitic, grading upwards into a dolostone, light green, medium bedded to nodular, silty, sparsely fossiliferous (trilobites, brachiopods), glauconitic; shale, green, glauconitic, very thin to thinly laminated, wavy at base, grading upwards to thickly laminated to medium bedded, wavy. Horizontal burrows, absent to moderate, within shale interlayers. Boundary between shale and carbonate becomes increasingly indistinct with depth. Carbonate coarsely crystalline with large intraclastic pellets: 1.0' at 2767.5', 0.5' at 2770.5' and 0.3' at 2777.0'. Gypsum/Anhydrite, pink present at 2765.0', 2807.0' and 2809.0' as fracture fill. T.S. at 2770.5' and 2769.5'. Contact gradational.

2788.0±2-2822.0' Interlayered dolostone and siltsone: dolostone, light gray to green, medium bedded, planar, medium to coarsely crystalline, silty, glauconitic; siltstone, buff to light brown, thin to medium laminae, wavy. Very thin to thin, wavy shale laminae, dark gray becomes increasingly abundant towards top. Randomly oriented cobble size intraclasts from 2819.0' to 2820.0'. T.S. at 2796.0' and 2809.0'. Contact gradational.

2822.0-2823.5' Siltstone, buff, with interlaminated shale, dark gray, thin to medium, wavy.

2823.5-2826.5' Very sandy Dolostone; gray, sand fine grained, sub-rounded, fossiliferous (brachs), glauconite, coarsely crystalline. T.S. at 2825.0'.

2826.5-2833.0' Interlayered siltstone and shale; siltstone buff to dark gray, thinly laminated to medium bedded, wavy, slightly fossiliferous (brachs); Shale, dark gray, thin to medium laminae, wavy. Bioturbated at top of unit, horizontal; silt filled burrows. 0.5' of very coarsely crystalline dolomite, red, at 2832.5'.

MT. SIMON

2833.0-2855.2' Sandstone, light gray to buff, fine to coarse grained, sub rounded to rounded, poorly sorted, fossiliferous (brachs, trilobites), glauconitic with interlaminated shale, dark gray, very thin to thin, wavy. Horizontal burrows, with very fine to fine grained sand unfill within shale. 0.3' of dark gray shale at 2841.1'. Sandstone, buff, coarse to very coarse: 0.8' at 2842.7', 0.5' at 2852.8'. T.S. 2834.5'.

2855.2-2856.1' Sandstone, light gray, very coarse to granular, poorly sorted, subrounded.

2856.1-2857.0' Sandstone, light gray, fine grained with some very coarse grains, poorly sorted, subrounded.

2857.0-2870.0' Sandstone, light red-brown, very coarse, subrounded, poorly sorted, with some interlaminates of silt to very fine sand, thin. 0.2' of siltsone, red at 2865.0'.

2870.0-2871.3' Sandstone, light red brown, fine grained, with some coarse sand, subrounded, poorly sorted. 0.3' of siltstone, dark red brown at base.

2871.3-2899.0' Sandstone. Light red brown, coarse to pebble size, subrounded to sub angular, poorly sorted, with interlayered silt to very fine sandstone, light red brown: 0.3' at 2873.6', 0.8' at 2879.8', and 0.2' at 2884.5'. Medium interlaminae of blue-gray silty shale also present within sandstone at 2885.2', 2886.3', 2888.0' and 2895.4'. 0.3' dark red brown shale at 2883.0', medium scale crossbedding at 2875.0', 2879.0', 2886.4' and 2896.5'.

2899.0-2900.5' Siltstone, dark gray and red brown to rusts, thin to medium interlaminae.

2990.5-2924.0' Sandstone, light gray to rust, coarse to pebble, subrounded to subangular, poorly sorted, crossbedded, medium scale.

PRE CAMBRIAN

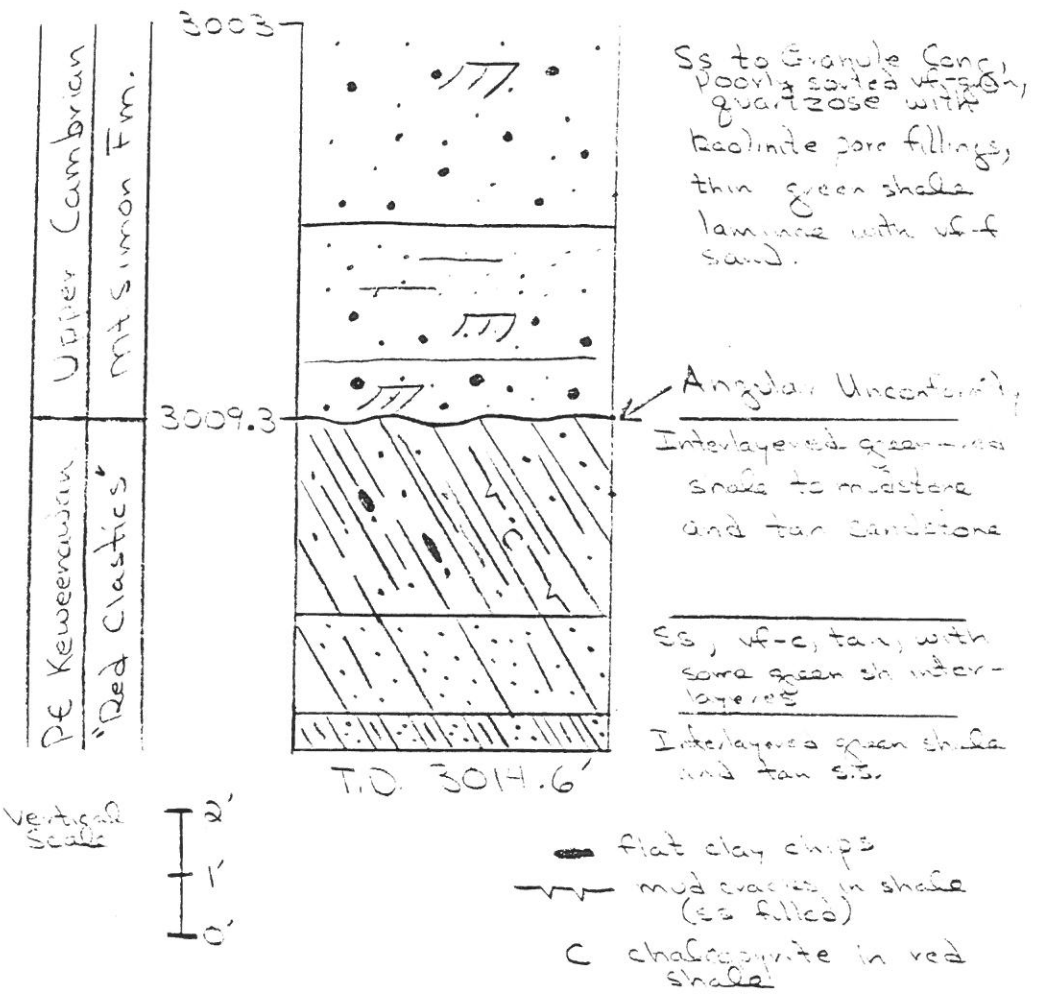
Red Clastic Series

2924.0-2925.0' Silty shale, brick red, massive.

2925.0-2931.0' Shale, silty, gray-green, massive. Contact gradational.
2931.0-2934.0' Shale, silty, mottled gray-green and brick-red, massive, Contact gradational.
2934.0-2964.0' T.D. Siltstone, brick-red, becomes increasingly shaley towards top. Localized irregular gray-green areas present s thin to medium beds, parallel, or as discrete 1.0 to 4.0 mm spheres. Contact gradational.

very similar to
- B. Lehman #1
- #1 Rhinehart

Northern Natural Gas Co.
McCallum A-1
NW NW SW sec. 5 T79N R27W
Dallas Co., Iowa
3.5" diameter core
IGS W-37172



In stock and for sale by Mid-West Prtg. Co., Tulsa W-2971

STATE Iowa	Mason City (Cerro Gordo)
N.E. 1/4 SE 1/4 NE 1/4 SE 1/4	Mason City Well #12
SEC. 16	
TWP. 96 N RGE. 20W	COMMENCED July 2, 1947 COMPLETED
	Layne-Western Co., Inc.
	CASING RECORD 10' of 30" curbing 0'-10'; 145' of 20" pipe 0'-145' cem. in 26" hole; 22' of 18" pipe 793'-815'; 147.5' of 14" pipe 732'-879.5'; Open 12 1/2" hole 878'-1377
	LOGGED February 9, 1948 BY R.W.
Elev. 1165.4 DC 1163.9 L.S.	REMARKS SWL 175
1577	PDL 207 @ 1356 g
	acidized & shot
C7-1	5/-20-1602

1400

Dol, crm aa.

Ls, crm, gr. mot, f-m, w glauc.; Sh, gr. gn w mica + cinn. specks
Dol, crm, f; Ls, gr + brn mot w glauc.
Tr. L, Ls.
Ls, a.a., little wh. chlky.
Sh, some soft calc.

Dol, gr, brn gran, silty w abun. glauc; Sh, gr w mica + cinne. specks

Sd, gr. brn, mot. w abun. glauc.

Ls, bf. wh, Ls bf silty w glauc.; Sh, bf w glauc
Ls, wh. chlky + brn. mot. m. w glauc.
Dol + Ls wh + brn, f-m, w glauc.; Sd. fst. sR.
Dol, bf, m, w glauc.
Dol, bf, brn mot, c.

1500

Sd, clr. + frst, yel, A-R.

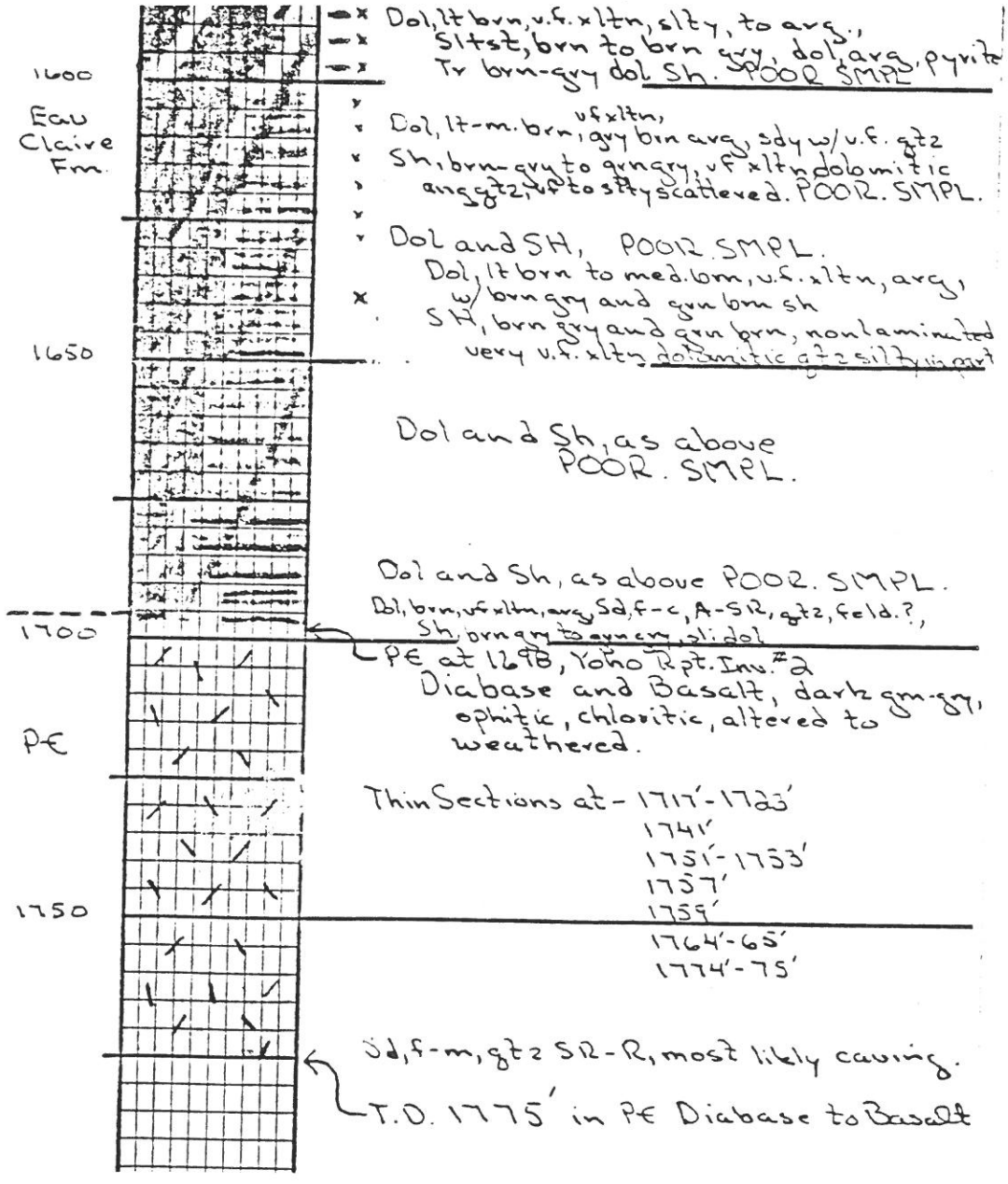
Sd, clr, frst, gr, yel., s A-sR.

Ss. w dol. cem., gr.
Ign., red + grn.
Ign., dk, basic.

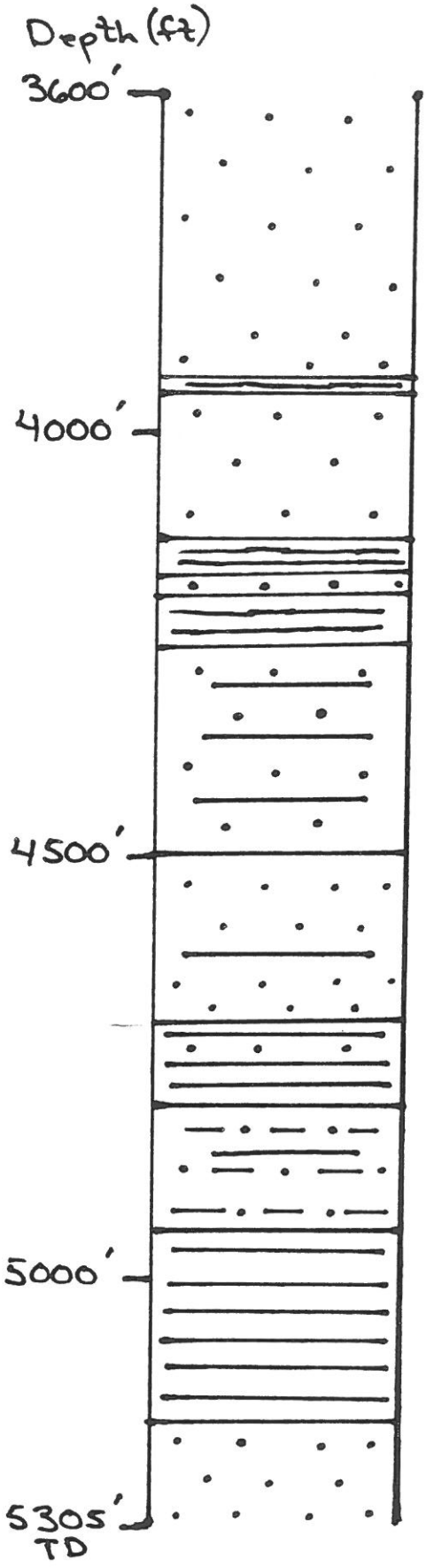
1600

FORM NO. 79—In stock and for sale by Ross-Martin Co., Tulsa. W0115

STATE Iowa	Mason City #9 (Cerro Gordo)
NW,NW,NE,SW	City Well #8
SEC. 3	
TWP. 96N RGE. 20W	COMMENCED COMPLETED 1946
	CASING RECORD
	LOGGED June, 1981 BY R. McKay
El: 1098'	REMARKS Relog of ¢ section
T.D.: 1775'	No Samples 0'-900'
	Thin Sections Available for PE from Yoho's I.C.S. 2pt. Inv. #2
	Several POOR SMPL intervals
W02-7,8	



Wilson # 1, W-0017
Iowa Oil Developement
sec. 25 T68N, R37W
Page Co., IA



Ss, qtz, f-m & f-c, A-r, friable, tr grn sh & dol rhombs, rd-brn slty sh in middle

Sh, lt rd brn, slty, sli sdy, minor lt grn gry micaceous sh from 4205'-4230' w/ inarticulate brach shells.

Intrbd Sh & Ss; Sh, lt rd brn, slty, sdy; Ss, vf-vc, qtz

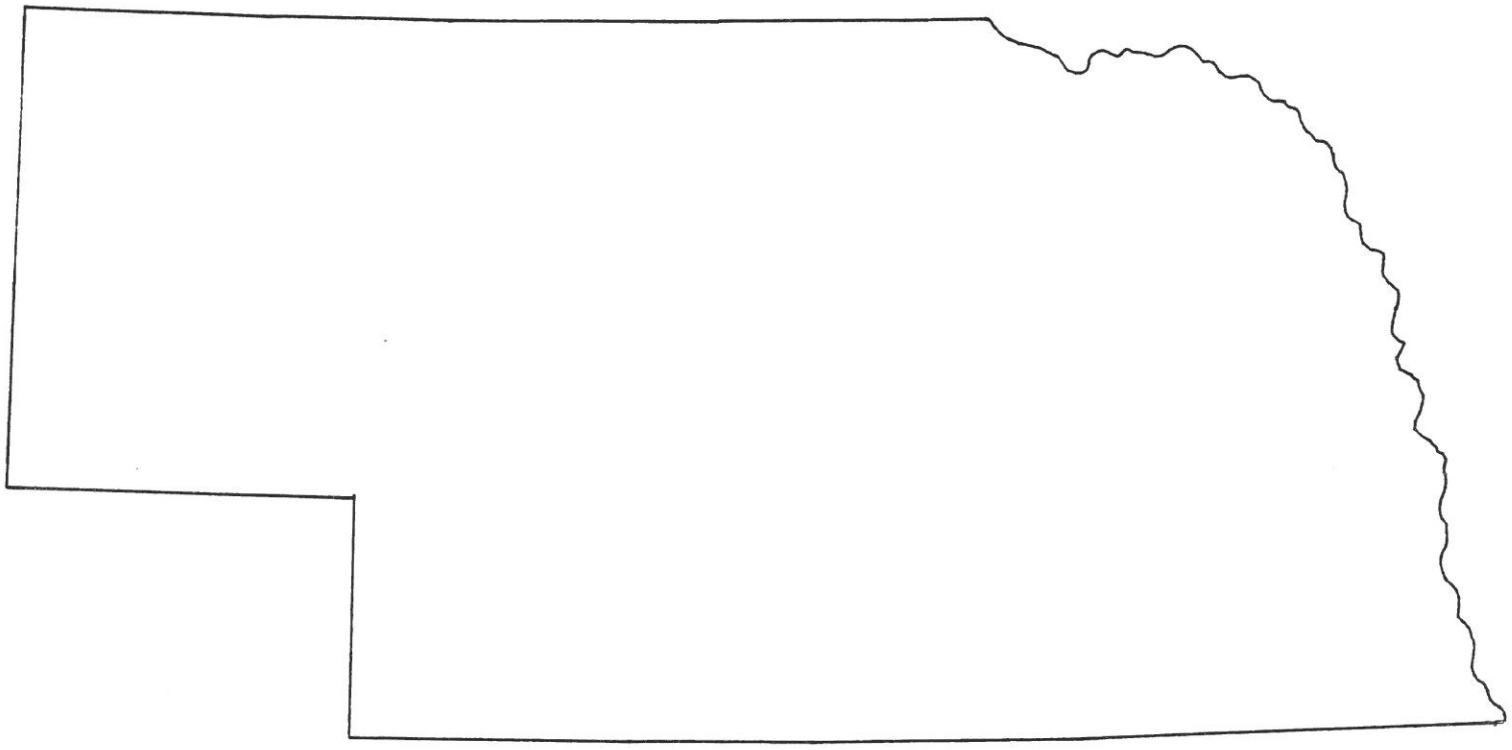
Sh, m rd brn - brn, sli mic, slty - vf sdy,

Sltst, lt brn, mic, vf sdy, with brn - rd brn intrbd sh

Sh, lt - m rd brn, slty, sli mic

Ss, vf-m, A-a, abun, feldspar, biotite, musc, Fe cmt

Nebraska Information



February 11, 1969
Marvin P. Carlson

SAUNDERS C SE SE 33-15N-8E Superior Oil No. 1 Nygren 1216 KB

(10')
650' Shale, medium gray, some black "coal" fiberous, limestone
660 Limestone, gray, very finely crystalline
670 As above, green gray shale
680 Limestone, tan gray, sublithic
700 Shale, gray to green gray, some red
710 Limestone, gray, very fine to finely crystalline, shale as above
720 Shale, medium gray, some red, trace sand
730 Dolomite, tan, very fine rhomb
740 Dolomite, gray, very finely crystalline, green gray shale
750 As above, very fine to fine rhomb, green sandy shale
760 As above, granular crystalline
Skip 780-790
790 Dolomite, tan gray, very fine rhomb, trace blocky chert
820 As above, cryptocrystalline to finely crystalline
830 Dolomite, tan, as above
840 Dolomite, tan gray, cryptocrystalline, some fine to medium rhomb
850 As above, cryptocrystalline, some fine rhomb
860 As above, fine, some medium rhomb, trace dead chert
870 Dolomite, gray, very finely crystalline, trace embedded sand
880 Dolomite, tan gray, very fine rhomb, sucrose, pyrite, 10% tan mottling conchoidal chert
890 Dolomite, gray, very finely crystalline sucrose, trace green shale
900 As above, granular crystalline
910 As above, very fine rhomb
920 As above, fine rhombic sucrose
930 Dolomite, light gray, dense to granular
990 Dolomite, tan gray, fine, some medium rhombic sucrose
1000 As above, 10% white blocky to dead chert
1030 As above, dark mottling, fine, some medium rhomb
1080 Dolomite, gray, very fine rhombic sucrose, 10% white blocky to dead chert
1110 Dolomite, tan gray, some fine to medium crystalline
1130 Dolomite, gray, fine to medium rhomb
1160 As above, dark mottling, fine to coarse crystalli[illegible]
1170 Dolomite, gray, very fine to fine rhomb, 10% white blocky to dead chert
1180 Dolomite, tan gray, very fine rhomb, 20% medium gray speckled chert
1190 As above, 10% white blocky chert
1200 Dolomite, as above
1210 As above, 20% medium gray speckled chert
1220 As above, chert as above, dead
1230 As above, dark mottling, some fine to medium crystalline
1250 Dolomite, tan, fine rhomb
1280 As above, very fine rhomb, 5% dead chert
1310 As above, very fine crystalline, much very fine embedded sand
1320 As above, some very fine rhomb, trace sand
1330 Dolomite, medium gray, very finely crystalline, argillaceous, embedded shale, some medium gray shale
1340 Dolomite, gray, black mottling, some fine to medium crystalline
1350 Dolomite, tan gray, some very fine to finely crystalline
1370 Dolomite, tan to dark gray, finely crystalline
1380 Shale, green
1390 As above, trace sand

February 11, 1969
Marvin P. Carlson

SAUNDERS C SE SE 33-15N-8E Superior Oil No. 1 Nygren 1216 KB

1400. Dolomite, tan to brown, cryptocrystalline, some finely crystalline
1410 Shale, green
1420 Dolomite, calcic, gray, very finely crystalline, argillaceous
1430 Dolomite, tan gray, dense, much fine to medium embedded sand
1440 Shale, green gray & red brown, some sand
1450 Sandstone, dolomitic, fine, some medium to coarse, pyrite
1460 Sand, medium to coarse, rounded, frosted
1470 ? Cave, dolomite, tan gray, some very fine to fine rhomb, 5% white blocky chert
1480 As above, sand & shale
1490 Dolomite, medium gray, cryptocrystalline, some rhomb, oolitic pyrite
1500 Dolomite, tan gray to medium gray, as above
1520 Dolomite, tan, dense
1540 Dolomite, tan gray, some very fine rhomb, trace embedded sand
1550 As above, cryptocrystalline, some rhomb
(5')
1560 As above
1575 As above, very fine to fine rhomb
1595 As above, fine, some medium rhomb
1610 Dolomite, gray, as above
1625 As above, 5% tan gray chert
1630 As above, trace chert as above & quartzose
1640 As above, fine to medium embedded sand, trace glauconite
1655 Dolomite, tan gray, very fine rhomb, embedded silt to very fine sand, glauconite
1665 As above, some very fine rhomb, glauconite
1690 As above, some very fine to finely crystalline
1710 As above, glauconite, medium gray to green gray shale
1720 Dolomite gray, fine to coarse crystalline, glauconite, shale as above
1730 As above, dark mottling as above
1750 Sandstone, fine to medium dolomitic to sandy dolomite
1755 Sand, fine to coarse, some very coarse
1760 Dolomite, gray to red, very finely crystalline, sand embedded to dolomitic sandstone
1765 Sand, fine to medium, dolomite as above
1770 Dolomite, gray to red, very finely crystalline, much embedded sand
1775 Sandstone, fine to medium, dolomitic to sandy dolomite
1790 Sandstone, fine, some medium, pink, subrounded to rounded
1805 Sandstone, very fine to fine, angular to subrounded, pyrite
1820-35 T.D. - As above with intergranular white "clay", trace mica

78-22

COUNTY: SAUNDERS			SEC 33	T 15N	R 8 E/W	— C — SE — SE —
FARM: NYGREN 4433	WELL NO: 1	OPERATOR: SUPERIOR OIL CO			STATUS: D & A	FIELD: WILC
ELEVATION: 1216 KB. DF. GL	TD: 1843	PBTD: -	PRODUCING FORMATION: -		IP: --	SPUD: 1-31-61	COMP: 2-7-61

DATA ON FILE:	WCR	PA	S	SL	SD	DL	DT	ES	I-ES	ML	LL	I	R	OTHER	RECORDED BY:
		✓	✓						✓					SGR/	MC

BASIS FOR FORMATION TOPS: ELECTRIC LOG: ✓ SAMPLE STUDY: ✓ OPERATORS REPORT: SCOUT REPORT:

FORMATION TOPS:

TOP OF:	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
CRETACEOUS				JURASSIC			
Pierre				Morrison			
Niobrara				Sundance			
Ft. Hays - Timpas				TRIASSIC			
Codell				PERMIAN			
Carlile				Cimarron			
Greenhorn				Blaine (Minnekahta)			
Belle Fourche				Stone Corral			
Mowry Bent.				Wellington			
Gurley "D"				Chase (Herington)			
Huntsman				Fort Riley			
Cruise "J"				Council Grove			
Skull Creek				Cottonwood			
Cloverly				Admire			

(over)

LOCATION: SEC: 33	T: 15S	R: 8 E/W	— C — SE — SE —	ELEVATION: 1216 KB

TOP OF:	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
PENNSYLVANIAN	302			MISSISSIPPIAN	A)		
WABAUNSEE				St. Louis - Osage			
Tarkio				Gilmore City (Chouteau)			
Howard				Chattanooga			
SHAWNEE (Topeka)				DEVONIAN	720		30
Deer Creek				SILURIAN			
Oread				ORDOVICIAN (Maquoketa)			
DOUGLAS	300			Galena (Viola)			
LANSING	346			Decorah (Simpson)			
KANSAS CITY	400			St. Peter (Wilcox)			
Wyandotte				Upper Arbuckle			
Winterset				CAMBRIAN			
Base Kansas City	574			Bonneterre (Lr Arb)			
MARMATON				LaMotte (Reagan)			
CHEROKEE	692			PRECAMBRIAN ?			

OIL SHOWS, DRILL STEM TESTS, CORE DATA, ETC:

DST 1090-1137 Rec 292' FRESH WTR

DST 1477-1502 Rec 1200' " "

W178-6

December 10, 1968
Marvin P. Carlson

LANCASTER NW NW NW 36-9N-5E Shar-Alan Oil No. 1 Sullivan 1342 KB

(10')
1200 Limestone, tan gray, very finely crystalline
1210 Limestone, medium gray, dense, much medium to dark gray shale
1220 Shale, as above & red
1230 Limestone, gray, crystalline, sand embedded
1240 Limestone, tan gray to pink, very finely crystalline
1260 Dolomite, tan, dense
1270 Dolomite, tan to brown, very fine rhombic sucrose, trace embedded sand
1280 As above, 5% white conchoidal chert
1300 Dolomite, tan, dense, some very fine rhomb, trace embedded sand
1330 Dolomite, gray to dark gray, dense to cryptocrystalline, embedded sand
1340 Dolomite, medium gray, cryptocrystalline, some fine rhomb, trace sand, 5% white conchoidal chert
1350 As above, dense, some fine to medium rhomb, trace green shale, 20% chert as above
1370 As above, cryptocrystalline, some medium rhomb
1400 Dolomite, gray to tan gray, fine to medium rhomb, crystalline quartz, trace chert
1450 Dolomite, gray, cryptocrystalline, some rhomb
1480 As above, cryptocrystalline to medium rhomb
1490 Dolomite, tan gray, dense to fine rhomb
1520 As above, 10% white blocky to dead chert
1540 Dolomite, gray, fine rhombic sucrose, chert as above
1560 Dolomite, tan gray, very fine to fine rhombic sucrose
1580 Dolomite, gray, fine, some medium rhomb
1620 As above, fine rhombic sucrose, 10% white dead chert
1630 Dolomite, tan, very finely crystalline, trace maroon to medium gray shale
1640 Dolomite, light gray, granular to very finely crystalline sucrose
1740 Dolomite, gray, very fine to fine rhomb
1750 As above, fine rhombic sucrose, 10% white blocky chert
1770 As above, some medium rhomb, 10% white blocky to dead chert
1790 As above, fine to medium rhomb
1830 As above, cryptocrystalline, some medium rhomb
1840 As above, fine to medium rhombic sucrose
1870 As above, dark mottling, fine to medium rhomb
1880 As above, some coarse
1890 Dolomite, tan gray, very fine to fine rhomb, 5% white dead chert
Skip 1900-1910
1910 As above, 10% gray speckled blocky chert
Skip 1920-1940
1940 Dolomite, tan to tan gray, very fine to fine rhomb
1950 As above, dark mottling, fine to medium rhomb
1980 Dolomite, tan, fine, some medium rhomb
1990 Limestone, dolomitic, gray, dark mottling, dense
Skip 2000-2010
2010 Dolomite, tan to brown, dense, some fine to medium rhomb
Skip 2020-2030
2030 Dolomite, medium gray, some finely crystalline, dark gray shale
2040 Dolomite, tan to brown, very fine to finely crystalline
Skip 2060-2070

12/10/68 - MPC

LANCASTER Shar-Alan Oil No. 1 Sullivan

2070	Shale, green to green gray
2080'	Limestone, tan gray to tan, dense to lithic
2090	Dolomite, dark gray to tan, finely crystalline, green gray shale
2110	Dolomite, tan gray, dark mottling, finely crystalline
2120	As above, green shale
2130	Dolomite, tan, very fine to finely crystalline, fine to medium sand
2160	Sand, fine to medium, rounded
2190	Sand to sandstone, very fine to fine, some medium Basalt ? fragments pyrite
2200	Dolomite, tan gray, fine, some medium rhomb
2220	Dolomite, gray, as above, trace granular glauconite
2230	As above, dense, some fine to coarse crystalline, glauconite pellets
2240	Dolomite, medium gray, as above
2250	Dolomite, medium to dark gray, dense to medium crystalline
2270	Sand, fine to coarse, rounded
2310-19	T.D. - Basement, weathered, pink to orange feldspar to clay, quartz (Reported as arkosic sandstone, appears as highly weathered felsic crystalline rock)

55-11

COUNTY: LANCASTER	SEC 36	T 9N	R 5 E/W	— NW — NW — NW —
FARM: Sullivan	WELL NO. 1	OPERATOR: [illegible]	STATUS: D & A	FIELD: W C
ELEVATION: 1342 KB. DF 1336 GL.	TD: 2328	PBTD:	PRODUCING FORMATION: (")	IP: · SPUD: [illegible]/60 · COMP.: 6/12/60

DATA ON FILE: WCR | PA ✓ | S ✓ | SL | SD | DL | DT | ES | I-ES ✓ | ML ✓ | LL | I | R | OTHER | RECORDED BY: MPC

BASIS FOR FORMATION TOPS: ELECTRIC LOG: ✓ SAMPLE STUDY: OPERATORS REPORT: SCOUT REPORT:

FORMATION TOPS:

TOP OF:	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
CRETACEOUS				JURASSIC			
Pierre				Morrison			
Niobrara				Sundance			
Ft. Hays - Timpas				TRIASSIC			
Codell				PERMIAN			
Carlile				Cimarron			
Greenhorn				Blaine (Minnekahta)			
Belle Fourche				Stone Corral			
Mowry Bent				Wellington			
Gurley "D"				Chase (Herington)			
Huntsman				Fort Riley			
Cruise "J"				Council Grove			
Skull Creek				Cottonwood			
Cloverly				Admire	391	[illegible]	

(over)

LOCATION	SEC. 36	T. [illegible]	R. 5 E/W	[illegible]	ELEVATION: 1342 KB		
TOP OF	DEPTH	ELEV	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
PENNSYLVANIAN	380	[illegible]	878	MISSISSIPPIAN	"		"
WABAUNSEE			305	St. Louis - Osage			
Tarkio				Gilmore City (Chouteau)			
Howard				Chattanooga			
SHAWNEE (Topeka)	658	+684	[illegible]	DEVONIAN	1258	+84	92
Deer Creek				SILURIAN	1350	-8	230
Oread				ORDOVICIAN (Maquoketa)	[illegible]	[illegible]	[illegible]
DOUGLAS	822			Galena (Viola)	[illegible]	[illegible]	[illegible]
LANSING	930	+412		Decorah (Simpson)	20[illegible]	[illegible]	[illegible]
KANSAS CITY				St. Peter (Wilcox)	2144		
Wyandotte				Upper Arbuckle			
Winterset				CAMBRIAN			
Base Kansas City	1179	+163		Bonneterre (Lr. Arb.)	[illegible]	[illegible]	
MARMATON				LaMotte (Reagan)	[illegible]		
CHEROKEE				PRECAMBRIAN	[illegible]	9[illegible]2	

OIL SHOWS, DRILL STEM TESTS, CORE DATA, ETC.:

January, 1970
Marvin P. Carlson

SAUNDERS NW NW SW 6-13N-10E N.N.G. No. 21 Strat 1080 KB

(5')
350 ' Shale, red to maroon, silty
360 As above & medium gray
365 Limestone, medium to dark gray, dense
370 Sandstone, very fine to fine, micaceous
380 Shale, medium to dark gray, pyrite
385 Shale, medium gray
390 Limestone, light medium gray to tan-gray, very finely crystalline
400 Shale, calcic, light medium gray
405 Limestone, tan-gray, some finely crystalline
415 Limestone, tan, very finely crystalline
420 Shale, light medium gray, mottled yellow to red
435 Dolomite, tan to brown, very finely crystalline
450 Dolomite, tan, very fine rhomb, trace green shale
455 Dolomite, light gray, granular to very finely crystalline with fine to medium embedded sand
460 Dolomite, light to medium gray, cryptocrystalline, some fine rhomb, pyrite
465 Dolomite, tan to gray, dark mottling, cryptocrystalline to fine rhomb
475 Dolomite, tan to gray, very fine to fine rhomb
480 As above, green shale
500 Dolomite, light to medium gray, fine, some medium rhomb, 10% gray conchoidal chert
515 Dolomite, tan-gray, as above, chert, as above
520 Dolomite, medium to dark gray, cryptocrystalline, some rhomb, 20% chert
530 As above, 20% chert, dark mottling
545 Dolomite, medium gray, cryptocrystalline, some coarse rhomb, chert, as above
560 Dolomite, tan to dark gray, some finely crystalline, 10% chert, as above, green shale
565 As above, gray blocky chert
570 ? As above, much green gray & red shale
575 Dolomite, tan-gray, fine rhomb
580 As above, fine to medium rhomb, vuggy, trace oolitic dolomite
590 Dolomite, light gray, very finely crystalline
610 As above, very fine rhomb
620 Dolomite, light to medium gray, some fine rhomb, vuggy
635 Dolomite, medium gray, some rhomb, 10% gray, dark mottled chert
650 Dolomite, light gray, very finely crystalline to argillaceous, 10% white blocky chert
660 As above, granular
685 As above, very fine, some finely crystalline, pyrite, 10% white blocky to dead chert
690 Dolomite, gray, fine rhombic sucrose, 5% chert as above
695 As above, trace gray & red shale
705 Dolomite, gray, argillaceous, green & red shale, pyrite
710 Shale, medium gray to green gray, some fine rhombic dolomite
715 Dolomite, tan-gray, dark mottling, fine rhomb, shale, as above
720 Mostly shale, as above
730 Shale, medium gray to green-gray, dolomitic
740 Dolomite, tan-gray, fine to medium rhomb
790 As above, some finely crystalline

SAUNDERS NW NW SW 6-13N-10E N.N.G. No. 21 Strat 1080 KB

800 Dolomite, light medium gray, some fine to coarse crystalline
815 As above, finely crystalline
820 As above, dark mottling, finely crystalline, 10% white blocky to dead chert
835 Dolomite, gray, very fine to finely crystalline, chert as above
850 As above, dark mottling, fine rhomb, 5% chert, as above
875 Dolomite, gray, fine rhomb, 10% dead speckled chert
915 As above, very fine to finely crystalline, 20% chert, as above
925 Dolomite, tan-gray, fine rhombic sucrose
935 As above, fine to medium rhomb
965 As above, very fine to fine rhomb, some very fine sand embedded
975 Dolomite, tan, very fine rhomb
990 As above, very fine to fine rhomb, pyrite
1010 Dolomite, tan-gray, dark mottling, as above
1020 Shale, light medium gray, some red mottling
1030 Dolomite, calcic, tan gray, sublithic, some fine rhomb
1035 Dolomite, tan, fine rhomb, green-gray shale
1045 Dolomite, tan to brown, very fine to fine rhomb
1050 As above, dense
1055 As above, some gray, dense limestone & medium gray shale
1060 Dolomite, calcic, tan-gray, dense
1065 As above, dark speckling
1070 Shale, medium gray to green-gray

Core 1080-1145

(Core chips representing 2')
1080 Limestone, tan to brown, dense to lithic
1082 Limestone, as above
1084 Shale, green
1086 Shale, green with brachiopods
1088 Shale, as above
1090 Dolomite, calcic, brown-gray, dense, some very finely crystalline, brachiopods
1092 Dolomite, as above, argillaceous
1094 Dolomite, as above
1096 Dolomite, as above
1098 Dolomite, calcic, brown, black speckled, dense to lithic
1100 Dolomite, as above
1102 Shale, calcic, brown to gray
1104 Dolomite, argillaceous, medium gray, dense
1106 Shale, calcic, medium gray to green-gray
1108 Shale, as above
1110 Dolomite, calcic, tan, dark speckling, dense
1112 Dolomite, as above
1114 Shale, calcic, medium gray
1116 Dolomite, tan-gray, very fine to finely crystalline, much fine to medium embedded sand
1118 Dolomite, brown, red & black speckled, argillaceous, dense
1120 Dolomite, as above
1122 Shale, dolomitic, red to brown, light gray lenses
1124 Shale, green, waxy
1126 Shale, as above, sandy
1128 Sandstone, very fine to fine, dolomitic
1130 Sandstone, as above
1132 Sandstone, as above
1134 Sandstone, as above, some medium
1136 Dolomite, tan, very finely crystalline, much very fine to fine sand embedded

SAUNDERS NW NW SW 6-13N-10E N.N.G. No. 21 Strat 1080 KB

1138 Sandstone, dolomitic, very fine to fine
1140 , Sandstone, as above
1142 Sandstone, as above
1144 Sandstone, as above, contains 20% medium coarse sand
(larger core fragments representing 1', 1131'-1145')
5' Rotary Samples 1145-1190
1145 Cave, varied dolomite, sand, shale
1155 Sandstone, dolomitic, fine to coarse
1170 Shale, medium gray & red, some fine sandstone
1185-90 - Questionable basement: sandstone, as above, pyritic
& light gray, fine rhombic dolomite

78-6

COUNTY	SEC	T	R
SAUNDERS	6	13N	10E

FARM: STRAT #21

OPERATOR: NORTHERN NATURAL GAS

PERMIT NO: / DATE:	FIELD	WILDCAT:	SPUD:	COMP:
				10-2-53

D&A	OIL	GAS	KB	DF	GL	TD	PBTD
			1053		1038	1125	

PROD. ZONE:	IP:	PIPE:
		5" 1125'

DATA ON FILE

PWR	PAR	S	SL	DL	DT	ES	ML	LL	I	R	OTHER
		✓				✓	✓				

FORMATION TOPS

SAMPLE STUDY:	ELECTRIC LOG:	OPERATORS REPORT:	SCOUT:	DATE:
	✓			

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
CRETACEOUS				Skull Creek			
Pierre				Fall River			
Niobrara				Fuson			
Ft. Hays				Lakota			
Carlile				JURASSIC			
Belle Fouche				Morrison			
Gurley "D"				Sundance			
Huntsman				TRIASSIC			
Cruise "J"							

over

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
PERMIAN				MISSISSIPPIAN			
Blaine				St. Louis			
Stone Corral				Gilmore City			
Wellington				Chattanooga			
Chase				DEVONIAN	435		?
Council Grove				SILURIAN	500		100
Admire				ORDOVICIAN			
PENNSYLVANIAN				Maquoketa (Sylvan)	600		112
Wabaunsee				Galena (Viola)	712		294
Shawnee				Decorah (Simpson)	1006	+74	176
Douglas				St. Peter (Wilcox)	1182	-	?
Lansing				Oneota (Arbuckle)			
Kansas City				CAMBRIAN ?			
Marmaton				Bonneterre			
Cherokee				La Motte (Reagan)			
				PRECAMBRIAN ?	1125	-102	

OIL & GAS SHOWS	DRILL STEM TESTS	CORE DATA
		1000 - 1125

W-78-A

Correlation Summary-Layne Western #3 Lonergan Lake

Douglas Co., NW SE SW 11-16N-12E

Elev. 1222 G.L. T.D. 2355

Pleistocene 0 - 334	
Silt and clay	0 - 245
Sand	245 - 334
Pennsylvanian Shale	334 - 460
Mississippian Dolomite	460 - 560
Devonian Dolomite and Shale	560 - 910
Silurian cherty Dolomite	910 - 955
Ordovician 955 - 1330	
Maquoketa-Galena Dolomite	955 -1330
Decorah Shale and Dolomite	1330 -1445
St. Peter Sandstone	1445 -1475
Oneota Dolomite	1475 -1555
Cambrian 1555-1915	
Jordan Sand and Dolomite	1555 -1660
Franconia Dolomite	1660 -1760
Dresbach Sand and Dolomite	1760 -1915
Precambrian	1916 -2355 T.D.

September, 1969
M. P. Carlson

DOUGLAS CO., NW SE SW, 11-16N-12E, Layne-Western #3 Lonergan Lake

(5 feet samples, figures indicate top of interval)

0	Silt, red brown, some fine to coarse sand
30	Silt, medium to dark gray
45	Silt, clay, light tan
70	As above, 10% fine to medium sand
80	As above, more sand
100	Silt, light gray to tan gray, some sand and gravel
20	As above, some medium gray, silty clay
30	Clay, silty, medium to dark gray, 20% sand and gravel
230	As above, 50% fine to coarse sand
45	Sand, fine to coarse
55	Sand, fine to medium, some coarse
310	Sand, medium to coarse, some very coarse
30	Shale, red and gray mottling, sand as above
85	Shale, red to yellow, in part sandy
90	As above, some light gray to green gray
400	Shale, light medium gray, mottled red and yellow
10	Shale, light to light medium gray
55	As above, trace green gray sandy shale
60	Dolomite, medium gray, dark mottling, some finely crystalline, pyrite
65	Dolomite, light medium gray, fine to medium rhombic sucrose, green gray shale
70	Dolomite, calcic, light gray to tan gray, dense
95	Dolomite, medium gray, some fine to medium crystalline, green gray shale
505	As above, fine to medium, some coarse rhomb
10	As above, dense to finely crystalline, green gray shale
30	Dolomite, light tan gray, very fine, some finely crystalline
60	As above, green gray shale
70	Dolomite, light medium gray, argillaceous to very finely crystalline
85	As above, very fine to fine rhomb, green shale
600	Dolomite, tan gray, fine rhomb
10	As above, very finely crystalline, green gray shale
35	As above, very fine to fine rhomb, vuggy
45	Dolomite, tan, fine rhombic sucrose
65	Dolomite, tan gray, very fine to fine rhomb
80	Dolomite, light gray, very fine rhombic sucrose
90	Dolomite, tan gray, very fine, some finely crystalline
705	Dolomite, gray, very fine to finely crystalline, green gray shale
20	Dolomite, tan, very fine rhomb, green shale
30	Dolomite, gray, very finely crystalline
40	Shale, green to medium gray
55	Dolomite, medium gray, dense to argillaceous
70	As above, very fine to finely crystalline
80	As above, green gray shale
90	Dolomite, tan gray, very fine to finely crystalline
800	(circ. prob.) Dolomite, medium gray, argillaceous
10	Dolomite, tan, very fine to finely crystalline
15	Dolomite, light gray, dense to granular
30	As above, finely crystalline
55	As above, very fine to finely crystalline

DOUGLAS CO., NW SE SW, 11-16N-12E, Layne-Western #3 Lonergan Lake

860	Dolomite, tan gray to tan, dark speckling, very finely crystalline
80	Dolomite, gray, very fine, some finely crystalline, sand embedded
95	As above, very fine to fine rhomb, sand embedded
910	As above, some very fine to medium crystalline, sand embedded, 10% dark mottling, conchoidal chert
20	As above, fine to medium crystalline, trace white blocky chert
55	Dolomite, light gray, granular to very finely crystalline
70	As above, very fine, some finely crystalline
80	As above, some white dead to blocky chert
1015	As above, very finely crystalline sucrose
30	Dolomite, light gray to tan gray, dense, some finely crystalline
45	As above, some fine to medium crystalline
60	Dolomite, light medium gray, very fine, some finely crystalline
80	As above, some fine to medium crystalline
95	As above, dense, some fine rhomb
1105	As above, fine to medium rhomb
35	As above, cryptocrystalline, some fine to medium crystalline
55	Dolomite, light tan gray, some fine to coarse crystalline
70	Dolomite, light medium gray, very fine rhomb, 20% white blocky to dead chert
1230	Dolomite, light tan gray, dark mottling, some fine to medium crystalline
55	As above, fine, some medium rhomb
85	Dolomite, tan gray, very finely crystalline
1310	Dolomite, light medium gray, dark speckling, very finely crystalline
30	Dolomite, medium to dark gray, dense to argillaceous, sand embedded, gray shale
35	Dolomite, light medium gray, dark mottling, very fine to finely crystalline, pyrite
40	Shale, medium gray to green gray, dolomite as above
50	Dolomite, medium gray, fine to medium crystalline
55	As above, very fine rhomb
65	Dolomite, tan, very fine, some finely crystalline
75	Shale, medium dark gray to green gray
95	Dolomite, tan, some very finely crystalline
1405	Shale, green to green gray
10	Dolomite, tan gray, very fine rhomb, shale, as above
15	Dolomite, calcic, light medium gray, dense to argillaceous
30	Dolomite, tan, dark mottling, dense
35	Shale, dark gray to brown, speckled red
40	Dolomite, tan gray, speckled red, dense
45	Dolomite, as above, argillaceous, medium gray shale, trace medium sand
50	Sandstone, very fine to fine, some medium, pyrite
75	Chert, gray, dark mottling, in part oolicastic, in part quartzose
80	Dolomite, tan gray, dense, some finely crystalline
	Skip 1500-1510 Circulation Prob.
1510	As above
30	As above, fine, some medium crystalline, trace medium gray chert
40	As above, crystalline quartz
45	As above, some embedded sand
55	Dolomite, light to medium gray, very fine, some finely crystalline, much embedded sand
60	Sandstone, dolomitic, very fine to fine, trace medium to sandy dolomite
65	As above, glauconite

DOUGLAS CO., NW SE SW, 11-16N-12E, Layne-Western #3 Lonergan Lake

1575	Dolomite, light gray, very finely crystalline, much embedded sand to dolomitic sandstone
1610	Dolomite, tan gray, green mottling, some fine to medium rhomb
25	Dolomite, light medium gray, very finely crystalline, glauconite
50	Dolomite, tan gray, dense, some fine to medium crystalline, glauconite
65	Dolomite, gray to tan gray, some fine to coarse crystalline, glauconite
1700	Dolomite, tan gray to tan, cryptocrystalline, some rhomb
45	Lost circulation - cave
85	As above, trace fine to medium dolomitic sandstone
	No samples 1815 - 1943
1950	Shale, green and maroon mottling, some very fine to fine orange arkosic sandstone
55	Lost circulation - cave
2055	Shale, as above, some green gray, weathered, igneous ?
70	Basic igneous, green gray to black, very finely crystalline
2130	As above ? Cave
2200	Shale, red and mottled, some as above
30	As above and weathered, igneous
45	Basic igneous, green gray to black
55	Shale, clay, light red brown
75	Basic igneous
85	Shale, as above
2350-55	T.D. Varicolored shale and weathered basic igneous

28-23

COUNTY: DOUGLAS		SEC 11	T 16N	R 12E	NW SE SW
FARM: LONERGAN	WELL NO 3	OPERATOR: LAYNE-WESTERN	STATUS:		FIELD:
ELEVATION: KB. DF 1222 GL	TD: 2355	PBTD:	PRODUCING FORMATION	IP:	SPUD: 1-1-69	COMP: 6-1-69

DATA ON FILE:	WCR	PA	S ✓	SL ✓	SD	DL ✓	DT ✓	ES ✓	I-ES	ML	LL	I	R	OTHER	RECORDED BY: RS

BASIS FOR FORMATION TOPS:	ELECTRIC LOG: ✓	SAMPLE STUDY:	OPERATORS REPORT:	SCOUT REPORT:

FORMATION TOPS:

TOP OF:	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
CRETACEOUS				JURASSIC			
Pierre				Morrison			
Niobrara				Sundance			
Ft. Hays - Timpas				TRIASSIC			
Codell				PERMIAN			
Carlile				Cimarron			
Greenhorn				Blaine (Minnekahta)			
Belle Fourche				Stone Corral			
Mowry Bent.				Wellington			
Gurley "D"				Chase (Herington)			
Huntsman				Fort Riley			
Cruise "J"				Council Grove			
Skull Creek				Cottonwood			
Cloverly				Admire			

CON SUR 35000 1000 4-68(IT) (over)

LOCATION:	SEC 16	T 12N	R 12E	NW SE SW	ELEVATION: 1222 GL

TOP OF:	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
PENNSYLVANIAN				MISSISSIPPIAN	445		
WABAUNSEE				St Louis - Osage			
Tarkio				Gilmore City (Chouteau)			
Howard				Chattanooga			
SHAWNEE (Topeka)				DEVONIAN ?	575	+647	
Deer Creek				SILURIAN ?			
Oread				ORDOVICIAN (Maquoketa)	870		
DOUGLAS				Galena (Viola)			
LANSING				Decorah (Simpson)	1430		
KANSAS CITY				St. Peter (Wilcox)	1442		
Wyandotte				Upper Arbuckle	1475		
Winterset				CAMBRIAN			
Base Kansas City				Bonneterre (Lr Arb)			
MARMATON Lm.	354			LaMotte (Reagan)			
CHEROKEE	540			PRECAMBRIAN Est	1915	-693	

OIL SHOWS, DRILL STEM TESTS, CORE DATA, ETC:

December 6, 1968
Marvin P. Carlson

SEWARD C SE NW 14-10N-4E Superior No. 1 Ihde 1410 KB

(10')

1400 Limestone, medium gray to tan gray, dense to very finely crystalline, shale, medium gray, some red to green
1420 Limestone, tan gray, dense
1430 Shale, medium gray to dark gray
1440 Limestone, gray to tan gray, very fine to finely crystalline
1450 Limestone, tan, dense
1460 As above, "oolitic"
1470 As above, gray & red shale
1480 Dolomite, gray to tan gray, fine, some medium rhomb
1500 As above, dense to fine rhomb, pyrite, trace green shale
1510 As above, dense, some fine to medium rhomb, vuggy
1520 Dolomite, tan, very fine rhomb, 5% tan mottling gray blocky chert
1540 Dolomite, tan gray, very fine rhombic sucrose, green shale
1550 Dolomite, gray, very finely crystalline, much embedded sand
1560 Dolomite, medium gray, cryptocrystalline, some rhomb, dolomitic sandstone, fine to medium
1580 As above, cryptocrystalline
1590 As above, some medium to coarse rhomb
1600 Dolomite, medium to dark gray, cryptocrystalline, some fine to medium rhomb
1610 Dolomite, tan, dense, some fine rhomb
1630 Dolomite, tan gray, cryptocrystalline, some fine to medium rhomb, 5% gray blocky to dead chert
1640 As above, some crystalline quartz
1650 As above, cryptocrystalline, some rhomb, 20% chert as above
1660 As above, 20% tan gray conchoidal chert
1670 Dolomite, medium gray, as above, 10% chert as above
1690 Dolomite, tan gray, cryptocrystalline, some fine to medium rhomb
1700 Dolomite, medium gray, cryptocrystalline, some rhomb
1710 Dolomite, tan, as above
1730 Dolomite, tan gray, very fine to fine rhomb
1740 As above, 10% white dead chert
1750 Shale, medium gray, green gray, red
1760 Dolomite, tan gray, very fine, some fine rhombic sucrose, green gray shale
1770 Dolomite, light gray, granular to very finely crystalline, argillaceous
1810 As above, dense
1830 As above, dense to very finely crystalline
1860 Dolomite, gray, very fine rhomb, trace dead white chert
1880 As above, sucrosic, chert as above
1890 Dolomite, tan gray, dense to fine, some medium rhomb, 20% white blocky to dead chert

Skip 1920-1950

1950 Dolomite, light medium gray, fine to medium, some coarse crystalline
1990 As above, dark mottling, dense, some medium to coarse crystalline
2010 As above, in part vuggy
2020 Dolomite, tan gray, very fine, some fine rhomb, 5% white blocky to dead chert
2040 As above, dense to very fine rhomb, 10% white blocky chert
2060 As above, very fine rhombic sucrose
2080 As above, fine, some medium rhomb
2100 As above, dense, some fine to medium rhomb

SEWARD C SE NW Superior No. 1 Ihde

2120 Dolomite, tan, dense, some rhomb vuggy
2130, As above, dense to fine, some medium rhomb
2140 As above, dense, some very finely crystalline
2150 Shale, medium to dark gray, dolomitic, some red, argillaceous dolomite
2160 Dolomite, medium gray, dark mottling, fine rhomb, pyrite
2170 As above, fine, some medium rhombic sucrose
2180 As above, argillaceous, trace fine sand
2190 Shale, green gray
2210 Dolomite, tan-brown, dense, some very finely crystalline
2220 As above, green shale
2230 Dolomite, gray to tan gray, dark mottling, finely crystalline
2240 Dolomite, tan gray, dense, some fine to medium crystalline, trace gray conchoidal chert
2250 As above, dark mottling, dense, some very finely crystalline
2260 As above, some fine to medium rhomb, green shale
2280 Sand, fine to medium, subrounded to rounded, frosted
2300 Sand, very fine to fine, some medium to coarse
(5')
2320 Dolomite, medium gray, dense, some finely crystalline
2325 Dolomite, gray to tan gray, finely crystalline
2335 As above, fine, some medium rhomb
(10')
2340 Cave, dolomite as above
2350 Dolomite, tan, cryptocrystalline, some rhomb, much embedded sand
2360 Dolomite, tan gray to tan, fine to medium, some coarse rhomb, dead stain ?, no CCl_4 cut, some embedded sand
2370 As above, cryptocrystalline, some rhomb
2430 As above, fine to medium crystalline, much embedded sand to fine to medium dolomitic sandstone
2480 Sandstone, dolomitic, fine to medium, some coarse
2490 Sand, fine to coarse, rounded to spherical
(5')
2500 As above
2510 Sand, fine to medium
2520 Sandstone, very fine to medium
2525 Sandstone, dolomitic, fine to coarse
2530 Sandstone, very fine to fine, some pink
2545 Sand, fine to medium, some coarse to very coarse
2550 Sand, fine to medium, some coarse
2560 Sandstone, as above, dolomitic
2570 Sandstone, pink, fine, some medium, subangular to subrounded, some opaques, argillaceous (micaceous)
2590 As above, very fine to fine
2610 As above, fine
2760 As above, very fine to fine
2820 As above, some red hematitic "shale"
2830 As above, trace gneiss ?

80-4

COUNTY: SE[illegible]	SEC 14	T 10	R 11	E/W	— C SE NW
FARM: Thole	WELL NO. [illegible]	OPERATOR: [illegible]		STATUS: [illegible]	FIELD: [illegible]
ELEVATION: [illegible] KB, DF 14[illegible] GL	TD: [illegible]	PBTD:	PRODUCING FORMATION	IP:	SPUD: [illegible] COMP: [illegible]

DATA ON FILE:	WCR	PA	S	SL	SD	DL	DT	ES	I-ES	ML	LL	I	R	OTHER	RECORDED BY: RB
		✓	✓						✓						

BASIS FOR FORMATION TOPS:	ELECTRIC LOG: ✓	SAMPLE STUDY:	OPERATORS REPORT:	SCOUT REPORT:

FORMATION TOPS:

TOP OF:	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
CRETACEOUS				JURASSIC			
Pierre				Morrison			
Niobrara				Sundance			
Ft. Hays - Timpas				TRIASSIC			
Codell				PERMIAN			
Carlile				Cimarron			
Greenhorn				Blaine (Minnekahta)			
Belle Fourche				Stone Corral			
Mowry Bent.				Wellington			
Gurley "D"				Chase (Herington)			
Huntsman				Fort Riley			
Cruise "J"				Council Grove			
Skull Creek				Cottonwood			
Cloverly				Admire			

(over)

LOCATION	SEC 14	T 10	R 11	E/W	— C — —	ELEVATION: 1410 KB

TOP OF:	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
PENNSYLVANIAN				MISSISSIPPIAN	A		
WABAUNSEE	670			St. Louis - Osage			
Tarkio				Gilmore City (Chouteau)			
Howard	810			Chattanooga			
SHAWNEE (Topeka)	854			DEVONIAN	1473	-63	92
Deer Creek				SILURIAN	1555	-145	204
Oread				ORDOVICIAN (Maquoketa)	1759	-349	91
DOUGLAS	1053			Galena (Viola)	1850	-440	294
LANSING	1164	[illegible]		Decorah (Simpson)	[illegible]	[illegible]	[illegible]
KANSAS CITY				St. Peter (Wilcox)	2067		
Wyandotte				Upper Arbuckle	[illegible]	[illegible]	
Winterset				CAMBRIAN			
Base Kansas City	1355	63		Bonneterre (Lr Arb)	[illegible]		
MARMATON	13[illegible]			LaMotte (Reagan)	2576		
CHEROKEE	1451	-41	14	PRECAMBRIAN	2605		

OIL SHOWS, DRILL STEM TESTS, CORE DATA, ETC.:

DST #1 2324-40' rec 60' fresh wtr.

Tst #2 2013-25' rec 50' fresh mdy wtr.

W180-2

February 13, 1969
Marvin P. Carlson

DOUGLAS NW SE SE 25-16N-9E Great Western No. 1 Smith 1150 KB

(10')
550 Shale, medium gray, trace red
560 Limestone, tan, gray, dense
570 Shale, varied gray & red, limestone as above
580 Shale, mottled, gray to red to yellow
600 Shale, red, hemic
610 Dolomite, tan to gray, very fine rhomb, trace green shale, sand
620 Dolomite, gray & tan, some very finely crystalline, some embedded sand
630 As above, sand embedded, sandy green shale
640 Dolomite, light gray, very finely crystalline sucrose, some fine to medium embedded sand
650 Dolomite, as above
660 Dolomite, tan, cryptocrystalline, some fine rhomb, green shale
670 Dolomite, tan to brown, cryptocrystalline
680 As above, some very fine rhombic sucrose
690 Dolomite, brown to dark gray, very fine rhombic sucrose, stain ?, no CCl_4 cut
700 Dolomite, tan gray, very fine rhomb
720 Dolomite, tan to brown, cryptocrystalline
730 Dolomite, tan, very fine to fine rhomb
770 Dolomite, medium gray, dense, some finely crystalline, green gray shale
780 Shale, green gray, argillaceous dolomite
790 Dolomite, medium gray, argillaceous, shale as above
800 Dolomite, tan, dark mottling, some rhomb, argillaceous
810 Dolomite, medium gray, some very fine crystalline, green shale
850 As above, dense to cryptocrystalline
860 Dolomite, gray, very fine rhomb
880 Dolomite, medium gray, dense
890 Dolomite, tan, very finely crystalline
910 Dolomite, tan gray, very fine rhomb, trace embedded sand
920 Dolomite, gray, dense, much embedded sand
930 Dolomite, light gray, granular, green gray, dolomitic shale
940 Dolomite, gray, very finely crystalline
950 Dolomite, light gray, granular crystalline
970 Dolomite, tan gray, very finely crystalline, vuggy
980 As above, dense to cryptocrystalline
990 Dolomite, tan gray to dark gray, cryptocrystalline to some rhomb
1010 Dolomite, tan gray, very fine rhomb
1020 Dolomite, light gray, very finely crystalline, vuggy
1030 As above, granular crystalline
1040 Dolomite, gray, very fine rhombic sucrose
1060 Dolomite, tan gray, fine to medium rhomb, 10% white dead chert
1070 As above, very fine to fine rhomb, 10% white blocky to dead chert
1090 As above, very finely crystalline, 20% blocky to conchoidal chert
1110 As above, very fine rhomb, chert as above
1120 As above, fine, some medium crystalline
1140 Dolomite, gray, dark mottling, fine to medium rhomb
1170 Dolomite, tan gray, dark mottling, some fine to coarse crystalline
1200 Dolomite, gray, fine to medium, some coarse rhomb
1220 Dolomite, tan gray, dark mottling, some fine to coarse crystalline
1240 Dolomite, tan gray, very fine rhomb, 20% medium gray speckled chert
1260 As above, 10% chert as above

February 13, 1969
Marvin P. Carlson

DOUGLAS NW SE SE 25-16N-9E Great Western No. 1 Smith 1150 KB

1290. Dolomite, tan, dark mottling, some fine to medium crystalline
1300 Dolomite, tan gray, dark mottling, some fine to coarse crystalline crinoids
1310 Dolomite, gray, fine to coarse crystalline, crinoids
1320 Dolomite, tan, fine to medium crystalline
1340 Dolomite, tan gray, fine rhombic sucrose, some embedded sand
1350 Dolomite, tan, very finely crystalline
1370 As above, trace gray dead chert
1380 As above, very fine embedded sand
1390 Dolomite, gray, black mottling, some fine to medium crystalline, medium gray shale
1410 Dolomite, tan, fine rhomb
1430 As above, green gray shale, trace sand
1440 Dolomite, tan gray to brown, dark mottling, finely crystalline
1450 Dolomite, brown to black, cryptocrystalline, green gray to red shale
1460 Cave, dolomite, tan to brown, some very finely crystalline, green gray shale
1470 Dolomite, tan gray, dark mottling, finely crystalline
(5')
1490 As above, embedded sand
1495 Shale, red brown & green
1500 Sand, fine to medium, some coarse, shale as above
1505 ? Shale, green gray
1510 Sand, fine to medium
1515 Sandstone, dolomitic, fine to medium
1525 Sand, fine to coarse
1540 Sand, fine to medium, much pyrite, in part oolite

Skip 1545-55

1555 Dolomite, tan gray to dark gray, dense
1560 Dolomite, tan gray, cryptocrystalline, some finely crystalline
1565 As above, trace embedded sand
1575 Dolomite, tan gray to dark gray, dense, some sand as above
1585 Dolomite, tan, some very finely crystalline
1590 Dolomite, gray, dense, much embedded sand
1595 Dolomite, medium gray, dense, crystalline quartz
1600 Dolomite, tan gray, some very finely crystalline
1605 As above, some finely crystalline
1620 As above, finely crystalline, crystalline quartz
1635 As above, some fine to medium crystalline
1665 As above, some fine rhomb
1675 As above, fine to medium rhomb
1680 As above, some coarse rhomb, trace embedded sand
1690 Sand, fine to medium, subangular to rounded
1695 Sandstone, fine, some medium, dolomitic, glauconite
1700 Sandstone, fine to medium, as above
1705 Dolomite, gray, very fine to fine rhomb, glauconite
1715 As above, very fine rhomb, much embedded sand
1720 Sandstone, fine, dolomitic, to sandy dolomite
1725 Sandstone, very fine to fine dolomitic, some coarse sand, to sandy dolomite
1730 Dolomite, tan gray, very finely crystalline, sand embedded
1735 As above, very fine rhomb, glauconite
1745 Dolomite, light gray, very fine, some fine rhomb, glauconite

February 13, 1969
Marvin P. Carlson

DOUGLAS NW SE SE 25-16N-9E Great Western No. 1 Smith 1150 KB

1750,	Dolomite, tan gray, some fine to medium crystalline, trace glauconite
1765	As above, fine to coarse crystalline, glauconite
1780	As above, fine to medium rhomb, glauconite
1790	Dolomite, tan, dark mottling, fine to coarse rhomb, trace sand embedded
1810	As above, fine to medium rhomb, fine to medium embedded sand
1830	Dolomite, tan gray, fine to coarse rhomb
1840	Dolomite, gray, very finely crystalline, silty
1845	Dolomite, tan gray, fine to coarse crystalline, glauconite
1850	As above, finely crystalline, glauconite, embedded sand
1855	As above, much embedded sand to dolomitic sandstone
1870	Sand, fine to medium, some coarse, rounded, pyrite
1875	Sandstone, dolomitic, fine to medium to sandy dolomite
1885	Sand, fine to medium, rounded
1890	As above, oolitic pyrite
1910	Sandstone, very fine to fine, argillaceous, pyrite
1920	Sand, fine to medium, rounded, red shale
1930	Sandstone, very fine to fine, argillaceous, red to maroon shale
1945	Sand, fine to very coarse, subrounded to rounded, some yellow & pink
1955	"Shale" red to maroon, some sand as above
1970	As above, red, silty & medium gray
2145	Shale, green, maroon, purple
2160	Shale, red, silty, medium gray shale
2185	Siltstone to very fine sandstone, gray arkosic, mica, some as above, crystalline gypsum
2205	As above, red hemic
2240	Shale, green gray to maroon
2265-2345	T.D. - Siltstone, red hemic

Sept. 17, 1965
Marvin E. Carlson

OTCE SE SE SE SE 7-9N-12E Stanolind No. 11 Schutz 1238 K.B.

(10),
620 - Shale, gray & red, limestone, gray-brown
630 - As above, more red
640 - Sand, very fine to fine, shale as above
650 - Dolomite, gray to tan-gray, dense to very fine, some finely crystalline
660 - As above, some pink, dense
670 - Mostly green-gray to red shale
680 - Dolomite, light to light medium gray, dense, some very finely crystalline, very fine to fine sand embedded
690 - As above, some white very finely crystalline, some sandstone, green sandy shale
700 - Dolomite, light medium gray, dense to very finely crystalline sucrose
710 - Dolomite, tan-gray to tan, cryptocrystalline, trace rhomb
720 - Dolomite, white, sublithic to very finely crystalline, fine sand embedded
730 - Dolomite, light to light medium gray, cryptocrystalline to fine rhomb, some medium rhomb
740 - Dolomite, light gray, very fine to fine rhombic sucrose
750 - As above, dense to rhombic sucrose, trace white conchoidal chert
760 - As above, crystalline quartz
770 - Dolomite, light medium gray, cryptocrystalline to fine rhomb
780 - As above, in part fine rhombic sucrose, white dead to blocky chert
790 - As above, cryptocrystalline, fine to medium rhomb, much white blocky to conchoidal chert
800 - As above, some scattered pyrite, crystalline quartz
810 - As above, dense to fine rhomb, in part sucrose, white dead to blocky chert
820 - Dolomite, gray to tan-gray, dense, some very fine to fine rhomb
830 - Dolomite, light medium gray, cryptocrystalline, some rhomb, trace pale green shale
840 - As above, cryptocrystalline to very fine rhomb, crystalline quartz
850 - As above, in part sucrose
1000 - As above, some white dead to blocky chert
1010 - Dolomite, gray to tan-gray, dense to very fine, some fine rhomb, in part sucrose, more chert
1030 - Dolomite, gray, some yellow, as above, limonite pellets
1070 - Dolomite, light gray, dense to very finely crystalline, some sublithic, trace red shale
1090 - Dolomite, light gray, dense to very fine rhomb, pyrite speckled, medium gray to green-gray shale
1100 - All as above, much granular silica
(3)
1110 - Circulation, as above, some ?, light gray blocky to conchoidal chert
1115 - Dolomite, light to light medium gray, dense, some crystalline, some silica
1130 - As above, trace silica
1140 - Dolomite, light to light medium gray, dense cryptocrystalline, trace rhomb
1165 - As above, more fine rhomb, trace pyrite
1175 - Dolomite, light gray, dense to fine, some medium rhomb, sucrose
1210 - Dolomite, light gray, dense to very fine to fine rhomb, trace dead to blocky chert
1230 - Dolomite, light to light medium gray, dense to very fine rhomb, white blocky to conchoidal chert
1245 - Dolomite, light to light medium gray, dense to very fine rhombic sucrose, more dead to blocky chert
1270 - Dolomite, light to light medium gray, dense to very finely crystalline, light & medium gray to blue-gray blocky chert
1280 - As above, some tan-gray, light & medium gray to blue-gray blocky chert
1295 - Dolomite, light gray, dark mottling, dense, some fine to medium rhomb, some gray blocky to conchoidal
1315 - Dolomite, light gray, dense to very fine, some fine rhomb, ? gray shale, some gray blocky to conchoidal
1345 - Dolomite, light medium gray, dense to fine rhomb, medium gray speckled chert

ATOE Stanolind No. 11 Schutz

1355 - Dolomite, light medium gray, very finely crystalline rhomb, medium gray speckled chert
1375 - Dolomite, light medium gray, very finely crystalline rhomb, trace chert
1380 - Dolomite, gray, dark mottling, dense to medium rhomb
1400 - Dolomite, tan-gray, dense to fine, some medium sucrose
1415 - Dolomite, tan-gray, dense, some fine rhomb (much very fine to fine sand)
1435 - As above, more rhombic sucrose
1445 - Dolomite, light medium gray, black mottled & speckled, dense to fine, some medium rhomb, trace green-gray shale
1460 - Limestone, light to medium gray, sublithic
1465 - Limestone, in part dolomitic, gray, dark mottled, dense, medium gray shale
1475 - Dolomite, tan, dense to finely crystalline
1490 - Limestone, tan-gray to tan, dense, in part dolomitic
1515 - Limestone, gray-tan, dense to lithic, medium gray shale
1525 - Mostly very fine sand, clear, subangular to rounded, some green-gray shale
1540 - Dolomite, medium gray, very fine rhomb, sand & shale
1550 - ? as above
1565 - Dolomite & limestone, sand & shale, trace rounded, frosted sand
1570 - Sandstone, dolomitic, very fine, some fine to medium, rounded, frosted
1575 - Sand, as above, very fine to medium
1610 - Sand, as above, very fine to fine, trace medium, trace green-gray shale
1634 - 1/2 hr. circulation, as above, trace granite, mostly feldspar

46-14

COUNTY: OTOE	SEC 7	T 9	R 10E	-SE-SE-SE-SE
FARM: STRAT #11 (SCHULTZ)	OPERATOR: STANOLIND OIL & GAS CO			
PERMIT NO: DATE:	FIELD:	WILDCAT:	SPUD:	COMP: 4-28-44
D&A ✓ OIL GAS	KB 1138	DF	GL	TD 1634 PBTD
PROD. ZONE:	IP:	PIPE:		

DATA ON FILE

PWR	PAR ✓	S ✓	SL ✓	DL ✓	DT ✓	ES	ML	LL	I	R	OTHER

FORMATION TOPS

SAMPLE STUDY: | ELECTRIC LOG: | OPERATORS REPORT: | SCOUT: | DATE:

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
CRETACEOUS				Skull Creek			
Pierre				Fall River			
Niobrara				Fuson			
Ft. Hays				Lakota			
Carlile				JURASSIC			
Belle Fouche				Morrison			
Gurley "D"				Sundance			
Huntsman				TRIASSIC			
Cruise "J"							

over

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
PERMIAN				MISSISSIPPIAN			
Blaine				St. Louis			
Stone Corral				Gilmore City			
Wellington				Chattanooga			
Chase				DEVONIAN			
Council Grove				SILURIAN			
Admire				ORDOVICIAN			
PENNSYLVANIAN			551	Maquoketa (Sylvan)	1057	+121	93
Wabaunsee				Galena (Viola)	1150	+128	315
Shawnee	110	+1028		Decorah (Simpson)	1465	-207	125
Douglas	[illegible]	[illegible]		St. Peter (Wilcox)	1590		
Lansing	[illegible]	[illegible]		Oneota (Arbuckle)			
Kansas City				CAMBRIAN			
Marmaton	[illegible]	[illegible]	[illegible]	Bonneterre			
Cherokee	[illegible]			La Motte (Reagan)			
				PRECAMBRIAN	1634	-396	

OIL & GAS SHOWS	DRILL STEM TESTS	CORE DATA

78-13

COUNTY Saunders	SEC 5	T 16	R 8 E	— — —SE —NE

FARM: Fox [illegible] #1	OPERATOR: Midland Oil Co.

PERMIT NO: DATE	FIELD:	WILDCAT:	SPUD: 3-17-35	COMP: 11-35

D&A √	OIL	GAS	KB	DF 1373	GL 1370	TD [illegible]	PBTD

PROD. ZONE:	IP:	PIPE: - 831

DATA ON FILE

PWR	PAR	S √	SL	DL	DT	ES	ML	LL	I	R	OTHER

FORMATION TOPS

SAMPLE STUDY: √	ELECTRIC LOG:	OPERATORS REPORT:	SCOUT:	DATE:

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
CRETACEOUS				Skull Creek			
Pierre				Fall River			
Niobrara				Fuson			
Ft. Hays				Lakota			
Carlile				JURASSIC			
Belle Fouche				Morrison			
Gurley "D"	311			Sundance			
Huntsman				TRIASSIC			
Cruise "J"							

over

	DEPTH	DATUM	THICK.	1373	DEPTH	DATUM	THICK
PERMIAN				MISSISSIPPIAN	[illegible]	1428	78
Blaine				St Louis			
Stone Corral				Gilmore City			
Wellington				Chattanooga	A		
Chase				DEVONIAN	[illegible]	+368	[illegible]
Council Grove				SILURIAN	[illegible]		
Admire				ORDOVICIAN			
PENNSYLVANIAN			384	Maquoketa (Sylvan)	[illegible]	+43	140
Wabaunsee				Galena (Viola)	[illegible]	-57	[illegible]
Shawnee				Decorah (Simpson)	[illegible]	-382	[illegible]
Douglas				St Peter (Wilcox)	[illegible]		[illegible]
Lansing	441			Oneota (Arbuckle)	[illegible]	-552	127
Kansas City	531			CAMBRIAN			
Marmaton	685			Bonneterre	2037		120
Cherokee	800			La Motte (Reagan)	[illegible]	-797	15
				PRECAMBRIAN	2187	-814	

OIL & GAS SHOWS	DRILL STEM TESTS	CORE DATA
Oil [illegible]		
[illegible]		
1395-[illegible], [illegible]		
[illegible]		
[illegible]		
[illegible]	WI 78-12	

St. Peter sandstone, 1875'-1925' (50'):

1. Sandstone, medium to coarse-grained, subangular to rounded and frosted, friable, some green shale cave, 1875'-1888'
2. Sandstone, as above, with much green shale, probably cave, 1888'-1900'
3. Sandstone, medium grained, subangular, in part rounded and frosted, friable, 1900'-1925'

(IV) Prairie du Chien group, 249':

1. Willow River, 1925'-2040' (115'):
   (1) Dolomite, light gray to white, finely to moderately crystalline, broken by the bit in tiny fragments, common sand, probably cave, 1925'-1945'
   (2) Dolomite, as above, with abundant sand, may be the New Richmond sandstone, 1945'-1960'
   (3) Dolomite, as above, with common sand, 1960'-1985'
   (4) Dolomite, light gray to white, crystalline, friable, 1985'-2040'
2. New Richmond sandstone, medium-grained subangular, dolomitic, 2040'-2052'
3. Oneota formation, 2052'-2172' (122'):
   (1) Dolomite, light gray, crystalline, with some sand, 2052'-2065'
   (2) Dolomite, light gray, crystalline, glaucomatic, sandy, 2065'-2135'
   (3) Dolomite, light gray, crystalline and sand, 2135'-2172'

VIII Cambrian System, 17':

(I) Jordan sandstone, medium to coarse grained, friable, 2172'-2187'

IX Cambrian or Pre-Cambrian, 17':

(I) Sandstone, medium-grained, angular, reddish, with reddish silty clay cementing material and some glaucomite, 2187'-2204' (Total depth)

FORSTER #1

1965-1995	Predominantly fine-grained, angular, quartz sand, some in crystals; occasional coarser, rounded and frosted grains; a little white, siliceous material; common pyrite and oil residue.
1995-2003	Fine-grained, angular quartz sand; common pyrite; some oil residue.
2003-2010	Fine, pyritic, angular sand, as above; some white secondary silica; some oil residue.
2010-2025	Considerable sand, as above; new element: flood of chert, grading from white, opaque, dense, sharp, partly dolocastic, through brownish, finely crystalline sparkling, to crystal clear secondary quartz; some finely dolocastic pyrite; elongate silicified oolites; crinoid joints.
2025-2031	Much as above with some rope-like masses and some concentric flattened oolites (similar to Eminence oolites).
2031-2040	Flood of small pieces of white, opaque, finely granular, secondary silica with some siliceous oolites, some pyrite, a little angular quartz; trace of oil residue.
2040-2065	Flood of fine to medium-grained, well-sorted, quartz sand, angular to subangular, rarely rounded and frosted, some of grains are crystals.
2065-2070	Poorly sorted quartz sand, fine to coarse, typically angular; fairly common glauconite; some oil residue.
2070-2082	Sand, as above, with little or no glauconite.
2082-2095	Sand, as above, with a little glauconite and a trace of white, opaque, secondary silica.
2095-2110	Sand, as above; some pyrite and oil residue; a little glauconite.
2110-2145	Sand, as above; some pyrite; a trace of glauconite.
2145-2160	Sand, as above, with a little more coarse sand, usually rounded and frosted; fairly common pyrite; a little glauconite; rare oil residue.
2160-2177	Flood of quartz sand, medium to coarse-grained; the coarser grains are subangular to rounded and generally frosted.
2177-2204	Sand, fine to coarse, generally angular, many pink-stained grains; common oil residue; in part feldspathic.

55-E

COUNTY:	SEC	T	R	E/W		
FARM	WELL NO	OPERATOR:	STATUS:	FIELD:		
ELEVATION: 1307 KB DF GL	TD:	PBTD:	PRODUCING FORMATION	IP:	SPUD:	COMP:
DATA ON FILE: WCR PA S SL SD DL DT ES I-ES ML LL I R OTHER	RECORDED BY:					
BASIS FOR FORMATION TOPS:	ELECTRIC LOG: ✓	SAMPLE STUDY:	OPERATORS REPORT:	SCOUT REPORT:		

FORMATION TOPS:

TOP OF:	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
CRETACEOUS				JURASSIC			
Pierre				Morrison			
Niobrara				Sundance			
Ft. Hays - Timpas				TRIASSIC			
Codell				PERMIAN			
Carlile				Cimarron			
Greenhorn				Blaine (Minnekahta)			
Belle Fourche				Stone Corral			
Mowry Bent				Wellington			
Gurley "D"				Chase (Herington)			
Huntsman				Fort Riley			
Cruise "J"				Council Grove (Lower Gp.)	1532	-225	
Skull Creek				Cottonwood			
Cloverly				Admire	2228		

(over)

LOCATION SEC	T.	R.	E/W		ELEVATION: 1307 K.B

TOP OF	DEPTH	ELEV.	THICK.	TOP OF:	DEPTH	ELEV.	THICK.
PENNSYLVANIAN				MISSISSIPPIAN			
WABAUNSEE	330			St. Louis - Osage			
Tarkio				Gilmore City (Chouteau)			
Howard				Chattanooga			
SHAWNEE (Topeka)	610			DEVONIAN			
Deer Creek				SILURIAN	1172		
Oread				ORDOVICIAN (Maquoketa)	1450		
DOUGLAS	821			Galena (Viola)	1544		
LANSING	875			Decorah (Simpson)	1611		
KANSAS CITY	2			St. Peter (Wilcox)	1724		
Wyandotte				Upper Arbuckle			
Winterset				CAMBRIAN			
Base Kansas City	2			Bonneterre (Lr. Arb.)			
MARMATON	1102			LaMotte (Reagan)			
CHEROKEE				PRECAMBRIAN	1990		

OIL SHOWS, DRILL STEM TESTS, CORE DATA, ETC.:

1327
1442
+115

13-2

COUNTY CASS	SEC 08	T 10	R 12 E/W	- SW NE NW	
FARM: STRAT #11	OPERATOR: [illegible]				
PERMIT NO: DATE	FIELD:	WILDCAT:	SPUD:	COMP: 11-17-52	
D&A ✓ OIL	GAS	KB 1216	DF [illegible]	GL 1207	TD 1357 PBTD
PROD. ZONE:	IP:	PIPE:			

DATA ON FILE

PWR	PAR	S ✓	SL	DL	DT	ES ✓	ML	LL	I	R	OTHER

FORMATION TOPS

SAMPLE STUDY: | ELECTRIC LOG: ✓ | OPERATORS REPORT: | SCOUT: | DATE:

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
CRETACEOUS				Skull Creek			
Pierre				Fall River			
Niobrara				Fuson			
Ft. Hays				Lakota			
Carlile				JURASSIC			
Belle Fouche				Morrison			
Gurley "D"				Sundance			
Huntsman				TRIASSIC			
Cruise "J"							

over

1357

1216	DEPTH	DATUM	THICK.	1216 KB	DEPTH	DATUM	THICK.
PERMIAN				MISSISSIPPIAN			
Blaine				St. Louis			
Stone Corral				Gilmore City			
Wellington				Chattanooga			
Chase				DEVONIAN	625	591	27
Council Grove				SILURIAN	652	-64	358
Admire				ORDOVICIAN			
PENNSYLVANIAN				Maquoketa (Sylvan)	960	+256	70
Wabaunsee				Galena (Viola)	1030	+186	316
Shawnee	75			Decorah (Simpson)	1346	-130	118
Douglas	230			St. Peter (Wilcox)	1464		16
Lansing	296	+920		Oneota (Arbuckle)			
Kansas City	340			CAMBRIAN			
Marmaton	506	+710		Bonneterre			
Cherokee				La Motte (Reagan)			
				PRECAMBRIAN	1480	-264	

OIL & GAS SHOWS	DRILL STEM TESTS	CORE DATA

13-5

COUNTY CASS	SEC 5	T 11	R 15E [illegible] — [illegible]-NE-NW-NW
FARM: RUFFNER #1	OPERATOR: CASS OIL RESEARCH TRUST		
PERMIT NO: DATE:	FIELD:	WILDCAT:	SPUD: 11-12-51 / COMP: 11-23-51
D&A / OIL / GAS	KB 1155± / DF	GL	TD 1540 / PBTD
PROD ZONE:	IP:	PIPE: 8⅝ 96' / 155 SX	

[illegible] / [illegible] DATA ON FILE

PWR	PAR ✓	S ✓	SL ✓	DL	DT	ES	ML	LL	I	R	OTHER

FORMATION TOPS

SAMPLE STUDY:	ELECTRIC LOG:	OPERATORS REPORT:	SCOUT:	DATE:

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
CRETACEOUS				Skull Creek			
Pierre				Fall River			
Niobrara				Fuson			
Ft. Hays				Lakota			
Carlile				JURASSIC			
Belle Fouche				Morrison			
Gurley "D"				Sundance			
Huntsman				TRIASSIC			
Cruise "J"							

over

118[illegible]	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
PERMIAN				MISSISSIPPIAN			
Blaine				St. Louis			
Stone Corral				Gilmore City			
Wellington				Chattanooga	A		
Chase				DEVONIAN	[illegible]	[illegible]	[illegible]
Council Grove				SILURIAN	[illegible]	+335	210
Admire				ORDOVICIAN			
PENNSYLVANIAN	95		[illegible]72	Maquoketa (Sylvan)	1010	+110	70
Wabaunsee				Galena (Viola)	[illegible]	+105	325
Shawnee				Decorah (Simpson)	[illegible]	[illegible]	100
Douglas	95			St. Peter (Wilcox)	15[illegible]	[illegible]	[illegible]
Lansing	[illegible]	[illegible]		Oneota (Arbuckle)			
Kansas City				CAMBRIAN			
Marmaton	[illegible]	+820		Bonneterre			
Cherokee				La Motte (Reagan)			
				PRECAMBRIAN	[illegible]	[illegible]	

OIL & GAS SHOWS	DRILL STEM TESTS	CORE DATA

66-3

COUNTY: OTOE	SEC: 11	T: 7N	R: 10E	-SW-SW-SW-SW
FARM: STEAT #1 (CALVERT)	OPERATOR: STANOLIND OIL & GAS CO.			
PERMIT NO: DATE:	FIELD:	WILDCAT: ✓	SPUD: 6-26-43	COMP: 7-16-43
D&A ✓ OIL	GAS	KB 1175	DF	GL
TD 3128	PBTD			
PROD. ZONE:	IP:	PIPE:		

DATA ON FILE

PWR	PAR	S ✓	SL ✓	DL	DT ✓	ES	ML	LL	I	R	OTHER

FORMATION TOPS

SAMPLE STUDY: | ELECTRIC LOG: | OPERATORS REPORT: | SCOUT: | DATE:

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
CRETACEOUS				Skull Creek			
Pierre				Fall River			
Niobrara				Fuson			
Ft. Hays				Lakota			
Carlile				JURASSIC			
Belle Fouche				Morrison			
Gurley "D"				Sundance			
Huntsman				TRIASSIC			
Cruise "J"							

over

X,

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
PERMIAN				MISSISSIPPIAN			
Blaine				St. Louis			
Stone Corral				Gilmore City			
Wellington				Chattanooga			
Chase				DEVONIAN			
Council Grove				SILURIAN	980	-195	375
Admire				ORDOVICIAN			
PENNSYLVANIAN			615	Maquoketa (Sylvan)	1250	-75	90
Wabaunsee	170		340	Galena (Viola)	1330	-155	275
Shawnee			170	Decorah (Simpson)	1605	-430	140
Douglas	650			St. Peter (Wilcox)	1745	-570	40
Lansing	700	+475		Oneota (Arbuckle)			
Kansas City				CAMBRIAN			
Marmaton	930	+245		Bonneterre			
Cherokee				La Motte (Reagan)			
				PRECAMBRIAN	1794	-619	

OIL & GAS SHOWS	DRILL STEM TESTS	CORE DATA

66-11

COUNTY	SEC	T	R		
CLOE	13	8S	14E	- - C - NW - SW	

FARM:	OPERATOR:
BRICK TRAFT #1	INGERSOLL BROS.

PERMIT NO: / DATE:	FIELD:	WILDCAT:	SPUD:	COMP:
			1911	1912

D&A ✓	OIL	GAS	KB	DF 732	GL	TD 2950	PBTD

PROD. ZONE:	IP:	PIPE:
		CABLE TOOLS

DATA ON FILE

PWR	PAR	S ✓	SL	DL ✓	DT	ES	ML	LL	I	R	OTHER

FORMATION TOPS

SAMPLE STUDY: | ELECTRIC LOG: | OPERATORS REPORT: | SCOUT: | DATE:

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
CRETACEOUS				Skull Creek			
Pierre				Fall River			
Niobrara				Fuson			
Ft. Hays				Lakota			
Carlile				JURASSIC			
Belle Fouche				Morrison			
Gurley "D"				Sundance			
Huntsman				TRIASSIC			
Cruise "J"							

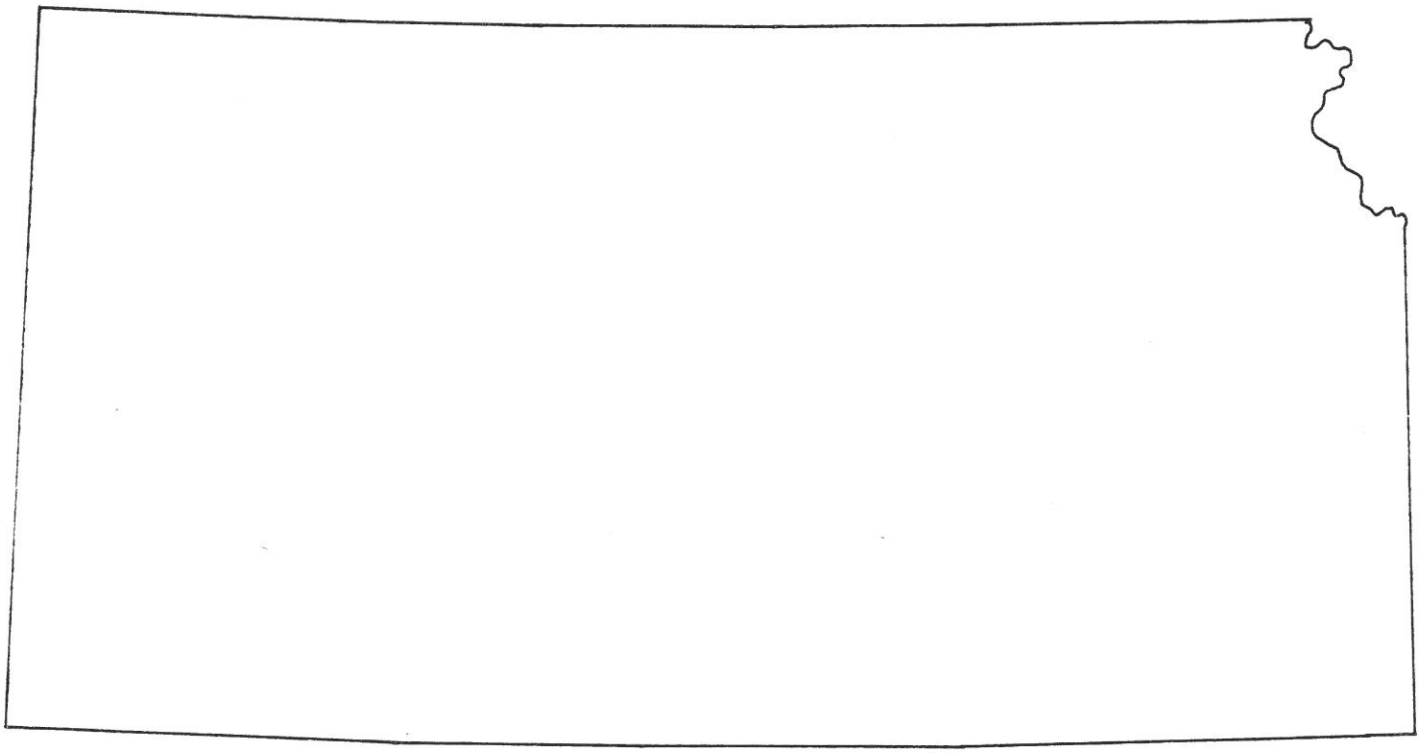
over

	DEPTH	DATUM	THICK.		DEPTH	DATUM	THICK.
PERMIAN				MISSISSIPPIAN	1051		
Blaine				St. Louis			
Stone Corral				Gilmore City			
Wellington				Chattanooga			
Chase				DEVONIAN	1240		
Council Grove				SILURIAN	1460	-728	340
Admire				ORDOVICIAN	1858	-926	250
PENNSYLVANIAN				Maquoketa (Sylvan)	2102	-1170	60
Wabaunsee			246	Galena (Viola)	2214	-1282	56
Shawnee	246	-717	45	Decorah (Simpson)	2262	-1331	100
Douglas	415			St. Peter (Wilcox)	2362		88
Lansing	505			Oneota (Arbuckle)			
Kansas City				CAMBRIAN			
Marmaton	760			Bonneterre			
Cherokee	800			La Motte (Reagan)			
				PRECAMBRIAN	2450	-1418	

OIL & GAS SHOWS	DRILL STEM TESTS	CORE DATA
	T:	

W1166-20

Kansas Information



Catherine

MARSHALL COUNTY SYNIDCATE #1 FINN — 4-4-7E, NW NE NE

Contr. ______ MARSHALL County

E 1328 L&S Comm. 8-28-26 Comp. 5-23-29 IP D & A

*(1370)

Tops	Depth	Datum
LANS	1176	
B/KC	1425	(-97)
HUNT	1520	
SYL	1800	
VIO	1913	
SIMP	2075	
PRE CAM	2245	(? 2365 (-1035))
TD	3025 / 3935	

Casing

SO 1300-1350: 1810

Galena 1940
Decorah 2070
Platteville 2120
St Peter 2148

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS

Lithology — Formation — Top — Thickness
Eolridge 340'
Cerro Haven? 660'
Old shale — Viola? 1740' 10'
Iron [illegible] 1800'

*Type of Deposit
Showing Oil
" "
Pyrites
Showing Oil

Seneca (Weir)

NEMAHA OIL & GAS CO #1 MEYERS — 19-3-11E, NW NW NW

Contr. ______ NEMAHA County

E 1218 L&S Comm. 7-5-26 Comp. 3-20-29 IP D & A

Tops	Depth	Datum
T. Lans	610	+607
GR WASH	707	
GRAN	750	
TD	3256	

Casing

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS

Company J. J. Healey et al No. 1 Farm Thiere

Elev. 1264 Location NW NE NW S 20 T 10 S.R. 7 E

17-5854 10-39—20M

County Riley

I.P. Dry

T.D. 2965

Comm. 1-28-27

Comp. 5-23-29

P.B.

Shows		
Water	Oil	Gas

Formation	Depth	Datum
T. Wellington		
T. Donegal		
T. Winfield		
B. Florence		
B. Wreford		
B. Foraker		
T. Brownville		
T. Tarkio		
T. Burlingame		
Howard		
T. Topeka		
T. Deer Creek		
T. Lecompton		
B. Oread		
T. Haskell		
T ~~Stanton~~ L.S.	1250	+14
T. Plattsburg		
T. Iola		
"Layton" sd		
B. Hertha	1545	-319
Knobtown sd		
"Basal Mo." sd		
T. Des Moines		

Formation	Depth	Datum
Top Pawnee		
Base Ft. Scott		
"Squirrel" sd		
Ardmore ls.		
"Burbank" sd		
"Bartlesville"		
Burgess		
Basal Penn		
Top. Miss		
Kinderhook		
Misener		
Hunton	1728	
Sylv. Maqo	2148	
Viola	2205	
Simpson	2306	
Arbuckle	2366	
Prec	2420	
Basal sd.		
Pre-Camb		
T.D.		

Y 12-78

NFW

STATE KANSAS 11-4-38 MAP NO. S-T-R 25-9S-1E WF

OPER CLOUD EXPLORATIONS INC SPOT N/2 NW NE INIT

231 W 20TH, CONCORDIA, KS CO CLAY WF

WELL 1 STEFFEN ELEV 1376 KB FIN

CONTR DUNBAR DRLG

FIELD WILDCAT 16 MI W ABND WAKEFIELD(MISS)

IP D&A

API 15-027-20012

SPUD 11-4-78, 8 5/8 @ 206

RTD 2496

D&A, COMPLETED 11-9-78

TD IN MISS

COMP ISSUED 11-28-78

KB SPL TOPS

HOWARD	1460 - 84
TOPEKA	1509 - 133
HEEBNER	1750 - 374
DOUGLAS	1780 - 404
IATAN	1853 - 477
LANSING	1869 - 493
B/KANSAS CITY	2118 - 742
MARMATON	2131 - 755
CHEROKEE	2210 - 834
BURGESS	2398 - 1022
MISS	2407 - 1031
MISS DOLO	2434 - 1058
RTD	2496 - 1120

Petroleum Information

KEWANEE OIL CO #1 SHERMAN 13-5-3E SW SW NE

2310' FNL 2310' FEL

Contr. GRAHAM-MICHAELIS WASHINGTON County (D)

E. 1389 (W) (D) Comm. 8-10-59 Comp. 9-4-59 (D) 8-19-59 (D) IP D & A

Tops	Depth	Datum
TOP 1262 (D)	1263	+126
HEEB 1570	1512	-123
BR LM	1572	-183
LANS 1617	1588	-199
B/KC	1878	-489
MARM	1902	-513
HUNT	2334	-945
MAQ	2720	-1331
VIO	2763	-1374
SIMP	2956	-1567
GR WSH	3140	-1751
TD 3266 (D)	3264	-1875

Casing 8" 285

CORRECTED CARD 11-13-59

Kind 2080

WC

ADDED INFORMATION

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS

D- Oct 7, 1969

log - ID

171

11-174 Map. No. REPL#1 WILDCAT

OPER MCCULLOCH OIL, VENUS OIL & ALEX MCCOY
1200 NBC BLDG, SAN ANTONIO, TEXAS

WELL #1 IRELAND

CONTR B&N DRLG

WC 30 MI NE GRIFFITH (MISS)

IP D&A

API 15-117-20012

S-T-R 8-5S-7E SPOT SE NE NE CO MARSHALL, KS ELEV 1380 GR

WF INIT

WF FIN

SPUD 8-26-70; 7"@30 not cemented; Geol-Dean Seeber;
No Cores or Dsts;
RTD 2360; Log; D&A COMPLETED 11-11-70.
REPLACES COMP ISSUED 11-19-70.
REPLACED TO ADD ADDITIONAL DATA.

FD 2360 11/11/71

GR LOG TOPS

HOWARD	886 + 494
TOPEKA	920 + 460
OREAD	1066 + 314
HEEBNER	1107 + 273
DOUGLAS SHALE	1136 + 244
BROWN LIME	1149 + 231
LANSING	1172 + 208
B/PENN HUNTON	1583 - 203
MAQUOKETA	1916 - 536
VIOLA	1978 - 598
DECORAH	2130 - 750
SIMPSON SHALE	2184 - 805
SIMPSON SAND	2245 - 865
GRANITE WASH	2295 - 915
LTD	2359 - 979
RTD	2360 - 980

TD IN GRANITE WASH FORM

REPL COMP ISSUED 2-17-72

VEEDER SUPPLY #1 GRAVENSTINE 21-8-6E C NW NW

NW NW NW

Contr. RILEY County

1258 KB

E 1255 Comm. 12-10-45 Comp. 1-6-46 IP D & A

Tops	Depth	Datum
HEEB	1260	
LANS	1345	
B/KC 1386	1664	
MARM	1673	
CONG	1724	
MISS CHERT	1744	
MISS LS	1755	
KIND	1776	
MISN SND	1964	
HUNT	1970	
SYL SH	2420	
MAQ DOL	2506	
XLN VIO	2525	

Casing 8" 102

ADDITIONAL TOPS

SIMP SH 2645

SIMP SND 2661

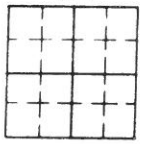
NO ARB

NO REAG SND

GRAN WSH 2676

TD 2702

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS



H. GROGE #1 SUGGETT 34-2-8E NW SW NW

Contr. MARSHALL County

E 1325 Comm. Comp. 6-22-51 IP D & A

Tops	Depth	Datum
LANS	1040	+285
PRE CAMB	1700	-375
TD	2373	-1048

Casing 8" 105

CORRECTED CARD 10-7-60

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS

(ADDED TOPS AND ELEVATION)

11-171 Map. No. REPL#1 **WILDCAT**

OPER MCCULLOCH OIL, VENUS OIL&ALEX MCCOY
1200 NBC BLDG, SAN ANTONIO, TEXAS

WELL #1 Henley

CONTR BGN DRLG

WC 33 MI NW SOLDIER POOL (HU-VI)

IP D&A

API 15-117-20017

S-T-R 34-4S-8E

SPOT C NE NW

CO MARSHALL, KS

ELEV 1246 GR

WF INIT

WF FIN

SPUD 10-14-70; 7" @32 not cemented; Geol-Dean Seeber
No Cores or DSTS;
RTD 1680; Log; D&A COMPLETED 11-11-70.
REPLACES COMP ISSUED 11-19-70,
REPLACED TO ADD ADDITIONAL DATA,

TD 1680 10/18/70

GR LOG TOPS

HOWARD	674 + 572
TOPEKA	717 + 529
OREAD	865 + 381
HEEBNER	903 + 343
DOUGLAS SHALE	931 + 315
BROWN LIME	950 + 296
LANSING	976 + 270
B/PENN MAQUOKETA	1250 - 4
VIOLA	1305 - 59
DECORAH	1450 - 204
SIMPSON SHALE	1504 - 258
SIMPSON SAND	1573 - 327
ARKOSIC SAND	1629 - 383
RTD	1680 -434
LTD	1682 - 436

TD IN ARKOSIC SAND FORM

REPL COMP ISSUED 2-17-72

Petroleum Information Corporation.

OPER Continental Oil Co. SEC 5-4S-8E

WELL 1 W.E. Neal ELEV 1443 KB LOG SW SE NE

(KB Spl)		(KB Log)		
How	870	How	870	+ 573
Top	904	Top	904 ✓	+ 539
Hb	1093	Hb	1092 ✓	+ 351
Lans	1153	Lans	1153 ✓	+ 290
BKc	1397	BKc	1396 ✓	+ 47
B/Penn	1429	Cong	1426 ✓	+ 17
Decorah	1448	Decorah V.I. Im	1447 ✓	- 4
Simp sh	1502	Simp sh	1500 ✓	- 57
Simp sd	1570	Simp sd	1569	- 126
Grt W	1623	Grt W	1624 ✓	- 181
RTD	1715 - 272			

DST #1 (Simp) 1568-77 Op 45" R 1118' Fresh wtr w/tr salt wtr, IBHP 505#/45", IFP 90#, FFP 505#, FBHP 505#/60" RTD 1715, Ran Log, D&A

COMPLETED (2-1-63)

Plotted

SHAWVER-ARMOUR, INC #1 SEDLACEK 31-4-8E SE SE NE

Contr. SHAWVER-ARMOUR MARSHALL County

KB (m) 12-8-59 (2) 12-18-59 (e)

E 1290 Comm. 12-10-59 Comp. 12-25-59 IP D & A

Tops	Depth	Datum
TOP 842	841	+449
HEEB (m)	1018	+272
TOR 1039	1036 (m)	+254
LANS (m) 1046 (e)	1088 1039	+202
B/KC	1336 (m)	-46
HUNT 1407	1406	-116
MAQ (m)	1548 1550	-258
VIO 1611	1610 (m)	-320
SIMP (m)	1762 1750	-472
SIMP SH 1819	1818 (m)	-528
SIMP SND (m)	1882 1888	-592
GRAN WSH	1920 (m)	-630
TD	2264	-974

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS

Casing
8" 155

(NW)

log - m- 12/22/59 LD

No Fe-cells

RE-EXAMINE, DESCRIBE IN DET

DOUG 1046 (e)

I EXECUTED

71

11-170 Map. No. REPL #1 **WILDCAT**

OPER MCCULLOCH OIL, VENUS OIL&MCCOY
1200 NBC BLDG, SAN ANTONIO, TEXAS

WELL #1 Fincham

CONTR BGN DRLG

WC 34 MI NW SOLDIER (HU-VI)

IP D&A

API 15-117-20007

S-T-R 26-4S-8E

SPOT SW SE SE

CO MARSHALL, KS

ELEV 1280 GR

WF INIT

WF FIN

SPUD 8-18-70; 7" @32 not cemented; Geol-Dean Seeber
No Cores, or DSTS
RTD 2500; Log; D&A COMPLETED 11-11-70.
REPLACES COMP ISSUED 11-19-70.
REPLACED TO ADD ALL ADDITIONAL DATA.

TD 2500 3/25/70

GR LOG TOPS

HOWARD	752 + 528
TOPEKA	788 + 492
OREAD	939 + 341
HEEBNER	977 + 303
DOUGLAS SHALE	1006 + 274
BROWN LIME	1018 + 262
LANSING	1047 + 233
B/PENN HUNTON	1336 - 56
MAQUOKETA	1403 - 123
VIOLA	1460 - 180
DECORAH	1617 - 337
SIMPSON SHALE	1673 - 393
SIMPSON SAND	1742 - 462
ARKOSIC SAND	1791 - 511
RTD	2500 -1220
LTD	2503 -1223

TD IN ARKOSIC SAND FORM

REPL COMP ISSUED 7-17-72

Petroleum Information Corporation.

ELECTRIC LOG

STATE KANSAS 3-1-67 MAP NO. S-T-R 14-5S-12E WF
OPER CITIES SERVICE SPOT SW SE SE INIT
700 SUTTON PLACE, WICHITA, KS 67202 CO NEMAHA WFD
WELL 1 BECK "A" ELEV 1278 KB, 1274 GR FIN
CONTR MENDENHALL DRLG
FIELD WC - 19 MI SW STRAHM (HUNT-VI)
IP IPP 65 BOPD + 11 BWPD (VI) 2462-72
API 15-131-20010 ER 11-30-77

SPUD 12-26-77, 8 5/8" @ 257 w/180
DST 1 (CHER) 1510-71, op20, si45, op30, si60, Rec 240' Mud + 240' SW, ISIP 433, FP 20-134/134-227, FSIP 483
DST 2 (HUNT) 1831-85, op45, si60, op30, si60, Rec 70' Mud, ISIP 516, FP 10-21/21-21, FSIP 516
DST 3 (VI) 2456-69, op30, si60, op30, si60, Rec 5' Oil, 55' SOCM, ISIP 820, FP 10-20/20-31, FSIP 820
DST 4 (VI) 2469-79, op30, si60, op30, si60, No Rec, ISIP 42, FP 10-10/10-10, FSIP 31
DST 5 (SP) 2636-54, op30, si45, op30, si60, No Rec, All Press 6

(CON'T)

KB LOG TOPS:

LANSING	982 + 296
KANSAS CITY	1023 + 255
PLEASANT	1245 + 33
MARMATON	1280 - 2
CHEROKEE	1409 - 131
MISS	1604 - 326
KINDERHOOK	1654 - 376
HUNTON	1832 - 554
MAQUOKETA	2400 - 1122
VIOLA	2448 - 1170
SIMPSON	2567 - 1289
PRE-CAMBRIAN	2708 - 1430

STATE KANSAS 5-4-82 MAP NO. S-T-R 25-5S-12E WF
OPER CITIES SERVICE CO SPOT NW NW SE INIT
700 SUTTON PLACE, WICHITA, KS 67202 CO NEMAHA WF
WELL 1 STEELE GRIFFEE "A" ELEV 1310 KB, 1303 GR FIN
CONTR B&N DRLG
FIELD WC - 1 3/4 MI SE UNNAMED (VI)
IP D&A
API 15-131-20014 ER 4-10-78

SPUD 4-25-78, 8 5/8" @ 338 w/250
CORE #1 (HUNT) 2500-50, Rec 50' Descrip NA
DST 1 (HUNT) 2539-52, op15, si30, op15, si30, Rec 540' SWCM, ISIP 821, FP 31-177/161-260, FSIP 790
CORE #2 (VI) 3165-95, Rec 30' Descrip NA
DST 2 (VI) 3170-95, op15, si30, op15, si30, Rec 2400' SW, ISIP 1144, FP 275-998/998-1107, FSIP 1159, BHT 115
RTD 3523, logs: DILL, CNL, FCC, BHC, Sonic
D&A COMPLETED 5-8-78

TD IN PRE-CAMBRIAN
COMP ISSUED 5-22-78

KB LOG TOPS:

LANSING	1205 + 105
B/KANSAS CITY	1493 - 183
MISS	2281 - 971
KINDERHOOK	2338 - 1028
HUNTON	2537 - 1227
MAQUOKETA	3110 - 1800
VIOLA	3166 - 1856
SIMPSON	3298 - 1988
SIMPSON SD	3413 - 2103
PRE-CAMBRIAN	3473 - 2163
LTD	3522 - 2212
RTD	3523 - 2213

granite 5% biotite 20% quartz 75% k-feldsp

CORRECTED CARD

OHIO OIL COMPANY #1 KRATCHOVIL 30-5-7E SE SE SW

CONTR OHIO OIL COMPANY CTY MARSHALL

GEOL FIELD WC

E 1407 CM 3/4/51 CARD ISSUED 3/30/51 IP D&A/PRE CAMBRIAN 3/24/51

API

TOPS	DEPTH	DATUM
HOW	953	+ 454
TOP	1000	+ 407
OREAD	1131	+ 276
HEEB	1200	+ 207
LANS	1232	+ 175
MARM	1551	- 144
HUNT	1655	- 248
MAQ	2129	- 722
VIOLA	2199	- 792
SIMP	2390	- 983
SIMP SD	2450	-1043
*PRE CAM	2496	-1089
TD	2526	-1119

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS

10 3/4" 163

DST(1) 1654-70/1", 25'M
DST(2) 2056-2160,/40", 800'M
DST(3) 2199-2230/35", 400'MW, BHP 765#
DST(4) 2380-2446/30", 5'M, BHP 95#

CORRECTED CARD: 6/14/73

*SCHIST no schist
Arb? or mafics
dark comb. thin section

CORRECTED CARD

SHAWVER-ARMOUR, INC. #1 WEAKLEY 26-5-7E NW NW NE

CONTR SHAWVER-ARMOUR, INC. CTY MARSHALL

GEOL FIELD WC

E 1303 PB CM 12/14/59 CARD ISSUED 1/1/60 IP D&A/PRE CAMBRIAN 12/22/59

API

E LOG TOPS	DEPTH	DATUM
TOP	892	+ 411
HEEB	1079	+ 224
TOR	1098	+ 205
LANS	1154	+ 149
BKC	1418	- 115
HUNT	1494	- 191
MAQ	1545	- 342
VIOLA	1720	- 417
SIMP	1852	- 549
SIMP SH	1906	- 603
SIMP SD	1962	- 659
*PRE CAM	2014	- 711
TD	2030	- 727

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS

8" 205/150sx

NO TESTS

CORRECTED CARD: 5/31/73

CORRECTED LOG TOPS

* CLASTICS

Repl #1

WILDCAT

11-179 Map. No.

OPER MCCULLOCH OIL, VENUS OIL, &ALEX MCCOY
SAN ANTONIO, TEXAS

WELL #1 FAGERBERG

CONTR STERLING DRILLING

WC APP 26 MI NE GRIFFITH (MISS)

IP D&A

API # 15-149-20010

S-T-R 31-6S-8E

SPOT SE SE NE

CO POTTAWATOMIE, KS

ELEV 1432 GR

WF

INIT

WF

FIN

SPUD 9-3-70, 7" @56 /not cemented, Geol-Dean Seeber

No Cores, No Dsts

RTD 2150, log, D&A COMPLETED 11-11-70

REPLACE COMP ISSUED 11-19-70

REPLACE TO ADD ADDITIONAL DATA

T.D. 2150 9/9/70

GR LOG TOPS

HOWARD	907 + 525
TOPEKA	957 + 475
OREAD	1137 + 295
HEEBNER	1165 + 267
DOUGLAS SHALE	1191 + 241
BROWN LIME	1226 + 206
LANSING	1247 + 185
B/PENN HUNTON	1593 - 161
MAQUOKETA	1766 - 334
VIOLA	1852 - 420
DECORAH	1953 - 521
SIMPSON SHALE	2004 - 572
SIMPSON SAND	2070 - 638

CONT

ARKOSIC SAND	2114 - 682
LTD	2147 - 715
RTD	2150 - 718

TD IN ARKOSIC FORM

REPL COMP ISSUED 2-17-72

2-199 MAP NO

REPL. COMP.

SEC 8-6S-6E

STATE Kansas COUNTY Riley

C SE NE

OPER Phillips Pet. Co.

WELL #1 FARM Winkler (Strat Test)

FT FR LINE

FT FR LINE

POOL WC

ELEV GR 1413 DF KB

CONT Co. Tools

GEOL

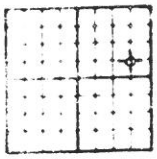
CO INT

FR 1/22/62 SPUD 1/27/62 COMP 2/20/62

TD 2735 FM Pre-Cambrian TOTD

COMP RECORD 8-5/8" @ 216

D&A



Mark Inc.

DF Spl Tops	
Top	985
Heeb	1190
Tor	1208
LKc	1264
BKc	1556
Kh	1632
Hunt	1733
Maq Sh	2214
Vi	2299
RTD	2735

Elec. S-J Tops		
Top	1004	+ 409
Heeb	1195	+ 218
Tor	1213	+ 200
LKc	1269	+ 144
BKc	1568	- 155
Kh	1650	- 237
Hunt	1737	- 324
Maq Sh	2234	- 821
Vi	2305	- 892

Simp	2444	Simp	2440 -1027
		Pre ¢	2584 -1171

No tests/shows plugged

D & A - COMPLETE (2/4/62)

REPLACEMENT COMPLETION: (2/26/63) For additional information

• Phillips Pet. Co.
Winkler #1 (Strat Test)
8-6S-6E

Crawford(a)(log) 1-7-3E

EL CAPITAN OIL CO. #1 WOOD SE SE SW

Contr. STRAIN DRILLING CO. CLAY County

E 1411 Comm. 8-2-49 Comp. 8-15-49 IP D & A WC

Tops	Depth	Datum
KC	1691	
MISS	2138	
HUNT	2353	
MAQ	2785	
VIO	2838	
SIMP	3079	
ARB	3114	
QTZ	3162	
T.D.	3255	

Casing

8" 136 N.S.

8/19/49
INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS
M8-17-49
Log

REPL #1 **WILDCAT**

STATE KANSAS 4-4-52 MAP NO.

OPER ANADARKO PROD CO & TESORO PETROLEUM
BOX 351, LIBERAL, KS

WELL 1 EULER "A"

CONTR MENDENHALL DRLG

FIELD WC - 35 MI NW EASTON(MISS)

IP D & A

API 15-043-20011

S-T-R 1-3S-21E WF

SPOT APP C SW NE INIT

CO DONIPHAN WF

ELEV 1070 GR FIN

635'fwl, 790'fsl of NE/4

SPUD 3-25-74, 7"@ 254 w/200, Geol-Ed Donnelly
RTD 1630, Log
D & A, COMPLETED 4-6-74

REPLACES CARD ISSUED 4-22-74
REPLACED TO ADD ALL COMPLETION DATA
WAS TEMPORARILY COMPLETED

REPL COMP ISSUED 5-10-76

GR LOG TOPS:

DOUGLAS SH	262 + 808
LANSING	471 + 599
KANSAS CITY	596 + 474
B/KANSAS CITY	769 + 301
CHEROKEE SH	962 + 108
BARTLESVILLE SD	1198 - 128
BURGESS SD	1560 - 490
MISS	1600 - 530
LTD	1635 - 565
RTD	1630 - 560

TD IN MISS

Petroleum Information CORPORATION

OPERATOR Five Nations Drlg. Co. WELL NO. 1 Seemaster ELEV. 1239 KB

SAMPLE TOPS	DEPTH	SUB SEA	ELEC. TOPS	DEPTH	SUB SEA
Lans	902		Lans	904 ✓	
BKC	1117		BKC	1122 ✓	
Hunt	1175		Hunt	1168 ✓	
Maq Sh	1306		Maq Sh	1308 1309 I Log	
Vi	1347		Vi	1349 ✓ 1350 I Log	
Simp sd	1381		Simp sd sh I	1382 ✓	
PreCam	1466		PreCam	1440 ✓	
RTD (PreCam)	1627		LTD	1628	

RTD 1627 in PreCam. Log. NS, D & A, COMPLETED.

PLOTTED

Log -

5-326

MAP NO.

1240 RBL

STATE Kans COUNTY Marshall SEC. 24 TWP. 3S RGE. 8E ELEV. 1239 KB ✓

OPERATOR Five Nations Drlg., Co., Inc. LOC. C NW NW

WELL NO. 1 FARM NAME Seemaster SEEMATTER (Log) FT. FROM LINE

POOL WC FT. FROM LINE

FR. 4/10/61 SPUD 4/14/61 COMP 5/25/61 4-28-61 I

CONT./GEOL. Augusta Tools Bob Boley - Geol.

COMPLETION RECORD	NAME PRODUCING INTERVAL	FROM — TO	PERF. W/HOLES	TREATMENT RECORD
a				
b				
c				
d				

e I. P. OIL/DIST. WTR. GAS M.C.F.P.D. CHK. HRS.

b " " " " " "

c " " " " " "

d D & A

SIP# FI TP # FI CP# SIBHP D & A ( )

GOR. GR. PBTD TD 1628 ✓ 1627 I

CASING - CEMENT RECORD	SIZE	DEPTH	W/SAX.	SIZE	DEPTH	W/SAX.
	8 5/8"	140	80			

71

11-169 Map. No. REPL#1 **WILDCAT**

OPER MCCULLOCH OIL, VENUS OIL&GAS, IEX MCCOY
1200 NBC BLDG, SAN ANTONIO, TEXAS
WELL #1 BEACH
CONTR BGN DRLG
WC APP 36 MI NW SOLDIER (HU-VI)
I P D&A
API 15-117-20009

S-T-R 3-4S-8E
SPOT NW NW SW
CO MARSHALL, KS
ELEV 1401 GR

WF INIT
WF FIN

SPUD 8-10-70; 7" @63 not cemented; Geol-Dean Seeber
No Cores or DSTS;
RTD 2168; Log; D&A COMPLETED 11-11-70.
REPLACES COMP ISSUED 11-19-70,
REPLACED TO ADD ADDITIONAL DATA,

TD 2168 8/18/70

GR LOG TOPS

B/GIACIAL	36 +1365
ADMIRE	711 + 690
HOWARD	782 + 619
TOPEKA	815 + 586
OREAD	962 + 439
HEEBNER	999 + 402
DOUGLAS SHALE	1026 + 375
BROWN LIME	1035 + 366
LANSING	1063 + 338
B/KANSAS CITY	1331 + 70
B/Penn DECORAH	1357 + 44
SIMPSON SAND	1397 + 4
B/SIMPSON SAND	1435 - 34
ARKOSIC	1454 - 54
LTD	2168 - 767
RTD	2168 - 767

TD IN ARKOSIC FORM

REPL COMP ISSUED 2-17-72

Petroleum Information Corporation.

WILDCAT

9-268

OPER WILLIS WATERMAN ET AL - Salina, Ks.
WELL #1 KUNZE
CONTR White & Ellis
WC 12 mi NEof Griffith Field (Miss)
I.P. D&A

S-T-R 3-7S-5E
SPOT C NW SE
CO RILEY (Ks)
ELEV 1206 KB

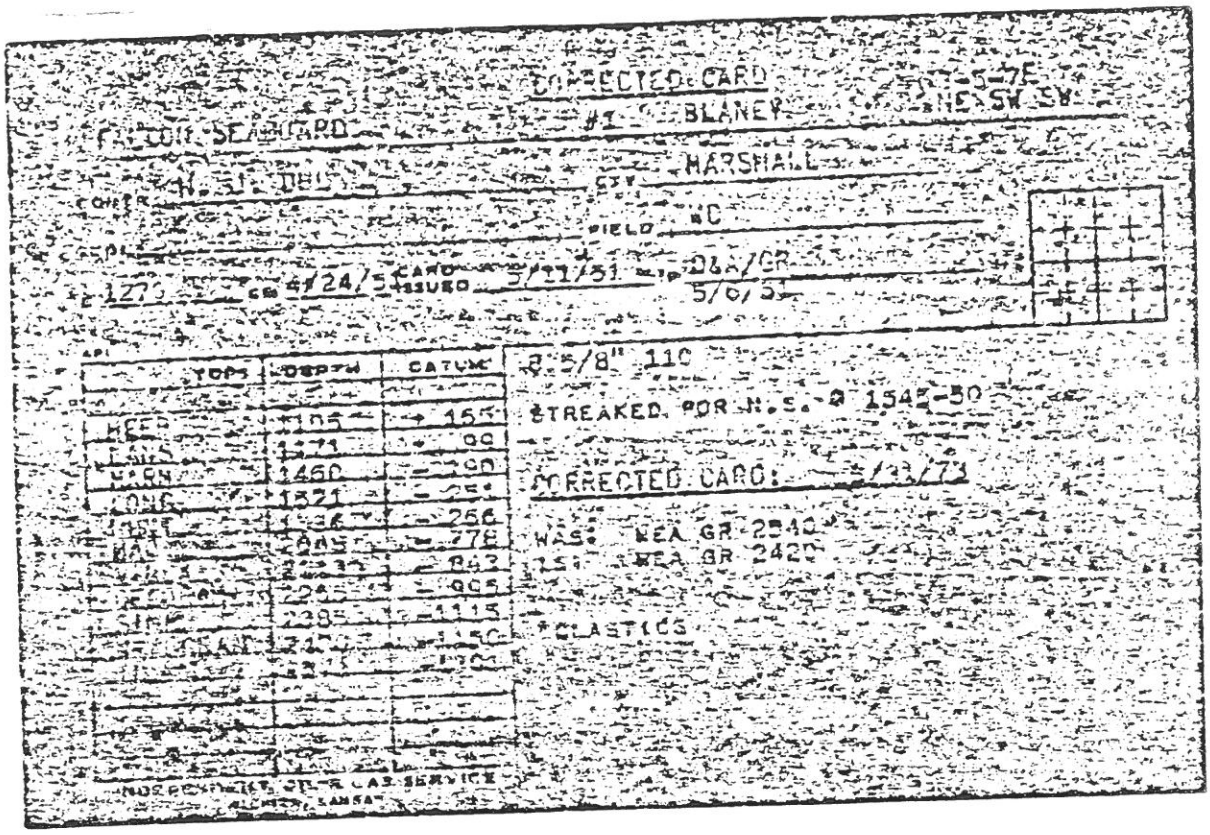
Magobar Gas sniffer on loc
RTD 2503' - No log - D&A 9-22-65 COMPLETED

Spls (KB)

Lan	1148/ 58
BKC	1460- 254
Miss	Not Present
Kh	1554- 348
Hunt	1683- 477
Mq sh	2131- 925
Mq Dol	Not Present
Vi	2201- 995
Sp sh	2371-1165
Sp sd	2425-1219
Sp sd	2456-1250
Wea Grt	2486-1280
RTD	2503-1297

Data Inc

ID



REPL #1 N/C **WILDCAT**

STATE	KANSAS	10-2-58 MAP NO.	S-T-R	20-11S-3E	WF
OPER	BARNETT OIL, INC.		SPOT	SE SE SW	INIT
	1625 VICKERS KSB&T BLDG, WICHITA, KS		CO	DICKINSON	WF
WELL	1 REILLY		ELEV	1250 KB	FIN
CONTR	BERENTZ DRLG				
FIELD	WC-30 MI NW LOST SPRINGS(KC-MISS)				
IP	D & A				
	API 15-041-20034				

SPUD 8-31-76, 8-5/8"@ 210 w/160
RTD 3175, logs
D & A, COMPLETED 9-9-76

10-2-58

KB SPL TOPS:

HOWARD	1132 + 118
TOPEKA	1192 + 58
HEEBNER	1459 - 209
TORONTO	1478 - 228
DOUGLAS SH	1489 - 239
BROWN LIME	1576 - 326
LANSING	1594 - 344
MISS	2142 - 892
KINDERHOOK	2307 - 1057
HUNTON	2483 - 1233
MAQUOKETA	2708 - 1458
VIOLA	2775 - 1525

(CONT FOR TOPS)

DECORAH	2870 - 1620
SIMPSON SH	2912 - 1662
U/SIMPSON SD	2921 - 1671
L/SIMPSON SD	2972 - 1722
ARBUCKLE	2994 - 1744
PRE-CAMBRIAN	3154 - 1904
RTD	3175 - 1925

TD IN PRE-CAMBRIA N

REPL COMP ISSUED 11-8-76

Petroleum Information

REPLACES COMP ISSUED 10-11-76
REPLACED TO ADD SPL TOPS
WAS TEMPORARILY COMPLETED

Lewellen (m) 11-9-4E

SALINA DRILLING #1 LEWELLEN (log) NE NE NE

Contr. Salina Drlg. Co. RILEY County

1291 (log) 1-27-53 2-12-53

E ~~1289~~ Comm. ~~1-29-53~~ Comp. ~~2-24-53~~ IP D & A

1294 (m)

Tops	Depth	Datum
KC 1604 (m)	1603 (1524 log)	354
Marmaton	1901 (m)	
MARM	1878	- 629
MISS	1910 (1901 log)	661
HUNT	2082 (log)	- 833
VIO	2550 (log)	-1301
SIMP	2706 (2700 log)	-1457
GRAN, ε (log)	2813 (log)	-1564
TD 2815 (m) (log)	2821	-1572

Casing

8" 200 95 (log)

1/2 Washington NE

NW C

log	data
B/Flo Flint	136
Wre lime	196
Bader lime	308
Beattie lime	345
Green.	404
Red Eu. ls.	451
Falls City ls	585
Tark	775
How.	1018
Top.	1066
Deer Cr.	1140
Oread	1262
Lans	1326
B/KC	1744
Chal	1[illegible]
Chat. sh.	1925
Miss lime	2494
Arb. dol	2731

INDEPENDENT OIL & GAS SERVICE
WICHITA, KANSAS

m - 4-15-53 log

4-2-83 REPL #1

STATE KANSAS CO NEMAHA MAP NO

OPER PENDLETON LAND-EXPL
23 INVERNESS WAY E ENGLEWOOD, CO 80112

WELL 1 HARTTER

CONTR SILVERADO DRILLING

FIELD WC-1 1/4 MI N ABND ROKEY (VI)

IP D&A

API 15-131-20023 FR 1/25/82 COMP *2/26/82

S T R 34-1S-14E

LOC APP C NW SW
610 FWL, 660 FNL, SW/4

ELEV *1316 KB, 1312 GR

SUB STRUCTURE

WI

UNIT

WF

FIN

SPUD 2/6/82, *10 3/4 @ 254 w/206, Geol: Woody Paul
*DST 1 (SIMP) 3864-93, op30,si63,op90,si69, Rec 630' MCSW (chl- 34,000 ppm), ISIP 1388, FP 59-93,148-260, ISIP 1371, HP 1954-1922
RTD 3980, *logs: DIL/SFL/FDC/CNL/GR/BHC/GR/CWL

*D&A COMPLETED 2/26/82

*ADDED/CORRECTED DATA - (Elev was 1140 TS)

REPLACED TEMP COMP ISSUED 4/13/82
REPL #1 ISSUED 5/10/83

*KB LOG TOPS:

HEEBNER	1139 +	177
LANSING	1278 +	38
B/KANSAS CITY	1619 -	303
MISS	2482 -	1166
KINDERHOOK	2643 -	1327
HUNTON	2861 -	1545
VIOLA	3575 -	2259
SIMPSON SD	3856 -	2540
REAGAN SD	3950 -	2634
PRE-CAMBRIAN	3975 -	2659
RTD	3980 -	2664

TD IN PRE-CAMBRIAN