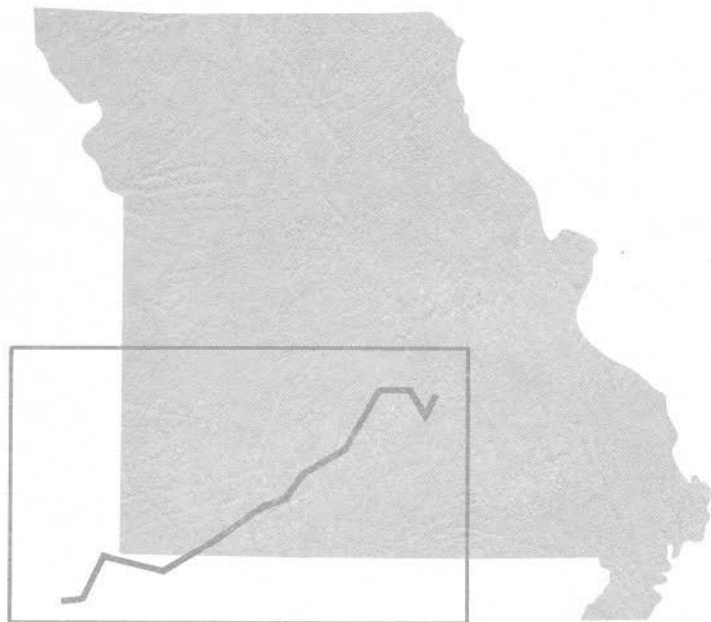


TRAVERSE IN LATE CAMBRIAN STRATA

FROM THE ST. FRANCOIS
MOUNTAINS, MISSOURI
TO DELAWARE COUNTY,
OKLAHOMA

By Vincent E. Kurtz
Joseph L. Thacker
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TRAVERSE IN LATE CAMBRIAN STRATA

TRAVERSE IN LATE CAMBRIAN STRATA FROM
THE ST. FRANCOIS MOUNTAINS, MISSOURI
TO DELAWARE COUNTY, OKLAHOMA

ABSTRACT

Studies of late Cambrian strata in the subsurface of southern Missouri and adjacent areas, utilizing megascopic core examinations, insoluble residue techniques, and faunal information, reveal a series of regionally persistent lithic units which may change facies abruptly.

Along the line of cross section, sediments of varying age rest on a Precambrian terrane of high-silica igneous rocks. The Cambrian section thickens to a maximum in Douglas County, Missouri, reflecting progressive increase in stromatolite content and associated reef and calcarenite buildups. West of the area of thickest Cambrian, the Lamotte Sandstone pinches out against a westward-rising land surface, and the Bonneterre and Davis Formations change facies to a time-transgressive clastic section interpreted as the Reagan Sandstone, with the Derby-Doerun Dolomite ultimately resting on the latter formation in Delaware County, Oklahoma. East of Douglas County, the Lamotte Sandstone shows a regional thinning toward the St. Francois Mountains, but local relief on the Precambrian strongly influences Lamotte thickness.

Bonneterre strata maintain a generally uniform thickness along the cross section from Wright County eastward. To the west, the Bonneterre thins to Taney County and then all but the uppermost part of the formation changes facies to a nearshore, clastic section in Carroll County, Arkansas. Lower Bonneterre strata are a sandy and shaly "zone" transitional with the Lamotte. The middle part of the Bonneterre Formation can be best characterized as a micrite, with contiguous oolitic micrite facies, and shale and micrite facies. The upper part of the Bonneterre Formation consists of a micrite and siltstone unit, the Sullivan Siltstone Member (new), overlain by a heterogeneous shale, limestone, sandy and glauconitic unit, the Whetstone Creek Member (new).

Post-Bonneterre Cambrian sediments thicken toward Douglas County and there change character to what is interpreted as a very shallow water reef and calcarenite facies. The Derby-Doerun Dolomite maintains its lithologic character across Douglas County, but expands downward as a reef and calcarenite facies of the shaly Davis Formation. The Potosi and Eminence Dolomites, characterized by "quartzose" chert (microdruse) residues elsewhere, change character in the Douglas County holes--the Potosi to a "green clay residue facies" and the Eminence to a "spongy chert residue facies." The Gunter Sandstone contains more carbonate from Douglas County eastward.

TRAVERSE IN LATE CAMBRIAN STRATA



Figure 1
Locations of drill holes used in this study.

INTRODUCTION

This report is second in a series of subsurface studies on Late Cambrian sedimentary rocks in Missouri and surrounding areas. The first report (Howe, Kurtz, and Anderson, 1972) correlated lithostratigraphic and biostratigraphic units making up the surface Ozark section in Missouri northward with the type Croixian section in the Upper Mississippi Valley and demonstrated the geographic limits to which names given to the subdivisions in the two outcrop areas could be applied in the subsurface section. The reader is referred to the foregoing paper for a discussion of Late Cambrian formations cropping out in the Ozarks and for references to earlier work in Missouri.

This second investigation transects the Ozarks westward from the St. Francois Mountains in Missouri to northeastern Oklahoma (fig. 1). Information for the traverse is derived from a series of 13 drill holes in Crawford, Dent, Phelps, Texas, Wright, Douglas, Christian, Taney, and McDonald Counties, Missouri; Carroll and Benton Counties, Arkansas; and Delaware County, Oklahoma. The line of section in a general way follows the regional structural high trending southwest from the St. Francois Mountains in Missouri into northeastern Oklahoma toward a generally positive area including the "Delaware Islands" of Chenoweth (1968), which exert strong local influence on the type and distribution of sediments. Additional correlations are made from the Benton County core through two drill holes in southeastern Kansas, which in turn have a direct bearing on correlation with the subsurface Cambrian in northeastern Oklahoma.

Other workers have been involved in subsurface studies of Cambrian strata in the immediate area of the present study. Koenig (1954) described the thickness and regional facies of the Bonneterre Formation in southern Missouri; McCracken (1965) described and correlated Cambrian and Lower Ordovician strata in the four-state area of northeastern Oklahoma, southeastern Kansas, northwestern Arkansas, and southwestern Missouri; Howe (1968) described a "planar stromatolite and burrowed carbonate mud facies" in the St. Francois Mountains area; and Gerdemann and Myers (1972) made a study of facies patterns in the Bonneterre Formation in the area of the Viburnum Trend and in other areas of lead production in southeast Missouri. Larsen (1973) discussed depositional environments of the Bonneterre Formation in southeast Missouri.

The present report draws upon earlier reports, but is limited to an examination of stratigraphic units encountered in the cross section and the problems relating thereto, to correlation with the Missouri outcrop section, and to correlation with rock units in the subsurface of southeastern Kansas. Figure 2 shows the Time- and Rock-Stratigraphic classification of Cambrian strata in the Ozark region and is redrawn from Howe et al. (1972) and modified to better suit the present paper.

TRAVERSE IN LATE CAMBRIAN STRATA

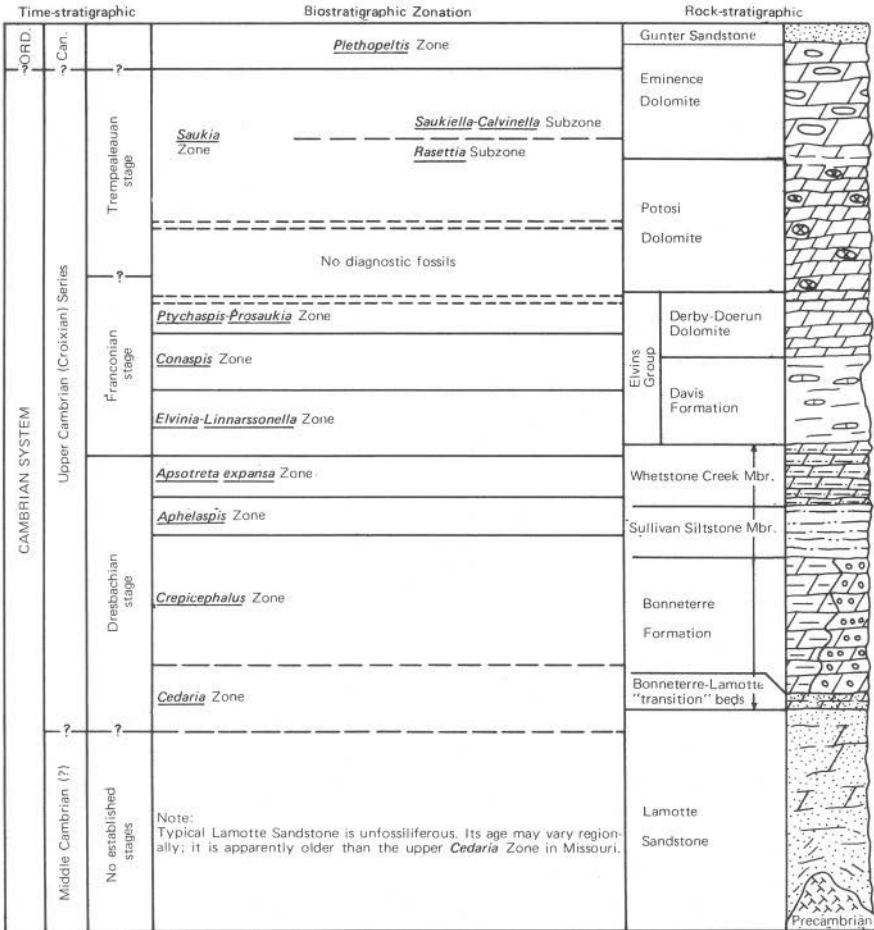


Figure 2
Time and rock stratigraphic classification of Cambrian strata in the Ozark region.

Churn drill cuttings and diamond drill cores were utilized in preparation of this report. Information derived from megascopic inspection of the cores, together with biostratigraphic information based on trilobite and brachiopod remains, is combined with insoluble residue data from both cuttings and cores presented on plate 1. Insoluble residue and core descriptions, together with faunal data, are in the appendix.

This report is a "team" effort by the authors in the true sense of the word. Gerdemann proposed this study and was instrumental in making available to the Office of State Geologist the cuttings and cores from St. Joe Minerals Corporation drill holes. He was deeply involved in the many discussions concerning the project and in criticism of the manuscript. Anderson and Thacker prepared the insoluble residue logs and are primarily responsible for correlations based on insoluble residue data. Anderson prepared the insoluble residue descriptions and is primarily responsible for correlations with the subsurface Cambrian in northeastern Oklahoma and southeastern Kansas. Thacker prepared the core descriptions. Thacker and Kurtz are primarily responsible for correlations based on megascopic core examinations. Kurtz is responsible for the faunal data and for the biostratigraphic correlations in the cross section and assumed most responsibility for the organization of this report.

State Geologist and Director of the DNR Division of Research and Technical Information, Wallace B. Howe, organized the team involved in this project and has since served as guide and critic in preparation of this report.

Christina Lochman-Balk made a critical review of this paper offering many suggestions and kindly gave us the opportunity to examine her manuscript (published Jan. 1974) on "Late Dresbachian (Upper Cambrian) Biostratigraphy of North America". We are happy to be able to refer to this current work and have found it useful in the final revision of this paper. W. J. Ebanks, Chief, Subsurface Geology Section, Kansas Geological Survey, has also criticized this paper. Many members of the staff of the Office of State Geologist have contributed their support to this effort. To all of these people the authors express their sincere appreciation.

STRATIGRAPHY OF THE CROSS SECTION

GENERAL CONSIDERATIONS

Figure 3 is a simplified version of plate 1 and serves as a convenient visual reference for the various lithic units encountered in this study. Among these subdivisions the following two lithic units are given formal names for the first time:

Sullivan Siltstone Member of the Bonneterre Formation

Although the Sullivan Siltstone is widespread in the subsurface, the only surface exposure is found in the Crooked Creek cryptoexplosive (cryptovolcanic) structure (Hendriks, 1954, 1965) in C, E $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 17, T. 36 N., R. 4 W., Crawford County, Missouri and this is designated as the type section. The name now formally given to this unit has been applied informally by mining company geologists working in southeastern Missouri and the Viburnum Trend for many years and comes from the town of Sullivan, just north of the Franklin-Crawford County line, Missouri. In our opinion it would be ill advised to propose a different formal name for this well-known and easily identified unit, even though the type section is 38 miles from the town of Sullivan. The name "Crooked Creek" is pre-occupied.

The surface section of the Sullivan Siltstone, together with overlying and underlying units, was measured by Kurtz and Thacker. Highly complex structural conditions make the piecing together of a stratigraphic succession difficult. However, we do think that there is a relatively continuous succession of strata along the creek that flows through the type section of the Sullivan Siltstone Member and the reference section of the Whetstone Creek Member. This sequence of beds also includes exposures of the "micrite and shale facies" and "oolite facies" of the Bonneterre Formation, and also lower Davis strata.

Hendriks (1954, p. 13-15) evidently included in his Bonneterre Formation only those strata we refer to as the "oolite facies" of the Bonneterre. Some of the shale and limestone outcrops he assigned to the Davis are actually the "micrite and shale facies" of the Bonneterre and contain *Crepicephalus* Zone fossils. Basal Davis strata of Hendriks (1954, p. 16) that contain abundant glauconite are included by us in the Whetstone Creek Member of the Bonneterre Formation. We are unable to determine just where in the stratigraphic succession Hendriks placed the beds we assign to the Sullivan Siltstone.

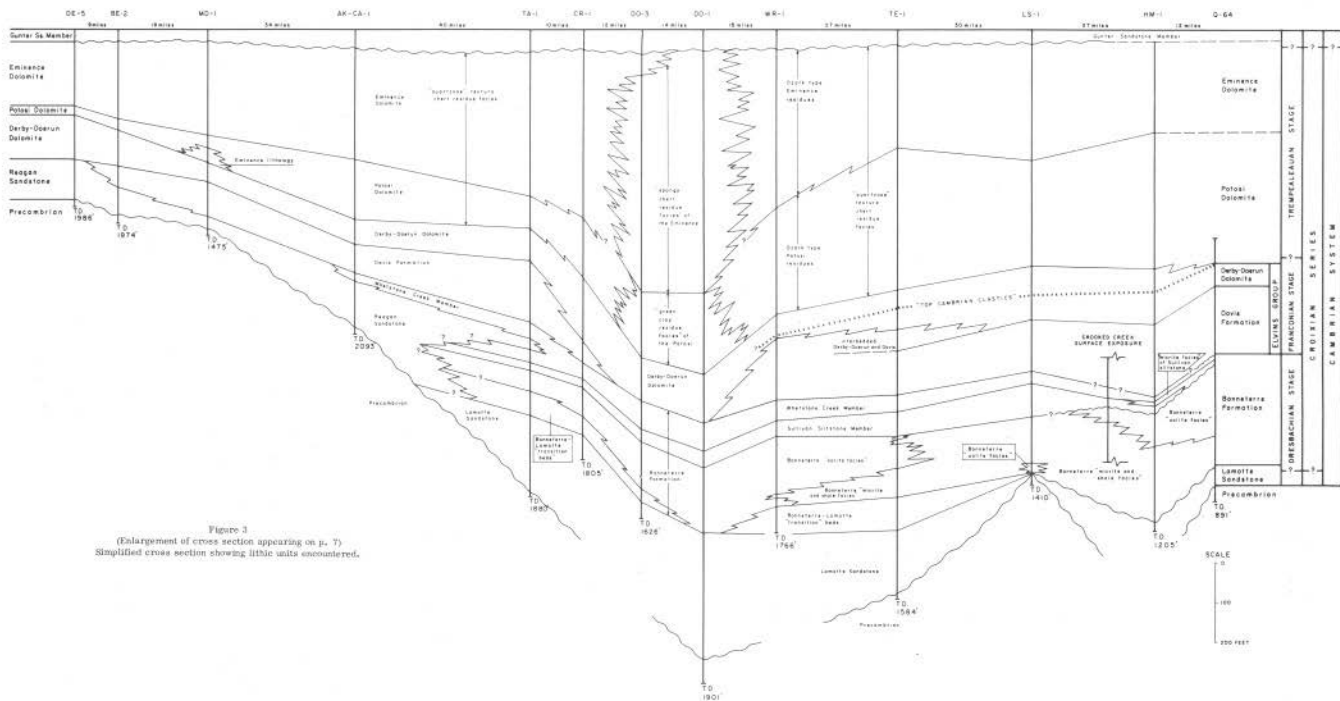


Figure 3
 (Enlargement of cross section appearing on p. 7)
 Simplified cross section showing lithic units encountered.

Figure 3
 Simplified cross section showing lithic units encountered. (See back of Plate 1 for enlargement.)

Stratigraphy of the Cross Section

TRAVERSE IN LATE CAMBRIAN STRATA

The type section of the Sullivan Siltstone, together with the reference section of the overlying member, the Whetstone Creek, is as follows:

Covered to Davis Formation exposures (interval apparently made up largely of green shale)----- 23.0'

Whetstone Creek Member (17' exposed)

Dolomite, crinozoan calcarenite with pellet glauconite, Apsotreta stricta, A. expansa?----- .2'

Mostly covered, green shale with fine-grained dolomite nodules----- 5.4'

Dolomite, crinozoan calcarenite with pellet glauconite, Apsotreta expansa----- 1.7'

Covered (probably underlain by shale)----- 3.0'

Dolomite, crinozoan calcarenite with pellet glauconite, Apsotreta attenuata, A. expansa, Angulotreta missouriensis----- .7'

Covered, float indicates dolomite nodules, probably embedded in shale----- 1.5'

Dolomite, silty and shaly, with crinozoan calcarenite lens----- 1.5'

Covered, probably underlain by shale----- 2.0'

Dolomite, medium-crystalline, mud-chip conglomerate, slightly glauconitic----- 1.0'

Sullivan Siltstone Member (22' exposed)

Siltstone, dolomitic, thin-bedded, irregular to nodular beds with internal laminae distorted and broken----- 8.0'

Siltstone, dolomitic, a single unit, internally made up of even laminae and regular thin beds. (Because of structural complications it is possible that this unit may actually be 19 feet thick.)----- 14.0'

Base of unit shows an undulating contact with underlying "oolite facies" of the Bonneterre Formation.

Because the type Sullivan Siltstone is relatively thin, a more typical, thick (38') siltstone reference section is described from the 1,495.0 to 1,533.0 feet interval in St. Joe Minerals Corporation Core #64W63 (WR-1), SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 16, T. 29 N., R. 13 W., Wright County, Missouri. (See description of Wright County core for description of reference section.)

Whetstone Creek Member of the Bonneterre Formation

This widespread subsurface unit overlies the Sullivan Siltstone. The surface exposures of the Whetstone Creek are inadequate as a type section. The surface

section described earlier along with the Sullivan Siltstone is simply designated as a reference section, and the type section is the 1,435.0-1,468.0-foot interval in the St. Joe Minerals Corporation Core #64W133 (WR-1), SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 16, T. 29 N., R. 13 W., Wright County, Missouri; the reader is referred to this core description. The name of the member comes from Whetstone Creek near which the Wright County core hole was drilled. Inarticulate brachiopod faunas serve to correlate the outcrop section with subsurface sections. Angulotreta missouriensis and Apsotreta expansa occur together 6.7 feet above the base of surface exposures of the reference section and indicate precisely the Angulotreta missouriensis-Apsotreta expansa Zone boundary. The two species are never associated in more than a few inches of sediment.

In addition to the above new, formally named members, the following two units deserve special attention.

Reagan Sandstone

This formation, as now recognized in Missouri, consists of fine- to coarse-grained, poorly sorted sandstone containing silt and shale; it is generally arkosic at the base and variably glauconitic. The Reagan is not comparable to the clean, monomineralic quartz sandstone making up the bulk of the Lamotte. The two formations are genetically related in that they are both nearshore clastic deposits laid down in the advancing Cambrian sea. As shown by the cross section, the Reagan is a predominantly time transgressive, nearshore facies of both the Bonneterre and Davis Formations, with most of it being the nearshore equivalent of the Davis.

"Green clay residue facies" and "spongy chert residue facies" of the Potosi and Eminence formations

In the Douglas County cores, insoluble residues in the Potosi and Eminence part of the section are not characterized by "quartzose" chert residue, but rather by green clay residue and "spongy" chert residue, respectively. Cored portions of the interval show extensive digitate stromatolite reef development.

All of the lithostratigraphic units are described on the basis of megascopic core descriptions and insoluble residues. A limited amount of petrographic information is also included.

FAUNAL ZONATIONS

The biostratigraphic zonation used in this report is shown on figure 2, of Howe et al. (1972, p. 5), except as noted below. It is pragmatic, utilizing taxa available in the cores. No faunas higher than the Conaspis Zone were found. Faunal zones recognized in the cores and residues are defined as follows:

Taenicephalus Subzone (of the Conaspis Zone). - The range zone of Taenicephalus. Billingsella is common throughout. Orygmaspis is found in the lower part. The upper limit of this subzone was not determined in the cross section.

Parabolinoïdes-Eoorthis Subzone (of the Conaspis Zone). - The range zone of Parabolinoïdes, including an epibole of Eoorthis at the base.

Elvinia-Linnarssonella Zone. - The range zone of these genera, including an epibole of Irvingella major and Comanchia at the top (Irvingella major Zonule). The base is defined by the lowest occurrence of Linnarssonella, rather than Elvinia, which may occur a few feet lower in the section. The trilobite genus Parahousia is by far the most abundant form in the lower part of the zone (Parahousia Zonule).

Apsotreta expansa Zone. - The range zone of this species. This zone can be subdivided into an upper Apsotreta stricta Subzone and a lower Apsotreta attenuata Subzone (Kurtz, 1971, p. 473, table 1) and contains trilobites from the upper part of the Aphelaspis Zone, the Dunderbergia Zone, and lowest Elvinia Zone of the Croixian standard. The Dunderbergia Zone is not well-represented, but the presence of Elburgia and Parahousia constricta indicates that the upper part of the zone is present, and an early species of Pterocephalia comparable with P. concava suggests that the lower part is also present. Lochman-Balk (personal communication) suggests that most, if not all, of the Dunderbergia Zone is absent, and a paraconformity occurs in the sections at or close to the base of the Apsotreta stricta Subzone or just above the Apsotreta attenuata Subzone. We agree that few diagnostic Dunderbergia Zone trilobites are present, but we contend that rather than having a single paraconformity, the section is full of minor paraconformities and shifting depositional sites, so that faunas have a patchy distribution. Scale limitations on the cross section (pl. 1) prevent the presentation of all possible lines of biostratigraphic and lithostratigraphic correlation. One important plane not shown is the top of the Apsotreta attenuata Subzone, which occurs 7 feet (\pm 3 feet) above the base of the Apsotreta expansa Zone.

Aphelaspis Zone. - The upper limit of this zone is placed at the faunal change from Apsotreta expansa and Apsotreta attenuata to Angulotreta missouriensis, rather than at the highest occurrence of Aphelaspis, which is known to occur a few feet higher than the brachiopod faunal change. Blountia may be abundant locally with Aphelaspis. The base of the zone is the lowest occurrence of Aphelaspis.

Crevicephalus Zone. - The upper limit is marked by the sharp faunal change from Aphelaspis above to Coosina and Tricrevicephalus below. The latter two genera dominate the fauna. Opisthotreta is found low in the zone.

Cedaria Zone. - The presence of this zone is not confirmed in the cores. Fragmentary Holcacephalus? and Syspacheilus? suggest this zone. Tricrevicephalus occurs yet below the two questioned genera.

PRECAMBRIAN IGNEOUS TERRANE

Although not strictly a part of this study, the character and age of the basement rocks deserve comment. All basement core samples seemingly are silicic

in composition, with orthoclase feldspar and quartz the dominant constituents. However, the Q-64 core encountered diabase, as well as granite and felsite.

Pre-Lamotte igneous rocks are Precambrian in age and part of the igneous complex exposed in the St. Francois Mountains. We see no good reason to infer that the basement rocks west of the Lamotte pinchout are other than Precambrian.

LAMOTTE SANDSTONE

Initial Cambrian sediments from the TA-1 (Taney County, Missouri) core eastward are represented by the Lamotte Sandstone, arkosic in the lower few feet of the formation, but otherwise a generally clean, medium-grained quartz sandstone, moderately to well sorted. A textural change occurs approximately 100 feet below the top. Below this change in the Lamotte the sand grains are not as well sorted, ranging from fine- to coarse-grained and from well-rounded and frosted to subangular in shape. Above this change the Lamotte is fine- to medium-grained, the grains are less rounded, and frosting is developed to a lesser degree than that found below. Large phosphatic, oboloid brachiopods, including Dicellomus, suggest a beach environment. (See discussion of the Bonneterre Formation.)

The Lamotte is extremely irregular in thickness in the eastern part of the cross section, reflecting the rugged paleotopography of the Precambrian surface on which the Lamotte was deposited. Between the TA-1 and AK-CA-1 (Carroll County, Arkansas) cores we conclude that typical Lamotte pinches out against a westward-rising Precambrian terrane, and a strongly time transgressive clastic section merges with the Reagan Sandstone.

The age of the Lamotte is not known. It predates Bonneterre carbonates carrying an upper Cedaria Zone fauna in the outcrop (Lochman, 1940) and a possible Cedaria Zone fauna in the cores.

BONNETERRE FORMATION

The Bonneterre Formation along the cross section is a complex unit dominated by micritic limestones altered in many places to dolomites. Shale content on the one hand, and wackestone layers distinguished by grains of quartz, glauconite, crinozoan debris, and oolites on the other, serve as bases for subdivision of the formation. The eastern end of the cross section terminates in sediments associated with what is described as a "barrier reef facies" by Gerdemann and Myers (1972) or a reef bank "digitate stromatolite facies" by Larsen (1973) in the area of the Viburnum Trend.

The basal unit of the Bonneterre is the sandy Bonneterre-Lamotte "transition" beds. The bulk of the Bonneterre consists of two lithologies--an intertonguing of oolite facies contemporaneous with micrite and shale facies; thicknesses average about 150 feet in the cross section. One or the other of these lithologies is usually in sharp contact with the overlying Sullivan Siltstone Member, which in turn is succeeded by a unit characterized by its lack of homogeneity, the Whetstone

Creek Member. These latter two members were designated as "Upper Bonneterre" by Howe et al. (1972).

West of the Taney County, Missouri core, the Bonneterre carbonates abruptly change facies to a nearshore, coarsely clastic, sandy section referred to the Reagan Sandstone in the Carroll County, Arkansas core.

Bonneterre-Lamotte "transition" beds

This variable unit is dominated by sandstone, especially in the lower part, but is distinguished from the underlying Lamotte by the addition of shale. Dolomite content varies, but usually increases upward. Inclined bedding is common. The contact between this unit and the Lamotte ranges from sharp to gradational. Between the Wright County core and the Taney County core, the "transition" beds exhibit a facies relationship with the lower part of the "oolite facies." West of the latter core, the "transition" beds probably change facies to the time transgressive clastic section which merges with the Reagan Sandstone in the AK-CA-1 core.

The large, oboloid brachiopods are far more abundant in the "transition" beds than in the upper Lamotte. It is inferred that the "transition" beds represent the substrate associated with the living animal, and that shells and shell fragments in the Lamotte proper represent debris cast up on beaches and further distributed by winds.

These "transition" beds generally predate the lower Bonneterre-upper Cedaria Zone (Lochman, 1940) so are likely Cedaria Zone age.

"Micrite and shale facies"

Much of the Bonneterre is characterized by alternating layers of green shale and micritic limestone in beds ranging in thickness from a fraction of an inch to several inches. Proportions may vary from all shale to all limestone. In the latter case, the contacts between the micritic layers are frequently stylolitic. Burrowing is common, but usually not to the extent that bedding is destroyed. Wackestone layers containing crinozoan debris and glauconite pellets are fairly common and are the only lithology in this facies containing retrievable megafossils. Residues are high in volume with silt and fine sand size quartz grains being important constituents. The "micrite and shale facies" of this report is the same unit as the "offshore facies" of Gerdemann and Myers (1972). This lithology is considered to have been deposited in deeper water than the associated "oolite facies" and "reef facies." The boundary between the Cedaria and Crepicephalus Zones may occur approximately 100 feet above the base of this micrite and shale unit in the HM-1 core.

"Oolite facies"

The "oolite facies" of the Bonneterre is a fairly homogeneous and generally thick-bedded wackestone unit. Contacts between beds are commonly stylolitic.

the oolites are sparse to abundant and are usually mud supported. Residues are low in volume and are characterized by porous brown shale and quartz silt, with sand-size quartz grains and pellet glauconite present locally. The "oolite facies" in the eastern part of the cross section is developed just west of what is described as a barrier reef by Gerdemann and Myers (1972) or an algal bank by Larsen (1973) in the Bonnetterre Formation. In the central part of the cross section, the oolite forms a broad, shallow water, offshore, carbonate platform. West of the Taney County core, the oolite changes facies to the Reagan Sandstone.

The large trilobite genera Coosina and Tricrepicephalus dominate the fauna, and identifiable fragments are locally common.

Sullivan Siltstone Member

This unit is a variably micritic, generally laminated siltstone. Local layers of calcarenites and mud-chip conglomerates are present. The high volumes of quartz silt with local concentrations of fine quartz sand and glauconite are believed to more strongly reflect the provenance of the sediment than any significant changes in water depth. The base of the unit is usually in sharp contact with the subjacent stratum. The plane of contact is interpreted as an unconformity in the HM-1 and Q-64 cores and in the Crooked Creek surface section. Westward, the unconformity is believed to die out before the LS-1 hole is reached. This contact is interpreted as profoundly diachronous, being coincident with the boundary between the Aphelaspis and Crepicephalus Zones in the Crooked Creek surface section and the HM-1 core, but 60 feet below the boundary in the LS-1 core. Although conclusive faunal evidence for the unconformity and related diachroneity of the base of the Sullivan Siltstone is lacking along the cross section in the Crooked Creek exposure, the HM-1 and Q-64 cores, and other cores along the Viburnum Trend do contain faunas which document these relationships.

The lower part of the siltstone is unique in showing a nearly complete absence of burrowing. The upper part of the siltstone may change facies to a moderately burrowed micrite unit containing some shale beds, as shown in the HM-1 (Dent County) core. The entire Sullivan interval changes facies to a non-silty micrite in the Q-64 (Crawford County) core. This different expression of the Sullivan Siltstone is referred to informally as the "micrite facies" of the member. West of the Taney County core (TA-1), the siltstone changes facies to the nearshore Reagan Sandstone. The Sullivan Siltstone Member is the "upper marker bed" in the Bonnetterre Formation referred to by Gerdemann and Myers (1972, p. 430; fig. 5, p. 431).

Whetstone Creek Member

This unit is distinguished by its lack of homogeneity and can best be described as a facies mosaic (LaPorte, 1967). Shifting sites of deposition have rendered internal characteristics highly variable. Numerous pellet glauconite layers and the presence of reworked acrotretid brachiopods at different horizons suggest multiple paraconformities, each representing short intervals of very slow

deposition to nondeposition, with local minor re-resolution of earlier-deposited carbonates. Shale, silt, sandstone, or carbonate may dominate the facies at any one locality. The sand frequently occurs as coarse, rounded grains "floating" in a finer-grained shale, silt, sand, or carbonate matrix. Almost all of the calcarenites have a micrite matrix and are wackestones to packstones. Grains are usually crinozoan fragments, trilobite fragments, and glauconite pellets. Thin layers may be made up of nearly 100 percent glauconite. Burrowing is common. Residues are high in volume, the shales tend to be gray or brown rather than green, and sand-size quartz grains and pellet glauconite may make up a significant portion. High carbonate content seemingly reflects shallower water, while high shale content suggests deeper water. This does not necessarily relate to the tectonism of an area. The Crawford County (Q-64) and Dent County (HM-1) cores show a thin Whetstone Creek with high carbonate content. The Douglas County cores show relatively thick (70') Whetstone Creek--also with a high carbonate content. The member in the intervening core holes (Wright County, WR-1; Texas County, TE-1; and Phelps County, LS-1) is intermediate in thickness, but has a high shale content. The thin carbonate section in the two eastern cores does reflect slight positive tectonism in the area, whereas the thicker carbonate section in Douglas County is an offshore carbonate buildup which persists throughout the remainder of Cambrian time. (See discussion following on the Derby-Doerun, Potosi, and Eminence formations.)

The thin Whetstone Creek in the CR-1 (Christian County) core is believed due to multiple subaqueous slumpings. The core shows slumped and brecciated intervals not only in the Whetstone Creek, but also to a lesser extent above and below.

Between the Christian County (CR-1) and Taney County (TA-1) cores, the Whetstone Creek Member expands upward by reason of facies change with the Davis. In the latter core it is also split into upper and lower units by a 30-foot-thick sandstone layer interpreted as a tongue of the nearshore Reagan Sandstone extending from the west, deposited during a partial regression of the Cambrian seas, and reflected a seaward shift of nearshore depositional environments. Elvinia Zone fossils are present in the upper part of the sandstone, and the presence of Elburgia 12.5 feet above the base confirms the presence of at least part of the Dunderbergia Zone. The unconformity resulting from this partial regression--the well known post-Dresbachian and pre-Franconian unconformity--is present only in structurally high areas, and the writers contend that no single, areally persistent depositional break occurs in the Whetstone Creek or lower Davis section from the Phelps County (LS-1) core through the Taney County (TA-1) core. The Whetstone Creek-Davis contact is interpreted as one of possible unconformity in the Dent County (HM-1) core and a definite unconformity in the Crawford County (Q-64) core which continues farther east into the type area of the Bonneterre and Davis Formations. There, on the outcrop, lowermost Davis strata carry Linnarssonella girtyi and rest on an unfossiliferous oolite facies of the Bonneterre, of probable Crepicephalus Zone age. The contact exhibits a local microrelief of an inch or so, and occasional clasts of Bonneterre are present in lowermost Davis strata. In the Carroll County, Arkansas (AK-CA-1) core, the unconformity may coincide with the Whetstone Creek-Reagan contact or be a few feet down in the Reagan. The area traversed by the cross section from McDonald County westward did not receive sediments until Franconian time.

The upper part of the Whetstone Creek thins westward from the Taney County (TA-1) core, gradually changing facies to the Reagan, and cannot be identified west of the Carroll County, Arkansas (AK-CA-1) core. This uppermost Bonneterre unit cannot be satisfactorily distinguished from the lower part of the Davis Formation everywhere in the subsurface. For this reason, there is lack of unanimity among the authors, and some would find assignment of the member to the Davis more palatable, because the overall character of the unit is more like the Davis than the Bonneterre.

The upper part of the Aphelaspis Zone, all of the Apsotreta expansa Zone, and--with the exception of the Dent County (HM-1) and Crawford County (Q-64) cores--the lower few feet of the Elvinia-Linnarssonella Zone is present. In the aforementioned cores, Apsotreta expansa occurs in the lowest foot of the Davis Formation. Both trilobite and brachiopod faunas are abundant in the limestones.

REAGAN SANDSTONE

This unit is a nearshore facies of the Bonneterre and Davis Formations and is also known to be the nearshore equivalent of formations as young as the Roubidoux Formation, of Early Ordovician age in Tulsa County, Oklahoma. It is generally a poorly sorted unit, made up of a mixture of shale, silt, and poorly sorted sandstones, and may be slightly dolomitic. Arkosic material is common near the base. Pellet glauconite may be present. Residues are high in volume--up to 100 percent of the sample--and are variable in composition. In general, the lower part is dominated by rounded to subangular, coarse quartz grains, with some weathered feldspar grains. The sands tend to fine upward and are mixed with quartz silt and gray shale in the upper part of the unit, but silt, shale, and glauconite can occur anywhere in the section. The Reagan-Davis contact is highly diachronous between the McDonald County (MD-1) core and the Delaware County (DE-1) core, and in the latter core the Davis is absent by reason of facies changes with the Reagan.

The presence of an early variant of Linnarssonella girtyi near the top of the Reagan at 1,438 feet in the McDonald County (MD-1) core indicates the proper age placement of this formation at that point.

ELVINS GROUP

Davis Formation

The Davis is characterized by its high shale content, in contrast to units above and below. Mud-chip conglomerates are also quite common. Fine glauconite grains tend to be sprinkled throughout. Fine sand and silt may predominate locally. Both laminated and burrowed micrites are found throughout the unit, with crinozoan debris, trilobite fragments, and glauconite pellets as important constituents. In the Phelps County (LS-1), Texas County (TE-1), and Wright County (WR-1) cores, dolomitization does not extend as far downward in the Davis as elsewhere. Davis residues

are high in volume and are characterized by green shale, fine quartz sand, and quartz silt, with fine glauconite pellets common. The lowest part of the Davis characteristically shows a nearly 100 percent residue by volume, consisting mostly of green shale and with glauconite pellets assuming a significant proportion of the lithology.

The contact between the Davis and Derby-Doerun is not everywhere sharply defined. Davis and Derby-Doerun beds intertongue in some areas and the lower Derby-Doerun may contain nearly as much shale and silt as the underlying Davis. From both east and west, the Davis changes facies to Derby-Doerun in the Douglas County cores (see following discussion). The Davis section also changes facies westward to the nearshore Reagan Sandstone between the McDonald County, Missouri (MD-1) core and the Delaware County, Oklahoma (DE-1) core.

Most of the Elvinia-Linnarssonella Zone and the lower part of the Conaspis Zone--including the Parabolinoides-Eoorthis Subzone and the lower part of the Taenicephalus Subzone--are present in the Davis Formation. Retrievable trilobites and phosphatic brachiopods are common in the limestones. The latter are also obtainable from the dolomite facies, and an occasional Eoorthis or Billingsella may also be found.

Derby-Doerun Dolomite

Within the Derby-Doerun Dolomite is a stratigraphic level, indicated in the eastern half of the cross section (plate 1) as a line of "X's" marked "Top Cambrian Clastics", which marks an overall change in character of upper Cambrian sediments from a generally high clastic content below to a very low clastic content, sometimes accompanied by chert, above. The change takes place about the middle of the formation. This marker is a probable isochron over wide areas and a useful datum in correlation.

The lower Derby-Doerun is generally a finely crystalline dolomite, locally burrowed, with stromatolites and calcarenites. Appreciable brown shale, fine sand, and glauconite make up the residues. This unit is similar to the Davis, except that the stromatolites and associated calcarenites occupy more of the interval, leaving, as it were, less space available for fine-grained clastic sediments.

The sedimentary record of the upper Derby-Doerun--as well as the succeeding Potosi and Eminence Dolomites--reflects a shallow water, carbonate-platform depositional environment. Sedimentary cycles of planar stromatolites, digitate stromatolites, and calcarenites are common throughout the section. Planar stromatolites serve as a base for digitate stromatolite growth, with oolites and other calcarenites occurring between the stromatolite "fingers". Oolites also occur as discrete, thick-bedded units (Howe, 1966). Chert first appears in residues from the upper Derby-Doerun and continues upward through the Potosi and the Eminence. The upper Derby-Doerun is also characterized by thin shale partings along bedding planes, dickite-filled vugs, and residues containing small amounts of white, fine, intercrystalline, doloclastic chert.

In the Douglas County cores, the entire Derby-Doerun and Davis interval is occupied by upper Derby-Doerun lithology and residues. The shallow water environment first heralded by extensive oolite development in the Bonnetterre became areally localized in younger strata in Douglas County.

Only poorly preserved specimens of Billingsella were recovered from cores low in the Derby-Doerun. Preservation is such that assignment to the proper faunal zone cannot be accurately made.

POTOSI DOLOMITE

The planar and digitate stromatolites, oolites, and burrowed carbonate muds continue upward from the Derby-Doerun into the Potosi Dolomite. The overall crystal size of the dolomites is larger, and vugs are generally abundant. Commonly the vugs are lined with quartz druse. These characteristics persist through the overlying Eminence Dolomite. Megascopically, Potosi dolomites are characteristically brown, and the vugs are lined with quartz druse on a thick-banded chalcledony base. Dolomitization has frequently obliterated the character of the original carbonate grains, but the Potosi and Eminence apparently have more oolitic grainstones than do the formations above and below. Potosi residues are brown and white and dominated by microscopic quartz druse ("quartzose" chert) on banded chalcledony. The lower 100 feet or so of Potosi has a very low volume of druse and chert residue and minor amounts of green shale. Oolites appear to be wackestones and packstones. Upper Potosi oolites appear to be largely grainstones. Several siliceous oolite zones are encountered and may be carried over large areas. Oolites may be free, or incorporated in chert. The upper two-thirds of the Potosi exhibits a higher volume of residue, characterized not only by chalcledony and druse, but also by doloclastic chert. The latter residue persists into the overlying Eminence Dolomite.

East of the Douglas County holes, the Potosi maintains a thickness of 250 to 350 feet. West of the Douglas County cores, the Potosi ranges from 150 down to 20 feet in the Delaware County, Oklahoma (DE-5) core.

In the McDonald County (MD-1) core, an interval of Eminence lithology substitutes for the lower part of the Potosi and is in contact with the Derby-Doerun Formation. No fossils were found in the Potosi.

"Green clay residue facies"

In the Douglas County holes, typical Potosi is absent by reason of facies changes, and the rock present is a massively bedded, finely crystalline, mottled dolomite. Digitate stromatolites and calcarenites suggest shallow water. Residues are low in volume and consist of green shales rather than "characteristic" Potosi-chert residues. Because of limited knowledge of the areal extent of this newly recognized rock unit, we prefer to refer to it informally by the characteristic residue rather than to apply a formal name.

EMINENCE DOLOMITE

Stromatolites and oolites persist up into the Eminence from below. The rock is generally coarsely crystalline and gray in color. Vugs are abundant and lined with quartz druse. Sometimes the druse occurs on a thin ring of chalcedony in contrast to the thick, banded chalcedony base characteristic of Potosi residues. Eminence residues are mostly gray, microscopic quartz druse ("quartzose" chert), with lesser amounts of doloclastic chert--the latter showing larger dolocasts than the upper Potosi, reflecting a coarser crystal size of the dolomites. Oolites are generally wackestones and packstones and are concentrated in the upper part of the formation. Several thick, siliceous oolite zones are present. Oolites usually have "quartzose" surfaces.

The Eminence Dolomite thickens conspicuously toward Douglas County from both east and west. Some of this is probably depositional thickening, and some is probably due to facies changes with the Potosi.

No fossils were found in the Eminence cores. There is evidence that the upper Eminence may be Lower Ordovician in age. (See Howe et al. (1972) for a discussion regarding the age of the Eminence.)

"Spongy chert residue facies"

With exception of the 490-to-540-foot interval in the DO-3 hole, the Eminence has changed character in the Douglas County cores by reason of facies changes to a rock more similar in gross character to the rock immediately underneath than to typical Eminence lithology. Residues are characterized by "spongy" chert. Typical Eminence residues are scarce to absent. We do not think it best to give a formal name to this distinctive, but areally restricted facies at this time.

GASCONADE DOLOMITE

Gunter Sandstone Member

This sandy layer--ranging from 100 percent sandstone to nearly 100 percent dolomite containing sparse "floating" quartz grains--exhibits a sharp and unconformable contact with the underlying Eminence.

West of Douglas County, the Gunter is a sandstone, whereas east of Douglas County the Gunter is best described as a sandy dolomite. The Gunter Member, a basal unit of the Ordovician Gasconade Dolomite, is a useful key bed, which correlates well and serves as the lithostratigraphic datum for the cross section under study.

CORRELATIONS IN THE FOUR-STATE AREA

Missouri rock names have been applied in the subsurface of Kansas, Oklahoma, and Arkansas for some time. Especially relevant to the present study are portions of works by Keroher and Kirby (1948), McCracken (1965), Chenoweth (1968), McNight and Fischer (1970), and Lochman-Balk (1971), pertaining to southwestern Missouri, northwestern Arkansas, northeastern Oklahoma, and southeastern Kansas. Figure 4 shows how we would correlate the Benton County, Arkansas (BE-2) core with the Eagle-Picher, King Brand P-1, Cherokee County, Kansas (McNight and Fischer, 1970, p. 15, fig. 3) and the La Salle No. 1 Gobl, Crawford County, Kansas (Keroher and Kirby, 1948, p. 64, fig. 10; well No. 13 on cross section B-B, p. 85-87). An insoluble residue log of the Eagle-Picher core is on file with the DNR Geological Survey. The La Salle Oil Company residue log is prepared from sample descriptions made by Keroher and Kirby (1948, p. 85-87).

Our interpretation of the Cambrian succession in the four-state area as compared with the interpretations of the foregoing authors is as follows:

1. No Dresbachian-age sediments are present.
2. The Lamotte is not present; rather, the basal lithology is a time transgressive clastic section dominated by quartz sandstone, usually poorly sorted and may be mixed with shale, silt, and glauconite. The unit is usually arkosic at the base and may be dolomitic at the top. We refer this clastic unit to the Reagan Sandstone. This lithology was called Lamotte by Keroher and Kirby (1948) and Chenoweth (1968) and considered of Dresbachian age by them. McCracken (1965) applied the name Lamotte to the basal quartz sandstone, but excluded overlying silty and shaly beds containing variable amounts of glauconite, which we include in the upper Reagan. McNight and Fischer (1970) called the basal sandstone the Lamotte, but referred to the aforementioned silty and shaly beds as "Bonneterre(?)."
3. The Bonneterre Formation is not present in the four-state area. The lower part of the "Bonneterre" of Keroher and Kirby (1948) is referred by us to the Davis, although this glauconitic sandy dolomite also fits the description of the Honey Creek Formation of Oklahoma. The upper part of the "Bonneterre" of Keroher and Kirby (1948) is Derby-Doerun. Chenoweth (1968) apparently followed Keroher and Kirby's interpretation. McNight and Fisher (1970) included in the Davis Formation rocks that we include in both the Davis and Derby-Doerun. They also termed "Potosi(?)" certain strata that we interpret as upper Derby-Doerun. McCracken (1965) did not differentiate the rocks we call Davis and Derby-Doerun, but referred them to an undifferentiated "Gray Series of Beds" in which she also included Bonneterre as well as Davis and Derby-Doerun.

TRAVERSE IN LATE CAMBRIAN STRATA

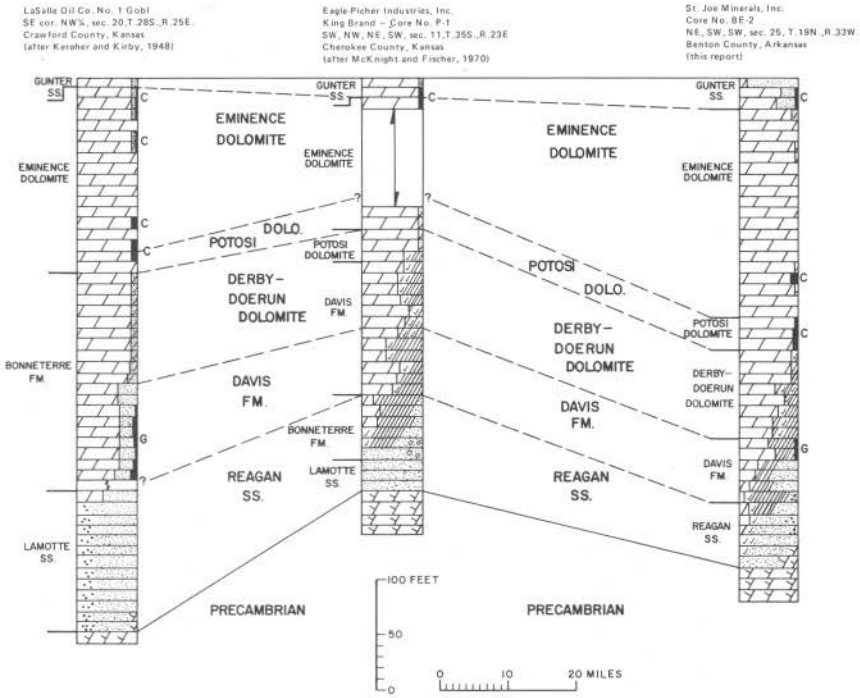


Figure 4
Correlation between the BE-2 core and selected drill holes in Kansas.

4. The Potosi Dolomite is present, but much reduced in thickness as compared with outcrops in the Ozarks to the east. The Potosi was not differentiated from the Eminence by Keroher and Kirby (1948) and McCracken (1965).

5. We agree that typical Eminence and Gunter are developed in the four-state area.

Our interpretation of the geologic history of the four-state area does not agree entirely with that of Keroher and Kirby (1948), Chenoweth (1968), or Lochman-Balk (1971):

1. Cambrian seas did not reach the four-state area until Franconian time. In addition, Stitt (1971) considers the Reagan in areas of outcrop in Oklahoma to be of Franconian age. Therefore, the "Dresbachian Transgression" of Chenoweth (1968) is somewhat confused, since it contains strata of both Dresbachian and Franconian age, and the true position of the late-Dresbachian shoreline should be 100-200 miles farther east than indicated (p. 1678, fig. 8). Lochman-Balk (1971, p. 99, fig. 13) also shows Crepicephalus Zone seas covering the four-state area. The writers contend that during the post-Dresbachian, pre-Franconian regression Cambrian seas were still present in south-central Missouri, rather than absent as indicated by Lochman-Balk (1971, p. 100, fig. 17).

2. The "Franconian Regression" of Chenoweth (1968) did not occur. Rather, the seas were generally transgressing during Franconian time and continued to do so during the Trempealeauan. All Cambrian formations within the four-state area are believed conformable. McCracken (1965) and Lochman-Balk (1971) found no evidence for any unconformity in late Cambrian strata. In other words, sedimentation was essentially continuous, and the positions of the early Franconian shoreline (Chenoweth, 1968, fig. 9, p. 1680) and late-Franconian-early-Trempealeauan shoreline (fig. 10, p. 1680) should be to the west of the four-state area--not to the east, as indicated.

3. The Bonneterre Formation of Dresbachian age is not present in the four-state area because Cambrian seas did not arrive until Franconian time. Therefore, the post-"Bonneterre"--pre-Potosi or pre-Eminence unconformity of Keroher and Kirby (1948) and Chenoweth (1968) does not exist. This "unconformity" came about by a miscorrelation of the Bonneterre Formation and the Dresbachian age assigned to it. Actually, there never was any physical evidence for this unconformity--only the inference that if Potosi or Eminence rested on Bonneterre there had to be an unconformity.

4. The regression of the seas from the shelf and development of a pre-Gunter unconformity apparently does not mark the Cambrian-Ordovician boundary, but rather is an early Lower Ordovician event (Howe et al., 1972, p. 16-18).

CONCLUSIONS

Megascope core descriptions by hand lens together with insoluble residue descriptions combine to form a pragmatic system of analysis of subsurface core and drill samples. Neither technique is mutually exclusive. Discrepancies between formation tops and questionable recognition of lithic units do not mean that the two techniques are antagonistic, but rather that differences are largely of interpretation or emphasis, and where less-than-10-foot discrepancies exist the variance is probably due to sampling technique. The addition of faunal control promotes recognition of coeval lithofacies whose true relationships might otherwise be obscure. The aforementioned three-pronged attack has resolved a number of serious problems in correlation of late Cambrian strata in the subsurface of Missouri and nearby areas and has also given insight into both regional and local relationships of lithic units.

Cambrian sediments in this study are shelf deposits and are influenced by both the local paleotopography of the Precambrian surface and the regional west-northwestward rising paleoslope of the shelf. Topographically high elements are the St. Francois Mountains, in southeastern Missouri, situated near the shelf edge, the "Delaware Islands" in northeastern Oklahoma, and other local paleotopographic features. Most of the noncrossbedded and nonstromatolitic sediments show evidence of burrowing.

Local Lamotte Sandstone thickness is controlled principally by the paleotopography of the Precambrian surface. Regionally, the Lamotte thins westward. At approximately the Taney-Stone County (Missouri) line the Lamotte pinches out, or may, in part, change character and merge with the thinner, time-transgressive Reagan Sandstone.

The lower, pre-Sullivan Siltstone portion of the Bonnetterre Formation in the cross section is thickest just west of the St. Francois Mountains in Dent County where it consists of an upper oolitic wackestone facies and a lower "micrite and shale facies". Farther west in Wright and Douglas Counties the unit is made up of an oolitic wackestone facies coeval with a basal, sandy carbonate facies and an upper, "micrite and shale facies". The "oolite facies", which developed on and maintained shallow water carbonate banks along the Viburnum Trend, is associated with a barrier reef. The "micrite and shale facies" was deposited in deeper water, in a more offshore position than the oolites. The entire lower Bonnetterre section thickens regionally eastward toward the St. Francois Mountains, concurrently thins to the west, and near the Taney-Stone County line changes character to a nearshore sandstone facies, the Reagan Sandstone.

The Sullivan Siltstone Member of the Bonneterre Formation reaches a maximum thickness in the cross section in southeastern Phelps County. Information derived from other core holes indicates that the trend of maximum thickness extends in a southerly direction through western Dent County and eastern Texas County. East of the area of thickest siltstone, the base is an unconformity, and the unit thins by onlap to a fraction of its maximum thickness in less than 15 miles across the depositional strike. This phenomenon is well documented in the cross section. Sixty feet of Crepicephalus Zone age siltstone in the LS-1 core is absent by reason of onlap at the Crooked Creek exposure. Core information south of the cross section indicates that this abrupt pinchout also takes place in less than 15 miles. The upper part of the siltstone changes facies to a nonlaminated micrite with variable amounts of shale in the eastern end of the cross section. Elsewhere along the Viburnum Trend--and farther to the east--Sullivan Siltstone disappears by onlap and facies changes not yet clearly understood. From the trend of maximum thickness westward to where it changes facies to the Reagan Sandstone, the siltstone thins gradually, and the base is conformable with the underlying strata.

The Sullivan Siltstone is a unique unit, in that the laminated character is generally uniform from bottom to top throughout its 1,500-square-mile extent. Its existence seems to be due to a unique combination of provenance and depositional environments. Especially noteworthy is the near absence of an infauna, yet there seems to be no indication of a hostile environment--except, perhaps, high depositional rates or possible lack of nutrients in the quartz silt and fine sand and micrite. Trilobites constitute the only visible epifauna, and their disarticulated remains occur in current sorted calcarenites. Layers of intraclast conglomerates are fairly common and attest to brief periods of storm activity. Algal mats may have had an influence in producing some laminated structures.

The axis of maximum thickness of Cambrian sediments along the cross section shifts 40 to 50 miles to the west with the advent of Whetstone Creek deposition and stays essentially fixed upward through the section to the base of the Gunter Sandstone. The thicker Cambrian section also is changed in character and is developed on an extensive carbonate platform of shallow subtidal to supratidal environments.

The heterogeneous Whetstone Creek shows no sedimentary pattern consistent with the record above and below. Carbonates dominate in shallow water in the central part of the cross section (Douglas County), due to reef buildup and associated calcarenites, and in the eastern end of the cross section, due to nearshore, shallow water conditions. Between these two areas, water was apparently deeper, and shales predominate. The nearshore Whetstone Creek in the western part of the cross section is conspicuously more sandy than elsewhere, and the thickest Whetstone Creek, in the Taney County core, appears to be a nearshore, undaform, clastic and calcarenite buildup, with a tongue of Reagan Sandstone marking the maximum regression of Upper Cambrian seas during Apsotreta expansa Zone time and dividing the Whetstone Creek into upper and lower units. The post-Dresbachian, pre-Franconian unconformity which developed on high areas during the aforementioned regression is identified in the easternmost core and continues eastward into the type area of the Bonneterre and Davis Formations. The unconformity is provisionally identified in the upper part of the Reagan Sandstone in the Carroll County, Arkansas (AK-Ca-1) core. After the regression, the seas again advanced

and continued to do so during the remainder of Cambrian time. The Davis Formation changes facies westward into the Reagan Sandstone, and in the Delaware County, Oklahoma (DE-5) core the Derby-Doerun rests on Reagan. We refer the time transgressive, basal clastic section in the four-state area to the Reagan because of general lithic similarity, rather than propose a new name. The formation is definitely not Lamotte in character. The Davis Formation as expressed in the four-state area is essentially the lithic equivalent of the Honey Creek Formation.

The Davis and Derby-Doerun Formations show a variety of facies relationships, one with the other. This generally happens in two ways: (1) increase in shaliness in lower Derby-Doerun strata until the rock is best described as Davis, and (2) decrease in shaliness in Davis strata concurrent with increases in stromatolite and calcarenite content until the rocks are better designated as Derby-Doerun. The Derby-Doerun-Potosi contact appears to be isochronous over large areas, but locally the lower Potosi and upper Derby-Doerun may be contiguous facies.

A major pre-Potosi unconformity does not exist in the four-state area. Its inferred presence came about through previous miscorrelation of the Bonneterre Formation. It is concluded that what was called "Bonneterre" is actually Davis and/or Derby-Doerun, and the Reagan-Davis-Derby-Doerun-Potosi succession contains no such major unconformity.

The Potosi and Eminence Dolomites are similar in gross lithologic character and have the same general type of residues. The contact between these two formations may be isochronous for considerable distances, whereupon abrupt facies changes render the contact quite diachronous. The Potosi and Eminence thicken toward Douglas County, and here a change--both in gross rock type and in residues--takes place. These previously unknown rocks are interpreted as shallow-subtidal to supratidal reef and calcarenite facies of the Potosi and Eminence Dolomites. It is noteworthy that facies boundaries shifted little during deposition of some 800 feet of sedimentary rock. Determination of the age of the upper Eminence must await further faunal studies.

The Gunter-Eminence contact is regarded as unconformable. In the subsurface, the contact is sharp, but with little evidence of any significant amount of channeling or subaerial erosion. The Gunter itself is an easily recognized unit and although it is Ordovician in age serves as a lithostratigraphic key bed upon which to hang the cross section.

We regard the combination of whole rock and insoluble residues (lithostratigraphic) information with faunal (biostratigraphic) data to be a most effective approach in unraveling the complex facies relationships and associated depositional environments which exist in the Cambrian of Missouri.

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APPENDIX

DESCRIPTION OF CORE LOGGING AND INSOLUBLE RESIDUE METHODS

CORE LOGGING METHODS AND FOSSIL RETRIEVAL

Cores were logged megascopically, with the aid of a 10x hand lens.

Lithologies encountered in the cores are grouped into major subdivisions for purposes of core description. Minor changes can be noted on individual logs making up the cross section.

Megafossils (trilobites and articulate brachiopods) were obtained by sampling the intervals in which cross sections of these forms were visible on the core exterior.

Microfossils (acrotretid brachiopods) were obtained by dissolving core samples in acid. Limestone samples were dissolved in formic acid, dolomite samples in monochloroacetic acid.

INSOLUBLE RESIDUE TECHNIQUES APPLIED TO SAMPLES

1. Log summaries are simply written descriptions of each log as seen from the insoluble residue point of view.
2. Details on insoluble residue logging techniques and explanations of symbols are available in selected publications of the DNR Geological Survey.
3. Apparent discrepancies between core logs and insoluble residue logs are inherent to the diverse and repetitive nature of the insoluble residues in much of the carbonate rocks throughout the study area. However, years of refinement of the technique have established confidence in the system--much the same as trial and error has established other techniques. It is a valid and useful subsurface technique to use in mapping the thick sequences of lithologically similar Lower Ordovician and Upper Cambrian carbonates of the Midcontinent.
4. Chips were taken every foot from core and each 5-foot interval was combined. The materials were digested in acid, washed, and dried. The resulting

insoluble residue was logged, with the lithologic log prepared from the remaining core. All insoluble residue work at the DNR Geological Survey is done at 10x for standardization.

5. Druse refers to coarse quartz crystals on a banded chalcedony base.

6. "Quartzose" in residue work means a texture which displays bright quartz faces at 10x but the crystal faces are not large enough to be distinguished at this magnification. This could also be described as a microscopic quartz druse, a "microdruse".

GENERAL RESIDUE CHARACTERISTICS ALONG LINE OF CROSS SECTION

Lamotte Sandstone

The Lamotte is a medium- to coarse- and fine- to medium-grained quartz sand. There is a prominent break over subregional areas at about 100 feet below the top. Sand grains above this break are usually finer than below and somewhat less rounded and frosted. Black phosphatic brachiopods may be found in this upper interval. The lower Lamotte is usually mixed coarse- to fine-grained, well-rounded to subangular quartz grains.

Bonneterre Formation

Residues of the lower Bonneterre (below the Sullivan Siltstone) are made up of porous brown shale, varying amounts of quartz silt, and green shale. The residue percentages are usually quite low, but commonly increase in volume toward the base of this formation. The silt and shale content in the lower one-third to one-half of the Bonneterre varies from area to area.

The insoluble residues of the Sullivan Siltstone Member are dominated by quartz silt in volumes up to 100 percent. However, small amounts of gray, brown, and occasionally green shale commonly occur within this unit.

The residues of the uppermost Bonneterre, or the Whetstone Creek Member, are quite variable in volume. They are made up of varying amounts of gray, brown, or green shale; quartz grains ranging in size from silt to coarse sand; and fine to coarse pellet glauconite. The residues of this unit, depending upon location, may be similar to those of the Davis Formation. However, they are typically less in volume and different in color than the residues of the Davis.

Davis Formation

Davis residues vary from almost 100 percent residue to no residue. Generally, residues are composed of green to gray shale, with quartz grains making up a secondary constituent. Glauconite is abundant in the quartz grain aggregates, which range from silt-size to medium-coarse sand grains.

Reagan Sandstone

Reagan Sandstone residue is composed of varying amounts of feldspar grains, coarse- to medium-angular quartz grains, and green and gray shale. Fine, angular quartz grains become a more important constituent eastward from Delaware County, Oklahoma.

Derby-Doerun Dolomite

Residues from the Derby-Doerun are low in volume--less than 10 percent of total in the upper half and less than 20 percent in the lower half and show two important characteristics. The upper residue is largely a fine, doloclastic, white, intercrystalline chert with some fine glauconite particles and dickite present. The lower half of the Derby-Doerun residues are usually made up of porous brown shale and fine quartz grains, or any proportion of the two. Some fine glauconitic grains can be found.

The Derby-Doerun is the first unit upward from the Precambrian where chert is found and, in general, the last where appreciable clastic material is encountered. Hence, the "top of the Cambrian Clastics", a useful marker, is pinpointed stratigraphically at the middle of the Derby-Doerun Dolomite.

Potosi Dolomite

Residues may range up to 75 percent (5-foot sample) chert by volume, but typical percentages are 15 to 25 percent chert and druse. Residue colors for Potosi cherts and "quartzose" cherts are white and brown.

No sand is found in typical samples, but some green shale is found in the lower 100 feet of much of the Potosi in southeastern Missouri. In this zone, very little other residue is present (the "low residue" zone known to field and sample workers).

Several siliceous oolite zones are encountered and may be carried over large areas. Oolites may be free or incorporated in chert.

Much of the residue throughout the upper two-thirds of the Potosi is doloclastic, white and brown intercrystalline chert, but a significant portion is also "quartzose" chert and fine "quartzose" chert. The size of the dolocasts is a function of the grain size of the dolomite.

Eminence Dolomite

Eminence residues in general are gray in color, whereas Potosi types are white or brown. Gray, rough, "quartzose" chert is found throughout. Several thick siliceous oolite zones are present. Oolites usually have "quartzose" surfaces. Green "quartzose" chert and green shale are frequently found, as well as some

TRAVERSE IN LATE CAMBRIAN STRATA

rounded and frosted quartz grains and thin-banded "rinds" of druse--usually non-crystalline. Dolocastic material usually shows large openings representing coarser dolomite than the Potosi.

Brown and white dolocastic chert is not common.

Gunter Sandstone Member of the Gasconade Dolomite

Gunter residues are chiefly angular to subangular, poorly sorted, medium to coarse quartz grains; green shale; and minor amounts of gray "quartzose" chert in the base. Percentage of residue ranges from 100 percent to less than 5 percent by volume.

St. Joe Minerals Corporation - Core #56W37 - Hole No. Q-64
Crawford County, Missouri - SW NW sec. 14, T. 35 N., R. 2 W.
Elevation: 792' - Total depth: 891' - MGS No. 26096
Samples 0 to 250 feet are not available
Core from 250 feet to total depth

CORE DESCRIPTION

Coring operations began at a depth of 251 feet, in the lower Potosi Dolomite.

POTOSI DOLOMITE

Depth

251.0'-306.0' This interval is a massively bedded, finely crystalline, dense dolomite which is light gray to tan in color. The entire interval has a mottled appearance due to burrowing organisms. Small to large cavities, which are usually lined with large dolomite crystals and often with quartz druse, are common throughout. Small fillings of dickite are sprinkled throughout this section. A digitate stromatolite was noted in the interval 275-277 feet. Most of this interval has a yellowish cast because of iron staining.

55.0'

DERBY-DOERUN DOLOMITE

- 306.0'-338.0' A massively bedded, fine- to medium-crystalline dolomite which is light gray to tan in color makes up this interval. The entire interval appears mottled due to burrowing. Small pores which may represent relict oolites are abundant throughout and occasionally are filled with dickite. The lower 6 feet of this interval is thin-bedded, the dolomite beds being separated by apple-green-colored shale partings. A 1-inch thick shale bed occurs at the top of this thin-bedded section (332 feet). This interval is yellowish in color due to iron staining. 32.0'
- 338.0'-372.0' This section is made up of finely crystalline, dense, argillaceous dolomite which is light- to medium-brown in color. It is thin bedded, with the dolomite beds separated by wavy, brownish-gray shale partings and shale-filled, low amplitude stylolites. Like the intervals described above, this section has a mottled appearance which is probably due to burrowing organisms. Small, irregularly shaped vugs, which are often filled with dickite, are scattered throughout. Thin bands of porous dolomite which may represent relict oolites occur throughout. Silt is noted in the lower 7 feet of this section. 34.0'

DAVIS FORMATION

- 372.0'-397.0' The top of the Davis Formation in this core is characterized by a thin bedded, fine- to medium-crystalline, medium- to dark-gray dolomite which is interbedded with thin beds of green shale up to $\frac{1}{2}$ -inch thick. Thin zones of "edgewise" conglomerate occur in the dolomite beds and are noted throughout the interval. Small fillings of dickite within the dolomite beds are rare, but occur throughout. Silt is common throughout. Much of the dolomite in this interval contains trilobite debris. 25.0'
- 397.0'-418.0' This interval is made up of beds of green shale up to 2 inches thick, alternating with thin beds of dolomite up to 4 inches thick. The carbonate beds commonly contain zones of "edgewise" conglomerate while the shale units contain irregularly shaped clasts of finely crystalline dolomite. Silt is common throughout, with pellet glauconite occurring in the lower one-half of this interval. 21.0'
- 418.0'-442.0' This section is thin bedded and made up of interbedded units of green shale and very silty dolomite. Thin zones of "edgewise" conglomerate occur in the dolomite beds

throughout this interval. "Pepper" glauconite is abundant throughout.

24.0'

442.0'-526.0' Thin bedded, argillaceous dolomite which is fine to medium crystalline and grayish-brown in color makes up this interval. These thin dolomite beds appear to be silty in the upper one-half of the interval and sandy in the lower half and are separated by thin, green shale beds up to ½-inch thick. Zones of "edgewise" conglomerate occur throughout this interval. Pellet and "pepper" glauconite is very common throughout and is occasionally concentrated in thin layers. FeS₂ is noted throughout this interval and occurs as small masses and as fillings along small fractures. Small clasts of finely crystalline, silty dolomite are commonly contained within the shale beds.

84.0'

526.0'-536.0' This interval is made up of green "poker chip" shale. Thin beds of silty, finely crystalline dolomite occur, rarely, throughout. Faunal data: Linnarssonella girtyi? at 528.1 and 534 feet; Apsotreta expansa, A. stricta at 535.5 feet.

10.0'

BONNETERRE FORMATION

536.0'-544.0' Whetstone Creek Member. The top of the Bonneterre Formation is represented by coarsely crystalline dolomite which is medium-gray in color. It is thin bedded, with the beds separated by green shale filled, low-amplitude stylolites. Pellet glauconite is common throughout the interval and is concentrated in a 2-inch band at 539.5 feet. Small masses of FeS₂ and unidentifiable fossil debris occur throughout. Faunal data: Apsotreta expansa, A. stricta at 536-537.8 feet; Apsotreta expansa, A. attenuata at 540.7 and 542.1 feet.

8.0'

544.0'-559.0' Sullivan Siltstone Member-"micrite facies". This interval is represented by finely crystalline, dense, argillaceous dolomite which is thin bedded, with the beds separated by gray-shale partings and shale filled, low-amplitude stylolites. Megascopically, this interval has a silty appearance; however, upon microscopic examination, no silt was noted.

15.0'

559.0'-737.0' "Oolite facies". This interval is made up of fine- to medium-crystalline, argillaceous dolomite with bedding characteristics much like those described above. Most of the interval appears mottled due to burrowing, and the entire interval appears to have been very oolitic, but during dolomitization most of the oolites were destroyed,

- and now only ghost structures remain. Pores and small vugs which are usually lined with dolomite crystals and occasionally serve as openings for the growth of FeS_2 crystals are common throughout. Small masses of FeS_2 and small, irregularly shaped fillings of dickite are also scattered throughout the interval. A well defined digitate stromatolite occurs in the interval 728.5 to 731 feet. 178.0'
- 737.0'-805.0' "Micrite and shale facies". This interval is comprised of thin, alternating beds of fine- to medium-crystalline, highly porous, brown dolomite and finely crystalline, dense, green, shaly dolomite. There are a few irregularly shaped fillings of massive dolomite and, more rarely, fillings of massive and crystalline quartz scattered throughout the interval. FeS_2 lines many of these fillings. Minute clasts of detrital dolomite are abundant throughout. Narrow zones of yellow iron staining occur throughout this interval. 68.0'
- 805.0'-834.0' Missing interval. The top of the Lamotte Sandstone is within this interval. 29.0'

LAMOTTE SANDSTONE

- 834.0'-853.0' This interval is a medium-grained, well sorted sandstone which is light-gray to white in color. The sand grains for the most part are rounded and frosted. Small masses of FeS_2 are abundant and scattered throughout the interval. Highly weathered igneous cobbles occur at depths of 843 and 845 feet. Thin beds of what appears to be volcanic ash occur in the lowest 6 feet of this section. 19.0'

PRECAMBRIAN

- 853.0'-876.0' The Precambrian here is represented by granite which has been intruded by altered diabase dikes up to 4 feet thick. The granite body at the top of this interval is highly weathered, while the remainder of the section is relatively unweathered. The entire interval is highly fractured. 23.0'
- 876.0'-891.0' The upper one-half of this interval is basic igneous T.D. material which has the appearance of diabase and contains numerous thin veins of calcite or dolomite. (This section may represent a dike.) The lower one-half of the interval returns to an unaltered pink granite. 15.0'

FORMATION SUMMARY

Interval	Formation	Thickness
251.0'-306.0'	Potosi Dolomite	55.0'
306.0'-372.0'	Derby-Doerun Dolomite	66.0'
372.0'-536.0'	Davis Formation	164.0'
536.0'-834.0'	Bonneterre Formation	298.0'
536.0'-544.0'	Whetstone Creek Member	8.0'
544.0'-559.0'	Sullivan Siltstone Member	15.0'
559.0'-737.0'	"Oolite facies"	178.0'
737.0'-805.0'	"Micrite and shale facies"	68.0'
805.0'-834.0'	Missing interval	29.0'
834.0'-853.0'	Lamotte Sandstone	19.0'
853.0'-891.0' T.D.	Precambrian	38.0'

INSOLUBLE RESIDUE LOG SUMMARY

St. Joe Minerals Corporation - Hole No. Q-64

POTOSI DOLOMITE - 250 TO 280 FEET

Insoluble residues from this interval are finely doloclastic, white chert, fine-grained "quartzose"* chert and quartz crystal fragments (from druse). Residue percentages are about 10 percent of each 5-foot interval. Recognition of the indistinct top of Derby-Doerun Dolomite below the Potosi was made possible by more conclusive criteria from core logging. This reflects the interbedded nature of Potosi and Derby-Doerun lithology in this drill hole.

DERBY-DOERUN DOLOMITE - 280 TO 365 FEET

Basically, insoluble residues from the Derby-Doerun are of two types: an upper, more or less cherty half, and a lower, silty (quartz), shaly half. In this drill hole, the residues from the top of the Derby-Doerun (280 to 335 feet) are composed of finely doloclastic, white chert, dickite, fine glauconite grains, green shale, and quartz grains of differing sizes and degrees of rounding. In the lower 30 feet of the Derby-Doerun (335 to 365 feet) residues are predominantly brown shale and silt (quartz). Residue percentages for the entire Derby-Doerun interval are small and in the range of 12 percent in a few samples to less than 8 percent in most

* "quartzose" in this instance and throughout all insoluble residue discussions in this paper refers to a texture visible at 10x as, sucrosic, microdruse. Higher magnification reveals quartz crystal faces.

samples for this drill hole. The carbonate in the Derby-Doerun is dense to finely crystalline, brown dolomite. A characteristic insoluble residue contact is shown between the Derby-Doerun and Davis Formations in this hole. Low residue volume in the base of the Derby-Doerun contrasts with the sharply increased volume in the top of the Davis Formation.

DAVIS FORMATION - 365 TO 540 FEET

Throughout the Davis Formation in this drill hole, insoluble residues average 50 percent or more of each sample. They consist of glauconite in the sand-size range, fine, rounded and frosted quartz grains, and green shale. The shale and quartz grains are in about equal proportions, the glauconite being a minor constituent. The carbonate portion of the Davis is fine- to medium-crystalline brown dolomite.

BONNETERRE FORMATION 540 TO 805+ FEET (805 TO 835 FEET MISSING)

The Whetstone Creek Member and Sullivan Siltstone Member are not recognized in this drill hole. The Bonneterre Formation residues are unusually uniform throughout the entire interval. They constitute less than 5 percent in most samples and contain small quantities of brown shale and angular to rounded and frosted quartz grains. Noncrystalline quartz is found in small amounts throughout, as well as grains of weathered and somewhat fresher "igneous" material (felsite?). The break between the Davis Formation and the Bonneterre Formation is abrupt and is characterized by a high residue in the lower Davis (green shale) to less than 5 percent residue (brown shale) in the upper Bonneterre. The absence of glauconite is also notable in the Bonneterre. The interval between 560 and 730 feet is the "oolite facies". The lower 70 feet, or "micrite and shale facies", of the Bonneterre contains increased percentages (up to 30% of sample) of brown shale.

The carbonate portion of the Bonneterre in this drill hole is composed of fine- to medium-crystalline, brown dolomite throughout. The interval between 560 and 730 feet is strongly oolitic and is an excellent example of dolomitized oolite facies described elsewhere in this paper.

LAMOTTE SANDSTONE ----- TO 855 FEET (TOP SAMPLES MISSING)

The Lamotte Sandstone here is composed of mixed angular and rounded and frosted sand (quartz) grains. Some gray and red (hematitic) shale is present. Precambrian felsite and chloritic igneous rocks are in sharp contact with the overlying Lamotte.

TRAVERSE IN LATE CAMBRIAN STRATA

New Jersey Zinc, Incorporated - Hole No. HM-1
Dent County, Missouri - Sec. 26, T. 36 N., R. 3 W.
Elevation: 1,224' - Total depth: 1,205' - MGS No. 20975
Drill cuttings to 430 feet - Core from 430 feet to total depth

CORE DESCRIPTION

Coring operations began at a depth of 435 feet, in the Potosi Dolomite.

POTOSI DOLOMITE

Depth

- 435.0'-508.0' This interval is made up of medium- to coarse-crystal-line dolomite which is light- to medium-gray in color. It is massively bedded, with occasional apple green colored shale partings separating the beds. This interval has a distinct, mottled appearance due to burrowing organisms and is also highly porous, with quartz druse commonly lining or filling the larger-sized vugs and cavities. Much of the interval contains small, spherical masses of what appear to be algal material. The entire interval is iron-stained to a yellowish-orange color and has a moderately weathered appearance. 73.0'
- 508.0'-559.0' This interval is made up of fine- to medium-crystalline, medium-brown colored dolomite. It is massively bedded, with the beds separated by green shale partings, and does not appear as porous as the interval described above, but the small cavities which occur here are commonly lined with quartz druse. The entire interval has a mottled appearance due to burrowing. Thin beds of what appear to be algal material, occur throughout. This interval has a much fresher appearance than the above interval. 51.0'

DERBY-DOERUN DOLOMITE

- 559.0'-607.0' The top of the Derby-Doerun Dolomite is represented by fine- to medium-crystalline dolomite which is medium-brown in color. It is massive to thin-bedded, with green shale partings rare, but occurring throughout. A $\frac{1}{2}$ -inch thick bed of apple green colored shale occurs at the top of the interval. The entire interval has a very distinct, mottled appearance due to burrowing and shows much less porosity than the overlying interval. No quartz druse was noted here. Small fillings of dickite occur in the lower

- one-half of the interval, and large calcite crystals frequently line larger cavities. Occasionally, the rock is iron-stained to an orangish color. 48.0'
- 607.0'-696.5' This interval is made up of finely crystalline, dense dolomite which is light gray to tan in color. The upper one-half of the interval is massively bedded, while the lower half is thin bedded. Green shale partings are noted throughout and are quite numerous in the lower portion of the section. Thin, alternating beds of tan colored dolomite and green, argillaceous dolomite are scattered throughout the lower half of the interval. The entire interval has a mottled appearance due to burrowing organisms, but is less distinct than above. Small vugs are common throughout the interval, but are not as abundant as above. Small fillings of dickite are common throughout. Note: The interval 680 to 695 feet is missing from the core. 89.5'

DAVIS FORMATION

- 696.5'-725.0' The top of the Davis Formation is represented by interbedded green shale and medium- to coarse-crystalline, sandy and silty dolomite which is dark-gray to brown in color. The dolomite units are thin bedded, with abundant wavy, green and gray shale partings, and on occasion contain pelletal glauconite. Beds of flat pebble conglomerate up to 4 inches thick are noted in the dolomite beds of the upper portion of the interval. All of the shale beds of this interval contain small, angular clasts of dolomite similar to that described above. The dolomite-to-shale ratio of this interval approaches 1:1. 28.5'
- 725.0'-755.0' This interval is made up of green shale containing small, rounded clasts of limestone and thin, scattered beds of dark gray limestone. The limestone beds are commonly made up of flat pebble conglomerates and contain abundant fine sand, silt, and pepper glauconite. 30.0'
- 755.0'-810.5' This interval is made up of fine sand and silt interbedded with green shale partings and thin beds. The entire interval is slightly limy and contains abundant pepper glauconite. Beds of flat pebble conglomerate are very common throughout this interval, and unidentifiable fossil debris is concentrated in a few thin zones which occur throughout. 55.5'
- 810.5'-877.0' The overall appearance of this interval is very similar to that described above; however, green shale and limestone

are much more common here. The limestone is fine- to medium-crystalline and medium- to dark-gray in color. Silt, fine sand, and pepper glauconite are common throughout. Zones of flat pebble conglomerate occur in the carbonate beds throughout the interval, but are not as common as above. Generally, the limestone appears to be the major lithic characteristic in the upper one-half of the interval, while green shale dominates the lower portion of the section, with the lowest 6 feet of the interval being made up entirely of green shale. Faunal data: Iddingsia sp. at 856 feet; Pterocephalia sanctisabae, Linnarssonella girtyi at 858 feet; Parahousia sp. cf. P. subequalis, Apachia? sp., Elvinia? sp., Linnarssonella girtyi at 858.3-866.2 feet; Pterocephalia? sp., Prehousia sp. cf. P. diverta, Linnarssonella girtyi, L. costa at 868.3-870.0 feet; Elvinia? sp., Parahousia sp. cf. P. constricta, Iddingsia? sp., Minupeltis? sp., Linnarssonella girtyi, L. costa at 870.3-870.5 feet; Parahousia sp. cf. P. subequalis, Prehousia sp. cf. P. diverta, Minupeltis? sp., Apsotreta expansa, A. stricta at 872.2, 875.0 feet; Apsotreta expansa at 876.0 feet.

66.5'

BONNETERRE FORMATION

877.0'-890.0' Whetstone Creek Member. The Whetstone Creek is represented by coarsely crystalline dolomite which is medium- to dark-brown in color. It is thin bedded, with the beds separated by brown shale partings. Fine pellet glauconite occurs throughout the interval, as do zones of high porosity which may represent relict oolite development. A 5-inch thick bed of flat pebble conglomerate occurs at 888.5 feet, and the lowest 1-foot of the interval is green shale. Faunal data: Apsotreta expansa at 877.0-882.0 feet; Apsotreta expansa, A. attenuata at 884.0, 886.0 feet; Angulotreta sp. cf. A. missouriensis at 886.5 feet.

13.0'

890.0'-901.5' Sullivan Siltstone Member-"micrite facies". The "micrite facies" of the Sullivan Siltstone Member is made up of finely crystalline, medium- to dark-brown dolomite. This unit is thin bedded and is banded in appearance, with alternating beds of dense and highly porous dolomite. The lowest 1.5 feet of this interval shows a green shale containing small clasts of finely crystalline, brown dolomite.

11.5'

- 901.5'- 913.5' Sullivan Siltstone Member (cont...). This interval is made up of medium gray silt which is color banded by alternating bands of medium gray and darker gray (more argillaceous) silt. 12.0'
- 913.5'- 995.0' "Oolite facies". This interval is made up of argillaceous limestone which is calcarenitic in appearance. It is fine- to medium-crystalline, medium brown in color, and thin-bedded, with the beds separated by wavy, brown shale partings and shale filled, low amplitude stylolites. The entire interval has a mottled appearance due to burrowing and is very oolitic. Unidentifiable fossil debris is abundant throughout. Faunal data: Tricrepicephalus sp., Coosina sp. at 918.0-952.0 feet. 81.5'
- 995.0'-1165.0' "Micrite and shale facies". This interval is made up of limestone which is fine- to medium-crystalline (more coarsely crystalline in the lowest portion of the interval). It is light-gray in color, thin, and irregularly bedded, with the beds separated by wavy, green shale partings and shale beds up to $\frac{1}{2}$ -inch thick. This interval has a variegated appearance due to its irregularly bedded nature and the abundance of shale. The limestone-to-shale ratio of this interval is approximately 2:1. Unidentifiable fossil debris and minute, rounded masses of what appear to be algal material are common throughout, but are particularly abundant in the lower one-third of the interval, giving this portion of the interval an appearance somewhat like a coquina. Pellet glauconite is noted throughout the lower one-half of the interval and is concentrated in the lowest 20 feet. Faunal data: Opisthotreta depressa at 1,025 feet; Tricrepicephalus sp. at 1,046 feet; Syspacheilus? sp. at 1,100.5 feet; Holcacephalus? sp. at 1,113 feet; Tricrepicephalus sp. at 1,119.5 feet. 170.0'
- 1165.0'-1184.0' This interval is made up of medium- to coarse-crystalline dolomite, medium gray in color. It is thin and irregularly bedded, with the beds separated by wavy, brown and green shale partings and thin beds. As above, the carbonate-to-shale ratio of this section approximates 2:1. Pellet glauconite is noted throughout, and the lowest 5 feet of this interval has a greenish cast due to an abundance of glauconite. 19.0'

LAMOTTE SANDSTONE

- 1184.0'-1205.0' The top of the Lamotte Sandstone is represented by fine-T.D. to medium-grained sandstone which is rounded and

TRAVERSE IN LATE CAMBRIAN STRATA

frosted and relatively well sorted. This interval is "clean" in appearance, with the exception of a few bands of argillaceous(?) material. No phosphatic brachiopods were noted in this portion of the Lamotte.

21.0'

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
435.0'- 559.0'	Potosi Dolomite	124.0'
559.0'- 696.5'	Derby-Doerun Dolomite	137.5'
696.5'- 877.0'	Davis Formation	180.5'
877.0'-1184.0'	Bonneterre Formation	307.0'
877.0'- 890.0'	Whetstone Creek Member	13.0'
890.0'- 913.5'	Sullivan Siltstone Member	23.5'
913.5'- 995.0'	"Oolite facies"	81.5'
995.0'-1184.0'	"Micrite-and-shale facies"	189.0'
1184.0'-1205.0' T.D.	Lamotte Sandstone	21.0'

INSOLUBLE RESIDUE LOG SUMMARY

New Jersey Zinc, Incorporated - Hole No. HM-1

EMINENCE DOLOMITE - 10 TO 230 FEET

Insoluble residue types throughout the Eminence interval in this drill hole are typical Ozark residue types, being gray in color and consisting of rough, smooth, and "quartzose" chert. The chert buildups, as shown on the insoluble residue log, represent intervals of silicification in what was formerly oolitic limestone. The lower 70 feet of the Eminence at this location contains some brown and rough, "quartzose" chert in addition to the more typical, gray, rough, "quartzose" chert. Druse development throughout the Eminence interval is at a minimum. Minor amounts of rough and "quartzose" white chert are scattered throughout.

POTOSI DOLOMITE - 230 TO 560 FEET

The break between the Eminence and Potosi Dolomites at this location is represented by a change in color of the insoluble residue from predominantly gray to predominantly white. In addition, a change from "quartzose" chert to rough, "dead",

and dolomoldic chert takes place. The Potosi is represented here by large amounts of druse throughout, and the upper half is composed of predominantly rough, "dead", dolomoldic, white chert, with some intervals of fine, brown, "quartzose" chert. Quartz crystals and coarse druse are common. The upper half is higher in residue content than the lower half. The lower half of the Potosi here is represented by low-volume residues composed of fine, dolomoldic, brown chert; fine, "quartzose" white and brown chert; and druse. Green shale begins to show up at 460 feet. This green shale can be found in large areas of the Ozarks, usually confined to the low residue portion of the Potosi, the lower 100 feet.

DERBY-DOERUN DOLOMITE - 560 TO 695 FEET

The contact between the Potosi Dolomite and the Derby-Doerun Dolomite, in this drill hole, is characterized by high chert percentage in the Potosi, with typical low chert residue content in the upper Derby-Doerun. At the contact, the residue in the Derby-Doerun is composed of dolomoldic white chert. Typically, the Derby-Doerun Dolomite residues are composed of white chert and fine brown "quartzose" chert in the upper portion and porous brown shale, fine quartz silt, and fine glauconite particles in the lower portion. The uppermost horizon at which the fine quartz silt occurs is termed the "Top of the Cambrian Clastics", as discussed in Missouri Geological Survey, Report of Investigations 52. The horizon is widely known and used by geologists of the Ozark and Midcontinent regions of the U. S.

In this drill hole, the division between the upper, low chert residue portion and the lower silt and glauconite portion of the Derby-Doerun is sharp and well-developed and occurs at 615 feet. Typically, in the Ozark region the upper Derby-Doerun will contain dickite and will be somewhat finer-grained dolomite than the Potosi Dolomite above.

DAVIS FORMATION - 695 TO 877 FEET

The insoluble residues of the Davis Formation in this drill hole are typical Ozark residues. The upper two-thirds of the Davis residues is composed of almost equal parts of green shale and fine quartz silt. Glauconite is a component of the insoluble residue throughout the Davis interval. Most of the glauconite is in the form of fine pellets; however, toward the base of the Davis the glauconite typically becomes a pellet glauconite up to 1 mm. in diameter. The Davis below 800 feet in this drill hole is composed of large amounts of green shale and lesser amounts of fine to medium quartz grains and glauconite, with pellet glauconite at the base. Carbonate oolites were found in the limestone in the lowest 5-foot sample of the Davis interval.

BONNETERRE FORMATION - 877 TO 1,185 FEET

The Bonneterre Formation in this drill hole can be divided into an upper one-third containing low percentage residues of gray shale and silt and a lower two-thirds, below 1,000 feet, containing high percentage residues of green shale and

little silt. The contact between the Davis Formation above and the Bonneterre Formation below is characterized by an abrupt reduction in the amount of insoluble residue and a break between limestone above in the Davis Formation and dolomite in the Bonneterre Formation below. Residue percentages in the upper 23 feet of the Bonneterre Formation, or Whetstone Creek Member, are very low and composed of gray and brown porous shale. The Sullivan Siltstone occupies the interval 900-920 feet and consists of fine quartz silt grains, with minor amounts of gray shale. The typical Bonneterre "oolite facies", with very small amounts of gray shale, begins at 920 feet. Beginning at 1,000 feet, the lower two-thirds of the Bonneterre, or "micrite and shale facies", is characterized by a 15-foot thick, quartz-silt interval at the top and high residue percentages of green and brown shale to the total depth of the Bonneterre Formation. The shales are porous and in this particular drill hole are nonsilty, and glauconite is patchy. The lower two-thirds of the Bonneterre Formation in this core is composed of 50 percent residue and 50 percent fine- to medium-crystalline limestone. The lower 15 feet of the Bonneterre at this location is dolomite and contains some glauconite and silt.

LAMOTTE SANDSTONE - 1,185 TO 1,205 FEET

Only the upper 20 feet of the Lamotte was drilled in this location, and the sandstone is composed of medium to coarse, rounded to subrounded quartz grains which are fairly well-sorted.

St. Joe Minerals Corporation - Core #61W48 - Hole No. LS-1
Phelps County, Missouri - Sec. 36, T. 36 N., R. 7 W.
Elevation: 1,140' - Total depth: 2,601' - MGS No. 26041
Drill cuttings to 800 feet - Core 801 feet to total depth

CORE DESCRIPTION

Coring operations began at a depth of 801 feet, in the lower Potosi Dolomite.

POTOSI DOLOMITE

Depth

801.0'-872.0' This interval is made up of fine- to medium-crystalline, medium gray dolomite. It is massively bedded, with a few widely scattered, gray shale filled, medium amplitude stylolites. Small to large, irregularly shaped vugs, which are lined with large dolomite crystals or quartz

druse, are abundant throughout. The entire interval has a subtle mottled appearance which is due to burrowing. The upper two-thirds of this interval has an orangish color which is due to iron staining, and the uppermost 10 feet of this section contains numerous, small, vertical fractures. Small vugs filled with apple green colored clay are common in the center portion of the interval. The interval 838-842 feet has a thinly laminated appearance and may represent planar stromatolite material.

71.0'

DERBY-DOERUN DOLOMITE

872.0'-931.5' The top of the Derby-Doerun Dolomite is represented by a finely crystalline, dense- to medium-crystalline, argillaceous dolomite which is medium brown in color. It is massively bedded, with a few widely scattered, brownish-gray, shale filled, low amplitude stylolites. The lowest 5 feet of this interval is a thinner bedded, finely crystalline, dense, gray dolomite which contains numerous gray shale partings and shale filled, low amplitude stylolites. Most of this interval shows a high degree of porosity. Large vugs and cavities filled with medium-to coarse-crystals of dolomite are common throughout. Minute fillings of dickite are common throughout the interval, with small masses of FeS_2 rare, but noted throughout.

59.5'

931.5'-955.0' This interval is represented by finely crystalline, dense dolomite which is medium gray to brown in color. It is thin and very irregularly bedded, with the beds separated by abundant wavy, gray shale partings and gray shale filled, low amplitude stylolites. Small fillings of dickite were noted throughout. The entire interval has a mottled appearance which is due to burrowing. Small masses of FeS_2 are common throughout. The lowest 4 feet of this interval is siltstone.

23.5'

955.0'-960.0' This interval is composed of interbedded green shale and finely crystalline, dense dolomite. Finely disseminated FeS_2 is common throughout the shale beds.

5.0'

960.0'-980.0' A medium crystalline, grayish-brown dolomite characterizes this interval. It is regularly bedded, with beds ranging from 1 to 2 inches in thickness and separated by thin, grayish-brown shale partings and shale filled, low amplitude stylolites. What appear to be fossil hash and minute clasts of detrital dolomite are abundant throughout. Finely disseminated FeS_2 is scattered throughout the interval, and a $\frac{1}{2}$ -inch bed of FeS_2 occurs at a depth

TRAVERSE IN LATE CAMBRIAN STRATA

- of 971.5 feet. This interval is interpreted as representing a dolomitized calcarenite. 20.0'
- 980.0'- 988.0' A highly irregularly bedded, finely crystalline, dense dolomite which is brown in color makes up this interval. The beds are separated by abundant and closely spaced, grayish-brown shale partings and shale filled, low amplitude stylolites. Silt is common throughout. 8.0'
- 988.0'-1006.0' This interval is represented by a finely crystalline, dense dolomite which is brown in color. It is regularly bedded, with beds ranging from 1/8 inch to 1 inch in thickness and separated by grayish-brown and greenish-gray shale partings and shale filled, low amplitude stylolites. Silt, in beds up to 1 inch thick and containing pellet glauconite, is common throughout. Small to large masses of FeS₂ are scattered throughout the upper one-half of the interval. This interval appears to represent a transition from Derby-Doerun to Davis lithologies. 18.0'
- DAVIS FORMATION
- 1006.0'-1030.0' The top of the Davis Formation is represented by green shale interbedded with thin beds of finely crystalline, silty dolomite. Zones of "edgewise" conglomerate--up to 4 inches thick and consisting of silty dolomite clasts contained within a matrix of coarse crystalline dolomite and dolomitic limestone--occur throughout the interval, but are particularly common in the upper half. A 3-inch thick oolitic bed occurs at a depth of 1,010 feet. Fossil debris is scattered throughout the interval. Faunal data: Billingsella? sp. at 1,014 feet; Eoorthis remnicha at 1,027 feet. 24.0'
- 1030.0'-1076.0' This interval is basically the same as the above interval, except that the carbonate material here is limestone rather than dolomite. The upper 4 feet of this interval shows inclined bedding. Thin zones of "edgewise" conglomerate up to 2 inches thick are common in the center portion of the interval, and the lower half of the interval has been oxidized, the rock now having a reddish or orangish color. Faunal data: Housia sp. at 1,069.5 feet; Linnarssonella girtyi at 1,075.7 feet. 46.0'
- 1076.0'-1140.0' This interval is composed of beds of green shale interbedded with beds of limy siltstone up to 4 inches thick.

This interval is basically the same as the above interval, except there is more silty carbonate material here. "Pepper" and small pellet glauconite are common throughout the silt beds and become increasingly higher in concentration toward the bottom of the interval. Zones of "edgewise" conglomerate up to 1 foot thick occur throughout and are made up of angular clasts of silty limestone contained within a matrix of coarser crystalline and "cleaner" appearing limestone. Unidentifiable fossil debris is common throughout. In a few thin, widely scattered zones, the shale and carbonate beds have been oxidized, resulting in an orangish color. Faunal data: Elvinia? sp. at 1,095 feet; Linnarssonella girtyi at 1,124.0 feet.

64.0'

BONNETERRE FORMATION

1140.0'-1173.0' Whetstone Creek Member. The top of the Bonneterre Formation is represented by fine- to medium-crystalline limestone which is interbedded with thin units of green shale. The upper half of this interval appears to have a higher percentage of limestone, while the lower half has a higher percentage of shale. Recognizable trilobite and brachiopod debris is noted in the lower 15 feet of the section. "Pepper" and pellet glauconite are common throughout and more abundant than in the above interval. Faunal data: Linnarssonella girtyi at 1,141.0 feet; Linnarssonella costa at 1,147.0 feet; Parahousia constricta at 1,148.5 feet; Parahousia sp. cf. P. subequalis, Apsotreta expansa at 1,152.2 feet; Apsotreta stricta, A. expansa at 1,153.8-1,154.2 feet; Parahousia sp. cf. P. subequalis, Apsotreta expansa at 1,156.2, 1,162.0 feet; Apsotreta attenuata, A. expansa at 1,163.0 feet; Angulotreta sp. cf. A. missouriensis at 1,170.0, 1,170.4 feet; Aphelaspis sp. cf. A. buttsi, Aphelaspis sp. cf. A. subdita at 1,172.0 feet.

33.0'

1173.0'-1251.0' Sullivan Siltstone Member. This interval is comprised of limy siltstone which is medium gray in color. It is regularly bedded, with the beds separated by green shale partings and beds up to 2 inches thick. This interval has a banded appearance due to an alternation of light and darker colored silt beds and shale beds. "Pepper" glauconite is common throughout and is occasionally concentrated in thin beds. Zones of "edgewise" conglomerate are rare, but occur throughout the interval. Thin zones of fossiliferous and slightly dolomitic material occur in the center portion

TRAVERSE IN LATE CAMBRIAN STRATA

- of the interval. Faunal data: Tricrepecephalus sp. at 1,196.0-1,222.0 feet; Coosina sp. at 1,226.5 feet. 78.0'
- 1251.0'-1264.0' "Micrite and shale facies". This interval appears to represent a slide breccia. It is a mixture of limy silt and greenish-gray shale. Pellet glauconite and small-to medium-size clasts of detrital limestone are abundant throughout the interval, with strongly contorted, lath-shaped clasts of siltstone abundant in the lower half. A 9-inch long fracture filled with calcite occurs at a depth of 1,260 feet. 13.0'
- 1264.0'-1354.0' This interval is made up of thin beds of finely crystalline, light gray to white limestone separated by abundant and closely spaced green shale partings and beds up to 1 inch thick. It appears to be composed of 50 percent shale and 50 percent limestone. Much of the limestone of this interval contains small detrital clasts of silt, shale, and limestone which is foreign to this interval. Unidentifiable fossil hash is common throughout. 90.0'
- 1354.0'-1384.0' "Oolite facies". This interval is made up of finely crystalline, dense, argillaceous dolomite which is medium brown in color. It is thin bedded, with the beds ranging from 1 to 3 inches in thickness and separated by gray shale filled, low- to medium-amplitude stylolites. Pellet glauconite is sprinkled throughout and increases in concentration toward the bottom of the interval. Occasionally, thin beds of large, brown, dolomitic oolites can be recognized. Small, calcite filled fractures are rare, but occur throughout the interval. What appears to be unidentifiable fossil hash is abundant throughout. 30.0'

PRECAMBRIAN

- 1384.0-1411.5' The top of the Precambrian is represented by porphyritic felsite which is reddish-black in color. The phenocrysts appear to be feldspar, probably orthoclase. The entire interval appears relatively unweathered. 27.5'
- 1411.5'-2601.0' Precambrian - undescribed. 1,189.5'
T.D.

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
801.0'- 872.0'	Potosi Dolomite	71.0'
872.0'-1006.0'	Derby-Doerun Dolomite	134.0'
1006.0'-1140.0'	Davis Formation	134.0'
1140.0'-1384.0'	Bonneterre Formation	244.0'
1140.0'-1173.0'	Whetstone Creek Member	33.0'
1173.0'-1251.0'	Sullivan Siltstone Member	78.0'
1251.0'-1354.0'	"Micrite and shale facies"	103.0'
1354.0'-1384.0'	"Oolite facies"	30.0'
1384.0'-2601.0' T.D.	Precambrian	1,217.0'

INSOLUBLE-RESIDUE-LOG SUMMARY

St. Joe Minerals Corporation - Hole No. LS-1

EMINENCE DOLOMITE - 335 TO 615 FEET

The entire Eminence interval in this drill hole contains typical Ozark residue types and is composed of "quartzose", dolomoldic, gray chert, with minor amounts of rough, nodular, white chert, some green shale, and minor amounts of irregular shaped quartz masses, fine quartz silt, and thin druse composed mostly of chalcidony. The overall residue color in the Eminence Dolomite here is gray, and intervals of siliceous oolites are somewhat less well defined than in the HM-1 core hole immediately to the east. The Eminence is typically very low residue dolomite. The samples are from drill cuttings. The residue curve shows very little fluctuation from high to low percentages.

POTOSI DOLOMITE - 615 TO 880 FEET

The entire Potosi interval in this drill hole is from samples taken from the core and shows a remarkably low residue curve throughout, the residues being composed mostly of quartz druse, irregularly shaped quartz masses, quartz crystals, and dolomoldic quartz. The lower two-thirds of the Potosi contains some mottled brown, "quartzose" and fine, brown, "quartzose" chert, together with dolomoldic, "quartzose" chert, in small amounts. Some fine, gray, "quartzose" chert is found below 800 feet. Dickite is found in the interval below 850 feet. The residue curve for the Potosi in this core shows a remarkably small fluctuation in percentages. More typically, the Potosi residue curve has numerous sharp fluctuations in residue percentages.

DERBY-DOERUN DOLOMITE - 880 TO 1,005 FEET

The top of the Derby-Doerun Dolomite in this area, based on insoluble residue characteristics, is indistinct and in this drill hole is largely based on data from the core itself. The top of the Derby-Doerun consists of very low residue percentages, with the residues composed mainly of dickite, small amounts of glauconite, and fine quartz grains. At 950 feet, roughly the middle of the Derby-Doerun interval, the first large percentage residue sample of glauconite, fine quartz grains, and green shale is encountered. This represents the "top of the Cambrian clastics" as used throughout the Ozark region. Residues below this point are composed of varying percentages of porous brown shale, fine quartz-silt grains, fine glauconite grains, and some green shale. The carbonate portion of the Derby-Doerun throughout is medium to finely crystalline, brown dolomite.

DAVIS FORMATION - 1,005 TO 1,140 FEET

The upper 25 feet of the Davis Formation here is composed of silty dolomite, the residue percentage ranging from 5 to 100 percent quartz silt grains, with lesser amounts of green shale. The dolomite is medium- to coarse-crystalline and brown in color. Below 1,030 feet, the carbonate portion of the Davis is finely crystalline, brown limestone, and the residues are high in percentages, ranging from 30 to 90 percent, and composed of green shale, very minor amounts of quartz silt and glauconite, and a high percentage of authigenic feldspar. The authigenic feldspar encountered in this drill hole is limited to the interval below 1,035 feet and above 1,150 feet. The lower two-thirds of the Davis Formation here is atypically low in the amount of quartz silt grains.

BONNETERRE FORMATION - 1,140 TO 1,385 FEET

The insoluble residues of the Bonneterre Formation differ from those found in the Ozark region; however, basic characteristics are still recognizable. The Whetstone Creek Member occurs between 1,140 and 1,170 feet. The upper 10 feet of the Bonneterre contains what appear to be authigenic feldspars, while the rest of the Bonneterre interval is lacking in this type residue. The upper 50 feet is composed of fine- to medium-crystalline, brown, somewhat oolitic, limestone with intervals of high percentage of green shale, pellet glauconite, and quartz silt grains. Quartz silt grains are more predominant in the lower portion of the interval. The 5-foot interval between 1,150 and 1,155 feet is a finely crystalline dolomite, and the residue in this interval is very high (20 percent), made up mostly of pellet glauconite, with minor amounts of fine quartz silt and porous brown shale. The Sullivan Siltstone in this drill hole (by insoluble residue) is found between 1,170 and 1,250 feet. This interval is characterized by up to 100 percent fine quartz-silt grains, gray shale, and glauconite, while the carbonate portion is made up of finely crystalline, brown limestone. Two intervals of high percentage silt residue occur--one at 1,190 to 1,210 feet, and the other at the base of the Sullivan Siltstone interval, as shown on the cross section. Fresh feldspar was encountered in one sample at 1,235 feet. The Bonneterre Formation below the Sullivan Siltstone to 1,385 feet, the "micrite and shale facies", is somewhat lower in residue percentage than holes east

of this location, and the residue is composed of fine quartz-silt grains, minor amounts of glauconite, porous brown shales, and green shales. The lower 30 feet of the Bonneterre, or "oolite facies", is composed of coarsely crystalline, brown, oolitic dolomite containing pellet glauconite. Feldspar chips occur 15 feet above the contact between the Bonneterre and the Precambrian crystalline rocks below. The contact between the Bonneterre Formation and the Precambrian rhyolite shows no indication of the Lamotte Sandstone. This hole was drilled on a known magnetic high, which reflects a Precambrian topographic high and accounts for the absence of the Lamotte Sandstone.

St. Joe Minerals Corporation - Core #63W121 - Hole No. TE-1
 Texas County, Missouri - NE SE sec. 25, T. 32 N., R. 10 W.
 Elevation: 961' - Total depth: 1,584' - MGS No. 25824
 Drill cuttings to 816 feet - Core 816 feet to total depth.

CORE DESCRIPTION

Coring operations began at a depth of 816 feet, in the lower Potosi Dolomite.

POTOSI DOLOMITE

Depth

816.0'-855.5' This lowest portion of the Potosi Dolomite is represented by finely crystalline, dense dolomite which is medium gray in color. It is massively bedded, with a few scattered, gray shale partings and shale filled, low- to high-amplitude stylolites separating the dolomite beds. The entire interval has a mottled appearance which is due to burrowing organisms. Irregularly shaped vugs are common throughout, and are particularly abundant in the upper 30 feet of the interval. The vugs are commonly lined with quartz druse or filled with dickite.

39.5'

DERBY-DOERUN DOLOMITE

855.5'-896.0' The top of the Derby-Doerun Dolomite is represented by finely crystalline, dense dolomite which is medium-gray to brown in color. It is thin bedded, with the beds separated by brownish-gray shale partings. Small, irregularly shaped vugs lined with dolomite crystals and oftentimes filled with dickite are common in the

TRAVERSE IN LATE CAMBRIAN STRATA

intervals 872 to 881 feet and 894 to 896 feet. The interval 872 to 881 feet has a spotted appearance due to an abundance of what appear to be clasts of algal material. A small scale slump structure, made up of dolomite clasts contained within a shale or highly argillaceous dolomite matrix, occurs in the interval 892.5 to 893.3 feet.

40.5'

896.0'- 924.0' This interval is made up of finely crystalline dolomite which is medium gray to brown in color. It is thin and irregularly bedded, with abundant and closely spaced, brownish-gray shale partings. Quartz silt or fine sand is abundant throughout. Thin beds of "edgewise" conglomerate occur throughout the interval. "Pepper" glauconite is common throughout.

28.0'

INTERBEDDED DERBY-DOERUN AND DAVIS

924.0'- 984.5' This unit is represented by interbedded finely crystalline, brown dolomite, which has basically the same lithology as that described above, and brown to green shale. The interval 966 to 978 feet contains less shale than the rest of the interval. Pellet glauconite is common throughout. Finely disseminated FeS₂ is rare, but occurs throughout the interval. The lowest 6 feet of the interval is made up of interbedded argillaceous dolomite and green shale in beds up to 3 inches thick. Faunal data: Billingsella sp. cf. B. texana at 927.0 feet.

60.5'

DAVIS FORMATION

984.5'-1039.0' The top of the Davis Formation is represented by green "poker chip" shale in beds up to 3 feet thick, interbedded with fine- to medium-crystalline, brown limestone in beds up to 3 inches thick. Many of the thicker shale beds contain small, irregularly shaped limestone clasts. Three-inch thick zones of abundant, small, algal balls occur at depths of 998 feet and 1,015.5 feet. The entire interval appears to be very silty. Faunal data: Huenella sp. cf. H. abnormis at 986.2 feet; Taenicephalus sp. cf. T. shumardi, Taenicephalus sp. cf. T. gouldi at 988.0 feet; Parabolinoides? sp. at 988.2, 991.0 feet; Parabolinoides sp. cf. P. contractus, Orygmaspis sp. cf. O. llanoensis at 995.5, 996.0 feet; Angulotreta microscopica at 998.0 feet; Parabolinoides contractus at 998.5, 999.8 feet; Eoorthis sp. at 1,000.0

feet; Linnarssonella girtyi at 1,003.0, 1,005.3 feet; Cliffia sp. cf. C. lataegenae, Elvinia? sp., Linnarssonella girtyi at 1,005.5, 1,008.0 feet; Linnarssonella girtyi at 1,010.0-1,014.5 feet; Housia sp. cf. H. varro, Linnarssonella girtyi at 1,021.2-1,026.4 feet; Homagnostus? sp., Dellea? sp., Linnarssonella girtyi var. "elongata", Housia sp. cf. H. varro, Homagnostus? sp., Drabia? sp. at 1,033.0, 1,033.2 feet; Pseudagnostus sp. cf. P. josepha, Linnarssonella girtyi at 1,036.2 feet.

54.5'

1039.0'-1086.0' This interval is made up of silty and argillaceous limestone which is light gray in color. It is thin bedded, with beds up to 3 inches thick separated by green shale in beds up to 1.5 feet thick. Much of the limestone in this interval is made up of medium- to large-size limestone clasts contained within an argillaceous limestone matrix. Pellet glauconite is common throughout. Faunal data: Linnarssonella girtyi var. "elongata" at 1,056.0 feet; Linnarssonella girtyi at 1,065.0 feet; Pseudagnostus? sp. at 1,071.0 feet; Bynumina sp. at 1,074.0 feet; Linnarssonella girtyi (a small, thin-shelled variant, in contrast to mostly thick-shelled forms below) at 1,075.0 feet; Bynumia? sp., Linnarssonella girtyi at 1,083.0 feet.

47.0'

BONNETERRE FORMATION

1086.0'-1131.0' Whetstone Creek Member. The top of the Whetstone Creek is tentatively placed at a depth of 1,086 feet in this core, as there is a decrease in shale and an increase in limestone, sand, silt, and glauconite below this depth, and, the next-lower described section is interpreted as representing the Sullivan Siltstone. Faunal data: Linnarssonella girtyi, L. costa? at 1,086.2, 1,093.8 feet; Linnarssonella costa, L. girtyi at 1,095.5 feet; Apsotreta expansa at 1,096.5, 1,096.8 feet; Apsotreta stricta? at 1,097.8, 1,098.5 feet; Apsotreta stricta, Parahousia sp. cf. P. subequalis at 1,099.0 feet; Apsotreta expansa, Parahousia sp. cf. P. subequalis at 1,100.0-1,102.0 feet; Glaphraspis? sp. at 1,103.0 feet; Apsotreta expansa, Dytremacephalus? sp. at 1,103.5 feet; Apsotreta expansa, A. stricta at 1,105.0-1,105.8 feet; Apsotreta attenuata at 1,112.5-1,113.5 feet; Apsotreta attenuata, Dytremacephalus? sp. at 1,114.5 feet; Apsotreta attenuata at 1,115.2-1,116.3 feet; Aphelaspis? sp., Angulotreta sp. cf. A. missouriensis at 1,123.0 feet; Aphelaspis sp., Dytremacephalus? sp. at 1,126.6, 1,127.8 feet; Angulotreta sp. cf. A. missouriensis at 1,130.1 feet.

45.0'

- 1131.0'-1191.0' Sullivan Siltstone Member. This interval is made up of light gray, limy siltstone. It is thin and irregularly bedded, with the beds ranging from $\frac{1}{2}$ to 5 inches in thickness and separated by gray shale partings. Thin zones of "edgewise" conglomerate are common and scattered throughout the interval. Pellet glauconite is common throughout, with thin zones of high concentration occurring at depths of 1,161.5, 1,174.0, and 1,187.5 feet. Faunal data: Aphelaspis sp. at 1,133.4 feet; Tricrepicephalus? sp. at 1,172.0 feet; Blountia? sp. at 1,178.0, 1,181.5 feet; Tricrepicephalus tripunctatus, Blountia? sp. at 1,184.5 feet; Tricrepicephalus sp. at 1,186.0 feet. 60.0'
- 1191.0'-1273.0' "Oolite facies". This interval is made up of finely crystalline limestone which is oolitic and light gray in color. It is thin and irregularly bedded, with beds ranging from $\frac{1}{2}$ to 4 inches thick and separated by wavy, green and gray shale partings and thin beds and shale filled, low amplitude stylolites. Most of the interval appears to be highly silty, and thin zones of "edgewise" conglomerate are common throughout. The interval 1,206.0 to 1,212.0 feet contains abundant small clasts of algal material. The lowest 30 feet of the interval contains a few thin zones of pellet glauconite. Faunal data: Tricrepicephalus? sp. at 1,191.8 feet; Crepicephalus? sp., Tricrepicephalus sp. at 1,192.0 feet; Meteoraspis? sp. at 1,200.5 feet; Llanoaspis sp. at 1,211.5 feet. 82.0'
- 1273.0'-1346.5' "Micrite and shale facies". This interval is made up of finely crystalline limestone which is light gray in color and silty in the upper portion. It is very thin-bedded, with beds ranging from $\frac{1}{2}$ to $1\frac{1}{2}$ inches in thickness and separated by green shale partings and beds up to 9 inches thick. Most of the limestone beds in this interval represent "edgewise" conglomerates, with limestone clasts contained in a matrix of argillaceous limestone. Small clasts of what appear to be algal material are common in the lower two-thirds of the interval. The lower 25 feet of the interval is made up of dolomite which has a larger crystal size than does the limestone. Faunal data: Opisthotreta? at 1,316.8 feet. 73.5'
- 1346.5'-1358.0' Bonneterre-Lamotte "transition" beds. The top of the Bonneterre-Lamotte "transition" is represented by medium- to coarse-crystalline, dolomitic sandstone. The entire interval has a "dirty" appearance, with numerous wavy, gray shale partings. Conglomerate

zones made up of clasts of sandy dolomite contained within a gray shale matrix occur in the intervals 1,353 to 1,354 feet and 1,355 to 1,355.5 feet. 11.5'

1358.0'-1420.0' This interval is made up of medium- to coarse-grained, well sorted sandstone. The entire interval has a "dirty" appearance due to an abundance of gray shale partings and a few shale beds up to 6 inches thick. Fragments of phosphatic brachiopods are abundant in the intervals 1,376 to 1,378 feet and 1,385 to 1,391 feet. Thin zones of brecciated sandstone occur rarely, throughout. 62.0'

LAMOTTE SANDSTONE

1420.0'-1480.0' The top of the Lamotte Sandstone is represented by fine- to coarse-grained, "cleaner" appearing sandstone. It is poorly sorted in the upper portion of the interval and well sorted in the lower portion, as there is an alternation of fine- and coarse-grained beds. The entire interval shows alternating bands of light- and darker-colored sand. 60.0'

1480.0'-1531.0' This interval is made up of fine- to medium-grained, well sorted sandstone. The entire interval is banded in appearance, with alternating zones of "clean" and ferruginous sand. 51.0'

1531.0'-1564.0' This interval is made up of fine- to coarse-grained, poorly sorted sandstone. The entire interval is ferruginous in appearance, with the sand grains cemented by hematite. Precambrian pebbles and small cobbles are common in the lowest 8 feet of the interval. 33.0'

PRECAMBRIAN

1564.0'-1584.0' The top of the Precambrian is represented by granite, T.D. the uppermost 6 feet of which appears to be highly decomposed material which has been recemented with hematite. The remainder of the interval is a slightly weathered, coarse-grained, pink granite which commonly shows fracturing. Slickensides are common throughout, with a few quartz veins present in the center portion of the interval. 20.0'

TRAVERSE IN LATE CAMBRIAN STRATA

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
816.0'- 855.5'	Potosi Dolomite	39.5'
855.5'- 924.0'	Derby-Doerun Dolomite	68.5'
924.0'- 984.5'	Interbedded Derby-Doerun and Davis	60.5'
984.5'-1086.0'	Davis Formation	101.5'
1086.0'-1420.0'	Bonneterre Formation	334.0'
1086.0'-1131.0'	Whetstone Creek Member	45.0'
1131.0'-1191.0'	Sullivan Siltstone Member	60.0'
1191.0'-1273.0'	"Oolite facies"	82.0'
1273.0'-1346.5'	"Micrite and shale facies"	73.5'
1346.5'-1420.0'	Bonneterre-Lamotte "transition" beds	73.5'
1420.0'-1564.0'	Lamotte Sandstone	144.0'
1564.0'-1584.0' T.D.	Precambrian	20.0'

INSOLUBLE RESIDUE LOG SUMMARY

St. Joe Minerals Corporation - Hole No. TE-1

EMINENCE FORMATION - 235 TO 485 FEET

The insoluble residues in the Eminence Dolomite of this drill hole are those residues typical of the Ozark region and consist of an upper oolitic interval from 235 to 275 feet, with the bulk of the chert composed of gray "quartzose" and rough, "dead" white chert. There is some smooth, rough and "dead" white chert in the lower portion of this interval. The rest of the Eminence residue at this location is made up of rough, white chert with large amounts of gray, "quartzose" chert in the lower 85 feet. Small amounts of gray shale, green shale, and rounded and frosted quartz grains are encountered throughout. A chert buildup in the lower 20 feet of the Eminence Dolomite consists of mostly rough, dolomoldic and finely porous, white chert, with a smaller amount of gray, "quartzose" chert.

POTOSI DOLOMITE - 485 TO 840 FEET

The entire Potosi interval in this drill hole is composed of residues consisting of brown, "quartzose", dolomoldic chert; quartz crystals; quartz druse and amorphous quartz from drusy vugs; small amounts of smooth, rough and dolomoldic, white chert; "quartzose", gray chert; and brown, "quartzose" chert. Druse is

encountered throughout the interval, with an especially large percentage in the interval between 670 and 690 feet. The lower 50 feet of the Potosi Dolomite contains a chert buildup, with the chert composed mostly of fine, gray, "quartzose" chert and quartz crystals from the druse-lined vugs.

DERBY-DOERUN DOLOMITE - 840 TO 940 FEET

Insoluble residues in the Derby-Doerun Dolomite interval in this drill hole are typical Ozark region types, consisting of an upper zone of low residues and a lower zone of higher-percentage residues. The upper interval is composed of large amounts of porous brown shale, with lesser amounts of silt-size quartz grains, glauconite, and dickite. The lower portion--or higher residue part--of the Derby-Doerun Dolomite begins at 880 feet and marks the "Top of the Cambrian Clastics" of the Ozark region. Residues in this interval, to the base of the Derby-Doerun Dolomite, consist of a large amount of silt-size quartz grains, with silt-size glauconite grains sparingly intermixed with brown shale and dickite.

DAVIS FORMATION - 940 TO 1,090 FEET

The insoluble residue curve in the Davis Formation shows a very high buildup of clastic material in the form of green shale and silt-size quartz grains, with silt-size pellet glauconite. The insoluble residue curve in the interval ranges from 50 to 90 percent of the total sample. The upper 45 feet of the carbonate interval is composed of dolomite, while in all the rest of the Davis interval the carbonate portion is fine- to medium-crystalline, brown and gray limestone.

BONNETERRE FORMATION - 1,090 TO 1,420 FEET

The Whetstone Creek Member, Sullivan Siltstone Member, and the lower "oolite facies" of the Bonneterre Formation are poorly defined in this drill hole. Clastic buildup throughout the entire formation disguises the breaks that occur farther eastward. The Bonneterre Formation in this drill hole is basically a silty limestone, with varying amounts of green shale, brown shale, gray shale, and pellet glauconite. The "oolite facies" in the lower portion is poorly developed and concentrated between 1,200 and 1,265 feet, at which point another clastic interval ("micrite and shale facies") begins and continues to 1,345 feet. The lower 40 feet of the Bonneterre is dolomitic and contains small amounts of quartz silt, larger amounts of green shale, and some pellet glauconite. The Bonneterre-Lamotte transition beds begin at 1,345 feet and continue to 1,420 feet. Insoluble residues in this interval are mostly angular to subangular quartz grains with small amounts of gray shale.

LAMOTTE SANDSTONE - 1,420 TO 1,565 FEET

Insoluble residues in the Lamotte Sandstone in this drill hole are composed of fine to coarse, rounded and frosted to angular quartz grains, with intervals

TRAVERSE IN LATE CAMBRIAN STRATA

in the lower portion heavily stained by hematite and some hematite filling the intergranular spaces. The sandstone rests directly on the Precambrian crystalline rocks, with no arkosic or shaly interval between. Twenty feet of Precambrian crystalline rock was drilled in this hole.

St. Joe Minerals Corporation - Core #64W133 - Hole No. WR-1
Wright County, Missouri - SE SE sec. 16, T. 29 N., R. 13 W.
Elevation: 1,190' - Total depth: 1,766' - MGS No. 25828
Drill cuttings to 800 feet - Core 805 feet to total depth

CORE DESCRIPTION

Coring operations began at a depth of 805 feet, in the Eminence Dolomite.

EMINENCE DOLOMITE

Depth

805.0'-873.5' This interval is made up of fine- to medium-crystalline dolomite which is medium gray in color and massively bedded. The entire interval has a mottled appearance which is probably due to burrowing organisms. Small to large, irregularly shaped cavities lined or filled with dolomite crystals are common throughout the interval. Calcite fillings are rare, but scattered throughout. Low- to high-amplitude, green shale filled stylolites occur in the center portion of the interval. Massive, white chert fillings are common in the lowest 8 feet.

68.5'

873.5'-927.5' This interval is made up of finely crystalline, dense dolomite which is medium gray in color and massively bedded. Scattered beds of medium crystallinity occur throughout. Low amplitude, gray shale-filled stylolites are rare, but occur throughout the interval. The entire interval has a mottled appearance which is due to burrowing. Irregularly shaped vugs which are lined with large dolomite crystals and/or quartz druse are scattered throughout. Small, randomly oriented fractures and small masses of FeS₂ are common throughout the interval. The uppermost 9 inches of

- this interval is made up entirely of white chert. A 4-inch thick "flat pebble" conglomerate, made up of lath-shaped dolomite clasts in a matrix of finely crystalline dolomite, occurs at a depth of 912.5 feet. This interval is underlain by a lighter gray colored dolomite. 54.0'
- 927.5'- 970.0' This interval is made up of finely crystalline dolomite which is light to medium gray in color and is massively bedded. The lithology of this interval is basically the same as that of the above interval, except that here quartz druse is more abundant. The interval 930 to 934 feet contains abundant quartz druse and white chert. The lowest 2 inches of the interval shows inclined bedding which probably represents slumpage of the carbonate material before consolidation. 42.5'
- POTOSI DOLOMITE
- 970.0'-1034.0' The top of the Potosi Dolomite is represented by medium- to coarse-crystalline, massively bedded dolomite which is medium gray to light brown in color. Small and irregularly shaped cavities, most of which are lined with quartz druse (and some with dolomite crystals), are scattered throughout. Quartz also occurs as small, massive fillings. Calcite fillings are rare, but occur throughout the lowest 20 feet of the interval along with finely disseminated FeS_2 , which produces a yellow stain in several localized intervals. A 2-foot thick bed of coarse-crystalline, porous dolomite, which may represent relict oolites, occurs at a depth of 1,026 feet. 64.0'
- 1034.0'-1131.0' This interval is made up of finely crystalline (locally, medium- to coarse-crystalline) dolomite which is light to medium gray in color. It is massively bedded, with the beds separated by gray or green shale-filled, low- to high-amplitude stylolites. Small, irregularly shaped cavities which are lined with dolomite crystals or quartz druse and sometimes filled with green shale, are scattered throughout. Finely disseminated FeS_2 commonly occurs along the edges of these cavities. Small, round, light colored masses of dolomite which may represent algal colonies are scattered throughout the center portion of the interval. Small, randomly oriented fractures are common throughout. Small calcite fillings are common in the lower portion of the interval. 97.0'

TRAVERSE IN LATE CAMBRIAN STRATA

- 1131.0'-1225.0' This interval is made up of finely crystalline, dense dolomite which is massively bedded and bluish-gray in color. The entire interval is made up of zones containing what appear to be Girvanella and Epiphyton and zones which may be planar-stromatolite material. Gray shale filled, low amplitude stylolites are rare, but occur throughout the interval. Small, randomly oriented fractures are common throughout. Small- to medium-size, irregularly shaped cavities, which are lined with dolomite crystals or quartz druse, are scattered throughout. Large, massive calcite fillings are common in the center portion of the interval, while small fillings of white chert occur in the lowest 6 feet of the interval. 94.0'

DERBY-DOERUN DOLOMITE

- 1225.0'-1296.0' The top of the Derby-Doerun Dolomite is characterized by fine- to medium-crystalline dolomite which is brown in color. It is massively bedded, with a few widely scattered, brownish-gray shale filled, low amplitude stylolites. The entire interval has a highly mottled appearance which is due to burrowing. This section of core is highly porous, with abundant small vugs filled with coarser-crystalline, brown dolomite. Four- to 8-foot thick zones of more dense, brownish-gray, finely crystalline dolomite, containing massive, white chert fillings, occur in the localized intervals 1,225 to 1,233, 1,249.5 to 1,255.5, and 1,289 to 1,296 feet. 71.0'

DAVIS FORMATION

- 1296.0'-1324.5' The top of the Davis Formation is characterized by interbedded green shale and coarsely crystalline, brownish-gray dolomite. Brownish-gray shale partings and small fillings of green shale are scattered throughout the dolomite units. The interval 1,318 to 1,322 feet consists of finely crystalline, dense dolomite which is brown in color and contains abundant greenish-gray, wavy shale partings and low- to high-amplitude, shale filled stylolites. FeS₂ is disseminated throughout most of the interval. Thin zones of "edgewise" conglomerate occur throughout. 28.5'
- 1324.5'-1435.0' This interval is made up of interbedded units of green "poker chip" shale and beds of limestone up to 6 inches thick. The limestone units are thin bedded, with abundant wavy, green shale partings and shale-

filled, high amplitude stylolites. Locally, the limestones contain pellet glauconite, carbonate oolites, and small algal masses. Much of the shale has incorporated within it small, angular clasts of limestone, while many of the limestone beds show thin zones of brecciation. Faunal data: Billingsella sp. cf. B. coloradoensis at 1,341 feet; Billingsella sp. cf. B. coloradoensis, Taenicephalus sp. cf. T. shumardi, Sinuella sp. at 1,350 feet; Billingsella sp. cf. B. coloradoensis (alate form), Angulotreta sp. cf. A. vescula at 1,351 feet; Angulotreta tetonensis at 1,351.5 feet; Billingsella sp. cf. B. coloradoensis, Plectotrophia sp., Taenicephalus sp. cf. T. shumardi, Sinuella sp., Angulotreta tetonensis at 1,352.5-1,353.9 feet; Taenicephalus? sp. at 1,356.0 feet; Orygmaspis sp. cf. O. llanoensis, Angulotreta sp., Billingsella sp. cf. B. coloradoensis, Taenicephalus sp. cf. T. shumardi at 1,360.5, 1,361.0 feet; Taenicephalus sp. cf. T. shumardi at 1,364.5 feet; Parabolinoidea sp. cf. P. contractus, Angulotreta sp., Billingsella sp., Sinuella sp. at 1,370 feet; Orygmaspis sp. cf. O. llanoensis at 1,371.5 feet; Angulotreta sp. cf. A. microscopica, Taenicephalus sp. cf. T. gouldi, Orygmaspis sp. cf. O. llanoensis, Parabolinoidea sp. cf. P. parallela, Sinuella sp. 1,372.0-1,373.2 feet; Parabolinoidea sp. cf. P. contractus, Billingsella sp. cf. B. coloradoensis at 1,373.6 feet; Parabolinoidea sp. cf. P. contractus, Angulotreta sp. cf. A. microscopica at 1,373.8, 1,374.0 feet; Parabolinoidea sp. cf. P. contractus, Billingsella sp. cf. B. coloradoensis, Angulotreta sp. at 1,374.5, 1,375.7 feet; Eoorthis sp. cf. E. remnicha at 1,376.5 feet; Irvingella major, Comanchia amploculata at 1,377.0 feet; Ocnorthis? sp. at 1,378.9 feet; Linnarssonella girtyi at 1,387.5 feet; Linnarssonella girtyi, L. girtyi var. "elongata", Elvinia? sp. at 1,387.5-1,395.5 feet; Linnarssonella girtyi at 1,408.0-1,433.0 feet.

110.5'

BONNETERRE FORMATION

Whetstone Creek Member (Type Section). This section exemplifies the heterogeneous nature of the member in being made up of an upper unit, 1,435-1,468 feet, a shallow water deposit dominated by crinozoan calcarenites containing abundant pellet glauconite, and a lower unit, 1,468-1,495 feet, distinguished by fine sandstones, siltstones, and shales with limestones.

1435.0'-1468.0' This interval is made up of finely crystalline, thin bedded, argillaceous limestone. The beds are separated by wavy, green-shale partings. The entire in-

TRAVERSE IN LATE CAMBRIAN STRATA

- terval contains abundant pellet glauconite, and the upper half of the interval contains localized zones of crinozoan debris, while the lower half appears as a crinozoan calcarenite. Faunal data: Linnarssonella girtyi at 1,436.0-1,448.3 feet; Linnarssonella girtyi, L. costa, Apsotreta expansa (reworked) at 1,449.0-1,455.8 feet; Apsotreta expansa, A. stricta, Parahousia sp. cf. P. subequalis at 1,456.6-1,457.7 feet; Apsotreta expansa, A. stricta at 1,458.0-1,467.3 feet. 33.0'
- 1468.0'-1477.5' This interval is made up of finely crystalline, thin-bedded, argillaceous limestone, interbedded with thin laminations of fine sand and silt. Zones of crinozoan debris are scattered throughout, and a flat-pebble conglomerate occurs at the base of this interval. Faunal data: Apsotreta expansa at 1,468.0-1,470.5 feet; Apsotreta expansa, A. attenuata at 1,471.0-1,473.8 feet; Apsotreta expansa, A. attenuata, Pterocephalia sp. cf. P. concava at 1,474.0 feet; Apsotreta expansa, A. attenuata?, Angulotreta sp. at 1,477.5 feet. 9.5'
- 1477.5'-1489.0' This interval is made up of calcareous, fine sandstone and siltstone which is laminated with green shale partings. Thin beds of flat pebble conglomerates are scattered throughout. Faunal data: Angulotreta missouriensis at 1,480.0-1,487.4 feet; Aphelaspis sp. at 1,488.0-1,489.0 feet. 11.5'
- 1489.0'-1495.0' This section is composed of thin bedded, finely crystalline to calcarenitic limestone which is interbedded with thin units of siltstone and sandy limestone. A flat pebble conglomerate with a crinozoan calcarenite matrix, containing abundant pellet glauconite, occurs in the lowest foot of this interval. Faunal data: Angulotreta sp. at 1,491.5-1,491.8 feet; Aphelaspis sp. at 1,492.5 feet; Aphelaspis sp. at 1,495.0 feet. 6.0'
- 1495.0'-1533.0' Sullivan Siltstone Member (Reference Section). This interval is made up of limy siltstone which is light-gray in color and interbedded with abundant, thin, greenish-gray shale beds. Green shale filled, low amplitude stylolites are common in the lower half of the interval. "Pepper" glauconite is common throughout. The interval 1,503 to 1,509 feet contains several thin zones of conglomerate in which clasts of gray silt are contained within a matrix of lighter-colored silt. Faunal data: Aphelaspis sp. at 1,495.5 feet. 38.0'

- 1533.0'-1653.0' "Oolite facies". This interval is made up of finely crystalline, oolitic limestone which is medium brown in color. It is thin and irregularly bedded, with the beds ranging from 1 to 3 inches in thickness and separated by wavy, brownish-gray shale partings and shale filled, low- to medium-amplitude stylolites. The uppermost 5 feet of the interval contains pellet glauconite, being particularly concentrated in the top 6 inches of the interval. Faunal data: Kingstonia? sp. at 1,588.0 feet. 120.0'
- 1653.0'-1671.0' This interval is made up of finely crystalline, medium-brown dolomite. The remainder of the lithology of this interval is the same as that described above. 18.0'
- 1671.0'-1684.0' "Micrite and shale facies". This interval is made up of interbedded green shale and silty, finely crystalline dolomite and is interrupted in the center by a 1.5-foot thick bed of brown dolomite which looks like that dolomite described above containing oolites and pellet glauconite. 13.0'
- 1684.0'-1701.0' "Oolite facies". This interval is made up of fine- to medium-crystalline, medium brown dolomite. It is thin and irregularly bedded, with the beds ranging from 1 to 4 inches in thickness and separated by wavy, gray shale partings and shale filled, low- to high-amplitude stylolites. The entire interval is oolitic and contains pellet glauconite. The upper 5 feet of the interval contains thin $\frac{1}{2}$ -inch thick beds of finely crystalline, dense, green dolomite which are regularly spaced throughout the oolitic dolomite. The lowest 4 feet of the interval shows an increase in the amount of pellet glauconite, which is accompanied by the occurrence of sand grains and fossil hash. 17.0'
- 1701.0'-1766.0' Bonneterre-Lamotte "transition" beds, This interval is made up of fine- to coarse-grained sandstone which is dolomitic and medium- to light-gray in color. Overall, the entire interval appears to be poorly sorted, but thin beds of well sorted sand occur. Wavy, gray shale partings and beds up to $\frac{1}{4}$ -inch thick, occur throughout the interval and occasionally are closely spaced. Fragments of phosphatic brachiopods are abundant throughout. The uppermost 1.5 feet of the interval contains pellet and "pepper" glauconite and a few scattered masses of FeS_2 . Faunal data: Dicellomus sp. at 1,722.0 feet. 65.0'
- T.D.

TRAVERSE IN LATE CAMBRIAN STRATA

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
805.0'- 970.0'	Eminence Dolomite	165.0'
970.0'-1225.0'	Potosi Dolomite	255.0'
1225.0'-1296.0'	Derby-Doerun Dolomite	71.0'
1296.0'-1435.0'	Davis Formation	139.0'
1435.0'-1766.0'	Bonnerterre Formation	331.0'
1435.0'-1495.0'	Whetstone Creek Member	60.0'
1495.0'-1533.0'	Sullivan Siltstone Member	38.0'
1533.0'-1671.0'	"Oolite facies"	138.0'
1671.0'-1684.0'	"Micrite and shale facies"	13.0'
1684.0'-1701.0'	"Oolite facies"	17.0'
1701.0'-1766.0' T.D.	Bonnerterre-Lamotte "transition" beds	65.0'

INSOLUBLE-RESIDUE-LOG SUMMARY

St. Joe Minerals Corporation - Hole No. WR-1

EMINENCE DOLOMITE 585 TO 970 FEET

This drill hole is near the boundary of the westward occurrence of typical Ozark region Eminence residue types. Residues from the stratigraphic interval 585-800 feet demonstrate the accentuation of high percentage residue intervals by the drilling process. Residues throughout the interval consist predominantly of fine, gray, "quartzose" chert, with minor amounts of rough, white chert and dolomitic, white chert. Some quartz grains are scattered throughout the upper half. Many of these are probably from the Gunter Sandstone interval above the Eminence. In the cored interval of the Eminence, below 800 feet, the lower Eminence contains very little insoluble residue. The residues are composed of fine, gray, "quartzose" chert with minor amounts of white, rough chert. Authigenic feldspar is found in the residues from 895 to 910 feet and from 950 to 970 feet.

POTOSI DOLOMITE - 970 TO 1,220 FEET

The insoluble residue curve in the Potosi Dolomite in this drill hole is markedly different from those occurring eastward toward the Ozark uplift. The Potosi interval contains considerable authigenic feldspar throughout and shows a marked decrease in the percentage of insoluble residue as compared to areas eastward from this point. The upper 25 feet of the Potosi contains quartz crystals and

druse. Otherwise, the entire Potosi interval is composed of insoluble residues of very low percentages, consisting of authigenic feldspar and very small amounts of green shale; fine, gray "quartzose" chert; some brown, "quartzose" chert; and dolomitic, brown chert. A 5-foot interval at 1,210-1,215 feet contains fresh feldspar chips. Quartz druse was again encountered below 1,175 extending to 1,220 feet.

DERBY-DOERUN DOLOMITE - 1,220 TO 1,300 FEET

Insoluble residues in this interval consist mostly of rough, "dead", white and brown chert and brown shale in the upper portion and silt-size quartz grains, brown shale, and authigenic feldspar in the lower portion. This change in residue characteristics from chert to quartz silt occurs at 1,280 feet and marks the "Top of the Cambrian Clastics". Dickite was also encountered in the upper portion in minor amounts, as well as small amounts of quartz and quartz druse. Very little glauconite was encountered in its usual position in the lower portion.

DAVIS FORMATION - 1,300 TO 1,430 FEET

Insoluble residues of the Davis Formation in this drill hole consist mostly of very high residue percentages of green shale, with minor amounts of brown, porous shale. The carbonate portion of the Davis is dolomite in the upper 25 feet and fine- to medium-crystalline, brown limestone in the lower portion. Glauconite occurs sparingly in only a few samples, as well as quartz silt being virtually absent, making this Davis section abnormal from those occurring eastward from this core.

BONNETERRE FORMATION - 1,430 TO 1,766 FEET

The upper 90 feet of the Bonneterre Formation here, or the Whetstone Creek and Sullivan Siltstone Members, show high percentages of insoluble residue. The residues are composed predominantly of silt-size quartz grains, pellet glauconite, and green shale, with minor amounts of gray shale. A 20-foot interval in the upper portion (Whetstone Creek Member) contains medium-crystalline, brown dolomite, while the rest of the interval contains limestone as the carbonate portion. The Sullivan Siltstone Member rests, typically, on the Bonneterre "oolite facies", which in this drill hole is limestone and composed predominantly of calcareous oolites. Beginning at 1,655 feet (top of the "micrite and shale facies"), the remainder of the Bonneterre Formation is dolomitized. Insoluble residue components of the "oolite facies" consist mostly of porous, brown shale, silt-size quartz grains, rounded and frosted quartz grains, and scattered pellet glauconite and green shale. The Bonneterre-Lamotte "transition" beds, from 1,700 to 1,766 feet, contain angular to rounded and frosted quartz grains, and gray shale, and the carbonate portion is gray and brown, finely crystalline dolomite.

St. Joe Minerals Corporation - Core #63W106 - Hole No. DO-1
Douglas County, Missouri - Sec. 24, T. 27 N., R. 15 W.
Elevation: 1,000' - Total depth: 1,901' MGS No. 25822
Drill cuttings to 710 feet - Core 716 feet to total depth

CORE DESCRIPTION

Coring operations began at a depth of 716 feet, in the "spongy chert residue facies" of the Eminence Dolomite

"SPONGY CHERT RESIDUE FACIES"

716.0'- 940.0' This interval is made up of finely crystalline, dense dolomite which is massively bedded and medium- to dark-gray to brown in color. The entire interval has a mottled appearance, due to burrowing for the most part, but in some areas due simply to color differences and in other areas due to brecciation of the dolomite. Small to large vugs and cavities which are lined with dolomite crystals, (occasionally with calcite crystals and rarely with small crystals of iron oxide) are abundant throughout the interval. Massive calcite fillings--some 6 inches in diameter--are scattered throughout. Small, randomly oriented fractures which are commonly filled with calcite (and rarely with FeS_2) occur throughout. Small masses of FeS_2 are common throughout, but are particularly abundant in the upper portion of the interval. What appears to be broken-up algal material occurs in the interval 790 to 793 feet. This interval appears to have been highly fractured and then recemented--primarily with calcite, but often with FeS_2 .

224.0'

"GREEN CLAY RESIDUE FACIES"

940.0'-1140.0' This interval is made up of finely crystalline, dense dolomite which is massively bedded and light- to medium-gray in color. The entire interval has a mottled appearance, due primarily to burrowing, but also due to brecciation of the dolomite. Small to medium-size vugs and cavities, which are commonly lined with dolomite crystals and occasionally filled with dolomite, are common throughout the interval, but are not as abundant as in the above interval. Massive calcite fillings (some 4 inches in diameter) are rare, but are noted throughout. Small, ran-

domly oriented fractures, which are commonly filled with calcite, occur throughout, but are not as abundant as in the above interval.

200.0'

DERBY-DOERUN DOLOMITE

- 1140.0'-1209.5' The top of the Derby-Doerun is represented by massively bedded, finely crystalline to dense dolomite. With the exception of a few localized thin beds of calcarenite, this interval has a distinct "reefy" appearance, containing numerous digitate structures interbedded with burrowed interreef muds. The entire interval is extremely porous, with carbonate mud filling the larger openings; in the interval 1,140-1,192 feet, some of these openings have been filled with sparry calcite. Vertically oriented fracturing is common in the center portion of the interval, and small fillings of dickite are common throughout the interval. 69.5'
- 1209.5'-1229.5' This interval is made up of thin and irregularly bedded dolomite which is finely crystalline. Wavy, brown shale partings and occasionally shale filled, low amplitude stylolites separate the dolomite beds. 20.0'
- 1229.5'-1261.0' This interval is made up of a fine grained dolomite-calcarenite, light- to medium-brown in color. It is massively bedded in the upper portion and thin and irregularly bedded in the lower portion, with the beds separated by wavy, brown shale partings and shale filled, low amplitude stylolites. The entire interval has a mottled appearance due to burrowing, and small masses of FeS₂ are common throughout. Small fillings of dickite are rare, but occur throughout the interval. 31.5'

BONNETERRE FORMATION

- 1261.0'-1329.0' Whetstone Creek Member. The Whetstone Creek is characterized by medium crystalline, argillaceous, sandy dolomite which is medium- to dark-gray in color. This interval is thin and irregularly bedded, with the beds separated by gray shale partings up to 1/8-inch thick and shale filled, low amplitude stylolites. "Pepper" and pellet glauconite is abundant throughout, but is particularly concentrated in the upper half of the interval. A few thin conglomerate zones are scattered throughout; small, irregularly

shaped calcite fillings are rare, but occur throughout the interval. A 5-inch thick, greenish-gray shale bed occurs at the top of the interval. Faunal data: Linnarssonella girtyi? at 1,279.2-1,285.4 feet; Apsotreta sp. at 1,289.5-1,293.0 feet; Apsotreta expansa at 1,293.4-1,298.6 feet; Apsotreta expansa, A. attenuata at 1,300.2-1,304.3 feet; Angulotreta missouriensis, Apsotreta attenuata at 1,304.3 feet; Angulotreta missouriensis? at 1,306.2 feet.

68.0'

1329.0'-1366.0' Sullivan Siltstone Member. This interval is made up of finely crystalline, dense, very silty dolomite which is medium gray in color. It is irregularly bedded, with beds ranging from 2 to 6 inches in thickness and separated by gray shale partings and beds up to 3 inches thick. "Pepper" glauconite and zones of "edge-wise" conglomerate up to 6 inches thick are common throughout the interval. Faunal data: Aphelaspis sp. cf. A. arses at 1,329.1 feet; Angulotreta sp. at 1,329.4 feet.

37.0'

1366.0'-1513.0' "Oolite facies". This interval is made up of finely crystalline, dense, oolitic dolomite which is medium brown in color. It is thin and regularly bedded, with the beds separated by gray shale partings and shale filled, low amplitude stylolites. Large size pellet glauconite is scattered throughout, with a particularly heavy concentration occurring in the uppermost 6 inches of the interval. A few zones containing small, irregularly shaped clasts of green, dense dolomite, which are usually associated with thin conglomerate beds, occur throughout the interval.

147.0'

1513.0'-1530.0' This interval is made up of fine- to medium-crystalline, sandy dolomite which is medium gray in color. It is thin and regularly bedded, with the beds separated by gray shale partings. This interval contains fewer oolites and more pellet glauconite than the interval described above, and concentrations of FeS₂ are scattered throughout. A few 2-inch thick beds of greenish-gray shale occur in the lower 4 feet of the interval, and phosphatic brachiopods are noted in the lowest 2 feet of the interval.

17.0'

LAMOTTE SANDSTONE

1530.0'-1561.0' The top of the Lamotte Sandstone is characterized by medium- to coarse-grained, fairly well sorted sandstone which is "dirty" in appearance and contains

- abundant gray shale partings up to 1/8-inch thick. Fragments of phosphatic brachiopods are scattered throughout the interval. Much of this interval appears to have been fractured and brecciated. Faunal data: Dicellomus? sp. 1,540.0 feet and 1,556.0 feet. 31.0'
- 1561.0'-1614.0' This interval is made up of medium- to coarse-grained, poorly sorted sandstone which has a "dirty" appearance--much like the above interval--due to shale being incorporated within the sand, and abundant gray shale partings and beds up to 1/2-inch thick. A 4-inch thick shale bed occurs at a depth of 1,585.5 feet, and small, angular clasts of gray shale occur in the interval 1,594 to 1,602 feet. Phosphatic brachiopods are relatively abundant in the upper half of the interval. The sandstone of the two intervals described above may represent a transition from Bonnetterre to Lamotte lithology. Faunal data: Dicellomus? sp. 1,561 feet. 53.0'
- 1614.0'-1669.0' This interval is made up of fine grained, well sorted sandstone which is light gray in color and "clean" in appearance. The entire interval has a banded appearance due to an alternation of light and darker-colored sand. A few fractures which have been filled with a light colored (siliceous?) material are scattered throughout. 55.0'
- 1669.0'-1790.0' This interval is made up of fine- to coarse-grained sandstone which is light gray to light brown in color. It is well sorted, with alternating zones of fine-, medium-, and coarse-grained sand. The overall appearance of this interval is banded because of alternating zones of light gray and light brown sand. Gray shale partings and beds up to 1-inch thick are common in the lower third of the interval, with the shale appearing to become micaceous toward the bottom. What may be thin volcanic ash beds occur at depths of 1,785, 1,785.5 and 1,787 feet. 121.0'
- 1790.0'-1820.0' This interval is made up of fine- to very coarse-grained (granular) sandstone which is poorly sorted and light-gray in color. A few gray, micaceous shale beds up to 1-inch thick occur throughout the interval. Regenerated quartz grains are common throughout and are abundant in the lower half of the interval. 30.0'
- 1820.0'-1837.0' This interval is made up of fine- to very coarse-grained sandstone, with the quartz grains ranging up to pebble size. The entire interval is pink to maroon

TRAVERSE IN LATE CAMBRIAN STRATA

in color, due to the occurrence of pink feldspar grains and hematite, the darker colored zones being due to a high hematite content. Large quartz pebbles are common in the lower portion of the interval. This interval has an arkosic appearance.

17.0'

PRECAMBRIAN

1837.0'-1901.0' The top of the Precambrian is represented by an
T.D. extremely coarse grained granite. The upper two-thirds of the interval is highly weathered and rotten in appearance and shows the alteration of biotite to chlorite and iron oxides.

64.0'

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
716.0'- 940.0'	"Spongy chert residue facies"	224.0'
940.0'-1140.0'	"Green clay residue facies"	200.0'
1140.0'-1261.0'	Derby-Doerun Dolomite	121.0'
1261.0'-1530.0'	Bonneterre Formation	269.0'
1261.0'-1329.0'	Whetstone Creek Member	68.0'
1329.0'-1366.0'	Sullivan Siltstone Member	37.0'
1366.0'-1530.0'	"Oolite facies"	164.0'
1530.0'-1837.0'	Lamotte Sandstone	307.0'
1837.0'-1901.0' T.D.	Precambrian	64.0'

INSOLUBLE RESIDUE LOG SUMMARY
St. Joe Minerals Corporation - Hole No. DO-1

Residue types throughout the Eminence-Potosi interval in this drill hole and in DO-3 are atypical. For this reason-- plus the fact that no significant criteria exist in the core for breaking Eminence from Potosi--the entire interval has been referred to a "spongy chert residue facies" above and a "green clay residue facies" below.

"SPONGY CHERT RESIDUE FACIES" - 340 TO 940 FEET
(lost-sample interval 730-770 feet)

This drill hole shows atypical residues in the Eminence, Potosi, Derby-Doerun, Davis, and to some extent in the Bonneterre. The Eminence residue curve to the total depth of the drill cuttings shows abnormally high percentages of residue, which may be due to the drilling process and method used in collecting samples. The residue is composed of varying amounts of gray shale; finely porous, gray chert; dolomoldic, gray chert; gray, "quartzose" chert; mottled, "quartzose" chert;

and oolitic chert. The typical Eminence oolite intervals are poorly developed, and quartz grains--probably from the Gunter Sandstone Member above--are scattered throughout the interval.

"GREEN CLAY RESIDUE FACIES" - 940 TO 1,140 FEET

Insoluble residues in this interval are very low in volume and average less than five percent of any given sample. In the upper portion, the residues are composed of very small amounts of fine, gray, "quartzose" chert; rounded and frosted quartz grains; and gray shale. In the lower portion, the residues are composed of green shale, quartz crystals, some authigenic feldspar, and minor amounts of "quartzose" chert. Typical Potosi druse is virtually nonexistent. The entire interval between 340 and 1,140 feet is assigned to the "spongy chert residue facies" and "green clay-shale residue facies" on the basis of the atypical nature of the insoluble residues and the core itself. Much of the carbonate is dolomite in this interval and could be described as "white rock" (as used in the Southeast Missouri mining area), or, more specifically, coarse- to very coarse-crystalline, white, gray and brown, secondarily recrystallized(?) dolomite.

DERBY-DOERUN DOLOMITE - 1,140 TO 1,265 FEET

The top of the Derby-Doerun in this drill hole was drawn on lithology from the core, since no recognizable characteristics in the insoluble residue log were found to draw this top. Recognizable Derby-Doerun insoluble residues begin at 1,190 feet and consist of fine, brown, "quartzose" chert; some glauconite; fine, silt-size quartz grains; and authigenic feldspar. These typical Derby-Doerun insoluble residues occur to 1,240 feet, where 25 feet of typical lower Derby-Doerun occurs above the top of the Bonneterre Formation as drawn from core logging. Insoluble residues in the aforementioned 25-foot interval consist of small amounts of porous, brown shale; silt-size quartz grains; and fine glauconite particles. Insoluble residues in this interval are generally less than 10 percent by volume.

BONNETERRE FORMATION - 1,265 TO 1,530 FEET

The upper 65 feet of this formation (Whetstone Creek Member) is more typical of the Davis, by insoluble residue definition, than the Bonneterre. Insoluble residues consist of up to 50 percent by volume of fine, quartz-grain aggregates, gray shale, and fine glauconite particles, with some pellet glauconite interspersed. High volumes of quartz silt and fine glauconite occur between 1,330 and 1,370 feet and are typical of the Sullivan Siltstone Member elsewhere. This interval rests in typical fashion on the top of the dolomitic "oolite facies", which continues to the base of the Bonneterre in this drill hole. No "micrite and shale facies" or Bonneterre-Lamotte "transition" beds are present in this core. The "oolite facies" interval contains very low residue which is composed of sparing amounts of quartz silt, brown shale, and some pellet glauconite. The quartz grains increase in size toward the base of the interval. The increase in size of the quartz grains in the lower few feet of this interval does not show the transitional relationship between the

TRAVERSE IN LATE CAMBRIAN STRATA

lower Bonneterre and the upper Lamotte. Insoluble residue percentages are less than 25 percent to the base of the carbonate, which probably indicates unconformable relationships between the Bonneterre and Lamotte in this area.

LAMOTTE SANDSTONE - 1,530 TO 1,835 FEET

The largest portion of the sandstone from the Lamotte in this drill hole is made up of medium- to coarse-grained, angular to subangular quartz. At 1,775 feet, coarser quartz grains in the range of 2 to 3 millimeters are encountered. At 1,800 feet, weathered igneous material is encountered, and a mixture of igneous chips and very large quartz grains occurs to 1,835 feet, where arkosic, weathered igneous material is encountered which continues to 1,865 feet. The contact between the sedimentary section and the Precambrian basement rocks is drawn where the first weathered granite occurs, at 1,835 feet. The drill hole continued to 1,901 feet in the fresh, red feldspar containing large percentages of mica, hornblende, and plagioclase.

St. Joe Minerals Corporation - Core #64W30 - Hole No. DO-3
Douglas County, Missouri - NE NW sec. 24, T. 26 N., R. 17 W.
Elevation: 1,041' - Total depth: 1,626' - MGS No. 25825
Drill cuttings to 884 feet - Core 884 feet to total depth

CORE DESCRIPTION

Coring operations began at a depth of 884 feet, in the "spongy chert residue facies" of the Eminence Dolomite.

"SPONGY CHERT RESIDUE FACIES"

Depth

884.0'-1007.0'

This interval is made up of finely crystalline, dense dolomite that is massively bedded. It is light brown in the upper portion to light gray in the lower portion of the interval, and the entire interval has an orangish overtone due to iron staining. The entire interval has a mottled appearance which is due to burrowing organisms and/or color mottling. Vugs and small cavities are common throughout the interval and all of them are lined with dolomite and/or calcite crystals, most of which are iron-stained. Calcite fillings and small, calcite-filled fractures are rare, but scattered throughout. Quartz druse occurs at a depth of 991 feet.

123.0'

- 1007.0'-1051.0' This interval is made up of finely crystalline, dense (locally coarsely crystalline), massively bedded dolomite that is light- to medium- gray in color. Thin beds of coarsely crystalline dolomite are rare, but occur throughout. The entire interval has an indistinctly burrowed appearance. Small vugs which are lined or filled with dolomite, or occasionally with green shale, are abundant throughout the interval. Most of this interval is iron-stained--much like the above interval. Thinly laminated brown and gray, banded dolomite occurs in the interval 1,047 to 1,048.5 feet. 44.0'
- 1051.0'-1085.0' This interval is made up of fine- to medium-crystalline, massively bedded dolomite which is medium-gray in color. The entire interval is iron-stained, and most of the interval has a mottled appearance due to burrowing and brecciation of the dolomite. Vugs and irregularly shaped, small cavities, which are either lined with dolomite crystals or filled with dolomite, calcite, or green shale, are common throughout. FeS_2 is disseminated along the edges of many of the openings. 34.0'
- "GREEN CLAY RESIDUE FACIES"
- 1085.0'-1106.0' This unit is made up of medium-crystalline, argillaceous dolomite which is medium gray in color. Thin green shale partings and small, green clay filled, irregularly shaped cavities occur throughout the interval, as do large sparry-calcite fillings. 21.0'
- 1106.0'-1132.0' This interval is made up of very shaly appearing dolomite which is green in color and contains medium to large crystals of gray dolomite. A few thin beds of burrowed, argillaceous dolomite occur throughout the interval. Vugs lined with dolomite crystals and having disseminated FeS_2 along their rims are common throughout. What appears to be a slump structure occurs in the interval 1,112 to 1,113 feet. 26.0'
- 1132.0'-1168.0' This interval is made up of medium- to coarse-crystalline, massively bedded dolomite which is light-gray in color. Green shale filled, low amplitude stylolites are common in the center portion of the interval. The entire interval has an indistinct appearance of being burrowed. Fracturing of the dolomite is common in the interval 1,148 to 1,150 feet, with calcite and FeS_2

TRAVERSE IN LATE CAMBRIAN STRATA

- crystals scattered along the fracture planes. The interval 1,148 to 1,153 feet appears to be much more shaly than the remainder of the interval. 36.0'
- 1168.0'-1229.5' This interval is made up of coarsely crystalline, massively bedded dolomite which is medium gray in color. The entire interval has a mottled appearance due to burrowing. Small- to medium-sized, irregularly shaped vugs lined with dolomite crystals or finely crystalline FeS_2 are common throughout. Commonly these small vugs are filled with green shale. 61.5'
- 1229.5'-1252.0' This interval is made up of finely crystalline, dense, massively bedded dolomite. It is light- to medium-gray in color and has a mottled appearance due to indistinct digitate structures and to burrowing. Porosity in this unit is low, with the exception of a few vugs and small cavities. This entire interval has a "reefy" appearance, but lacks the high porosity which is usually associated with this type of depositional feature. 22.5'

DERBY-DOERUN DOLOMITE

- 1252.0'-1262.0' The top of the Derby-Doerun is represented by fine-grained, dense, massively bedded, medium-brown calcarenitic dolomite. The lowest 4 feet of this interval is highly porous and appears as "netted" rock. 10.0'
- 1262.0'-1338.0' This interval is made up of fine- to medium-crystalline, light- to medium-brown dolomite. It is massively bedded in the upper half of the interval to thin and irregularly bedded in the lower half, with the beds separated by wavy brown shale partings and shale filled, low amplitude stylolites. The shale content appears to increase with depth. Occurring throughout this interval are "reefy" appearing units of rock showing digitate stromatolites and associated high porosity. These thinner units of digitate structures are interbedded with layers of fine-grained, dense calcarenite, which occur in the intervals 1,278-1,284, 1,289-1,301, 1,303-1,316, and 1,329-1,338 feet. Small masses of dickite occur rarely in the lower portion of the interval, along with small masses of FeS_2 . 76.0'

BONNETERRE FORMATION

- 1338.0'-1412.0' Whetstone Creek Member. The top of the Bonneterre Formation is represented by finely crystalline, argillaceous dolomite which is medium brown to dark gray in color. It is thin and irregularly bedded, with the beds separated by wavy, greenish-gray shale partings and beds up to 1-inch thick, and shale filled, low amplitude stylolites. The entire interval appears to be silty, with the upper half of the interval containing abundant silt and "pepper" and pellet glauconite. Pellet glauconite is concentrated in the interval 1,358 to 1,368.5 feet. Thin zones of "edgewise" conglomerate and abundant, closely spaced shale partings give the lower half of the interval a highly broken-up appearance. Faunal data: Linnarssonella? sp. at 1,354.8, 1,356.8 feet; Apsotreta? sp. at 1,361.3 to 1,363.5 feet; Apsotreta sp. at 1,366.8, 1,367.8 feet; Apsotreta expansa? at 1,370.7 feet; Apsotreta expansa, A. attenuata at 1,372.6, 1,374.5 feet; Apsotreta expansa, Angulotreta missouriensis? at 1,376.4 feet; Apsotreta sp. at 1,378.8 feet; Angulotreta missouriensis? at 1,380 feet. 74.0'
- 1412.0'-1438.0' Sullivan Siltstone Member. This interval is made up of medium gray colored, dolomitic siltstone. It is thin bedded, with alternating bands of medium and dark gray silt. Beds of "edgewise" conglomerate up to 4-inches thick occur throughout. Beds of greenish-gray shale up to 2-inches thick are common in the lower half of the interval. Pellet glauconite is concentrated at depths of 1,437, 1,437.5, and 1,438 feet. 26.0'
- 1438.0'-1451.5' "Oolite facies". This interval is made up of fine- to medium-crystalline, argillaceous, highly oolitic dolomite which is medium gray to brown in color. It is thin and irregularly bedded, with the beds separated by low to medium amplitude, greenish-gray, shale filled stylolites. A few thin beds of "edgewise" conglomerate, made up of finely crystalline, dense dolomite clasts contained within a matrix of finely crystalline, argillaceous dolomite, occur in the upper half of the interval. The remainder of the interval contains small clasts of finely crystalline dolomite detritus. This interval may represent a dolomitic calcarenite. 13.5'
- 1451.5'-1464.0' This interval is made up of argillaceous dolomite, with a lithology basically the same as that described above. Here, however, the partings and stylolites are more abundant and closely spaced. 12.5'

- 1464.0'-1498.0' This interval is made up of finely crystalline and silty, argillaceous dolomite. It is bluish-gray in color and thin bedded, with the beds ranging from less than 1 inch to 3 inches in thickness and separated by wavy gray shale partings and shale filled, low- to medium-amplitude stylolites. The entire interval is oolitic, and the lower half of the interval appears to contain abundant silt or fine sand. A few thin zones of pellet glauconite are scattered throughout, with a heavy concentration occurring at 1,465.5 feet. The lowest 2 inches of the interval appears to contain abundant clasts of algal material. 34.0'
- 1498.0'-1527.0' This interval is made up of finely crystalline, highly oolitic dolomite which is medium brown in color. It is thin and regularly bedded, with the beds approximately 2 to 3 inches thick and separated by gray shale partings (green in the lowest 4 feet of the interval) and shale filled, low amplitude stylolites. Pellet and "pepper" glauconite are common throughout. 29.0'
- 1527.0'-1555.0' This interval is made up of medium-crystalline, oolitic, sandy dolomite which is medium-gray to brown in color. It is thin bedded, with the beds separated by greenish-gray shale partings and shale filled, low amplitude stylolites. Pellet and "pepper" glauconite are scattered throughout. FeS₂ is finely disseminated throughout the lower portion of the interval. 28.0'
- 1555.0'-1587.0' Bonne-terre-Lamotte "transition" beds. The Bonne-terre-Lamotte "transition" is represented by dolomitic sandstone which is medium gray to brown in color. It is thin bedded, with the beds separated by greenish-gray shale partings and shale filled, low amplitude stylolites. Pellet and "pepper" glauconite and finely disseminated FeS₂ are common throughout. Faunal data: Dicellomus sp. at 1,575-1,578 feet. 32.0'

LAMOTTE SANDSTONE

- 1587.0'-1626.0' The top of the Lamotte Sandstone is represented by fine- to coarse-grained, poorly sorted sandstone which is medium-gray in color. The entire interval contains numerous gray shale partings and beds up to 1 inch thick. A 2-foot thick bed of gray shale containing sandstone clasts occurs in the interval 1,573 to 1,575 feet. Fragments of phosphatic brachiopods are abundant in the upper half of the interval. 39.0'

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
884.0'-1085.0'	"Spongy chert residue facies"	201.0'
1085.0'-1252.0'	"Green clay residue facies"	167.0'
1252.0'-1338.0'	Derby-Doerun Dolomite	86.0'
1338.0'-1587.0'	Bonneterre Formation	249.0'
1338.0'-1412.0'	Whetstone Creek Member	74.0'
1412.0'-1438.0'	Sullivan Siltstone Member	26.0'
1438.0'-1555.0'	"Oolite facies"	117.0'
1555.0'-1587.0'	Bonneterre-Lamotte "transition" beds	32.0'
1587.0'-1626.0' T. D.	Lamotte Sandstone	39.0'

INSOLUBLE RESIDUE LOG SUMMARY
St. Joe Minerals Corporation - Hole No. DO-3

"SPONGY CHERT RESIDUE FACIES"

Residues from 485 to 915 feet are basically rough, "dead", and porous, white chert, with minor amounts of smooth, white chert, gray, "quartzose" chert, and some rounded and frosted quartz sand grains which probably fell down the drill hole from the Gunter Sandstone above during churn drill operations. (Percentage relationships of samples above 885 feet as compared to samples below 885 feet are in disagreement since those above samples are from drill cuttings and those below 885 feet are samples from core.)

Very little druse is found in either the upper or lower portion of this undifferentiated unit. Residues from 915 to 1,070 feet are more typically Eminence by definition, being predominantly gray, "quartzose" chert, with some white, "quartzose" chert.

"GREEN CLAY RESIDUE FACIES"

A facies not typical of the Potosi is found between 1,075 and 1,240 feet and is designated the "green clay residue facies". This facies contains very low residue volume and the residue is composed predominantly of green shale and small amounts

of quartz silt. Some authigenic feldspar is found in this interval and immediately above. Glauconite is also found in this facies, but not in lower Potosi--where typical Potosi is present.

DERBY-DOERUN DOLOMITE - 1,240 TO 1,340 FEET

Insoluble residues in this interval are those typical of Derby-Doerun Dolomite in areas farther southeast and consist of porous brown shale and varying amounts of fine, silt-size quartz grains and glauconite grains. Some gray shale is present in the upper portion, as well as small amounts of finely dolomoldic brown and gray chert. Percentage of insoluble residue by volume ranges from about 5 to 15. The Davis Formation is not recognized in this drill hole, and the Derby-Doerun rests directly on the Whetstone Creek Member of the Bonneterre Formation.

BONNETERRE FORMATION - 1,340 TO 1,590 FEET

The Whetstone Creek Member of the Bonneterre Formation occupies the interval between 1,340 and 1,420 feet in this drill hole. The Sullivan Siltstone Member occupies the interval between 1,420 and 1,435 feet. Insoluble residues in these two members of the Bonneterre Formation are not typical in their percentage or distribution. Insoluble residues are predominantly quartz-silt grains and medium- to fine-grained, rounded and frosted quartz grains, with minor amounts of porous brown shale, pellet glauconite, gray shale, and fine glauconite grains. The "oolite facies" of the Bonneterre Formation, found below 1,435 feet, is typical of that existing in the Ozark area, and the insoluble residues in this portion of the Bonneterre Formation are predominantly brown shale, silt-size quartz grains, and pellet glauconite. Residue percentages range from 5 to 10 percent throughout most of the interval to as much as 80 percent in some parts of the interval. The lower 65 feet of the Bonneterre Formation here is composed of increasing amounts of re-worked medium- to coarse-grained, rounded and frosted to subangular quartz from the pre-existing Lamotte Sandstone below. The carbonate in this interval of the Bonneterre consists of fine- to medium-crystalline dolomite, with a short interval near the base composed of coarsely crystalline brown dolomite. Dolomitized oolites composed much of the carbonate portion. The contact with the Lamotte Sandstone below is transitional, and the Bonneterre-Lamotte "transition" beds are found between 1,560 and 1,590 feet.

LAMOTTE SANDSTONE - 1,590 TO 1,626 FEET T. D.

Lamotte Sandstone is composed of fine to coarse, angular to rounded and frosted quartz grains, with some green and gray shale partings.

St. Joe Minerals Corporation - Core #64W49 - Hole No. CR-1
 Christian County, Missouri - SE SE sec. 33, T. 25 N., R. 18 W.
 Elevation: 861' - Total depth: 1,806' - MGS No. 25826
 Core from 560 feet to total depth.

CORE DESCRIPTION

Coring operations began at a depth of 560 feet, in the lower Gasconade Dolomite of early Ordovician age.

GASCONADE DOLOMITE Gunter Sandstone Member

Depth

740.0'- 790.0'

The Gunter Sandstone is represented by fine- to coarse-grained, rounded and frosted sand. It is medium- to coarse-grained, well sorted, and light gray to white in the upper half of the interval and poorly sorted and fine- to coarse-grained in the lower portion of the interval. Small bullseye appearing masses of FeS₂ occur in the center portion of the interval. The upper half of this unit is relatively uniform in color, while the lower half is made up of alternating bands of light and darker colored sand. A 1-inch thick flat pebble conglomerate bed marks the base of the Gunter.

50.0'

EMINENCE DOLOMITE

790.0'- 871.0'

The top of the Eminence Dolomite is represented by medium- to coarse-crystalline dolomite which is medium gray in color. It is irregularly bedded, with the beds separated by gray shale partings and shale filled, low- to medium-amplitude stylolites. The entire interval has a mottled appearance which is due to burrowing. Small to medium-sized, irregularly shaped vugs lined with dolomite and/or calcite crystals are common throughout. Small masses of gray and white chert and gray, finely granular quartz are scattered throughout the interval. Iron staining is common in the upper portions of the interval.

81.0'

871.0'-1106.5'

This interval is made up of finely crystalline, dense dolomite which is medium to dark gray in color. It is massively bedded, with few, gray shale filled, low- to medium-amplitude stylolites. The entire interval has a mottled appearance which is due to

TRAVERSE IN LATE CAMBRIAN STRATA

burrowing, Small- to medium-sized, irregularly shaped vugs, lined primarily with dolomite crystals (and sometimes FeS_2 crystals or small druse-like quartz crystals) are abundant throughout. Small masses of gray and white chert are rare, but occur throughout the interval. Small masses of black, finely granular quartz occur throughout, but are not as abundant as in the above interval. Small, vertically oriented, recemented fractures are common in the upper third of the interval. A few small zones of quartz druse occur near the bottom of the interval, and FeS_2 appears to become more abundant near the base. The lowest 10 feet of the interval has a tannish color.

235.5'

1106.5'-1196.0' This interval is made up of medium-crystalline dolomite which is light to medium gray in color and massively bedded. The entire interval has a mottled appearance due to burrowing. Small, irregularly shaped vugs lined with dolomite crystals or quartz druse are common throughout the interval; some of the vugs have finely crystalline FeS_2 disseminated around their rims. Massive white chert fillings are widely scattered throughout, but are particularly abundant in the upper half of the interval. The entire interval has the appearance of being highly fractured and brecciated.

89.5'

POTOSI DOLOMITE

1196.0'-1296.0' The top of the Potosi Dolomite is represented by finely crystalline, dense dolomite which is medium brown in color and massively bedded. The entire interval has a mottled appearance due to burrowing and has abundant small, randomly oriented fractures, some of which have been filled with dolomite and others of which are lined with quartz druse. Small, irregularly shaped vugs, many of which are lined with quartz druse and/or dolomite crystals, are common throughout; FeS_2 lines many of the vugs in the lower portion of the interval. Massive calcite fillings are rare, but occur throughout.

100.0'

1296.0'-1344.0' This interval is made up of brecciated dolomite, with angular clasts of finely crystalline dense dolomite, light brown to medium gray in color contained within a matrix of clear to amber colored sparry calcite (locally the dolomite clasts are contained within a

matrix of quartz druse). Finely disseminated FeS_2 lines the edges of the dolomite clasts, and many of the larger clasts contain small vugs lined with quartz druse and/or finely crystalline FeS_2 . The lowest 2 feet of the interval appears to have once been impregnated with oil. This interval is interpreted as representing a collapse breccia.

48.0'

DERBY-DOERUN DOLOMITE

1344.0'-1377.0' The top of the Derby-Doerun Dolomite is represented by finely crystalline dense dolomite which is medium gray in color, with brownish overtones. The entire interval is made up of alternating bands of dense and less dense dolomite and is highly fractured, with abundant small, vertically oriented fractures, many of which are filled with calcite or dotted with small masses of dickite. A few massive calcite fillings are scattered throughout the interval. Occasionally, thin breccia zones occur, in which angular clasts of dolomite are contained within a sparry calcite matrix. A 5-inch thick zone of highly porous, coarsely crystalline dolomite, which may represent relict oolite development, occurs at a depth of 1,372 feet.

33.0'

1377.0'-1419.0' This interval is made up of finely crystalline brown dolomite, interbedded with thin beds of brownish gray shale and finely crystalline, highly argillaceous dolomite. Thin zones of "edgewise" conglomerate are scattered throughout. Zones of high porosity and coarse crystallinity, which may represent relict oolite development, occur at depths of 1,384, 1,386 to 1,387.5, 1,391 to 1,393, 1,401, 1,403, and 1,408.5 to 1,409.5 feet. Many of these coarsely crystalline units appear to have been impregnated with oil at one time.

42.0'

1419.0'-1454.0' This interval is made up of fine- to medium-crystalline dolomite which is medium to dark brown in color. It is thin bedded, with the beds separated by brownish gray shale partings and shale filled, low- to medium-amplitude stylolites. Zones of small, randomly oriented fractures are scattered throughout. Small to large, irregularly shaped vugs lined with dolomite crystals and/or FeS_2 crystals are common throughout the interval. Thin zones of coarsely crystalline porous dolomite are often associated with many of the zones of larger vugs. A 6-inch thick bed of "edgewise" conglomerate occurs at a depth of 1,451 feet. Note: The top of this interval is an alternate top of the Derby-Doerun Dolomite.

35.0'

TRAVERSE IN LATE CAMBRIAN STRATA

- 1454.0'-1495.0' This interval is made up of finely crystalline argillaceous dolomite which is medium brown in color. It is thin bedded, with the beds separated by abundant gray to brownish gray, wavy shale partings. The entire interval contains abundant small, irregularly shaped detrital dolomite clasts. Inclined bedding with dips of approximately 45° occurs in the interval 1,488 to 1,493 feet. 41.0'
- 1495.0'-1508.5' This interval is made up of a dolomitized calcarenite which is medium brown to gray in color. The entire interval is composed of abundant small, irregularly shaped clasts of detrital dolomite, contained within a matrix of shale or highly argillaceous dolomite. 13.5'

DAVIS FORMATION

- 1508.5'-1531.0' The top of the Davis Formation is represented by a greenish gray dolomitized calcarenite, with a lithology which is much the same as that described above, except that in this interval the detrital dolomite clasts are larger. 22.5'
- 1531.0'-1540.0' This interval is made up of finely crystalline, highly argillaceous dolomite which is green in color. The argillaceous dolomite serves as a matrix containing small to medium-sized, angular clasts of finely crystalline dolomite and silt. 9.0'
- 1540.0'-1559.0' This interval is made up of very thin bedded, greenish-gray silt and shale. The entire interval shows an alternation of green shaly silt beds with very thin bedded green shale. Minute clasts of what appears to be gray dolomite are scattered throughout. Two-inch thick beds of pellet glauconite occur at depths of 1,557 and 1,557.7 feet. 19.0'
- 1559.0'-1565.0' This interval is made up of green "poker chip" shale which is interbedded with thin silt beds. Thin zones of heavy pellet glauconite accumulation occur at depths of 1,561, 1,563, and 1,565 feet. Medium crystalline, gray dolomite, which may represent dolomitized fossil hash, is commonly associated with the concentrated pellet glauconite beds. Two-inch thick beds of what appear to be low energy deformation features occur at depths of 1,562.5 and 1,563.5 feet. 6.0'

BONNETERRE FORMATION

- 1565.0'-1568.0' Whetstone Creek Member. The top of the Bonneterre Formation is represented by coarsely crystalline brown dolomite which is thin and regularly bedded, with the beds separated by green shale filled, low amplitude stylolites. Pellet glauconite is common throughout. Faunal data: Apsotreta expansa at 1,567.2 feet. 3.0'
- 1568.0'-1577.5' This interval is made up of glauconite which contains small- to medium-sized detrital clasts of dolomite, silt, and large dolomite rhombs. Fine crystals of FeS₂ are scattered throughout. Faunal data: Apsotreta expansa at 1,568.7 to 1,577.2 feet. 9.5'
- 1577.5'-1591.0' This interval is made up of medium- to coarse-crystalline dolomite which is gray in color and contains floating grains of fine sand. The entire interval contains abundant glauconite--in some places up to 50 percent of the rock is made up of pellet glauconite. In the lower half of the interval the coarsely crystalline dolomite serves as a matrix containing small detrital clasts of finely crystalline dolomite. Zones of what appears to be fossil hash are also scattered throughout the lower half of the interval. Faunal data: Apsotreta expansa?, A. attenuata? at 1,580.2 feet; Apsotreta expansa at 1,582.2 feet. 13.5'
- 1591.0'-1603.0' This interval is made up of medium crystalline dolomite which is medium gray in color. It is thin and irregularly bedded, with the beds separated by gray shale partings and beds up to $\frac{1}{4}$ -inch thick. Occasionally thin, interbedded units of finely crystalline brown dolomite occur. Zones of heavy accumulation of pellet glauconite, up to 2 inches thick, occur throughout the interval. FeS₂ is commonly associated with these glauconite zones. Faunal data: Apsotreta expansa?, Angulotreta missouriensis at 1,592 feet. 12.0'
- 1603.0'-1624.0' Sullivan Siltstone Member. This interval is made up of medium gray colored silt. The entire interval shows an alternation of zones of "clean" appearing silt with zones of breccia in which angular clasts of dolomite and siltstone are contained within a matrix of silt. Thin bands of heavy accumulations of pellet glauconite are scattered throughout the interval, along with finely crystalline FeS₂. 21.0'

TRAVERSE IN LATE CAMBRIAN STRATA

- 1624.0'-1666.0' "Oolite facies". This interval is made up of fine- to medium crystalline oolitic dolomite which is medium brown in color. It is thin and irregularly bedded, with the beds separated by gray shale partings and shale filled, medium amplitude stylolites. A few thin beds of limestone are scattered throughout. Zones of high porosity in the form of small round vugs, which probably represent relict oolite development, are common throughout the interval. Large pellets of glauconite are sprinkled throughout the lowest 8 feet of the interval. 42.0'
- 1666.0'-1677.0' This interval is made up of alternating zones of finely crystalline, silt size dolomite breccia and medium crystalline, oolitic dolomite zones much like that described above. Small pellet glauconite is sprinkled throughout and the entire interval has a greenish color. 11.0'
- 1677.0'-1694.0' "Micrite and shale facies". This interval is made up of dolomitic sandstone and siltstone. The uppermost 4 feet of the interval appears to be a medium grained, well sorted sand which is cemented with finely crystalline dolomite. The remainder of the interval is fine sand to silt. Pellet glauconite is abundant throughout and makes up 50 percent of the rock in some localized zones. Small, irregularly shaped clasts of detrital dolomite are scattered throughout the lower portion of the interval. 17.0'
- 1694.0'-1714.0' Bonneterre-Lamotte "transition" beds. The top of the "transition" beds is represented by finely crystalline brown, sandy dolomite which is irregularly bedded, with the beds separated by numerous green shale partings. The sand appears to be fine- to medium-grained. Pellet glauconite is abundant throughout the interval. 20.0'
- 1714.0'-1731.0' This interval is represented by sandy and silty dolomite and is made up of thick beds of coarsely crystalline brown sandy dolomite, alternating with thin beds of siltstone. The upper 6 feet of the interval contains abundant and closely spaced green shale partings and beds up to $\frac{1}{4}$ -inch thick. Pellet glauconite is also common in this upper portion. The remainder of the interval shows more widely spaced shale partings and lesser amounts of glauconite. 17.0'
- 1731.0'-1748.0' This interval is made up of fine- to medium-grained dolomitic sandstone which is medium gray in color.

It is fairly regularly bedded, with the beds separated by green shale partings in the upper portion of the interval and by gray shale partings in the lower portion. Pellet glauconite is common throughout and is locally concentrated in a few narrow bands.

17.0'

LAMOTTE SANDSTONE

- 1748.0'-1764.5' The top of the Lamotte Sandstone is represented by fine sand in the upper half of the interval and by medium grained sand in the lower portion. The entire interval appears to be well sorted and contains abundant and sometimes closely spaced wavy green shale partings. Fragments of phosphatic brachiopods are common in the lowest 9 feet of the interval. 16.5'
- 1764.5'-1806.0' T. D. This interval is made up of fine- to coarse-grained, poorly sorted sandstone which is light gray in color. The upper portion of the interval is made up of fine- to medium-size sand grains, while the lower portion contains predominantly coarse-grained sand. The entire interval shows an alternation of light and dark colored bands. Gray and green shale partings are widely scattered throughout the interval, with a 6-inch green shale bed occurring at 1,799.5 feet. Small masses of FeS₂ and iron staining are rare, but occur throughout the interval. 41.5'

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
740.0'- 790.0'	Gunter Sandstone Member	50.0'
790.0'-1196.0'	Eminence Dolomite	406.0'
1196.0'-1344.0'	Potosi Dolomite	148.0'
1344.0'-1508.5'	Derby-Doerun Dolomite	164.5'
1508.5'-1565.0'	Davis Formation	56.5'
1565.0'-1748.0'	Bonneterre Formation	183.0'
1565.0'-1603.0'	Whetstone Creek Member	38.0'
1603.0'-1624.0'	Sullivan Siltstone Member	21.0'
1624.0'-1677.0'	"Oolite facies"	53.0'
1677.0'-1694.0'	"Micrite and shale facies"	17.0'
1694.0'-1748.0'	Bonneterre-Lamotte "transition" beds	54.0'
1748.0'-1806.0' T. D.	Lamotte Sandstone	58.0'

INSOLUBLE RESIDUE LOG SUMMARY

St. Joe Minerals Corporation - Hole No. CR-1

EMINENCE DOLOMITE - 790 TO 1,200 FEET

Insoluble residues of the Eminence Dolomite section in this drill hole are characterized by very low volume throughout, with the residue being composed chiefly of translucent and mottled cherts, "quartzose" chert, and finely "quartzose" gray chert, with scattered green shale, nodular white chert, glauconite, and some thin druse fragments. Dolomoidic gray chert is found in the lower 100 feet. Oolite intervals are not well developed, and intervals of banded chalcedony are found in various parts of the Eminence section. A better residue base of the Eminence Dolomite may have been encountered at 1,260 feet; however, the cross section (plate 1) is drawn using the 1,200-foot base of the Eminence, which agrees with the megascopic core determination.

POTOSI DOLOMITE - 1,200 TO 1,350 FEET

Potosi Dolomite in this drill hole is thin and the residue curve is not characteristic of that obtained in the Ozark region farther east. Generally, the residues are low in percentage and atypical of the Potosi. The lower 55 feet of this interval is more typical of the Potosi Dolomite as it occurs in the Ozark region. In the upper 100 feet, the residue is composed of fine gray "quartzose" chert; banded chalcedony; some quartz crystals associated with druse development; intervals of large dolomoids in white and gray chert, associated with dolomite development of a coarsely crystalline nature; and a scattering of green shales throughout. The lower 50 feet of the Potosi is composed of residues up to 25 percent of the sample and composed of fine "quartzose" and "quartzose" brown chert; dolomoidic brown chert; and porous brown shale. Irregular shaped quartz masses, quartz crystals, and quartz druse are scattered throughout this interval.

DERBY-DOERUN DOLOMITE - 1,350 TO 1,505 FEET

Insoluble residues in the Derby-Doerun interval in this drill hole are predominantly composed of porous brown shale throughout, with minor amounts of green shale; fine brown "quartzose" chert; and dickite. The abrupt change at the top of the Derby-Doerun from "quartzose" brown chert in the Potosi to porous brown shale in the Derby-Doerun is characteristic. The characteristic development of the fine quartz silt zone in the lower portion of the Derby-Doerun is not present in this drill hole. One sample containing quartz silt was logged at 1,490 feet, with parts of this sample being composed of authigenic feldspar.

DAVIS FORMATION - 1,505 TO 1,565 FEET

The interval occupied by the Davis Formation is thin and may be only a portion of the Davis Formation as it occurs elsewhere. Insoluble residues in this

interval are as high as 70 percent by volume and are composed of a mixture of green shale, silt-size quartz grains, and fine glauconite particles. The lower two-thirds of this interval contains most of the insoluble residue. The lower 25 feet of the interval contains silt-size quartz grains in aggregates.

BONNETERRE FORMATION - 1,565 TO 1,745 FEET

The Whetstone Creek Member (1,565-1,605 feet) of the upper portion of the Bonneterre Formation contains up to 50 percent by volume insoluble residue, and the residue is composed chiefly of pellet glauconite; coarse, rounded and frosted to angular quartz grains; and small amounts of brown, gray, and green shale. The Sullivan Siltstone Member (1,605-1,620 feet) is composed of up to 80 percent fine quartz silt grains and fine glauconite particles. The lower portion of the Bonneterre Formation in this drill hole, or the "oolite facies" interval, is composed of insoluble residues up to 60 percent by volume, and basically the lower half of this interval contains most of the insoluble residue. The upper portion of the "oolite facies" interval is fairly low in residue content, and the residue in this portion is composed of authigenic feldspar; porous brown shale; and fine silt-size quartz grains. The oolite development is dolomitized throughout and best expressed in the upper 50 feet of the "oolite facies" interval. Beginning at 1,655 feet, coarser quartz grains appear and continue to the total depth of the Bonneterre Formation, at 1,745 feet, with a residue buildup in the lower 50 feet which defines the Bonneterre-Lamotte "transition" beds. Here, more than 50 percent of the samples (by volume) is composed of coarse angular quartz grains, with some igneous fragments scattered throughout, as well as glauconite, green shale, and gray shale.

LAMOTTE SANDSTONE - 1,745 TO 1,805 FEET

Lamotte Sandstone here is composed of medium- to coarse-grained, angular to subangular quartz and some gray and green shale in the lower portion of the interval. Precambrian crystalline rocks were not encountered in this drill hole.

TRAVERSE IN LATE CAMBRIAN STRATA

St. Joe Minerals Corporation - Core #64W58 - Hole No. TA-1
Taney County, Missouri - SE SE sec. 15, T. 24 N., R. 20 W.
Elevation: 750' - Total depth: 1,880' - MGS No. 25827
Core from 722 feet to total depth.

CORE DESCRIPTION

Coring operations began at a depth of 722 feet, in the basal portion of the Gasconade Dolomite.

GASCONADE DOLOMITE

Gunter Sandstone Member

Depth

729.5'-787.0' The top of the Gunter Sandstone is represented by medium- to coarse-grained, fairly well sorted sandstone. The sand grains are rounded and frosted, and the entire interval is light gray to white in color. Thin, wavy green shale partings occur in the lowest 2 feet of the interval. 57.5'

EMINENCE DOLOMITE

787.0'-801.0' The top of the Eminence Dolomite is represented by medium- to coarse-crystalline, medium gray sandy dolomite. It is thin and irregularly bedded, with the beds separated by wavy green shale partings and green shale filled, low amplitude stylolites. Small masses of finely granular gray quartz are abundant throughout. Irregularly shaped vugs and larger cavities occur throughout the interval. Most of these cavities are lined with FeS₂ crystals. What appears to be a domal stromatolite occurs at a depth of 800.5 feet. 14.0'

801.0'-871.5' This interval is made up of medium- to coarse-crystalline dolomite which is medium gray in color. Its bedding is highly irregular in thickness, with beds ranging from 1 inch to 1 foot thick and separated by green and gray shale partings and shale filled, low amplitude stylolites. The entire interval has a subtly mottled appearance due to burrowing. Small to large masses of finely granular gray quartz and thin zones of what appear to be unsilicified domal-stromatolite structures are scattered throughout. Small fillings of dickite are rare, but noted throughout the interval. 70.5'

- 871.5'- 930.0' Abundant thin zones of unsilicified domal stromatolites are the dominant feature of this interval. The dolomite here is medium- to coarse-crystalline, medium gray in color, and irregularly bedded. The beds are separated by gray shale partings and shale filled, low amplitude stylolites. Green shale fills many of the small cavities within the reef structures. The entire interval is highly porous and has a mottled appearance due to burrowing. Small masses of gray finely granular quartz are scattered throughout this interval, but are not as abundant as in the above interval. 58.5'
- 930.0'- 974.5' This interval is made up of fine- to coarse-crystalline dolomite which is medium gray in color. It is thin and irregularly bedded, with the beds separated by green and gray shale partings and shale filled, low amplitude stylolites. The entire interval has a mottled appearance due to burrowing. Small to large irregularly shaped cavities, lined or filled with large dolomite crystals, are abundant throughout. Small masses of gray finely granular quartz and gray translucent chert are rare, but occur throughout. A few widely scattered, thin reef-like structures occur in the lower portion of the interval. 44.5'
- 974.5'-1025.0' This interval is made up of medium- to coarse-crystalline, massively bedded dolomite which is medium gray in color. The beds are separated by green and gray shale partings and a few shale filled, low amplitude stylolites. The entire interval has a mottled appearance due to burrowing. Irregularly shaped vugs and small cavities lined with large dolomite crystals are scattered throughout, but are not as abundant as in the above interval. Small vertical fractures occur rarely throughout, and finely disseminated FeS₂ commonly occurs on these fracture planes. 50.5'
- 1025.0'-1064.0' This interval is made up of finely crystalline dense dolomite (the center portion of the interval is coarsely crystalline) which is massively bedded and medium to dark gray in color. The beds are separated by gray shale partings. Small irregularly shaped cavities lined with large dolomite crystals are scattered throughout. Small rounded masses of gray finely granular quartz occur throughout the interval. The interval 1,029 to 1,040 feet appears to represent a burrowed carbonate mud. 39.0'
- 1064.0'-1131.0' This interval is made up of finely crystalline dense dolomite which is massively bedded and medium to

dark gray in color. Small cavities lined with large dolomite crystals (and occasionally with quartz druse) are widely scattered, throughout. The entire interval has a mottled appearance due to burrowing. Very thin dolomite filled fractures occur in the center portion of the interval. The interval 1,081 to 1,084 feet contains abundant finely granular black quartz masses.

67.0'

POTOSI DOLOMITE

1131.0'-1212.0' The Potosi Dolomite here is characterized by finely crystalline brown, massively bedded dolomite. The lower half of the Potosi is thin and irregularly bedded, with the beds separated by gray shale partings and shale filled, low amplitude stylolites. The entire interval has a highly mottled appearance due to burrowing. Small to large cavities, lined or filled with dolomite crystals or quartz druse, are abundant throughout, while massive calcite fillings occur in the upper half of the interval.

81.0'

DERBY-DOERUN DOLOMITE

1212.0'-1238.0' The top of the Derby-Doerun Dolomite is characterized by finely crystalline brown dolomite. It is massively bedded, with brownish gray shale partings rare and widely scattered. The entire interval is highly porous, showing small rounded pores which may represent relict oolites. Small randomly oriented fractures, most of which have been recemented with calcite, occur throughout. FeS₂ is disseminated along many of the fracture planes.

26.0'

1238.0'-1296.5' This interval is made up of finely crystalline dense, argillaceous brown dolomite. It is thin and irregularly bedded, with the beds separated by brownish gray shale partings and shale filled, medium amplitude stylolites. Small to medium-size, irregularly shaped cavities, lined with large dolomite crystals and small masses of dickite, are scattered throughout. The lower half of the interval contains numerous thin beds of "edgewise" conglomerate, and the shale partings are more abundant and closely spaced than in the upper half of the interval. Massive calcite fillings also occur in the lower portion of the interval, but they are not as common as they are in the interval above.

58.5'

DAVIS FORMATION

- 1296.5'-1347.0' This interval appears to represent an interfingering of Derby-Doerun and Davis lithologies. It is made up of alternating beds of green shale and brown finely crystalline dolomite. The shale is commonly referred to as "poker chip" shale and contains very thin beds of limestone between thicker shale units. The dolomite units are thin and irregularly bedded, with the beds separated by abundant and closely spaced brownish gray shale partings. Thin zones of brecciation and what appears to be fossil hash occur throughout the dolomite units. 50.5'
- 1347.0'-1445.0' The top of the more typical Davis lithology is characterized by thin bedded, finely crystalline limestone which is light gray to white in color. It is irregularly bedded, with the beds separated by abundant and closely spaced green shale partings and beds up to $\frac{1}{4}$ -inch thick, and shale filled high amplitude stylolites. This interval appears to be made up of equal parts of limestone and shale. The limestone beds contain small, angular clasts of darker colored finely crystalline limestone, which appear to have silt in their centers. Unidentified brachiopods occur at a depth of 1,435 feet. Faunal data: Linnarssonella girtyi at 1,373 feet; Elvinia roemeri, Camaraspis convexa, Kindbladia? sp. at 1,393.3 feet; Linnarssonella girtyi at 1,396 feet; Camaraspis convexa at 1,403.6 feet; Kindbladia sp. cf. K. wichitaensis at 1,417 feet; Dendrograptus? sp. at 1,438.8 feet. 98.0'

BONNETERRE FORMATION

- 1445.0'-1480.0' Whetstone Creek Member. The top of the Bonneterre Formation is represented by medium crystalline gray dolomite containing abundant green-shale partings and some pellet glauconite. The remainder of the interval is made up of interbedded silty dolomite and green shale. "Pepper" glauconite is common throughout the interval, while the lower half of the interval contains abundant pellet glauconite and thin beds of sandstone up to 1-inch thick. 35.0'
- 1480.0'-1510.0' This interval is interpreted as a tongue of Reagan Sandstone within the Whetstone Creek Member and is characterized by medium gray colored silt and sand containing abundant and closely spaced brownish gray shale partings which develop into beds up to $\frac{1}{4}$ -

- inch thick in the lower portion of the interval. Fragments of phosphatic brachiopods are scattered throughout. Faunal data: Elvinia roemeri, Parahousia sp. cf. P. constricta, Kindbladia? sp. at 1,488.4 feet; Elvinia roemeri, Apsotreta sp. cf. A. expansa at 1,492 feet; Parahousia sp. cf. P. constricta at 1,492.1 feet; Apsotreta sp. cf. A. expansa at 1,497 feet; Elburgia sp. at 1,497.5 feet. 30.0'
- 1510.0'-1546.0' This interval is made up of units of fine- to coarse-grained sandstone, siltstone, and "pepper" glauconite mixtures, interbedded with beds of brown silty shale up to $\frac{1}{4}$ -inch thick. The sandy beds also contain hematite pellets and are in various stages of hematite staining. Localized intervals at depths of 1,513-1,517 feet and 1,534.5-1,540.5 feet are made up of alternating beds of brownish-green shale and glauconitic siltstone. Coarsely crystalline, gray dolomite containing pellet glauconite occupies the interval 1,531-1,533 feet. Faunal data: Apsotreta sp. cf. A. expansa at 1,517 feet. 36.0'
- 1546.0'-1565.0' Sullivan Siltstone Member. This interval is made up of clean, medium gray colored silt containing brownish gray shale partings and beds up to 1/8-inch thick. The lower half of the interval contains several zones of conglomerate up to 9 inches thick that are composed of brown lath shaped dolomite clasts contained within a matrix of silty material. 19.0'
- 1565.0'-1591.0' "Oolite facies". This interval is made up of fine- to medium-crystalline dolomite which is medium brown in color. It is thin and irregularly bedded, with the beds ranging from $\frac{1}{2}$ to 3 inches thick and separated by wavy brownish gray shale partings and shale-filled, low-amplitude stylolites. The entire interval shows abundant carbonate oolites. Silt with pellet and "pepper" glauconite is common throughout. The interval 1,585-1,589 feet is made up entirely of silt and wavy gray shale partings. 26.0'
- 1591.0'-1611.0' This interval is made up of green colored silty, finely crystalline dolomite. The entire interval contains an abundance of "pepper" and pellet glauconite and fossil hash. Small, irregularly shaped clasts of gray silty shale are scattered throughout, with beds of this shale developing in the lowest 2 feet of the interval. A 6-inch thick bed of finely crystalline brown oolite dolomite occurs at a depth of 1,598.5 feet. 20.0'

- 1611.0'-1628.0' Bonneterre-Lamotte "transition" beds. This interval is made up of silty dolomite containing numerous wavy, greenish gray shale partings. "Pepper" and pellet glauconite is scattered throughout, but is particularly concentrated in the upper half of the interval. 17.0'
- 1628.0'-1639.0' This interval is made up of fine-grained dolomitic sandstone containing abundant and closely spaced green shale partings and beds up to 1/8-inch thick. Fine grains of feldspar and "pepper" glauconite are common throughout. A 2-foot thick, hematite-stained zone occurs in the interval 1,633-1,635 feet. 11.0'
- 1639.0'-1671.0' This interval is made up of fine-grained sandstone and siltstone containing abundant and closely spaced green shale partings which develop into beds up to 1/4-inch thick in the lower half of the interval. Pellet glauconite is scattered throughout, but is particularly abundant in the lower half of the interval. Hematite pellets occur in the interval 1,645.5-1,647 feet, which is also heavily stained. Phosphatic brachiopods occur in the lowest 4 feet of the interval. 32.0'

LAMOTTE SANDSTONE

- 1671.0'-1754.0' The top of the Lamotte Sandstone is characterized by fine- to medium-grained sand. It is light gray to white in color and appears relatively "clean" and well-sorted. The entire interval contains thin bands of gray, shaly appearing material and bands of coarser-grained sand. A 1-inch thick green shale bed occurs at a depth of 1,728 feet. In general, the grain size of this interval appears to become coarser toward the base. 83.0'
- 1754.0'-1789.0' This interval is made up of fine- to coarse-grained poorly sorted sandstone. The entire interval has a pink to red color due to an abundance of feldspar grains in the upper half of the interval and hematite staining in the lower half of the interval. Beds of hematitic shale up to 4 inches thick also occur in the lower half of the interval. The lowest 4 feet of the interval contains structures which appear to represent crossbedding. Granule-size quartz grains become abundant in the lowest foot. 35.0'
- 1789.0'-1870.0' This interval has the same basic lithology as the above interval, except the hematite staining is less

TRAVERSE IN LATE CAMBRIAN STRATA

prevalent and the small feldspar grains and large quartz granules are more abundant. Brownish gray shale beds, ranging from $\frac{1}{4}$ to 4 inches thick, are common in the lower third of the interval, and large feldspar granules are very abundant in the lowest 7 feet.

81.0'

PRECAMBRIAN

1870.0'-1880.0' The top of the Precambrian is characterized by granite. The upper 3 feet of the interval is highly weathered, with practically all of the ferromagnesian minerals altered to chlorite. The remainder of the interval is relatively unweathered and consists of large quartz and feldspar grains contained within a matrix of biotite.

10.0'

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
729.5'- 787.0'	Gunter Sandstone Member	57.5'
787.0'-1131.0'	Eminence Dolomite	344.0'
1131.0'-1212.0'	Potosi Dolomite	81.0'
1212.0'-1296.5'	Derby-Doerun Dolomite	84.5'
1296.5'-1445.0'	Davis Formation	148.5'
1445.0'-1671.0'	Bonneterre Formation	226.0'
1445.0'-1546.0'	Whetstone Creek Member	101.0'
1546.0'-1565.0'	Sullivan Siltstone Member	19.0'
1565.0'-1611.0'	"Oolite facies"	46.0'
1611.0'-1671.0'	Bonneterre-Lamotte "transition" beds	60.0'
1671.0'-1870.0'	Lamotte Sandstone	199.0'
1870.0'-1880.0' T.D.	Precambrian	10.0'

INSOLUBLE RESIDUE LOG SUMMARY
St. Joe Minerals Corporation - Hole No. TA-1

EMINENCE DOLOMITE - 785 TO 1,130 FEET

Insoluble residues of the Eminence Dolomite at this location are classified in the "quartzose" texture type of cherts, are very low in volume, and somewhat atypical of those occurring eastward. Eminence residues here consist of very small quantities of gray "quartzose" chert; green shale; mottled and smooth brown chert;

some white chert; rounded and frosted quartz grains; and pelletal material. From 1,025 to 1,130 feet, the insoluble residues are more typically Eminence types, being small volumes of fine gray "quartzose" chert; some dolomoldic gray and white chert; and intervals of thin-druse development.

POTOSI DOLOMITE - 1,130 TO 1,210 FEET

Insoluble residues in this thin section of Potosi Dolomite are composed of fine brown "quartzose" chert; dolomoldic brown chert; some white dolomoldic chert; quartz crystals; druse; and some pelletal chert. A chert buildup in the lower 30 feet of the interval is composed of typical dolomoldic brown chert, as occurs in the Potosi of the Ozark area.

DERBY-DOERUN DOLOMITE - 1,210 TO 1,300 FEET

The insoluble residue curve in this interval is somewhat similar to those obtained farther eastward. The residues are composed of brown porous shale; some gray "quartzose" chert; medium-size angular quartz grains; and some silt-size quartz grains in the lower portion. A silicified spicule was found at 1,255 feet. These spicules can be found in the Derby-Doerun over a wide region from northeast Missouri to far southwestern Missouri as a silicified insoluble residue.

DAVIS FORMATION - 1,300 TO 1,445 FEET

The Davis Formation contains two shale buildups. The upper interval is from the top to 30 feet down into the formation, and the lower interval builds up gradually from 1,400 feet to the base of the Davis Formation. Shales in these two intervals are green, white, and gray, with some porous brown shales and sparing amounts of fine-grained glauconite. The lower two-thirds of the Davis Formation here is a medium- to coarse-crystalline brown limestone. The upper third is medium crystalline brown dolomite. Minor amounts of quartz silt occur in the upper half of the formation.

BONNETERRE FORMATION - 1,445 TO 1,670 FEET

The upper 35 feet of the Bonneterre Formation contains dolomite and up to 50 percent by volume of insoluble residue. The residue is composed of fine- to medium-grained, angular to rounded and frosted quartz; pellet glauconite; and some green shale. The Whetstone Creek Member of the Bonneterre Formation has expanded in thickness in this drill hole and is found between the depths of 1,445 and 1,540 feet. The interval between the upper dolomitic portion and 1,540 feet contains up to 100 percent medium- to fine-grained quartz, some silt, gray shale, pellet glauconite, and small amounts of green shale. A prominent glauconite interval is encountered at 1,520 to 1,530 feet and contains up to 20 percent glauconite by volume of the sample.

TRAVERSE IN LATE CAMBRIAN STRATA

The Sullivan Siltstone Member of the Bonneterre Formation is not well-developed in this drill hole but can be recognized between 1,540 and 1,560 feet. Neither is the "oolite facies" of the Bonneterre well developed, with oolites occurring only in the interval 1,565 and 1,580 feet. Insoluble residues in this lower portion of the Bonneterre consist of up to 80 percent by volume of coarse- to medium-grained, angular to subangular quartz, minor amounts of green shale, brown shale and gray shale, glauconite, and pellet glauconite. An interval in the lower 50 feet of the "oolite facies" contains coarse to extra coarse dolomite, as was found in other drill holes farther east. The Bonneterre-Lamotte "transition" beds are not readily distinguishable from overlying and underlying material by insoluble residue examination here.

LAMOTTE SANDSTONE - 1,670 TO 1,870 FEET

The Lamotte Sandstone at this location is composed of coarse to very coarse, angular to subangular quartz grains mixed with feldspar grains. Hematite-stained intervals are prominent in the lower half of the Lamotte Sandstone. Large amounts of feldspar grains are found in some intervals. The lower 10 feet of the Lamotte consists of very coarse quartz grains in the range of 2 to 3 mm. The Lamotte rests on Precambrian feldspar at 1,870 feet, and the total depth of the drill hole was in Precambrian feldspars at 1,880 feet. Some of the feldspars scattered throughout the Lamotte interval may be authigenic. The abnormal feldspar content of the Lamotte interval here may indicate an intertonguing of the Lamotte beds with the younger Reagan Sandstone farther west.

St. Joe Minerals Corporation - Core #67AK1 - Hole No. AK-CA-1
Carroll County, Arkansas - SW SW sec. 30, T. 21 N., R. 25 W.
Elevation; 1,440' - Total depth: 2,093' - MGS No. 25823
Core from 239 feet to total depth.

CORE DESCRIPTION

Coring operations began at a depth of 239 feet, in the Cotter Dolomite.

GASCONADE DOLOMITE

Gunter Sandstone Member

Depth

1334.0'-1376.0' The top of the Gunter Sandstone is represented by fine- to coarse-grained, rounded and frosted sandstone. The entire interval is light brown in color and is made up of alternating units of well sorted and poorly sorted sand.

- Gray shale partings which have been stained a yellow-brown color occur throughout and cause the entire interval to take on a brownish hue. 42.0'
- 1376.0'-1388.0' This interval is made up of coarsely crystalline, sandy dolomite which is light gray to bluish gray in color. It is thin and irregularly bedded, with the beds separated by wavy gray shale partings. The interval 1,381-1,382.5 feet is made up of slightly dolomitic sandstone. Most of the interval contains what appears to be white, tripolitic chert filling the spaces between dolomite rhombs. 12.0'

EMINENCE DOLOMITE

- 1388.0'-1553.0' The top of the Eminence Dolomite is represented by coarsely crystalline dolomite which is light to medium gray in color. It is thin to massively bedded, with the beds separated by gray shale partings and shale filled, low amplitude stylolites. The shale is stained a yellow-brown color in most of the interval. The entire interval has a mottled appearance due to burrowing. Small to medium-sized vugs, lined with dolomite and/or calcite crystals, are common throughout; the vugs in the lower portion of the interval are often filled with apple green colored shale. Small masses of gray and white (some bullseye) chert, along with small masses of black, finely granular quartz, are common throughout the interval. Beds of sandy dolomite up to 1 foot thick occur in the upper third of the interval. The lower half of the interval appears to be more dense and contains fewer openings than the upper half of the section. Beds of high porosity which probably represent relict-oolite development occur rarely throughout. 165.0'
- 1553.0'-1654.0' This interval is made up of coarsely crystalline dolomite which is blue gray in color. It is massively bedded, with the beds separated by gray or green shale-filled, low- to medium-amplitude stylolites. The entire interval is highly porous, with the porosity occurring as small pores and small- to medium-sized cavities, and is assumed to represent relict oolite development. The cavities are lined with very large dolomite crystals or filled with green shale; locally the shale is iron-stained a brownish-yellow color. FeS_2 occurring as small masses and disseminations along stylolite planes is common throughout the interval. 101.0'

POTOSI DOLOMITE

- 1654.0'-1661.0' The top of the Potosi Dolomite is represented by finely crystalline, dense dolomite which is medium to dark gray in color and is massively bedded. The entire interval appears to be a breccia, with large clasts of dark-gray dolomite contained within a matrix of light-gray dolomite. A few small cavities lined with large dolomite crystals are sprinkled throughout. 7.0'
- 1661.0'-1715.0' This interval is made up of finely crystalline dense dolomite which is tan or light brown in color and is massively bedded, with abundant small cavities, all lined with large dolomite crystals and rarely filled with sparry calcite. Most of the interval has an indistinct appearance of mottling. Fracturing occurs throughout and becomes the dominant feature in the lower third of the interval, with very large, angular dolomite fragments being recemented with sparry calcite. Small masses of FeS₂, some of which have been altered to limonite, occur throughout the interval. 54.0'
- 1715.0'-1760.0' This interval is made up of medium crystalline, massively bedded dolomite which is medium gray in color. Small vugs lined with dolomite crystals or filled with green shale are scattered throughout. Most of the interval is highly fractured, with the fracture surfaces being recemented with pink dolomite or sparry calcite. Some slumping is shown in the center of the interval. The undisturbed portions of the interval have a mottled appearance due to burrowing. FeS₂ is disseminated throughout, with several maroon-colored masses occurring in the center portion of the interval which probably represent the alteration of FeS₂ to hematite. 45.0'
- 1760.0'-1771.0' This interval is made up of medium- to coarse-crystalline dolomite which is medium to dark gray in color. It is thin to massively bedded, with the beds separated by wavy green shale partings and shale-filled, low amplitude stylolites. Two-inch thick green shale beds occur at 1,765 and 1,766.5 feet, and both contain abundant medium-size dolomite rhombohedrons. Much of the interval has been fractured, with many of the fracture planes now recemented with very coarsely crystalline pink dolomite. 11.0'
- 1771.0'-1801.0' This interval is made up of finely crystalline dense dolomite which is medium gray in the upper half of the interval to brown in the lower portions. The entire interval is massively bedded and appears mottled due

to burrowing. The lower half of the interval shows several well-developed digitate stromatolites. Small vugs to large cavities, lined with dolomite crystals in the gray portion of the interval and lined or filled with quartz druse in the brown portion of the section, are common throughout. Quartz druse is very common in the lowest 16 feet of the interval. The lowest 11 feet of the interval is extremely porous and may represent relict oolite development.

30.0'

DERBY-DOERUN DOLOMITE

1801.0'-1865.0' The top of the Derby-Doerun Dolomite is represented by finely crystalline dolomite which is medium brown in color. It is thin and irregularly bedded, with the beds separated by wavy brown shale partings and shale filled, low amplitude stylolites. The lower half of the interval contains much more shale than does the upper portion. The entire interval has a mottled appearance due to burrowing. Small vugs to medium-size cavities are common throughout, but are not as abundant as above. The cavities are often lined or filled with quartz druse in the upper half of the interval and filled with coarsely crystalline pink dolomite in the lower half. Small masses of FeS_2 are sprinkled throughout.

64.0'

DAVIS FORMATION

1865.0'-1913.0' The top of the Davis Formation is represented by an interfingering of beds of green "poker chip" shale (up to 2 feet thick) and beds of finely crystalline wavy-bedded brown dolomite much like that described above. However, here the dolomite is less porous than in the above interval. An igneous cobble occurs at a depth of 1,866.5 feet.

48.0'

1913.0'-1935.5' The top of the more typical Davis lithology is represented by beds of green "poker chip" shale up to 6 inches thick, interbedded with thin and wavy-bedded, finely crystalline brown dolomite. The shale-dolomite ratio of this interval appears to be approximately 60:40. Pellet glauconite is common throughout and is extremely abundant in the lowest 6 feet of the interval (this portion of the interval is also very sandy). Some coarsely crystalline dolomite is noted in the lower portion of the interval, and small masses of pink dolomite occur in the upper half of the section.

22.5

BONNETERRE FORMATION

1935.5'-1953.0' Whetstone Creek Member. Only the upper beds of the Bonneterre Formation (Whetstone Creek Member) are recognizable in this core. The member is represented by argillaceous siltstone and fine-grained sandstone which is thin and irregularly bedded, with the beds separated by abundant wavy gray shale partings. Generally, the interval appears to become less silty and more sandy with depth. Fragments of large phosphatic brachiopods occur throughout, with pellet glauconite noted in the upper portion of the interval. Small masses of FeS₂ are scattered throughout. 17.5'

REAGAN SANDSTONE

1953.0'-2070.0' This interval is made up of fine- to coarse-grained sand, with some granule-size grains. The entire interval is poorly sorted and shows an alternation of sand units with beds of green shale which range in thickness from wavy partings to beds 6-inches thick. Shale is particularly abundant in the intervals 1,993-2,005.5 feet and 2,053-2,070 feet. Minute clasts of feldspar and small pebbles of quartz occur in the lowest 9.5 feet of the interval. 117.0'

PRECAMBRIAN

2070.0'-2093.0' The top of the Precambrian is represented by relatively unweathered granite. Slight fracturing is noted throughout, with foliated structures occurring in the lower third of the interval. 23.0'
T.D.

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
1334.0'-1388.0'	Gunter Sandstone Member	54.0'
1388.0'-1654.0'	Eminence Dolomite	266.0'
1654.0'-1801.0'	Potosi Dolomite	147.0'
1801.0'-1865.0'	Derby-Doerun Dolomite	64.0'
1865.0'-1935.5'	Davis Formation	70.5'
1935.5'-1953.0'	Bonneterre Formation (Whetstone Creek Member)	17.5'
1953.0'-2070.0'	Reagan Sandstone	117.0'
2070.0'-2093.0' T.D.	Precambrian	23.0'

INSOLUBLE RESIDUE LOG SUMMARY

St. Joe Minerals Corporation - Hole No. AK-CA-1

EMINENCE DOLOMITE - 1,390 TO 1,650 FEET

The Eminence residue types here are in the "quartzose"—texture chert residue facies as noted on plate 1. Residues here are very low in volume and composed predominantly of very small amounts of beekite chert; gray "quartzose" chert; and fine gray "quartzose" chert, with minor amounts of fine- to medium-grained rounded and frosted quartz--probably from the Gunter Sandstone Member above. Green and gray shale are also major constituents of the very low-volume residue of this interval. Two samples near the base of the section contained authigenic feldspar, which continues into the Potosi Dolomite for 50 feet. Highest percentage volume of insoluble residue was in the upper 100 feet of the Eminence, where up to 25 percent of a 5-foot sample was insoluble residue.

POTOSI DOLOMITE - 1,650 TO 1,775 FEET

The Potosi is thin and contains insoluble residues not typical of the Potosi in the Ozark outcrop region. In the upper 60 feet, the residues are composed of varying amounts of authigenic feldspar, quartz crystals, rounded and frosted quartz grains, angular quartz grains, and silt-size quartz grains. The lower 65 feet of the Potosi interval here contains chiefly green and gray shale, with small amounts of rounded and frosted quartz grains. Minor constituents are brown, gray, and white "quartzose" chert and a small interval of pellet glauconite below 1,700 feet. The residue percentage was extremely low for the Potosi throughout.

DERBY-DOERUN DOLOMITE - 1,775 TO 1,900 FEET

These tops do not correspond to the tops on the cross section and represent insoluble residue types not apparent in the core itself. The residues in this interval are composed of typical Derby-Doerun Dolomite residues and are predominantly finely porous brown chert and brown shale, with minor amounts of green shale and glauconite. Quartz and silt-size quartz grains, with interlaminated brown shale, were found between 1,825 and 1,875 feet, with brown shale and green shale predominating below 1,875 feet.

DAVIS FORMATION - 1,900 TO 1,935 FEET

Insoluble residue in this interval is predominantly green shale--up to 50 percent by volume of any given sample. Pellet glauconite occurs in the lower two samples (10 feet). Gray and brown shale were minor constituents in portions of this interval. Quartz silt and sand grains were noticeably absent.

TRAVERSE IN LATE CAMBRIAN STRATA

BONNETERRE FORMATION - 1,935 TO 1,955 FEET

This interval of 50 percent residue and 50 percent dolomite is correlated as the Whetstone Creek Member. The interval is composed of insoluble residues, up to 75 percent by volume, which are predominantly silt-size quartz grains to coarse, angular, sand-size quartz grains, with minor amounts of glauconite and gray shale.

REAGAN SANDSTONE - 1,955 TO 2,075 FEET

This interval is composed of quartz grains in the size range of coarse to medium with some fine grains. The larger grains are angular to subangular, with some rounded and frosted. Green and gray shales are interbedded with the sand throughout this section. This sandy interval rests directly on the Precambrian crystalline rocks at 2,070 feet, and the total depth of this hole is 2,093 feet.

St. Joe Minerals Corporation - Core #66W84 - Hole No. MD-1
McDonald County, Missouri - NW NW NE sec. 28, T. 21 N., R. 31 W.
Elevation: 940' - Total depth: 1,474' - MGS No. 25812
Core from surface to total depth.

CORE DESCRIPTION

Coring operations began at the surface, in the Cotter-Powell Dolomite interval.

GASCONADE DOLOMITE

Depth

970.5'-981.0'	<u>Gunter Sandstone Member.</u> The top of the Gunter Sandstone is represented by medium- to coarse-grained, well-sorted sandstone. The entire interval is light gray with a few bands of darker colored sand occurring in the center portion. A few gray shale partings also occur in this portion of the interval.	10.5'
981.0'-997.0'	This interval is made up of finely crystalline, sandy dolomite which is medium gray in color. It is thin and irregularly bedded, with the beds separated by gray shale partings and a few shale filled, low amplitude stylolites. The entire interval is banded in appearance, with alternating zones of light and darker colored material. A few thin zones of intraformational conglomerate up to 2 inches thick occur throughout the interval. Small pink dolomite filled cavities are rare, but are noted throughout.	16.0'

EMINENCE DOLOMITE

- 997.0'-1003.5' The top of the Eminence is made up of finely crystalline sand-free dolomite which is light to medium gray in color. The entire interval is thinly laminated, with a few pink dolomite fillings scattered throughout. 6.5'
- 1003.5'-1148.5' This interval is made up of medium- to coarse-crystalline dolomite which is medium gray in color. It is thin- and irregularly-bedded to massively bedded, with the beds separated by gray shale partings and shale filled, low amplitude stylolites. The entire interval has a mottled appearance due to burrowing and is highly porous. The pores range in size from minute vugs to large cavities, with the cavities lined or filled with very large pink or gray dolomite crystals. Occasionally, large honey-colored calcite crystals fill the larger cavities. Small to large masses of white tripolitic chert and small masses of gray finely crystalline quartz are common throughout the interval. Finely disseminated FeS_2 is common throughout. An extremely porous zone which is interpreted as representing relict oolite development occupies the interval 1,133.5-1,137.5 feet. 145.0'
- 1148.5'-1218.0' This interval is made up of coarsely crystalline dolomite which is medium gray in color. It is massively bedded, with the beds separated by a few gray shale partings and shale filled, low amplitude stylolites. The entire interval has a mottled appearance due to burrowing and is highly porous--much like the above interval--but here the vugs and cavities are filled with green shale. Only small amounts of chert and finely crystalline quartz are noted in this interval. Finely disseminated FeS_2 is common throughout. 69.5'
- 1218.0'-1240.0' This interval is made up of medium- to coarse-crystalline massively bedded dolomite which is medium gray in color. The localized interval 1,230-1,235.5 feet contains thinly laminated, finely crystalline dense dolomite which may represent planar-stromatolite development. The only porosity evident in this interval is a few medium- to large-size, pink dolomite-lined cavities. Quartz druse is noted lining cavities below a depth of 1,234 feet. The entire interval has a mottled appearance due to burrowing. Some small scale fracturing is noted at 1,238 feet. 22.0'

POTOSI DOLOMITE

- 1240.0'-1255.0' The top of the Potosi Dolomite is represented by fine- to medium-crystalline, dense argillaceous dolomite which is massively bedded and medium brown in color. This interval appears to represent a calcarenite, as small angular to rounded clasts of detrital dolomite are contained within a matrix of argillaceous dolomite. Small pores filled with dickite and larger cavities lined with quartz druse or large crystals of pink or gray dolomite are common throughout. 15.0'
- 1255.0'-1293.0' This interval is made up of medium- to coarse-crystalline dolomite which is medium gray in color. It is massively bedded, with the beds separated by few gray shale partings. The entire interval has a mottled appearance due to burrowing. Small to large cavities lined with large crystals of pink dolomite are common throughout. The smaller cavities or vugs are often filled with dickite. Thin, inclined bedding occurs in the interval 1,262-1,264 feet and may represent planar stromatolites, while digitate stromatolites occur in the interval 1,288-1,293 feet. Finely disseminated FeS₂ is common throughout. Note: This interval has a lithology which is more typical of Eminence than of Potosi. 38.0'

DERBY-DOERUN DOLOMITE

- 1293.0'-1350.5' The Derby-Doerun Dolomite is represented by a dolomitic calcarenite, with minute clasts of gray detrital dolomite contained within a matrix of finely crystalline, highly argillaceous brown dolomite. This interval is massively bedded, but occasionally is thin-bedded, with the beds separated by wavy brown shale partings. Small vugs, commonly filled with dickite, and larger cavities which are lined with large pink dolomite crystals are common throughout, along with finely disseminated FeS₂. Digitate stromatolites are noted in the local intervals 1,296.5-1,297, 1,308, 1,309, and 1,315-1,316 feet. Highly altered igneous pebbles occur at 1,342 feet and 1,348 feet. 57.5'

DAVIS FORMATION

- 1350.5'-1375.0' The top of the Davis is represented by medium- to coarse-crystalline, highly silty dolomite. It is thin and irregularly bedded, with beds separated by closely

	spaced, wavy green shale partings. In some places the rock appears calcarenitic. Highly altered igneous material, ranging in size from small pebbles to large cobbles is common throughout. Small dickite-filled vugs and finely disseminated FeS ₂ are not as common as in the above interval, but occur throughout this interval.	24.5'
1375.0'-1395.0'	This interval has the same basic lithology as the above interval, with the exception that silt is much more abundant here.	20.0'
1395.0'-1425.0'	This interval is made up of finely crystalline, very silty dolomite which is medium gray in color. It is thin- and irregularly bedded, with the beds separated by closely spaced, wavy gray shale partings. This interval is more dolomitic than the above interval, and occasionally zones of high porosity occur which suggest relict oolite development. Highly altered pebble- and cobble-size igneous material occurs throughout the interval, as does finely disseminated FeS ₂ .	30.0'

REAGAN SANDSTONE

1425.0'-1459.0'	The top of the Reagan is represented by siltstone and fine-grained sandstone which is dolomitic in a few scattered beds. The entire interval appears argillaceous and is thin bedded, with the beds separated by partings and thin beds of gray shale. Locally, thin beds of coarser grained sand containing fragments of phosphatic brachiopods can be noted. FeS ₂ is disseminated throughout the interval. Faunal data: <u>Linnarssonella</u> sp. at 1,434.9-1,438.1 feet; <u>Linnarssonella costa?</u> at 1,438.1 feet.	34.0'
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PRECAMBRIAN

1459.0'-1474.0'	The top of the Precambrian is represented by granite, T.D. the uppermost 10 feet of which is highly weathered. The remainder of the interval appears relatively fresh.	15.0'
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FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
970.5'- 997.0'	Gunter Sandstone Member	26.5'
977.0'-1240.0'	Eminence Dolomite	243.0'
1240.0'-1293.0'	Potosi Dolomite	53.0'
1293.0'-1350.5'	Derby-Doerun Dolomite	57.5'
1350.5'-1425.0'	Davis Formation	74.5'
1425.0'-1459.0'	Reagan Sandstone	34.0'
1459.0'-1474.0'	T.D. Precambrian	15.0'

INSOLUBLE-RESIDUE-LOG SUMMARY

St. Joe Minerals Corporation - Hole No. MD-1

EMINENCE DOLOMITE - 1,000 TO 1,235 FEET

The Eminence Dolomite residues in this drill hole are very similar to those occurring in the next drill hole west in this cross section, the Benton County, Arkansas (BE-2) hole. The residues are composed chiefly of fine gray "quartzose" chert; gray "quartzose" chert; gray shale; minor amounts of green shale; rounded and frosted quartz grains; and dickite. The gray "quartzose" material occurs predominantly above 1,150 feet, while the gray and green shales predominate below this point. The insoluble residue percentage is low and never exceeds about 25 percent of the total sample.

POTOSI DOLOMITE - 1,235 TO 1,300 FEET

The Potosi residues are composed of fine brown dolomoidic chert and finely porous brown chert; irregularly shaped quartz masses; and angular quartz grains. No druse, as such, was observed in the Potosi interval. The Potosi interval on the cross section extends to almost 1,300 feet in depth; however, insoluble residues in this interval are not those of the Potosi and appear to be more closely related to the Eminence low residue, gray and green shale facies immediately above the Potosi interval. Fresh feldspar chips were found at two points in this green and gray shale facies. The carbonate portion of this interval is composed of very coarsely crystalline gray and brown dolomite, indicating "white rock" development (as used by the mining geologists of Southeast Missouri). The "white rock" classification could also be assigned to the lower 85 feet of the Eminence Dolomite in this drill hole.

DERBY-DOERUN DOLOMITE - 1,300 TO 1,350 FEET

The interval assigned to the Derby-Doerun in this hole is based on the megascopic examination of the core, as there is no sequence of residues here which can be recognized as belonging to the Derby-Doerun Dolomite.

The residues occurring in this interval are composed of weathered igneous chips, authigenic feldspar, gray shale, dickite, and small quantities of massive quartz and quartz crystals. The major portion of the residue in this interval is gray weathered feldspar with a coating of quartz microcrystals covering most of the grains. Residue percentages are low and in the range of 5 to 10 percent of the samples.

DAVIS FORMATION - 1,350 TO 1,430 FEET

This interval contains a marked increase in total insoluble residue and averages 25 to 75 percent of the total sample. The residue is composed of gray weathered feldspar, gray shale, quartz silt grains, glauconite, and some subangular to rounded and frosted quartz sand grains.

REAGAN SANDSTONE - 1,430 TO 1,460 FEET

This interval contains a sharp buildup in quartz grains as rounded and frosted to subangular grains and lesser amounts of weathered igneous material. The lower sandy interval rests directly on Precambrian crystalline rocks at 1,467 feet.

St. Joe Minerals Corporation - Core #AK-BE-2 - Hole No. BE-2
Benton County, Arkansas - NE SW SW sec. 25, T. 19 N., R. 33 W.
Elevation: 1,325' - Total depth: 1,974' - MGS No. 26042
Core from 138 feet to total depth.

CORE DESCRIPTION

Coring operations began at a depth of 138 feet, in the Chattanooga Shale.

GASCONADE DOLOMITE

Depth

- 1500.0'-1525.0' Gunter Sandstone Member. The top of the Gunter Sandstone is represented by fine- to medium-grained, fairly well sorted sandstone. It is light gray to white in color and contains thin gray shale partings and small, irregularly shaped shale clasts throughout. 25.0'
- 1525.0'-1534.0' This interval is made up of finely crystalline, dense sandy dolomite which is medium-gray in color and massively bedded with a few gray shale partings. Large crystals of dolomite either line or fill cavities, which occur throughout the interval. A flat pebble conglomerate occurs in the lowest 4 inches of this section. 9.0'

EMINENCE DOLOMITE

- 1534.0'-1647.0' The top of the Eminence Dolomite is characterized by medium- to coarse-crystalline dolomite which is medium gray in color and is thin to massively bedded. The beds are separated by gray shale partings and shale filled, low amplitude stylolites. The entire interval has a mottled appearance due to burrowing and appears to represent alternating zones of relict algal material and oolitic carbonates. The interval is highly porous, with medium- to large-size cavities lined with large dolomite crystals common throughout. Small masses of tripolitic chert are sprinkled throughout the interval. Thin stringers of quartz sand

occur in the upper foot of the interval. Small masses of FeS_2 occur throughout, and apple green shale filling some of the cavities and stylolites in the lower portion of the interval is common.

113.0'

1647.0'-1717.0' This interval is made up of medium- to coarse crystalline dolomite which is thin to massively bedded. The beds are separated by gray shale partings and shale-filled, low- to medium-amplitude stylolites. The interval generally appears to be thinner bedded in the upper portions and more massively bedded in the lower portions. The entire interval has a mottled appearance due to burrowing and shows an alternation of dense dolomite units with beds of more porous dolomite. Green shale replaces the gray shale in the center portion of the interval. Small masses of disseminated FeS_2 are sprinkled throughout.

70.0'

POTOSI DOLOMITE

1717.0'-1743.0' The top of the Potosi Dolomite is represented by finely crystalline dense dolomite which is medium gray in color. It is massively bedded, with the beds separated by a few gray shale partings and shale filled, low amplitude stylolites. The entire interval has a mottled appearance due to burrowing. Small masses of FeS_2 are scattered throughout.

26.0'

DERBY-DOERUN DOLOMITE

1743.0'-1838.0' The top of the Derby-Doerun Dolomite is represented by finely crystalline dense dolomite which is brown in color. It is thin bedded, with the beds separated by wavy brown shale partings and beds up to $\frac{1}{4}$ -inch thick and shale filled, low amplitude stylolites. The upper 12 feet of the section is less shaly than the remainder of the interval, as the shale partings become more numerous and closely spaced in the lower half of the interval. The lower two-thirds of the interval appears to be very silty, the lowest 12 feet being a dolomitic silt. The interval 1,818-1,822 feet contains a vertically oriented fracture which is filled with calcarenite. Finely disseminated FeS_2 is common throughout the interval.

95.0'

DAVIS FORMATION

- 1838.0'-1890.0' The top of the Davis Formation is represented by siltstone and fine sandstone. The entire interval is argillaceous and contains abundant pellet glauconite, which is particularly concentrated in the upper 5 feet. Gray shale partings and beds up to $\frac{1}{4}$ -inch thick are common throughout. Coarser grained sand and pellet glauconite in beds up to 5 feet thick occur throughout the interval, as do small masses of FeS₂. 52.0'

REAGAN SANDSTONE

- 1890.0'-1897.0' The top of the Reagan Sandstone is made up of dolomitic silt and fine sand which is thin bedded, with the beds separated by gray shale partings and beds up to 1 inch thick. This interval is marked by the absence of glauconite, and the sand does not appear to be argillaceous. 7.0'
- 1897.0'-1922.0' This interval is made up of fine- to coarse-grained sand which is slightly dolomitic. It is only slightly shaly, with the shale occurring as thin beds and as small clasts which are incorporated within the sand units. 25.0'
- 1922.0'-1951.5' This interval is made up of fine- to coarse-grained argillaceous sandstone. It is thin-bedded, with the beds separated by gray to brown shale partings and beds up to 1 inch thick. Small clasts of feldspar are sprinkled throughout and are abundant in the lower 16 feet of the interval, giving this section a pinkish color and an arkosic appearance. 29.5'

PRECAMBRIAN

- 1951.5'-1974.0' T.D. The top of the Precambrian is represented by granite, which appears relatively unweathered, with the exception of the upper 4 feet of the interval. 22.5'

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
1500.0'-1534.0'	Gunter Sandstone Member	34.0'
1534.0'-1717.0'	Eminence Dolomite	183.0'
1717.0'-1743.0'	Potosi Dolomite	26.0'
1743.0'-1838.0'	Derby-Doerun Dolomite	95.0'
1838.0'-1890.0'	Davis Formation	52.0'
1890.0'-1951.5'	Reagan Sandstone	61.5'
1951.5'-1974.0' T.D.	Precambrian	22.5'

INSOLUBLE RESIDUE LOG SUMMARY
St. Joe Minerals Corporation - Hole No. BE-2

EMINENCE DOLOMITE - 1,525 TO 1,740 FEET

The Eminence Dolomite in this drill hole contains typical gray "quartzose" chert and some beekite chert, as well as authigenic feldspar in the lower 25 feet, but the overall shale content is much higher than in the Eminence Dolomite as it occurs farther eastward. Insoluble residues are very low by volume and contain only a portion of the diversity of residues found elsewhere.

POTOSI DOLOMITE - 1,740 TO 1,755 FEET

The Potosi interval is only 15 feet thick, but contains typical Potosi insoluble residues in the form of fine brown "quartzose" chert, some brown shale, and quartz.

DERBY-DOERUN DOLOMITE - 1,755 TO 1,835 FEET

The insoluble residues in the Derby-Doerun in this drill hole are typical of those occurring in the lower half of the Derby-Doerun in the Ozark outcrop area. The residues are fine, silt-size quartz grains and brown shale, with glauconite scattered throughout the entire interval. Much of the silt occurs as aggregates, with mixtures of brown shale included within or between thin laminae of silt and glauconite.

DAVIS FORMATION - 1,835 TO 1,890 FEET

This interval contains insoluble residues typical of the Davis Formation, consisting of silt-size quartz grains, large pellet glauconite, and green and gray shale. It also contains elements more closely related to the Precambrian surface immediately beneath. These residues are irregularly shaped quartz masses and angular to subangular quartz sand grains.

REAGAN SANDSTONE - 1,890 TO 1,952 FEET

The insoluble residues of the upper half of the Reagan make up 80 percent of the rock by volume and are made up of coarse quartz grains, fine to granule-size quartz sand grains, and gray shale. The carbonate fraction of this portion of the Reagan is finely crystalline dolomite. The lower half of the Reagan is made up of fine- to coarse-grained quartz sandstone with varying amounts of gray shale. A mixture of weathered feldspar grains occurs in the lowest 20 feet. The Reagan rests directly on the Precambrian crystalline rocks, of which 23 feet were drilled in this hole.

St. Joe Minerals Corporation - Core #66OK-3 - Hole No. DE-5
 Delaware County, Oklahoma - SW NE NW sec. 22, T. 21 N., R. 25 E.
 Elevation: 990' - Total depth: 1,986' - MGS No. 26078
 Core from 15 feet to total depth.

CORE DESCRIPTION

Coring operation began at a depth of 15 feet, in the
 Burlington Limestone of Mississippian age.

GASCONADE DOLOMITE

<u>Depth</u>		
1555.0'-1566.0'	<u>Gunter Sandstone Member.</u> The top of the Gunter Sandstone is represented by fine- to medium-grained, well sorted, rounded and frosted sand. Thin gray shale partings are scattered throughout the interval. Finely crystalline FeS ₂ is rare, but occurs throughout.	11.0'
1566.0'-1587.0'	This interval is made up of finely crystalline dense dolomite which is very sandy in the upper 15-foot portion. Thin stringers of sand occur throughout the remainder of the interval. It is medium gray in color and is thin bedded, with the beds separated by gray shale partings. Most of the interval has a mottled appearance due to burrowing. Massive white chert fillings occur in the upper half of the interval.	21.0'

EMINENCE DOLOMITE

1587.0'-1655.0'	The top of the Eminence Dolomite is characterized by medium- to coarse-crystalline dolomite which is medium gray in color. This interval is thin-bedded, with the beds ranging from 2 to 6 inches thick and separated by wavy gray shale partings and shale-filled, low-amplitude stylolites. The entire interval has an indistinctly mottled appearance due to burrowing. The entire interval exhibits a high porosity, with vugs and small- to medium-size cavities lined with large gray or pink dolomite crystals. White tripolitic chert masses or fillings are rare, but occur throughout the interval, as do small masses of FeS ₂ .	68.0'
1655.0'-1747.0'	This interval is made up of coarsely crystalline dolomite which is medium gray in color. It is massively bedded, with the beds separated by a few gray shale partings and shale filled, low amplitude stylolites.	

The entire interval has a mottled appearance due to burrowing. This interval does not appear as porous as the above interval, but still contains numerous vugs and small cavities which are lined with large gray or pink dolomite crystals. Occasionally, small amounts of green shale occur along stylolite planes. Beds of high porosity, which probably represent relict oolites, occur throughout the interval. Small masses of FeS_2 occur throughout, with large masses of altered FeS_2 occurring in the lower portion of the section. The interval 1,729.5-1,741 feet shows brecciation of the dolomite, with some small scale faulting noted. The lowest portion of the interval is finer crystalline and more dense than the overlying material.

92.0'

POTOSI DOLOMITE

1747.0'-1768.0' The top of the Potosi Dolomite is characterized by finely crystalline, dense, argillaceous dolomite which is medium to dark brown in color. It is thin and irregularly bedded, with the beds separated by wavy brown shale partings and a few shale filled, low amplitude stylolites. Small to medium sized fillings of massive pink dolomite and small masses of FeS_2 occur throughout the interval. Fracturing is common in the upper 6 feet of the interval.

21.0'

DERBY-DOERUN DOLOMITE

1768.0'-1787.0' The top of the Derby-Doerun is characterized by finely crystalline argillaceous dolomite which is medium brown in color. It is thin and irregularly bedded, with the beds separated by brown shale partings and beds up to $\frac{1}{2}$ -inch thick. A fresh surface of rock in this section emits a petroliferous odor. Small cavities filled with pink dolomite occur throughout the interval. Thin beds of "edgewise" conglomerate occur at depths of 1,773, 1,780.5, and 1,785 feet.

19.0'

1787.0'-1829.0' With the exception of three interbedded units of finely crystalline medium gray dolomite occurring at depths of 1,793.5, 1,803, and 1,806 feet, this interval is made up of flat pebble conglomerate, with flat, lath-shaped clasts of finely crystalline brown dolomite contained within a matrix of finely crystalline grayish brown dolomite. Small fillings of coarsely crystalline pink dolomite are sprinkled throughout.

42.0'

- 1829.0'-1874.5' This interval is made up of finely crystalline dolomite which is medium gray in color. It is thin bedded, with the beds separated by wavy brown-shale partings and a few shale filled, low amplitude stylolites. The entire interval appears silty, with the silt apparently increasing toward the bottom of the section. Thin beds of flat-pebble conglomerate occur at depths of 1,842, 1,847, 1,855, 1,872, and 1,874 feet. FeS₂ occurs throughout the interval, along the contacts between dolomite beds and the thicker shale partings. Small fillings of coarsely crystalline pink dolomite are rare, but occur throughout the interval. 45.5'

REAGAN SANDSTONE

- 1874.5'-1940.0' The top of the Reagan Sandstone is represented by quartz sand and silt, with the size of the sand grains ranging from very fine to coarse. The entire interval is very shaly, with the shale occurring as small clasts incorporated within the coarser sand beds and as beds ranging up to 3 inches thick. The sand grains appear to be angular. "Pepper" glauconite and fragments of phosphatic brachiopods occur throughout. This interval has an overall "dirty" appearance. 65.5'
- 1940.0'-1970.0' This interval is made up of poorly sorted quartz sandstone whose grain size ranges from fine to granular. The grain shape ranges from angular to rounded. Shale occurring as small clasts within sand units and as beds, ranging in thickness from thin partings to 1 inch, is common throughout, but not as abundant as in the above interval. Small masses of FeS₂ are sprinkled throughout. The sandstone is occasionally stained a yellow-brown color. Igneous pebbles and cobbles are noted in the lower portion of the interval, and a small boulder occurs in the basal portion of the interval. 30.0'

PRECAMBRIAN

- 1970.0'-1986.0' The top of the Precambrian is represented by fine-grained porphyritic granite containing feldspar phenocrysts. The upper 3½ feet of the section is highly weathered, while the remainder of the interval is only moderately weathered. The biotite in the granite is commonly altered to chlorite. 16.0'
- T.D.

FORMATION SUMMARY

<u>Interval</u>	<u>Formation</u>	<u>Thickness</u>
1555.0'-1587.0'	Gunter Sandstone Member	32.0'
1587.0'-1747.0'	Eminence Dolomite	160.0'
1747.0'-1768.0'	Potosi Dolomite	21.0'
1768.0'-1874.5'	Derby-Doerun Dolomite	106.5'
1874.5'-1970.0'	Reagan Sandstone	95.5'
1970.0'-1986.0'	T. D. Precambrian	16.0'

INSOLUBLE RESIDUE LOG SUMMARY

St. Joe Minerals Corporation - Hole No. DE-5

EMINENCE DOLOMITE - 1,570 TO 1,750 FEET

The strata assigned to the Eminence Dolomite contains insoluble residues of very low percentage by volume. The residues are composed of gray and green shale; minor amounts of gray "quartzose" chert; gray finely "quartzose" chert; finely dolomoldic brown shale; and finely porous brown shale in the lower 25 feet. The typical gray "quartzose" chert and gray finely "quartzose" chert of the Eminence farther eastward is a minor constituent in the insoluble residues in this drill hole.

POTOSI DOLOMITE - 1,750 TO 1,790 FEET

The insoluble residues in this interval are not typical of the Potosi, but more like those in the Derby-Doerun. However, a chert buildup in the middle of this zone reflects the typical chert types and buildups in the Potosi Dolomite elsewhere. The insoluble residues are composed of finely dolomoldic brown chert and porous brown shale, with silt-size quartz grains scattered throughout. A chert buildup at 1,775 feet contains upward of 20 percent by volume of the chert.

DERBY-DOERUN DOLOMITE - 1,790 TO 1,875 FEET

Insoluble residues in the Derby-Doerun are somewhat typical of those occurring in the lower half of the Derby-Doerun elsewhere and are composed of quartz-silt aggregates, with interlaminated porous brown shales and gray shales. The interval from 1,845 to 1,850 feet contains fresh feldspar chips.

REAGAN SANDSTONE - 1,875 TO 1,970 FEET

This interval contains almost 100 percent insoluble residue which is composed chiefly of coarse, angular quartz grains, with minor amounts of silt-size quartz grains. Another minor constituent is gray shale, which is scattered throughout the upper two-thirds of the interval, with a section of pellet glauconite occurring from 1,900 to 1,930 feet. This interval rests on Precambrian granite at 1,970 feet. The total depth of the drill hole is 1,986 feet.

TRAVERSE IN LATE CAMBRIAN STRATA FROM THE ST. FRANCOIS MOUNTAINS, MISSOURI
TO DELAWARE COUNTY, OKLAHOMA

RI 55

MISSOURI DEPARTMENT OF NATURAL RESOURCES – DIVISION OF RESEARCH AND TECHNICAL INFORMATION
GEOLOGICAL SURVEY

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