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BULLETIN 72

UPPER CAMBRIAN AND LOWER ORDOVICIAN ROCKS IN KANSAS

By
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and
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UPPER CAMBRIAN AND LOWER ORDOVICIAN ROCKS IN KANSAS

By Raymond P. Keroher and Jewell J. Kirby

ABSTRACT

This report deals with Upper Cambrian and pre-Simpson Lower Ordovician beds that lie below the surface in Kansas and crop out in the surrounding states. The investigation was begun as a project of the Kansas Geological Survey and was completed under the auspices of the United States Department of the Interior.

The delineation of recognizable lithologic units within the Upper Cambrian and Lower Ordovician rocks is based upon the examination of well cuttings and cores and of insoluble residues prepared from such samples. A short description of the method of sample examination is included. This method, in part a modification of methods in common use, permits graphic representation of observations in considerable detail, thereby facilitating the correlation of the beds represented.

Insoluble residues from representative wells throughout Kansas are described in detail. Six lithologic units, five of which are separated by unconformities, are differentiated on the basis of insoluble residues and are correlated with the equivalent units in Missouri. The Missouri equivalents of the six units, named in ascending order, are: Lamotte sandstone, Bonneterre dolomite, Eminence dolomite, undifferentiated Van Buren formation and Gasconade dolomite, Roubidoux formation, and undifferentiated Jefferson City and Cotter dolomites. The most nearly typical development of these units in Kansas is in the southeastern part of the State. Other stratigraphic units that have been recognized in Missouri may be present in the southern part of Kansas but have not been identified.

A zone of sandstone composed of coarse sand grains immediately overlies the Pre-Cambrian surface in Kansas. This zone, in part, is correlated with the Lamotte sandstone of Missouri. It is overlain by a dark-colored dolomite, the insoluble residues of which characteristically consist of fine, angular, glauconitic sand that grades upward into fine sandy shale and dolocastic shale. This zone is correlated with the Bonneterre dolomite of Missouri. Next in upward order is a zone of light-colored dolomite that contains an abundance of quartzose chert; this overlies the Bonneterre dolomite throughout most of Kansas and is correlated with the Eminence dolomite of Missouri. Overlying the Eminence is a zone of dolomite characterized by a high percentage of insoluble material in which white and blue chert predominate. This zone, which is correlated with the Van Buren formation and the Gasconade dolomite of Missouri, is not differentiated in Kansas. A thin, sandy dolomite at the base is correlated with the Gunter sandstone member of the Van Buren of Missouri. A light-colored coarsely crystalline sandy dolomite which contains interbedded sandstones and which overlies

the Gasconade dolomite and older beds is correlated with the Roubidoux formation. The uppermost recognized zone consists of dolomites of various textures and colors, characterized by a high percentage of chert, some of which is oölitic, and interbedded sandstones. This part of the section is correlated with the Jefferson City and Cotter dolomites of Missouri but is not differentiated in Kansas.

Rocks of Early Ordovician age, including the Powell dolomite and the Smithville limestone which overlie the Cotter dolomite in Missouri and Arkansas, were not identified in Kansas. If present in Kansas, they are included in the undifferentiated Cotter-Jefferson City sequence.

The relations of the subsurface zones in Kansas reveal that there were four major cycles of deposition in Late Cambrian and Early Ordovician time, each of which was followed by deformation and erosion that resulted in uncomfortable relationships between the zones. The record indicates (1) unconformable deposition of Lamotte sandstone on the pre-Cambrian surface, followed by conformable deposition of Bonneterre dolomite and possibly the Davis formation and Derby and Doe Run dolomites; (2) unconformable deposition of the Eminence dolomite on the eroded Bonneterre surface; (3) unconformable deposition of the Van Buren formation and Gasconade dolomite on the beveled surface of pre-Van Buren rocks; (4) unconformable widespread deposition of the Roubidoux on the eroded surface of pre-Roubidoux rocks, followed by deposition of Jefferson City and Cotter dolomites, and probably the Powell dolomite and Smithville limestone; (5) the conformable deposition of St. Peter sandstone or the Simpson formation on the beveled surface of rocks ranging in age from Cotter to Pre-Cambrian.

After St. Peter time, deformation of major importance followed by erosion several times modified the original thickness and distribution of the younger rocks of the pre-St. Peter sequence. In this discussion, the effects of post-St. Peter deformation and erosion have been disregarded except insofar as they may have affected the interpretation of pre-St. Peter events.

At the beginning of Cambrian sedimentation in Kansas the central part of the State is believed to have been relatively high. The Lamotte sandstone, followed by the Bonneterre dolomite overlapping onto the granite, was deposited on the eastern and western flanks of this area. Lithologic differences suggest that the beds on the east flank are marginal deposits of the Ozark basin, whereas those on the west flank are eastward extensions of Sawatch and Deadwood deposition. Whether separate basins actually existed at this time or whether the two types of lithology represent facies changes has not been determined.

Resumption of sedimentation resulted in the spreading of Eminence deposits conformably over the Potosi dolomite, which was restricted to the deeper parts of the basin in Missouri, and over the beveled edges of the Bonneterre dolomite in Kansas. It has not been ascertained whether the Eminence dolomite covered the central uplift area. Beds occupying the stratigraphic position of the Eminence dolomite in the eastern part of the State are slightly different from those of the same apparent stratigraphic

position in the western part. This difference may or may not be due to a facies change.

The Van Buren formation, including its basal Gunter sandstone member, and the undifferentiated overlying Gasconade dolomite, which seem to have been restricted to eastern and southeastern Kansas, overlap the beveled edges of the older beds onto the Pre-Cambrian rocks exposed at the pre-Gunter surface in south-central Kansas.

After Gasconade deposition, deformation was renewed and erosion of the uplifted areas exposed, in places, rocks ranging in age from Pre-Cambrian to Gasconade. The Roubidoux formation was deposited widely upon this surface. It is present everywhere in the subsurface of Kansas except in local areas where it has been removed by post-Cotter erosion. Minor unconformities occur between the Roubidoux dolomite and the Jefferson City-Cotter sequence, and within the sequence.

Preceding St. Peter deposition, the region was tilted along a line parallel to the northern margin of Kansas. All the Jefferson City and Cotter deposits and part or all of the Roubidoux deposits were stripped from a wide area in the northern part of the State. The Cotter dolomite is now present only in the southern part of the State.

INTRODUCTION

The economic importance of the older Paleozoic rocks throughout the Midcontinent region of North America, particularly as a source of petroleum, has led to an increasing desire for a more complete understanding of that part of the geologic section. Accordingly, the Kansas Geological Survey in July 1937 initiated a study of the older Paleozoic rocks in the subsurface of Kansas.

The study was begun by Raymond P. Keroher as part of his duties. In July 1941, Jewell Kirby was also assigned to the work. It was nearly completed when in 1942 the authors left the Kansas Survey for private employment. Research was continued as time permitted and later, after both had joined the staff of the U. S. Geological Survey, H. D. Miser of the Fuels Section extended an invitation to the authors to complete the report. The allocation by the Federal Survey of a part of the time of both writers to the project during the winter of 1943-44 led to the completion of the report earlier than otherwise would have been possible.

ACKNOWLEDGMENTS

The authors extend thanks to various oil companies, drillers, and operators in Kansas for their cordial cooperation in the saving of well cuttings; to H. S. McQueen and the Missouri Geological

Survey for permission to examine at Rolla, Missouri, cuttings and insoluble residues of Missouri wells and outcrop samples, and for sample determinations of Missouri wells with which lithologic criteria Kansas wells were compared; and to E. C. Reed of the Nebraska Geological Survey for permission to examine samples from wells drilled in Nebraska, on file at the Nebraska Geological Survey. Wallace Lee, Henry Ley, John Garlough, and others have contributed directly and indirectly to the investigation. The mineralogical determinations made by Jewell J. Glass are sincerely appreciated. The samples were prepared and the residues were made by the staff of the subsurface laboratory of the Kansas Geological Survey.

Changes of various maps showing thickness and distribution of formations, based on information obtained subsequent to work by the authors, have been made by Wallace Lee.

Purpose and Scope of the Report

The specific purpose of this study has been to determine the character, thickness, stratigraphic sequence, and distribution of as many zones of the Upper Cambrian and Lower Ordovician rocks as possible. Such information will be useful in petroleum exploration in the State because (1) these beds are important sources of petroleum, (2) some beds within the older formations may be less prolific than others, if not wholly barren of oil, and (3) local variations in the thickness of members of the older formations probably reflect structural conditions that may have been influential in the accumulation of petroleum.

The study is limited to subsurface beds of Late Cambrian and Early Ordovician age that unconformably overlie the granites, schists, and quartzites of Pre-Cambrian age and are unconformably overlain by beds ranging in age from Chazyan to Early Pennsylvanian. In addition to subsurface studies in Kansas, the work included examination of outcrops of these beds in the Ozark region of Missouri, the Black Hills of South Dakota, and the Front Range of the Rocky Mountains. It also included examination of samples and insoluble residues from wells drilled in Missouri which were made available at Rolla, Missouri, by the Missouri Geological Survey.

At the beginning of the project it was intended only to examine samples from wells in Kansas situated east of the

Nemaha granite ridge, an area that includes approximately the eastern one-fourth of the State. This area is nearest the outcrop of the formations in the Ozark plateau and is adjacent to western Missouri where the Cambrian and Ordovician rocks in the subsurface have been studied by the Missouri Geological Survey. As the work progressed it became evident that the larger divisions recognizable in the eastern Kansas wells were remarkably persistent westward. Accordingly, it seemed desirable to trace those zones into western Kansas. The time necessary to prepare samples recovered from rotary drilling operations required limitation of the study to those wells in western Kansas that penetrate all or nearly all of the older Paleozoic rocks. In consequence, the work in western Kansas is not nearly so exhaustive as that in the eastern part of the State.

The approach to the regional study has been the correlation across the State of stratigraphic units that are lithologically similar. Correlation with the subdivisions in Missouri is based upon lithologic similarities between the stratigraphic units in the subsurface of Kansas and the formations that crop out in the Ozark region and have been traced in the subsurface into western Missouri and eastern Kansas. No attempt, however, has been made to differentiate all the subdivisions that have been recognized in Missouri. On the whole, only the larger subdivisions, in which the included units are believed to be conformable, have been differentiated.

Correlation of smaller stratigraphic units is possible in those areas where cores and uncontaminated samples are available and where wells that penetrate considerable depths of the beds are closely spaced. With the exception of local areas, such control generally is lacking in Kansas. Therefore it has seemed in keeping with the purpose of this report to make the degree of detail consistent with the amount of control available. It is realized that more detailed study of these wells and the drilling of new ones doubtless will call for revisions. The subdivision of these beds into the larger units, however, supplies a framework into which more detailed information may be fitted later.

The project involved several steps: (1) development of a method of study making possible differentiation and recognition of lithologic zones by microscopic examination of original samples and insoluble residues; (2) summation of the lithologic

characteristics of the subdivisions on the basis of microscopic examinations; (3) correlation across the State of the recognizable units and construction of geologic cross sections representing the stratigraphic sequence of units as they occur in representative wells; (4) summary interpretation of the geological history of the older beds, based on the correlation, thickness, distribution, and sequence of formations.

Nomenclature

The Upper Cambrian and Lower Ordovician rocks crop out to the east of Kansas in the Ozark region of Missouri, to the south in the Arbuckle and Wichita Mountains of Oklahoma, to the west along the Front Range of the Rocky Mountains, to the northwest in the Black Hills of South Dakota, and to the northeast in Minnesota, Wisconsin, and Michigan. They occur in the subsurface of all the intervening region except locally in structurally high areas from which they have been removed by erosion. The correlation table (Fig. 1) indicates the nomenclature and subdivisions of the lower Paleozoic beds in most of these areas.

Exploration for petroleum in northern Oklahoma and in Kansas has shown that the oldest Paleozoic rocks are composed of a series of beds consisting for the most part of dolomite but with minor amounts of interbedded sandstone and shale. These beds have been divided in the Arbuckle Mountains of southern Oklahoma into the Arbuckle group, the Honey Creek limestone, and the Reagan sandstone, as indicated in the correlation chart (Fig. 1).

The Upper Cambrian and Lower Ordovician dolomitic sequence, which is easily recognized, has become known among Oklahoma drillers as "Arbuckle lime," "Arbuckle formations," and "Siliceous lime." These names have also become common in Kansas.

On account of the difficulty of recognizing zones within the dolomite, no subdivisions of the Cambrian and Ordovician have become well known to drillers in Kansas, except the basal sand or conglomerate that is present in some places. Because of its position below the dolomites, this basal sand was correlated with the Reagan sandstone of the Arbuckle Mountains, which occupies the same stratigraphic position. Thus the term "Reagan

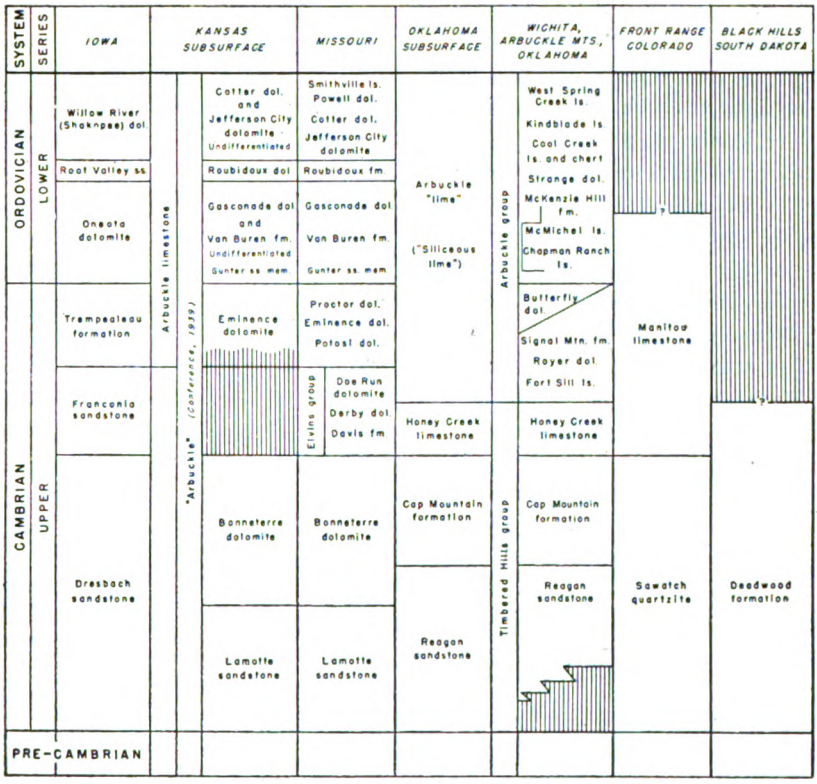

FIG. 1—Subdivision, nomenclature, and correlation of Upper Cambrian and Lower Ordovician rocks at the outcrop and in the subsurface of Kansas and adjacent states.

sand" which is correlated with the Lamotte sandstone of Missouri was introduced into the Kansas driller's terminology.

The Upper Cambrian and Lower Ordovician formations are well exposed in the Ozark region of Missouri, where their study by the Missouri Geological Survey has led to their detailed classification. From the study of insoluble residues developed by the Missouri Geological Survey, the various stratigraphic units of the Ozark outcrops have been traced westward in the subsurface to western Missouri and eastern Kansas, where their correlation with the outcrops has been established. (Since this report was written an investigation by H. A. Ireland [1944] has traced stratigraphic units of the Ozark outcrop in the subsurface into northeastern Oklahoma.) For these reasons it seemed de-

sirable to correlate recognizable units in the subsurface of Kansas with equivalent units in the Ozark region.

On the other hand, the name "Arbuckle" is so well established among geologists and others in the petroleum industry that its abandonment and the substitution of other names would confuse and complicate the records of oil companies and drilling organizations. On recommendation of oil geologists in Kansas therefore the name "Arbuckle" has been retained as a group name for all Paleozoic beds older than those included in the Chazy group (St. Peter sandstone or Simpson formation of Kansas) and subdivisions of the Missouri classification have been adopted. It is realized that older beds are comprised under this definition of Arbuckle than were included in the original Arbuckle formation (Abernathy, 1940, pp. 10-13; Jewett, 1940, pp. 12-14). Lee (1943, fig. 3, p. 19) has indicated the desirability of using the group name "Arbuckle" as restricted by Ulrich (1911) in the Arbuckle Mountains. Revision of the nomenclature of these beds on the basis of information now available seems premature.

METHOD OF STUDY

The difficulty encountered in attempts to subdivide the older Paleozoic beds in the subsurface of Kansas is the result of a number of factors. These include lack of fossils in well cuttings, absence of easily recognizable lithologic zones in a vertical section, rapid lithologic changes laterally within the same bed, and absence in the area of certain formations known in the general sequence.

Although fossils are fairly abundant in a few zones in these beds, their relatively large size prevents recovery of unbroken specimens in drill cuttings. A few identifiable specimens have been found in cores and have been used in determining the age of the enclosing formation, but the number so obtained is too small to permit zoning of the beds by paleontological methods. Differences in lower Paleozoic beds at different outcrop areas in other states suggest the impracticability of extrapolating the surface information for any considerable distance into the subsurface.

The methods of subsurface study commonly used by oil company geologists are adequate for the study of a sequence of formations in which easily recognizable "breaks" occur. More

specialized methods, however, are desirable for the study of a great thickness of beds in which well-defined markers are absent.

Interbedded shales and sandstones make up only a small percentage of the lower Paleozoic section of Kansas. The shales, for the most part, are thin and some are dolomitic. With few exceptions, the sandstones are highly dolomitic, resembling a sandy dolomite that may grade either laterally or vertically into beds or lenses of relatively pure sandstone. In addition, the lateral change in lithology, seemingly within the same bed, may be greater within a short distance than the vertical change in lithology from bed to bed. All these factors contribute to the difficulty of zoning the Upper Cambrian and Lower Ordovician beds in Kansas.

The absence of faunal material required that study be based entirely upon lithology in order to differentiate zones within the older beds.

Sampling

Samples from 110 wells were examined during the course of this investigation. Cuttings from nearly all wells drilled in the eastern part of the State prior to 1942 that penetrate significant amounts of the pre-St. Peter formations were studied. Relatively few of the wells that have been drilled to the top of the Lower Ordovician in western Kansas penetrate the dolomite more than a few feet. Some of the wells studied penetrate the entire section but some reach only the upper part of the Lower Ordovician section. Generalized descriptions of the dolomites are given in the part of this report dealing with the correlation of the formations. Detailed descriptions of the insoluble residues from 15 representative wells, the locations of which are shown in Figures 10 and 12, are given at the end of the report.

Most of the samples used in this study were obtained from the Kansas Geological Survey. Samples and insoluble residues from wells in western Nebraska and Colorado were borrowed from oil companies. Outcrop samples and specimens, for the most part, were collected by the writers although a few were borrowed from oil companies.

Certain inaccuracies connected with the method of drilling may cause seeming anomalies greater than actual lateral and

vertical lithologic changes in the rocks. Cuttings from cable tool wells drilled while the hole is full of water are of very fine size. This affects the interpretation of the samples in several ways. (1) Much of the relatively soft dolomite that has been reduced to a fine rock flour is lost during the sample washing operation. The amount of chert remaining in the sample therefore indicates a much higher percentage than was contained in the original rock. (2) It is impossible to determine from such fine material the color, texture, or other characteristics of the dolomite. (3) Insoluble residues from these fine samples are of very little value, especially in those parts of the section in which the diagnostic characteristic is an insoluble residue of soft dolocastic chert or shale. The difficulty of drilling the hard Pre-Cambrian rocks with cable tools causes less resistant material, such as feldspar, to be ground to a fine powder which may be lost when the samples are washed. The fine angular quartz grains which then compose the sample resemble a sand or quartzite. Traces of feldspar and mica may be interpreted as fragments of weathered granite that were included in a basal sand during deposition.

Samples from wells drilled with rotary tools are contaminated by material derived from beds higher in the well. Therefore, formation boundaries are not sharp but may extend over a zone 30 feet or more in thickness. Because of the lag in bringing samples to the surface where drilling is deep, the boundaries of formations are logged 10 to 30 feet below the actual depth at which they were encountered. The weight of the drilling mud may not bring cuttings of a limestone or dolomite to the surface as rapidly as it will bring cuttings of shale; the samples then consist almost entirely of caved shale. The sorting of extraneous material from rotary cuttings is not entirely satisfactory. It is impossible to exclude material from upper formations within the Upper Cambrian and Lower Ordovician beds or to recognize in every case new material indigenous to the formation. For example, it is probable that much green shale interbedded with the formations has been overlooked because of similarity to green shales encountered higher in the well.

Comparison of Dolomites

Microscopic examination of the dolomites in the well cuttings reveals many variations in color, texture, fracture, and other

features. Attempts to devise a method of describing these variations in a manner that would permit consistent recognition of each variant were so notably unsuccessful that a method was devised that would permit direct comparison of each variant with some unvarying standard.

Each distinctive kind of dolomite was designated as a type and was assigned an arbitrary color symbol which, when plotted on the log form, would represent graphically that particular variant in any subsequent sample in which it might be found. A few representative fragments of each variety of dolomite were glued on a small card with the adopted color symbol, the name and location of the well, and the depth from which the type was taken. In use, these type cards, together with the samples to be examined, were placed in a small tray on the stage of the microscope and direct comparisons were made under the microscope between the dolomite cuttings in the tray and the fragments of the type dolomite on the card. In addition to making possible close comparison between the dolomite in the cuttings and the fragments selected as dolomite types, these cards formed a permanent, easily accessible reference file of the large number of different kinds of dolomite in the samples examined.

The first dolomite types were selected from cable-tool wells located nearest the outcrop section in Missouri. As the studies progressed westward new dolomite types were encountered and these were differentiated in the same manner as those from wells that had been studied earlier.

Comparison of Insoluble Residues

The distinguishing characteristics of chert, sand, and shale in the Cambrian and Lower Ordovician dolomites are obscured to a great extent in samples as they come from the well but may be brought out satisfactorily by the use of insoluble residues. McQueen (1931) and others have shown that, in many cases, dissolving the dolomite from rock samples by means of hydrochloric acid leaves an insoluble residue that may be identified more readily than the original sample. Briefly summarized, McQueen's method of preparing insoluble residues consists of (1) measuring volumetrically in a straight-sided glass bottle a sample of drill cuttings, (2) dissolving the measured sample in an excess of hydrochloric acid in a 250 cc. beaker, (3) washing the remaining insoluble part by decantation, (4) drying the

insoluble residue, and (5) measuring volumetrically by means of a suitable scale the residue in the same bottle in which the original sample was measured. The bottle, when fiitted with a cork stopper, serves as a storage receptacle for the residue.

This method of preparation is rapid and is satisfactory when the samples are uncontaminated, as are outcrop samples or cuttings from wells drilled with cable tools. If this method is used it is desirable that the amount of sample be sufficient to permit the use of a large fraction (25 to 35 grams) for the preparation of the residue.

The practice in Kansas of dividing the well samples in order that each of several interested oil companies and State agencies may have a set reduces considerably the amount of sample available to each. In rotary cuttings, extraneous material included in some samples may compose all but a few fragments of rocks from the lower beds. As a result, the residue fraction available for use in this study usually was too small to permit accurate determination of the volume in a vial large enough in diameter to hold the largest rock fragments. Therefore, instead of following the volumetric method developed by the Missouri Geological Survey, the original fraction from which the residues were to be prepared and the residues that remained after solution of the dolomite in acid were weighed on an analytical balance to the closest 0.1 gram and the percentage of residue was then calculated.

Residues made from samples as they came from rotary wells were useless. To prevent the large amount of shale, sandstone, gypsum, and anhydrite that had caved from higher beds from obscuring the relatively small amount of residue from the dolomites in the lower part of the well, the samples were hand-picked and only the dolomite was retained for making the residue. This method has the obvious disadvantage of removing some material, especially shale, that might be indigenous to the lower beds, and leaves in the residue only the insoluble material that was included in the dolomite fragments. There probably is some contamination within the dolomite beds. This results in less precise determination of formational boundaries.

Notwithstanding all the difficulties inherent in the use of rotary samples, stratigraphic zones that were recognizable from residues in eastern Kansas were traceable across the State.

The kinds of chert present in the insoluble residues were divided into a relatively small number of types, mainly on the basis of such characteristics as color, degree of transparency, luster, texture, and presence of dolocasts. Each type was assigned a color symbol, which was plotted on log forms. In general, shale and sand grains in the residues were classified according to standard methods. Each type was represented by symbols on the logs, both as to type and as to relative amount. It should be noted that the color of some shales is considerably modified by the action of the acid, and that calcareous or dolomitic shales may be disintegrated by the action of the acid, with the result that fine shale fragments are lost when the residues are washed.

The presence of accessory minerals, such as pyrite and glauconite, was also recorded.

Terminology

Adoption of arbitrary symbols representing various types of dolomite or residues obviated the necessity for detailed description during study, but in order to publish the results of observations, it is necessary to use a number of descriptive terms. Most of these have been adopted from descriptions by Lee (1940, pp. 16-17, and 1943, pp. 14-16) and from publications of the Missouri Geological Survey (McQueen, 1931). The use of such terms in this report is indicated by the following definitions.

Cotton rock is a soft porous siliceous rock or insoluble residue composed of white opaque uncemented microscopic particles of silica.

Dolocast is a term introduced by McQueen (1931) for the impression left by a dolomite crystal removed from chert or other materials in the insoluble residues. It is widely used in spite of being a misnomer. Dolocasts may occur singly or be so numerous that they give rise to a porous or lacy texture.

Drusy texture applies to deposits of crystalline quartz, usually on chert fragments, or to aggregates of quartz crystals, probably originating in microscopic cavities.

Granular texture applies to microscopic crystals of dolomite or chert sparsely distributed in a dull opaque cryptocrystalline or earthy matrix.

Oöcast is used in this report to indicate the cavity from which an oölitic grain has been removed by weathering or by acid.

Porcelaneous chert is smooth, even-textured, homogeneous, somewhat vitreous, and opaque.

Porous texture is used to describe aggregates of quartz or chert or other materials in which the individual cavities are microscopic.

Quartzose chert has the glassy appearance and sharp fracture of crystalline quartz but lacks crystal faces.

Spongy texture applies to aggregates of quartz, chert, silt, or clay in insoluble residues from which the soluble matrix has been removed and in which the individual openings are submicroscopic.

Sucrose texture applies to microscopically coarse or fine crystals, usually dolomite, packed closely (without matrix) and resembling the grains of lump sugar.

Tripolitic texture refers to chert or siliceous rock that is soft, crumbly, rotten, and has a mealy appearance.

DESCRIPTION AND CORRELATION OF SUBDIVISIONS

In the following discussion of the general characteristics of the Upper Cambrian and Lower Ordovician subsurface rocks in Kansas, equivalent formations in Missouri that have already been studied and classified are used as type sections for comparison. In order to establish the identity of the stratigraphic zones that are correlated with the subdivisions of the type section, their limits are defined by contrasting the characteristics of each zone with those of the subjacent and superjacent beds. A columnar section (Fig. 2) summarizes the stratigraphic sequence, thickness, and general features of the Upper Cambrian and Lower Ordovician formations in Kansas.

In the central Ozark region of Missouri these beds, where fully developed, attain a maximum thickness of approximately 2,000 feet. In western Missouri the section thins to approximately 1,000 feet. In Kansas, the thickness of these rocks is controlled by differences in sedimentation and by pre-St. Peter and later intervals of erosion during which great thicknesses of these rocks were removed from structurally high areas. In southeastern Kansas the thickness ranges from 1,000 to 1,200 feet. Northward,

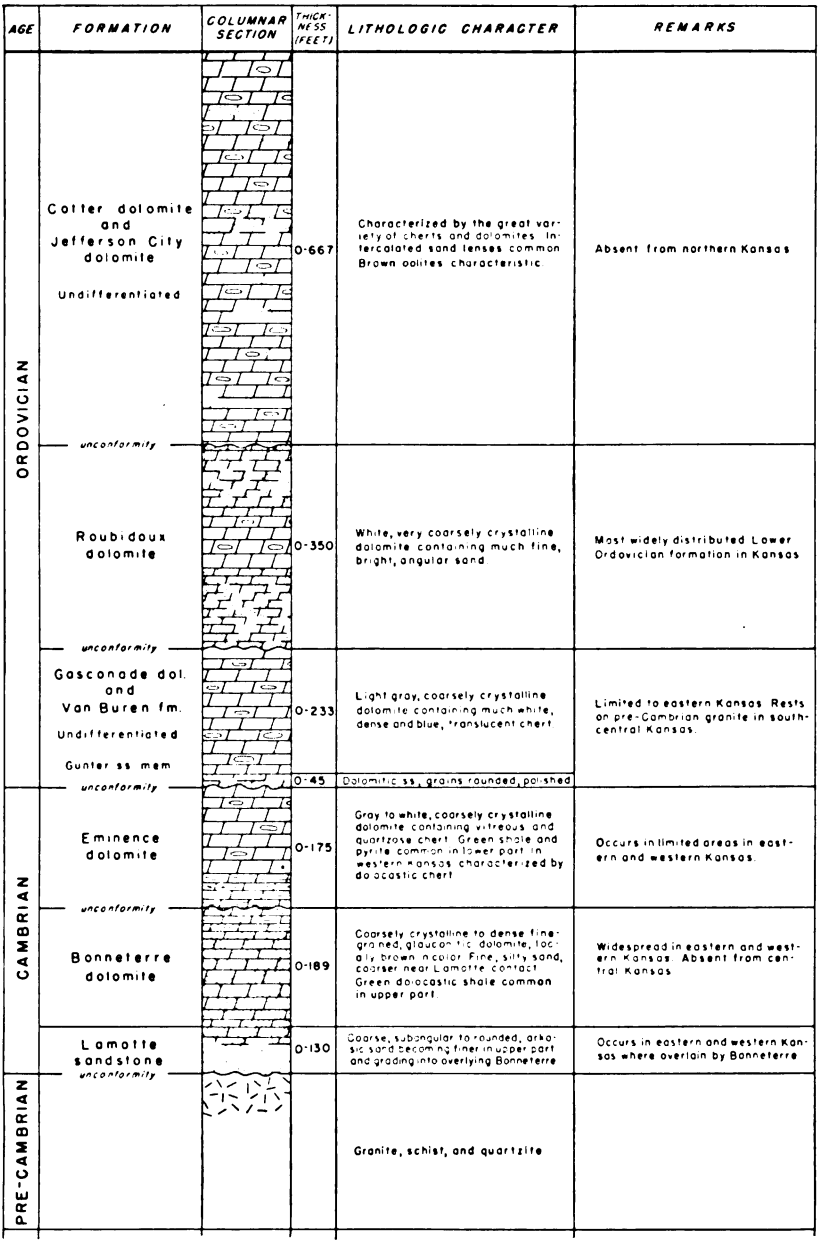

FIG. 2—Columnar section of Upper Cambrian and pre-St. Peter Lower Ordovician rocks in the subsurface of Kansas.

in the vicinity of Kansas City, the section thins to approximately 500 feet. In Richardson County, Nebraska, only 200 feet of these beds are present, and still farther north all Upper Cambrian and Lower Ordovician beds are absent in a well drilled at Nehawka, Nebraska (Condra, 1939, p. 12).

In south-central Kansas, Upper Cambrian and Lower Ordovician beds, exclusive of the St. Peter, are little more than 900 feet thick. The few wells in north-central Kansas that penetrate the entire thickness of Paleozoic rocks indicate a rapid northward thinning of the beds to less than 300 feet in Ottawa County. This measurement does not include 114 feet of quartzitic sand, probably of Pre-Cambrian age, at the bottom of one well. In the region of the Central Kansas uplift the thickness of these beds varies considerably from place to place as a result of local structural conditions. An average known thickness of 600 feet prevails in the west-central part of the State. In some areas that are structurally high, the beds are much thinner or locally absent. The thickness of Cambrian and Lower Ordovician beds in southwestern Kansas has not been determined owing to lack of sample information. However, the presence in this area of beds possibly equivalent to the Cotter dolomite, Powell dolomite, Smithville limestone, and perhaps younger beds suggests that the thickness of the sequence may increase considerably in that direction.

The Upper Cambrian and Lower Ordovician dolomitic sequence in Kansas here described is overlain by beds ranging in age from the Simpson group (Lower and Middle Ordovician) to the Pennsylvanian. Beds of the Simpson group immediately overlie this sequence throughout most of Kansas except in the structurally high areas of the Nemaha anticline, the Chautauqua arch, and the Central Kansas uplift. The Chattanooga shale and Mississippian rocks overlie the sequence of Upper Cambrian and Lower Ordovician rocks in the area of the Chatauqua arch in southeastern Kansas. Post-Mississippian removal of great thicknesses of the older beds from the crests of the Nemaha anticline and the Central Kansas uplift resulted in the deposition of Pennsylvanian sediments on the eroded surface of Upper Cambrian and Lower Ordovician rocks.

Upper Cambrian and Lower Ordovician rocks are within 500 feet of the surface in the southeastern part of the State. The

depth to the top of these formations increases westward to more than 6,000 feet.

Upper Cambrian Rocks

The Upper Cambrian sequence in Kansas comprises the Lamotte sandstone, the Bonneterre dolomite, and the Potosi and Eminence dolomites. The Davis formation and Derby and Doe Run dolomites are exposed at the surface in southeastern Missouri but are absent from large areas in the subsurface of western Missouri (McQueen, 1931, pp. 126-127), and they seemingly are not present in Kansas. The Proctor dolomite, a noncherty formation overlying the Eminence in Missouri, has not been recognized in Kansas.

LAMOTTE SANDSTONE

The Lamotte sandstone, which unconformably overlies much of the Pre-Cambrian surface, crops out in the St. Francois Mountain area of southeastern Missouri. There it consists of a brown to white, locally dolomitic sandstone. The sand grains are clear to frosted, and their shape is subangular to rounded. The base of the formation is conglomeratic, and in most places it is highly arkosic. The formation is finer grained in the middle and upper parts. The zone of transition into the overlying Bonneterre dolomite consists of alternating beds of sandstone and dolomite.

Lithology in Kansas.—A basal Paleozoic sandstone which lies unconformably upon Pre-Cambrian granite and metamorphic rocks is widespread in Kansas. Because it is overlain by beds ranging in age from Bonneterre to Roubidoux, Koester (1935, p. 1417) points out that it is a transgressive deposit of considerable continuity and of varying age. In this report, only that part of the basal sand in Kansas that is unconformable above the Pre-Cambrian granites and schists and conformable below the Bonneterre dolomite is correlated with the Lamotte sandstone of Missouri.

The Lamotte sandstone found in the Kansas subsurface lithologically resembles the Lamotte sandstone of Missouri in coarseness of grain, poor sorting, and relative purity. The average diameter of the sand grains is 1.5 mm, but angular quartz fragments 2.0 to 3.0 mm in diameter are common in the samples.

The large proportion of coarse sand grains may be due in part to loss of fine sand during drilling operations or during the washing of the cuttings. For the most part, the grains are rounded, frosted, or water polished, and minutely roughened and pitted. Clear, extremely angular grains, however, are abundant. Some of these seem to be the result of secondary quartz enlargement, as shown by quartz crystal faces and terminations.

Considerable arkosic material in the form of somewhat kaolinized pebbles of feldspar is present in the basal part of the formation. Pyrite in crystals and massive fragments is associated with the sand in many wells.

Distinguishing characteristics.—The basal part of the Lamotte sandstone is arkosic, which makes it difficult to determine its contact with the underlying granite in some wells. Flakes and needle-like fragments of broken quartz in samples from the base of the sandstone may represent a quartzitic phase of the Lamotte or they may represent a Pre-Cambrian quartzite. Loss through drilling of the softer feldspar constituents of granite may result in the production of cuttings resembling arkosic sand because of the seeming abundance of quartz.

The gradational contact of the Lamotte sandstone with the overlying Bonneterre dolomite is exhibited by two characteristics. (1) The size of the sand grains in the Lamotte sandstone decreases upward gradually. As a result, there is little contrast between the finest sand at the top of the Lamotte and the coarsest sand at the base of the Bonneterre. (2) Coarser sand grains, similar to those in the Lamotte sandstone, are incorporated in clusters of fine glauconitic sand of the Bonneterre. The distinction between the two formations is based upon the introduction and gradual increase in amount of dolomite and the introduction of a considerable amount of glauconite in the Bonneterre dolomite.

The use of drilling fluid that allows the admixture of more than a normal amount of extraneous material in the cuttings makes the separation of the Bonneterre dolomite and Lamotte sandstone difficult in many western Kansas wells. Bonneterre dolomite may be present in samples from the Lamotte sandstone, thus obscuring the relative purity of the sand. Moreover, glauconite from the overlying Bonneterre may contaminate the samples of the underlying sandstone.

Distribution and thickness.—The distribution of the Lamotte sandstone and its relation to younger basal Paleozoic deposits are shown in Figure 3. The Lamotte sandstone occurs in eastern Kansas in a broad curving belt parallel to the Kansas-Missouri state boundary, and in a less well-defined area in western Kansas. It is absent from an extensive area in the central part of the State (Fig. 3), except for 80 feet of sand overlain by typical Bonneterre dolomite in a well in southern McPherson County (well 16). It is absent also from wells in Kearny and Gove Counties and western Logan County.

Two interpretations of Figure 3 are possible.

(1) The Lamotte sandstone may have been deposited over the entire State and subsequently removed from central Kansas in pre-Roubidoux, pre-Van Buren, pre-Eminence, or possibly pre-Bonneterre time as a result of local upwarp across the central part of the State. This original widespread distribution of Lamotte and Bonneterre deposits would account for their occurrence in the well in McPherson County (well 16). Although such an interpretation is possible, some features of the relationship between the Lamotte and Bonneterre in Kansas indicate that it is open to question. Pre-Eminence erosion would account for absence of Lamotte from the central pre-Roubidoux granite "high" but it would not account for absence of Lamotte from those areas on the flanks of the pre-Roubidoux "highs" in central and far western Kansas where Bonneterre dolomite is the basal Paleozoic deposit. Removal of Lamotte from those areas by pre-Bonneterre erosion is contradicted by the gradational contact of the Lamotte and Bonneterre in areas where both are present.

(2) That the absence of Lamotte from the central Kansas "high" is due to overlap is suggested by the distribution of the basal Paleozoic beds. The Lamotte sandstone seems to have been deposited in basin areas in eastern and west-central Kansas. This was followed by deposition of the Bonneterre dolomite without a break in sedimentation, as indicated by the gradational contact of the two beds. Bonneterre sediments spread beyond the margins of Lamotte deposition onto the exposed Pre-Cambrian rocks, probably covering the central part of the State (later being removed by pre-Roubidoux erosion). This interpretation is further substantiated by the identification of thin sections of upper Bonneterre on the flanks of the central "high" (Greenwood County, well 15).

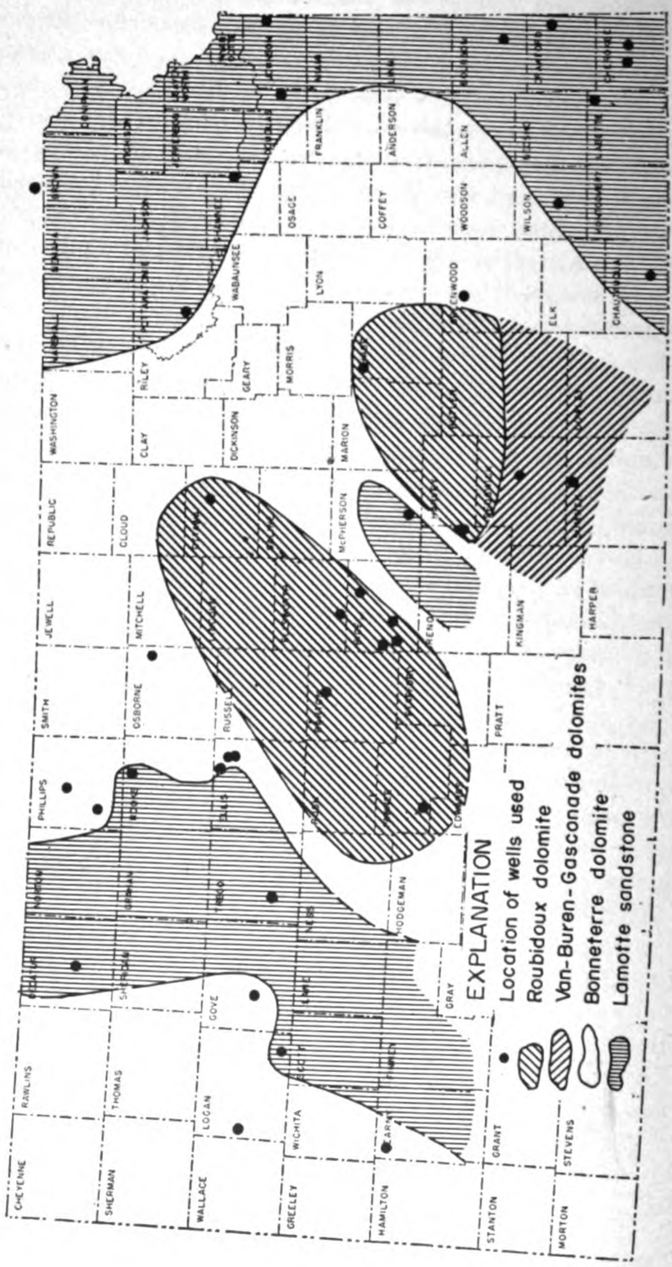

FIG. 3—Formations in contact with Pre-Cambrian surface in Kansas at the close of Cotter time.

The occurrence of Lamotte and Bonneterre deposits in the well in McPherson County (well 16) on the crest of the central "high," however, requires a special explanation if overlap is presumed. It is possible that a considerable thickness of Lamotte sandstone (80 feet is present in this well) could have been laid down in a local depression. It is probable that Bonneterre deposits were originally widely distributed throughout the State but were stripped by post-Bonneterre erosion from areas of greater elevation, as central Kansas is presumed to have been. If the area in McPherson County persisted as a local "low," a thick section of Bonneterre would remain.*

In eastern Kansas a maximum thickness of 130 feet of Lamotte sandstone was noted in eastern Crawford County. In western Kansas a maximum thickness of 70 feet was noted in northern Rooks County. Although the thickness of the Lamotte sandstone varies locally as a result of irregularities of the Pre-Cambrian surface upon which it was deposited, there is, in eastern Kansas, a general thinning of the Lamotte sandstone westward. In the central uplift area it is overlapped by the Bonneterre dolomite or grades into it.

BONNETERRE DOLOMITE

The Bonneterre dolomite is exposed at the surface in the St. Francois Mountain region of southeastern Missouri and has been found by deep drilling throughout most of Missouri. It consists of a light to dark, finely crystalline dolomite with thin partings of light-green and brown shale. The insoluble residues, as determined by McQueen (1931, pp. 111-112), consist of angular, extremely fine-grained, well-indurated, glauconitic sandstone or

*It is easy to over-emphasize the meaning of the presence or absence of Lamotte, which is thin in most wells. There are only seven wells drilled through the Bonneterre in which the Bonneterre is not underlain by Lamotte. On the Pre-Cambrian surface the Lamotte would be absent on hills or divides in the same way that Pennsylvanian basal conglomerate is locally absent in areas of topographic elevation. Well 21 of cross section B-B′ shows no Lamotte but wells 20 and 22 on either side do have Lamotte. The occurrence of an important Pre-Cambrian divide in central Kansas in any part of Late Cambrian time seems doubtful.

Pre-Van Buren and pre-Roubidoux erosion were active enough to bevel the older rocks on the flanks of the areas of uplift (so-called Pre-Cambrian "high") and would in any case have stripped off any rocks from the crests.

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siltstone with green and brown dolocastic shale in the upper part of the formation.

Lithology in Kansas.—The Bonneterre dolomite in eastern Kansas is medium finely crystalline and commonly dark gray or brown. In northeastern and western Kansas the dolomite generally is buff to white and coarsely crystalline. In wells in Phillips, Rooks, and Decatur Counties the dolomite is pink, red, and red brown, probably due to the inclusion of ferruginous material. Ulrich and Bain (1905, pp. 21-26) describe beds in the Bonneterre dolomite in Missouri that are pink or decidedly red.

Residues from the Bonneterre dolomite of eastern Kansas grade upward from a coarse-grained, angular, relatively pure sand to an extremely fine silty sand. In the basal part of the formation the sand grains average 0.6 mm in diameter. The sand occurs both free and in loosely cemented clusters associated with large glauconite grains, some of which are 1.0 mm or more in diameter. Above this basal part is a zone of medium-fine bright angular sand in clusters associated with finer grains of glauconite (Pl. 1A). Upward, there is a gradual increase in the amount of brown porous silt in the residues, which gives the sand a spongy texture. The uppermost part of the Bonneterre is characterized by a dark-brown finely dolocastic spongy-appearing shale. Less glauconite is present in the shaly part of the residues.

Residues from wells in Shawnee, Douglas, Linn, and McPherson Counties (wells 32, 30, 24, and 16) are composed of bright-green waxy shale with scattered dolocasts, associated with spongy masses of pyrite. These residues may represent an upper shaly phase of the Bonneterre dolomite or they may represent the base of the Eminence dolomite.

Residues from the Bonneterre dolomite in western Kansas are composed of sand grains that are subrounded, dull, polished, and somewhat pitted. Coarse bright very angular grains showing secondary quartz enlargement also are present. Although the sand is rather poorly sorted there is a general upward gradation from coarse rounded grains to fine more angular grains. The poor sorting may be due in part to contamination of samples from wells drilled with rotary tools. Coarse rounded fragments of feldspathic material occur in the basal part of the formation, particularly in those wells where Lamotte sandstone is absent. Associated with the sand is a considerable mass of large smooth

rounded grains of glauconite, in some samples as much as 50 percent of the residue. Spongy and massive pyrite, flecks of brown spongy and green dolocastic shale, and scattered flakes of mica are present also.

The coarse rounded grains of sand and glauconite are conspicuous in the dolomite, particularly in the basal part. In some places, these rocks may be described more accurately as dolomitic glauconitic coarse sandstone.

The coarse grain size and feldspathic content of the sand, the heavy glauconite content, the scattered mica flakes, and the red color of the dolomite found in the Bonneterre deposits in western Kansas are similar to the red-brown glauconitic quartzite and sandstone of the Deadwood formation and Sawatch quartzite of the Rocky Mountain area.

Beds of Bonneterre age are absent over a broad region in the central third of the State, except for a remnant in southern McPherson County. The absence of the formation in this area makes it impossible to trace the Bonneterre dolomite across Kansas from east to west. Correlation must therefore be based upon similarities of the insoluble residues and upon the stratigraphic position of the Bonneterre dolomite with relation to beds that can be traced.

The similarities in the residues from these beds in eastern and western Kansas are: (1) prominence of sand as a constituent of the insoluble material; (2) gradual decrease upward in size of sand grains; (3) presence of much brown to green, commonly dolocastic shale, particularly in the upper part of the formation; and (4) presence of glauconite as a major constituent, which in Kansas seems to be limited to the Bonneterre deposits.

Dissimilarities in the residues of the Bonneterre in the separated areas lie in the size and degree of rounding of the sand grains. Those in the western part of the State are coarse, rounded, dull, polished, pitted, and somewhat feldspathic as contrasted with the very fine bright angular silty sand found in the eastern part of the State.

Stratigraphic relations.—The Bonneterre dolomite is underlain by the Lamotte sandstone in the extreme eastern and western parts of the State. Toward the central uplift area (Fig. 3) the Lamotte sandstone is absent and the Bonneterre dolomite overlaps onto the Pre-Cambrian granite. Bonneterre dolomite also

rests on granite along the crest of a locally high area in Kearny County and western Logan County.

The relationship of the Bonneterre dolomite to younger, more widely distributed beds is shown by means of cross sections in Figures 10 to 13. Beds ranging in age from Eminence to Roubidoux overlie the Bonneterre dolomite. Throughout most of eastern Kansas the Bonneterre dolomite is overlain by the Eminence dolomite. In a well in Richardson County, Nebraska (well 41), the Roubidoux rests on the Bonneterre dolomite.

In western Kansas, the Bonneterre dolomite is overlain by sandy Roubidoux dolomite, except in an area centering around Logan, Gove, and Trego Counties, where it is overlain by cherty Eminence dolomite.

Distinguishing characteristics.—In places where the Bonneterre dolomite is underlain by the Lamotte sandstone, the contact is gradational and differentiation is based on an increased percentage of dolomite, somewhat finer more angular sand, and the presence of glauconite in the samples of the Bonneterre dolomite.

Separation of the Bonneterre dolomite from the overlying Eminence dolomite and the Van Buren-Gasconade sequence is based upon the contact of the dark-colored dolomite of the Bonneterre with the light-colored dolomite of the higher beds, and the contact of the silty sand residue of the Bonneterre dolomite with the dominantly cherty residue of the overlying formations. The extremely fine brown silty sand of the upper part of the Bonneterre dolomite is easily distinguished from the rounded, well-sorted, secondarily enlarged, relatively coarse sand of the Gunter sandstone member of the Van Buren formation.

In central and western Kansas where the Bonneterre deposits are overlain by a sandy dolomite of Roubidoux age, the separation of these beds is difficult. The contact is marked by a change from the coarse rounded pitted sand residue characteristic of the Bonneterre dolomite in this area to a fine bright angular sand residue of the Roubidoux dolomite, and by the absence of glauconite from the Roubidoux dolomite. No distinct and consistent change in the dolomites is noted.

Distribution and thickness.—The distribution and thickness of the Bonneterre dolomite in the subsurface of Kansas are shown by Figure 4, an isopachous map. Bonneterre dolomite is present

in eastern and western Kansas but is absent from parts of central Kansas where no beds older than Roubidoux have been found.

The maximum thickness of Bonneterre in eastern Kansas is 198 feet, noted in a well in eastern Crawford County (well 13). The formation becomes thinner to the north. It is 90 feet thick in Shawnee and Douglas Counties, Kansas, and 70 feet thick in Richardson County, Nebraska. The Bonneterre dolomite wedges out to the west against the central uplift area. Whether this wedging out is due to overlap on a high area over which Bonneterre sediments were not deposited or whether it was deposited over the area and later removed is problematical.

In western Kansas, a maximum thickness of 125 feet of Bonneterre dolomite is present in a well in southwestern Phillips County (well 48). Northward, thinning is indicated by the presence of only 96 feet of these beds in northern Phillips County (well 36) and 66 feet in Decatur County (well 37). Thinned sections of Bonneterre found in wells in Kearny County and western Logan County probably are reflections of a local area of considerable elevation at the beginning of Cambrian time. It is probable that the Bonneterre dolomite thickens to the south but lack of evidence prevents the determination of its distribution, thickness, or lithology in this area.

POTOSI AND EMINENCE DOLOMITES

In Missouri the Bonneterre dolomite is overlain by a section of cherty dolomite that includes, in ascending order, the Potosi dolomite and the Eminence dolomite. The noncherty Proctor dolomite overlies the Eminence. The bulk of the material found between the Bonneterre dolomite and the Gunter sandstone member of the Van Buren in Kansas probably correlates with the Eminence dolomite of Missouri. There is considerable question regarding the relationship between the Eminence and Proctor dolomites in the Ozark region. The Proctor, if present in Kansas, is included with the Eminence.

The Potosi dolomite crops out in the St. Francois Mountain area of southeastern Missouri where it consists of a dark-brown dolomite containing numerous quartz druses. McQueen (1931, pp. 114-115) found that these druses, mostly brown, are the principal constituent of the insoluble residues from the Potosi

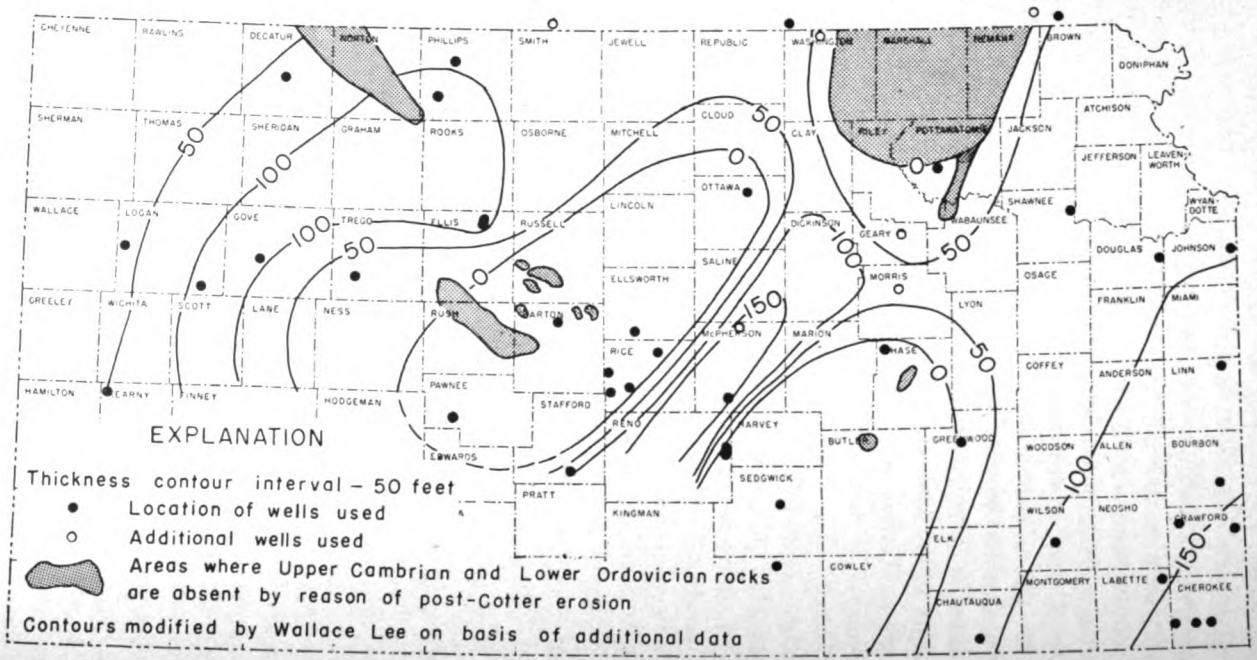

FIG. 4—Thickness of the Bonneterre dolomite in Kansas at the close of Early Ordovician time.

dolomite. This formation is missing from large areas in the subsurface of western Missouri (McQueen, 1931, p. 127), although it is reported to be 35 feet thick in Cass and Jackson Counties (Clair, 1943, p. 34). It seems to be absent from most of the Kansas subsurface. Dark-brown coarsely crystalline dolomite 16 feet thick at the contact of the Eminence and Bonneterre dolomites in the No. 1 Clark well in Cherokee County (well 3) is associated with an insoluble residue of drusy brown chert and may be of Potosi age (Pl. 1 B).

The Eminence dolomite is exposed at the surface in southeastern Missouri where it is gray to almost white, coarsely crystalline, and massively bedded, and contains thin partings of green shale and thin nonpersistent lenses of sandstone. McQueen (1931, pp. 115-116) described the insoluble residues from the Eminence as containing a considerable percentage of white to light bluish-gray very vitreous and quartzose chert and fine dolocastic lacelike chert. Oölites coated with drusy quartz occur in some zones.

In Jackson and Cass Counties of western Missouri, Clair (1943, p. 34) describes the Eminence in the subsurface as a "relatively non-cherty dolomite the insoluble content averaging less than 10 percent. . . . The chert is waxy gray quartzose, slightly oölitic and dolocastic. . . . The lower 100 feet of Eminence contains a green shale residue with some rounded sand."

Lithology in Kansas.—The dolomite of the Eminence in Kansas is consistently buff to white and very coarsely crystalline. The light color and coarse texture are in sharp contrast to the gray or brown dolomite of the underlying Bonneterre but are nearly indistinguishable from the light-colored dolomites of the overlying Van Buren and Gasconade formations.

The predominant constituent of the insoluble residues from the Eminence dolomite in eastern Kansas is a blue to white semitranslucent chert with a vitreous glassy luster (Pl. 2 A). Many fragments are incrusted with crystalline quartz. Drusy quartz, angular fragments of milky quartz, and dark-gray granular silica are common in the residues. Much lacelike dolocastic chert is associated with the quartzose chert. The dolocastic chert is characterized by the large size of the casts and thin chert walls. The cherty matrix is white and commonly soft and tripolitic. The combination of very fine casts and a soft tripolitic chert matrix

causes some of the dolocastic chert to be porous and spongy rather than lacy. Traces of fine angular sand grains less than 0.1 mm in diameter occur sparingly in the samples. Flecks of bright-green smooth waxy shale probably represent thin shale partings. Pyrite occurs in considerable amount, commonly in spongy masses, but also in aggregates of fine crystals. Clusters of small smooth pyrite balls were noted in several wells. The occurrence of a considerable amount of arkosic material in the basal part of the Eminence dolomite in some wells in eastern Kansas is especially noteworthy. Rounded and somewhat weathered fragments of feldspar in Eminence residues were found in wells in Chautauqua, Labette, Cherokee, and Douglas Counties. This implies pre-Eminence exposure of Pre-Cambrian rocks in areas not far distant.

In western Kansas in wells drilled in Logan, Gove, and Trego Counties, the cherty dolomite of the Eminence overlies sandy dolomite beds that are correlated with the Bonneterre dolomite and underlies beds that are correlated with the Roubidoux dolomite.

The Eminence dolomite is light buff and medium coarsely crystalline. The insoluble residues consist predominantly of soft brown to white fine to coarsely dolocastic chert (Pl. 2 B). Flecks of bright-green shale and a considerable amount of spongy pyrite are associated with the chert in the residues.

Stratigraphic relations and distinguishing characteristics.—In Kansas the Eminence dolomite is underlain by the Bonneterre dolomite from which it may be distinguished by characteristics of both the dolomite and the insoluble residue. In southeastern Kansas, where the Bonneterre dolomite is characterically dark, the light color of the Eminence dolomite is in sharp contrast. Elsewhere in the State the differentiation must be based on the character of the insoluble residues. The Bonneterre residue is typically a glauconitic silty sand with little or no chert, whereas that of the Eminence dolomite is composed of quartzose and dolocastic chert. In those areas (Linn, Douglas, Shawnee, and McPherson Counties) where the residue is composed of minute amounts of green shale, spongy pyrite, and sand grains, it is difficult to determine whether the beds represent the Eminence or an upper shaly phase of the Bonneterre.

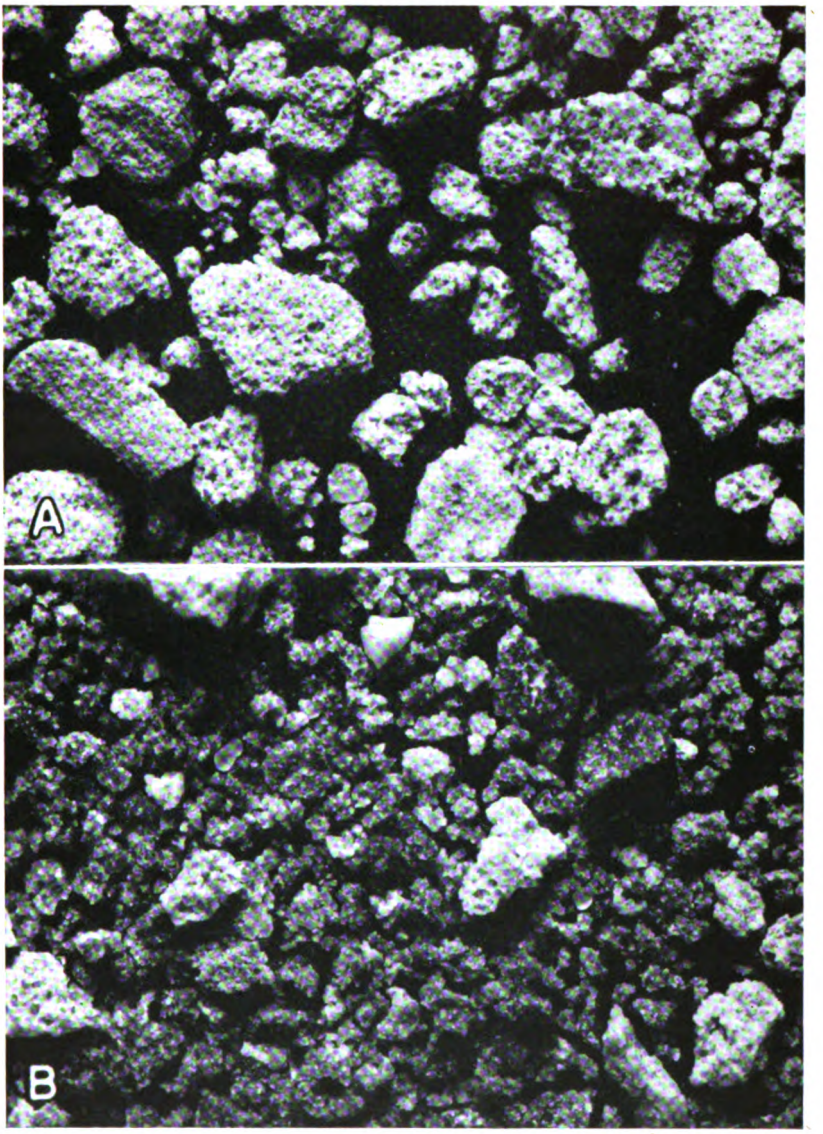

PLATE 1. Insoluble residues from the Bonneterre dolomite and the Eminence dolomite. *A*, Insoluble residue of the Bonneterre dolomite, consisting of loosely cemented clusters of medium fine glauconitic sand (x10). The sample is from the La Salle Oil Co. No. 1 Gobl well, SE cor. NW¼ sec. 20, T. 28 S., R. 25 E., Crawford County, Kansas, from a depth of 1687-90 feet. *B*, Brown quartzose druse which may represent the Potosi dolomite at the contact of the Eminence dolomite with the Bonneterre dolomite (x10). The light-colored fragments are Bonneterre sand aggregates. The sample is from the No. 1 Clark well, sec. 13, T. 33 S., R. 21 E., Cherokee County, Kansas, from a depth of 1669-74 feet.

The Van Buren-Gasconade sequence overlies the Eminence dolomite in eastern Kansas. The light-colored dolomite of the sequence is not consistently distinguishable from the Eminence. The quartz-encrusted cherts of the lower part of the Van Buren and Gasconade deposits are similar to the quartzose cherts of the Eminence. The well-defined Gunter sandstone member at the base of the Van Buren formation is the most reliable marker. In western Kansas the Eminence residues consist almost entirely of dolocastic chert, which affords a basis for distinguishing that formation easily from the overlying Roubidoux dolomite.

Distribution and thickness.—The Eminence dolomite is present in eastern and western Kansas, as shown by Figure 5. It was observed to be 172 feet thick in a well in eastern Crawford County (well 13) and 175 feet thick in eastern Douglas County (well 30). This represents the maximum development of the Eminence dolomite in Kansas. The beds thin rapidly to the west and wedge out against the central uplift area in which no beds older than Roubidoux have been recognized. In western Kansas the thickness of the Eminence ranges from 55 to 87 feet in Logan, Gove, and Trego Counties. The beds seemingly thin to the north and are absent from a well in Decatur County (well 37). The presence of Eminence dolomite in southwestern Kansas cannot be ascertained because well information is lacking. The absence of Eminence dolomite from the well in Kearny County (well 12) and slight thinning in western Logan County (well 23) reflect a local high area that is also reflected by the absence of the Lamotte sandstone and by the thinning of Bonneterre deposits in that region.

With the exception of dolomite and green shale 35 feet thick in a McPherson County well (well 16), no Eminence sediments are known throughout an extensive area in the central part of the State. Its absence in this area may be the result of nondeposition over the central uplift area, or of post-Eminence removal by erosion.

Lower Ordovician Rocks

The Lower Ordovician rocks in Kansas, exclusive of the St. Peter sandstone, or the Simpson sequence, comprise the Van Buren-Gasconade sequence, the Roubidoux dolomite, and the Jefferson City-Cotter sequence.

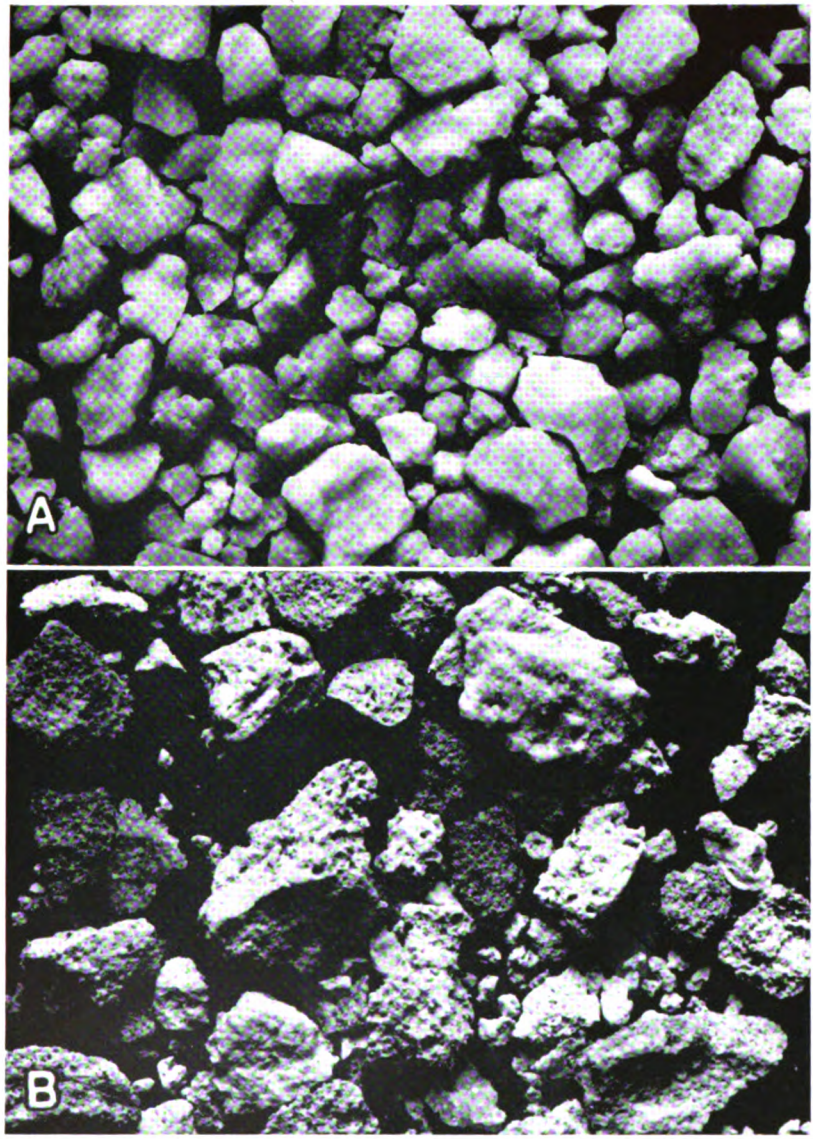

PLATE 2. Insoluble residues from the Eminence dolomite. *A*, White to blue semitranslucent vitreous to quartzose chert characteristic of the Eminence dolomite in eastern Kansas (x10). This sample is from the No. 1 Clark well, sec. 13, T. 33 S., R. 21 E., Cherokee County, Kansas, from a depth of 1569-75 feet. *B*, White to brown soft crumbly dolocastic chert characteristic of the Eminence dolomite in western Kansas (x10). This sample is from the Morgan, Flynn and Cobb No. 1 McMillen well, Cen. NW¼ sec. 9, T. 13 S., R. 37 W., Logan County, Kansas, from a depth of 5350 feet.

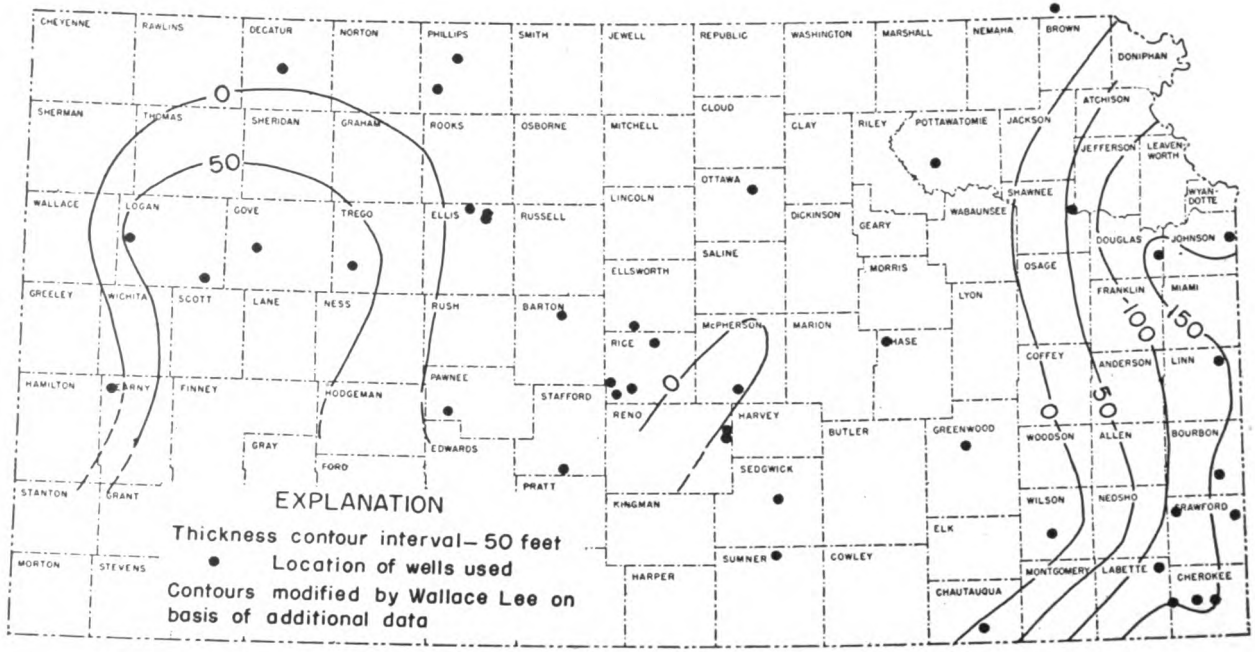

FIG. 5—Thickness of the Eminence dolomite in Kansas.

VAN BUREN-GASCONADE SEQUENCE

The Eminence dolomite is overlain by a section of cherty dolomite which in Missouri includes the Van Buren formation, with the Gunter sandstone member at the base, and the Gasconade dolomite. These formations crop out in Missouri along the Osage and Niangua Rivers and in the deeper valleys of the Ozark Plateau. Deep drilling has shown their presence throughout the southern part of the State.

The base of the Van Buren-Gasconade sequence is marked by the persistent Gunter sandstone member of the Van Buren, which is the basal Ordovician deposit in this area. The Gunter sandstone of Kansas may be younger than the Gunter sandstone of Missouri. The thickness of the sandstone varies from place to place, ranging from 2 feet to at least 35 feet, as a result of the unconformable surface upon which it was deposited and also as a result of lateral intergradation with dolomite. At the outcrop the sandstone is generally rather thin-bedded and shows numerous ripple marks and much cross bedding. In Kansas the Gunter grades into the overlying dolomite of the formation.

At the outcrop, the Van Buren-Gasconade dolomitic sequence is light gray to nearly white and fine grained at the base. It becomes more massive and coarser grained in the upper part and has thin partings of green shale and occasional intercalated lenses of sandstone. A dense earthy "cotton rock" is common near the base of the Van Buren formation.

The Van Buren formation and Gasconade dolomite, which were distinguished from each other at the outcrop by paleontological evidence, have been differentiated in the subsurface by McQueen (1931, pp. 117-120) on the basis of insoluble residues, but it has not been possible to provide accurate and persistent criteria for correlating these beds individually in the subsurface of Kansas. Accordingly, the two formations are grouped as a unit.

Lithology of the Gunter sandstone member in Kansas.—In Kansas, the Gunter sandstone member is a sandy dolomite rather than a pure sand. Insoluble material ranges from less than 10 to more than 50 percent of the sample. The dolomite commonly is dark gray and more fine grained than that of either the underlying Eminence or the overlying Van Buren-Gasconade units.

In Kansas, as in Missouri, the sand of the Gunter seems to be sorted into two distinct sizes. Coarse grains range from 1.0 to 0.6 mm in diameter; fine grains range from 0.3 to 0.1 mm in diameter; there are few intermediate-sized grains. For the most part the grains are rounded, some being almost perfectly spherical. Even the smallest grains are subrounded. The surfaces are highly frosted or polished to a dull luster, and minutely pitted. Bright angular grains, both coarse and fine, are present in the sand in nearly every well as the result of secondary quartz enlargement.

The Gunter in Cherokee County (well 1) is represented by a residue composed of sand grains in a cherty matrix. The sand grains are of pure clear quartz; in the samples these are broken across the grains due to the impact in drilling. The chert matrix is white, dense, and somewhat quartzose. Free sand and sand grains in chert of the Gunter sandstone member are shown in Plate 5 B.

In Sedgwick and Sumner Counties the Gunter is the first sedimentary bed above the Pre-Cambrian surface and seemingly is the basal Paleozoic deposit (Fig. 3). In a Sedgwick County well (well 7) the Gunter is 53 feet thick and consists of very coarse angular quartz fragments and quartz sand grains, averaging 2.0 mm in diameter, immediately above the weathered surface of the granite. Approximately 15 feet above the granite the grains are smaller, averaging 1.0 mm in diameter. A considerable amount of bright-green fissile waxy shale is introduced 25 feet above the granite, in amount equal to 50 percent of the sample. These constituents may indicate a change in sedimentation during Gunter time or they may be merely shale caved from Simpson rocks higher in the well.

The presence of relatively unweathered feldspar at the base of the Gunter at the contact with the Bonneterre dolomite in the well in Wilson County (well 14) is of interest in connection with the occurrence of the Gunter as the oldest bed above Pre-Cambrian in wells to the west (wells 5 and 6 of cross section A-A').

In summary, the Gunter sandstone member in the Kansas subsurface resembles the Missouri equivalent in (1) the sorting of the sand grains into coarse and fine sizes, with few intermediate-size grains, (2) the high degree of rounding of the grains,

(3) the polished and frosted surfaces of the sand grains, and (4) the considerable amount of secondary quartz enlargement.

Thickness of the Gunter sandstone member.—The average thickness of the Gunter sandstone member in the subsurface of Kansas is 10 feet. This member probably is represented in the 46 feet of sandy, somewhat cherty dolomite found in the Holeman and Edwards No. 9 Pollman well (well 24) in Linn County, but the contact with the overlying Van Buren formation and Gasconade dolomite is indefinite. Twenty-two feet of Gunter sandstone was noted in a Wilson County well (well 14) resting on sandy Bonneterre dolomite. Increased thicknesses of Gunter were noted in wells in which the Gunter sandstone rested on Pre-Cambrian granite. Thus, wells in Sumner and Sedgwick Counties (wells 6 and 7) penetrated Gunter sandstone 48 and 53 feet thick, respectively.

Lithology of the Van Buren-Gasconade sequence in Kansas.—The dolomite of the Van Buren-Gasconade sequence as found in the subsurface of Kansas is white to light gray and is very coarsely crystalline, resembling that of the overlying Roubidoux dolomite. Zones of darker gray and more finely crystalline dolomite are interbedded with the light dolomite, but the darker zones seem to be local in distribution and are not traceable laterally for even short distances.

The amount of insoluble material from the Van Buren formation and Gasconade dolomite generally is large, averaging 25 percent of the sample. The chert types are similar to those that characterize these formations in Missouri. A white dense smooth somewhat porcelaneous chert having a dull to vitreous luster is more common in the lower half of the section but is not limited to that part (Pl. 3 B). This may represent the equivalent of the Van Buren formation of Missouri. A chert that is very similar but more bluish translucent and with a vitreous to almost glassy luster (Pl. 3 A) is more common in the upper half of the section. It may represent the equivalent of the Gasconade dolomite of Missouri.

There seem to be few distinctive chert zones within the Van Buren-Gasconade sequence that can be traced for distances of more than a few miles. Immediately above the Gunter sandstone member of the Van Buren the chert is white, dense, and porcelaneous. Many of the chert fragments are encrusted with quartz

crystals and contain veinlets of crystalline quartz. Oölites occur in the chert in wells in Cherokee and Linn Counties approximately 50 feet above the contact with the Gunter. The oölites are brown, large, and translucent in the Holeman and Edwards No. 9 Pollman well in Linn County (well 24). White oölites that are somewhat translucent and therefore very difficult to distinguish from the cherty matrix occur in the Glower No. 1 Forkner well in Cherokee County (well 2). The oölites seem to be broken across the diameter and are seen in section in the chert matrix.

A persistent zone of dolocastic chert in the lower 50 to 75 feet of the Van Buren formation in Missouri was described by McQueen (1931, p. 118). In Kansas, dolocastic chert occurs above the oölitic zone in wells in Labette and Linn Counties. The casts are large and the walls thick. Dolocastic semiquartzose chert casts up to 0.4 mm in diameter lie immediately above the Gunter sandstone member of the Van Buren in a Crawford County well. The dolocastic chert is associated with much crystalline quartz and angular fragments of quartz crystals. In Cherokee County a zone of tripolitic chert lies above the oölitic zone. A sandstone with poorly sorted, rounded, and frosted grains up to 0.8 mm in diameter and fine bright angular grains 0.1 mm in diameter, occupies the zone above the oölites in a Chautauqua County well (well 4). The tripolitic and dolocastic chert is overlain by a section of alternating beds of white dense porcelaneous chert and bluish semitranslucent chert. Fragments of dark-gray granular crystalline quartz are associated with the chert.

In Sedgwick and Sumner Counties where the Van Buren-Gasconade sequence is the oldest unit above the Pre-Cambrian granite, the chert is white to bluish and semitranslucent. Oölitic, dolocastic, and tripolitic cherts are absent.

Stratigraphic relations and distinguishing characteristics.— The Van Buren-Gasconade sequence rests unconformably upon each of the older formations. In its most typical development in eastern Kansas, this sequence rests on the Eminence dolomite. The absence of Eminence dolomite from the No. 3 Smith well in Wilson County (well 14) allows the Van Buren-Gasconade sequence to rest on upper beds of the Bonneterre dolomite. The cherty dolomite of the Van Buren-Gasconade sequence in Sedgwick and Sumner Counties overlies the Pre-Cambrian rocks (wells 6 and 7).

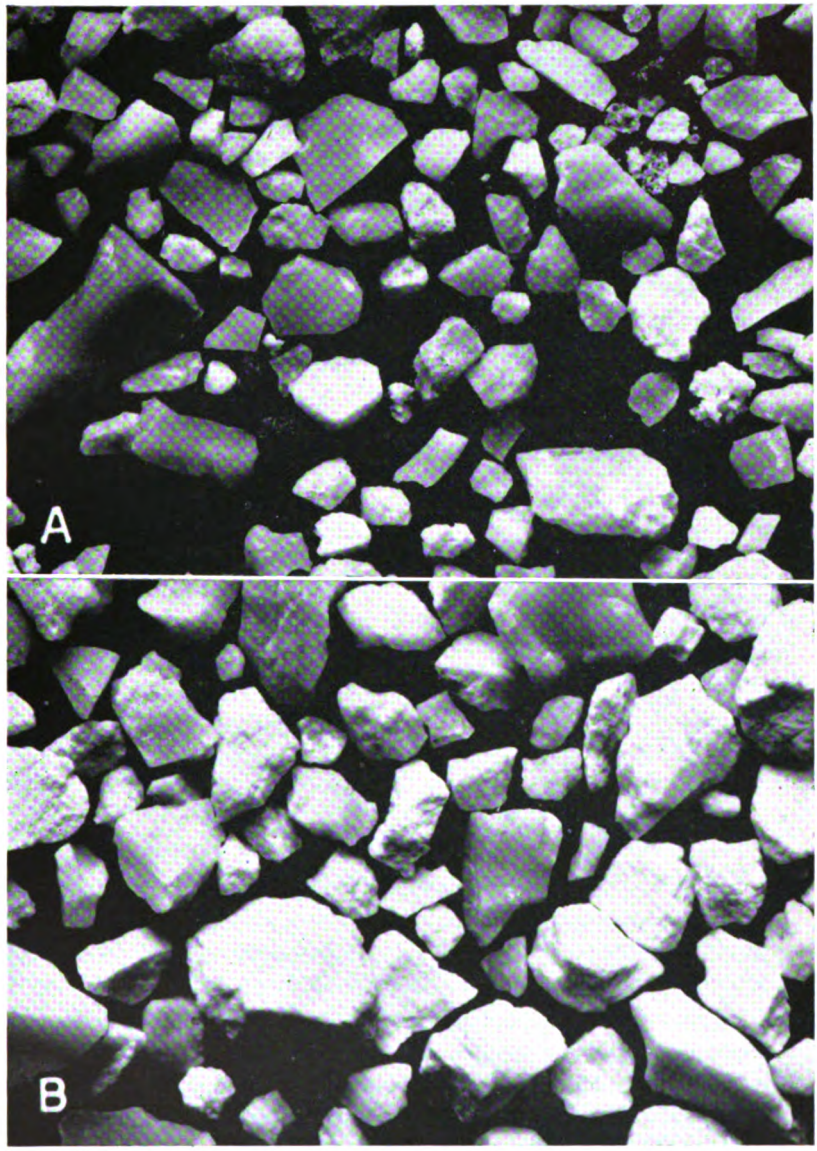

PLATE 3. Insoluble residues from the Van Buren-Gasconade sequence. *A*, Blue to tan translucent vitreous chert characteristic of the Van Buren-Gasconade sequence (x10). This sample is from the No. 1 Clark well, sec. 13, T. 33 S., R. 21 E., Cherokee County, Kansas, from a depth of 1467-72 feet. *B*, White dense smooth to rough chert characteristic of the Van Buren-Gasconade sequence (x10). This sample is from the No. 1 Clark well, sec. 13, T. 33 S., R. 21 E., Cherokee County, Kansas, from a depth of 1320-27 feet.

In addition to characteristic rounding and sorting of grains, the Gunter sandstone member of the Van Buren may be distinguished from other sandstone of Late Cambrian and Early Ordovician age by its position below the more easily recognized Van Buren-Gasconade unit. In areas where they rest on the Eminence dolomite, cherts of the Van Buren and Gasconade are found to be less quartzose than those of the Eminence dolomite. In addition, the green shale common to the Eminence dolomite in some wells is absent from the Van Buren-Gasconade dolomitic sequence. In the Wilson County well (well 14) in which the Van Buren-Gasconade dolomitic sequence rests on Bonneterre dolomite, the separation is based on the change from the fine silty sand residue of the Bonneterre to the coarser, rounded, or secondarily enlarged sand grains of the Gunter which is somewhat arkosic in this area.

Distribution and thickness.—The distribution of the Van Buren-Gasconade sequence in Kansas is shown by Figure 6. The area of greatest thickness lies in the extreme southeastern corner of the State. One well in eastern Crawford County (well 13), two wells in Cherokee County (wells 1 and 2), and one well in Wilson County (well 14) contain more than 200 feet of these beds. In northeastern Kansas the Duffens No. 1 Stanley well in Douglas County (well 30) also has slightly more than 200 feet of the Van Buren-Gasconade deposits. To the north, the section thins to 90 feet, noted in the Forrester No. 1 Hummer well in Shawnee County (well 32), and it is absent from the Pawnee Royalty Company No. 1 Meyer well in Richardson County, Nebraska (well 41).

In the central part of the State the Van Buren-Gasconade unit seemingly wedges out by overlap or by beveling against a high area in which no beds older than Roubidoux have been encountered.

The formation seemingly was prevented from being deposited in western Kansas by the granitic "high" in the central part of the State or by pre-Roubidoux regional elevation and erosion of the western part of the State. No Van Buren or Gasconade deposits were found in wells studied in western Kansas, even in basin areas. Its presence or absence in the southwestern part of the State cannot be ascertained because sample data are lacking.

The western limit of the Van Buren-Gasconade sequence is indicated by its absence from wells in Pottawatomie and Chase Counties and from wells west of McPherson County, Kansas.

ROUBIDOUX DOLOMITE

The Roubidoux crops out over much of the central and northwestern parts of the Ozark Plateau, where it consists of massive beds of sandstone near the top and base and beds of cherty dolomite in the middle. According to Lee (1914, pp 21-22) the exposed dolomite at the base of the Roubidoux is lithologically similar to that of the underlying Gasconade dolomite, whereas the beds at the top contain cotton rock and closely resemble beds in the Jefferson City dolomite.

In the Kansas subsurface the limits of the Roubidoux dolomite arbitrarily are placed at the lower and upper limits of the more or less homogeneous section of sandy dolomite. The subsurface boundaries described here are, therefore, not necessarily the same as those at the surface. Cherty dolomites at the base, if present, are included in the Gasconade dolomite; if present at the top of the formation, they are included in the overlying Jefferson City and Cotter dolomites.

Lithology in Kansas.—In Kansas, the Roubidoux dolomite consists of sandy dolomite and fine subangular sand, with cherty dolomites near the middle of the formation in some areas.

For the most part, the arenaceous character of the dolomite is not obvious in untreated samples. In both eastern and western Kansas, the Roubidoux dolomite is characteristically white and very coarsely crystalline. Coarse rhombs of dolomite are prominent near the base of the formation, becoming more finely crystalline upward.

In northeastern Kansas, brown medium coarsely crystalline dolomite occupies a zone averaging 40 feet thick near the contact with the Jefferson City and Cotter dolomites, as shown by wells in Shawnee, Jefferson, Douglas, Linn, and Bourbon Counties. In the western part of the State, variations from the typical white coarsely crystalline dolomite were noted in several wells. The dolomite throughout the Roubidoux in the Osborne County well (well 26) is medium dark brown. A distinct pink color characterizes the dolomite in wells in Phillips and Rooks Counties. (It should be remembered that the Bonneterre dolomite in these wells also is pink or red.) In Lane, Logan, and Gove Counties the tan to buff medium to coarsely crystalline dolomite of the Roubidoux dolomite is indistinguishable from that of the overlying Jefferson City and Cotter dolomites.

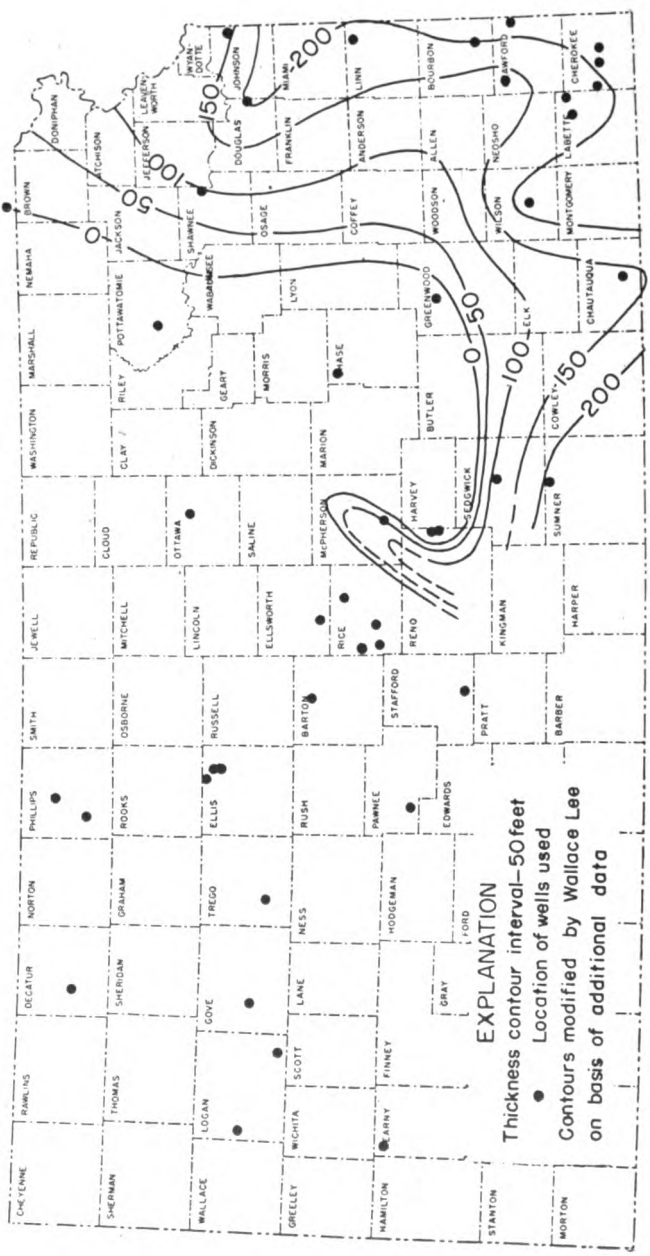

Fig. 6—Thickness of the Van Buren-Gasconade sequence in Kansas.

The insoluble residues of the Roubidoux dolomite range in amount from less than 5 percent to as much as 80 percent of the sample. The insoluble residues are strikingly alike over the entire State. In Kansas, as in Missouri, the principal constituent is clean white sand. In eastern Kansas the sand is fairly well sorted and the individual grains range in size from slightly more than 1.0 to less than 0.1 mm in diameter (Pl. 4 A). In western Kansas the grains average somewhat larger and the sand commonly is very poorly sorted. Coarse sand grains caved from higher beds may be responsible, in part, for the wide range in grain size (Pl. 4 B). In both eastern and western Kansas the larger grains are rounded, polished, or frosted and, in some cases, minutely pitted. Some of the larger grains, however, are bright and angular as the result of secondary quartz enlargement. Grains less than 0.2 mm in diameter are unfrosted and angular. Quartz crystal faces and striae on sand grains, indicative of secondary quartz enlargement, are characteristic of sand of the Roubidoux in Kansas as in Missouri. Doubly terminated quartz crystals and aggregates of crystalline quartz associated with the sand were noted in some residues.

In several wells in southeastern Kansas, the Roubidoux is composed of two sand or sandy dolomite members separated by a bed of cherty dolomite near the middle of the formation. In wells where the cherty zone is absent the Roubidoux formation is recognized by increasing percentages of sand in the residues at two distinct zones within the formation.

The chert of the middle zone closely resembles some of that found in the underlying Gasconade dolomite. White dense to bluish translucent chert amounts to as much as 75 percent of some samples. Veinlets of crystalline quartz cut through some of the fragments. Large brown translucent glassy oölites which probably resulted from the replacement of sand grains by secondary silica are common in the chert. Such chert has been found characteristic of the Roubidoux formation in Missouri (McQueen, 1931, p. 121).

Dark-brown and white banded oölites in a matrix of light-brown quartzose chert are associated with the sand in many residues at the contact of the Roubidoux with the Jefferson City-Cotter dolomites in wells in both eastern and western Kansas.

Flecks of bright-green shale, in some cases dolocastic, and spongy fragments of pyrite commonly are associated with the sand.

The presence of chert beds in the Roubidoux formation in western Kansas is obscured by chert caved from beds higher in the well. The admixture of sand from higher beds within the Roubidoux formation lessens the contrast in the percentages of sand residues and makes the determination of distinct sandy beds difficult.

Stratigraphic relations and distinguishing characteristics.— The Roubidoux dolomite overlaps progressively older beds as it is traced to the central part of the State, where it immediately overlies Pre-Cambrian rocks. This relationship is illustrated by Figure 7 which shows the pre-Roubidoux surface and by the cross sections (Figs. 10-13).

Sand of the Roubidoux dolomite overlies the Van Buren-Gasconade sequence in eastern and south-central Kansas. Although the dolomites of the two formations are similar, the insoluble residues show a distinct and sharp contrast between the bluish cherts of the Gasconade dolomite and the fine angular sand of the Roubidoux dolomite.

The Roubidoux dolomite was not found in contact with the Eminence dolomite in wells studied in eastern Kansas. The cherty dolomite underlying the Roubidoux dolomite in some western Kansas wells is tentatively correlated with the Eminence dolomite of Missouri. The formational boundary is placed at the contact of the dolocastic chert of the Eminence with the sand residue of the Roubidoux dolomite.

In eastern Kansas where the Roubidoux dolomite is in contact with the Bonneterre dolomite, the base of the formation is placed at the contact of the dark-brown dolomite and fine silty sand residue of the Bonneterre dolomite with the white coarsely crystalline dolomite and somewhat coarser angular sand of the Roubidoux. The contact also is marked by a heavy concentration of pyrite in some wells.

In western Kansas the separation is more difficult because the typical fine silty sand and dolocastic shale is absent from the Bonneterre dolomite, and the dolomites of the two formations are indistinguishable. The criteria found to be most reliable for the establishment of the contact are as follows. (1) The Roubidoux sand is fine (averaging 0.1 mm in diameter, unfrosted,

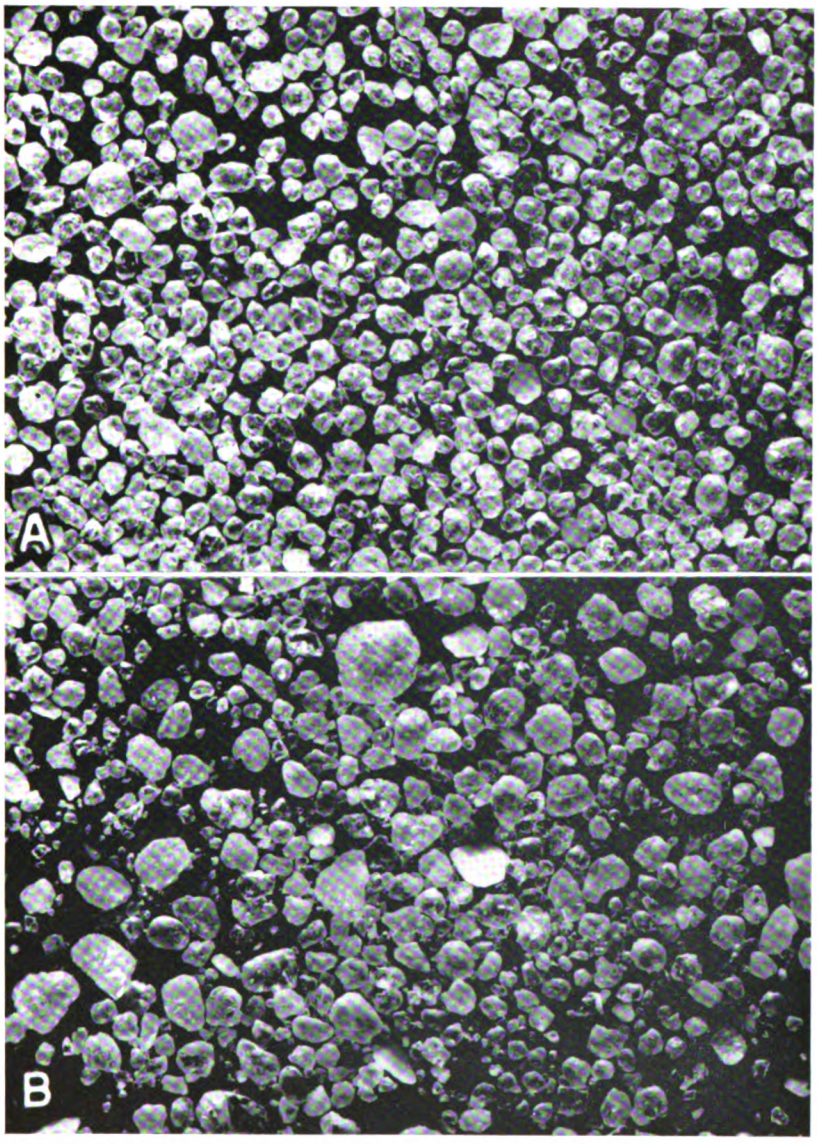

PLATE 4. Insoluble residues from the Roubidoux dolomite. *A*, Clear fairly well-sorted bright angular sand characteristic of the Roubidoux dolomite in eastern Kansas (x10). This sample is from the No. 1 Clark well in sec. 13, T. 33 S., R. 21 E., Cherokee County, Kansas, from a depth of 1262-68 feet. *B*, Coarser very poorly sorted sand characteristic of the Roubidoux dolomite in western Kansas (x10). This sample is from the Texas Co. No. 13-A Bemis well in the SE¼ NW¼ NE¼ sec. 28, T. 11 S., R. 17 W., Ellis County, Kansas, a rotary-drilled well, from a depth of 3702-25 feet.

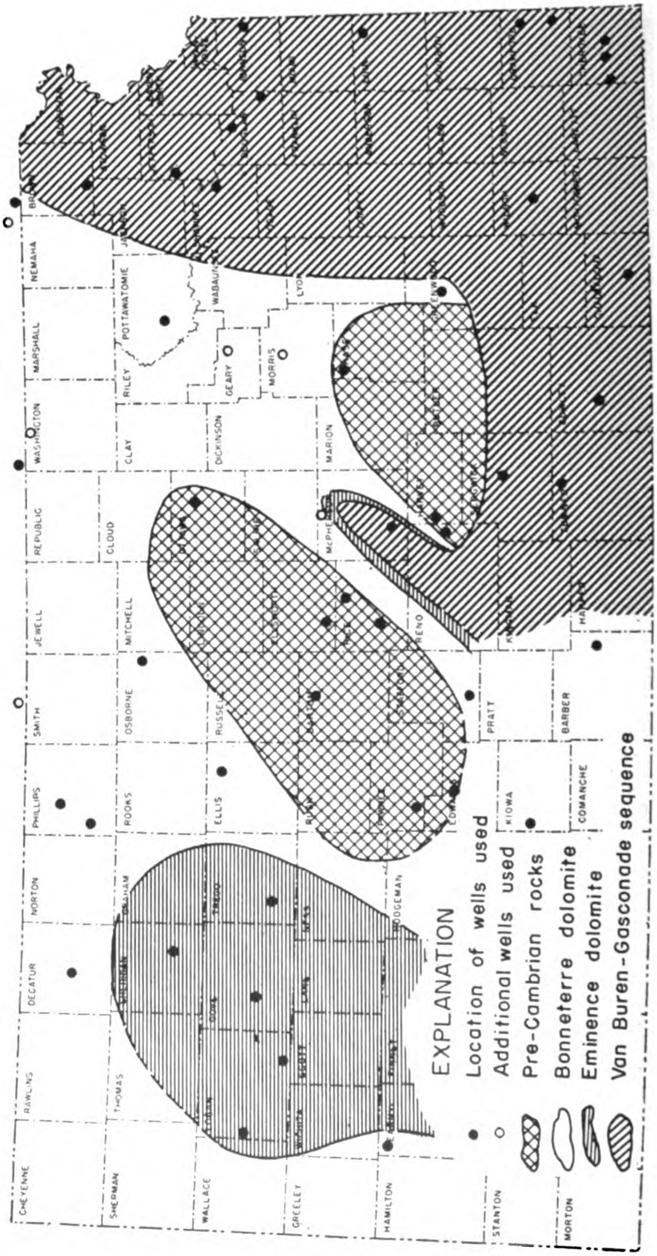

Fig. 7—Pre-Roubidoux paleogeologic map of Kansas.

angular, and enlarged, whereas that of the Bonneterre dolomite is much coarser and the grains are rounded, minutely pitted, and roughened. (2) Glauconite, which is common in Bonneterre deposits, is absent in the Roubidoux. (3) A considerable amount of pyrite is associated with Bonneterre residues but occurs sparingly in the Roubidoux dolomite. A heavy concentration of pyrite is common at the contact of the two formations.

The Roubidoux dolomite, including the basal sand, is underlain by an arkosic quartzite or quartzitic sand in wells drilled in Ottawa and Ellsworth Counties (wells 26 and 18). This quartzite may represent a thick deposit of "granite wash" that was formed by the weathering of the granite surface during Cambrian time or it may be a deposit of Pre-Cambrian quartzite. It may be granite that resembles a quartzitic sand in samples as a result of loss of the relatively soft feldspathic constituents which were drilled to fine rock flour and were washed from the sample leaving the relatively hard quartz elements intact. It is difficult to determine the formational boundary between the basal sand of the Roubidoux and the quartzite, but increasing amounts of arkosic material and the extreme angularity of the quartz fragments in the quartzite serve to distinguish it from the Roubidoux.

In one well in each of Barton and Chase Counties (wells 19 and 25) the sandy dolomite of the Roubidoux rested directly on Pre-Cambrian granite with no basal sand intervening. Probably these areas were topographically high at the beginning of Roubidoux deposition.

The Roubidoux dolomite is overlain by the Jefferson City-Cotter sequence throughout Kansas, except for local areas in the northern part of the State where the sequence was removed by post-Cotter erosion (Fig. 8). The features of the Roubidoux dolomite that serve to separate it from the overlying Jefferson City-Cotter sequence are as follows. (1) The insoluble residues from the Roubidoux dolomite are predominantly sandy whereas those of the Jefferson City and Cotter dolomites consist of varied cherts and dolomites; impersistent sand occurs in the Jefferson City dolomites as discontinuous lenses only a few feet thick. (2) The change from the sandy Roubidoux section to the cherty Jefferson City-Cotter sequence is accompanied by a slight change in the character of the dolomite. The dolomite of the Roubidoux in most areas is white and very coarsely crystalline, with little

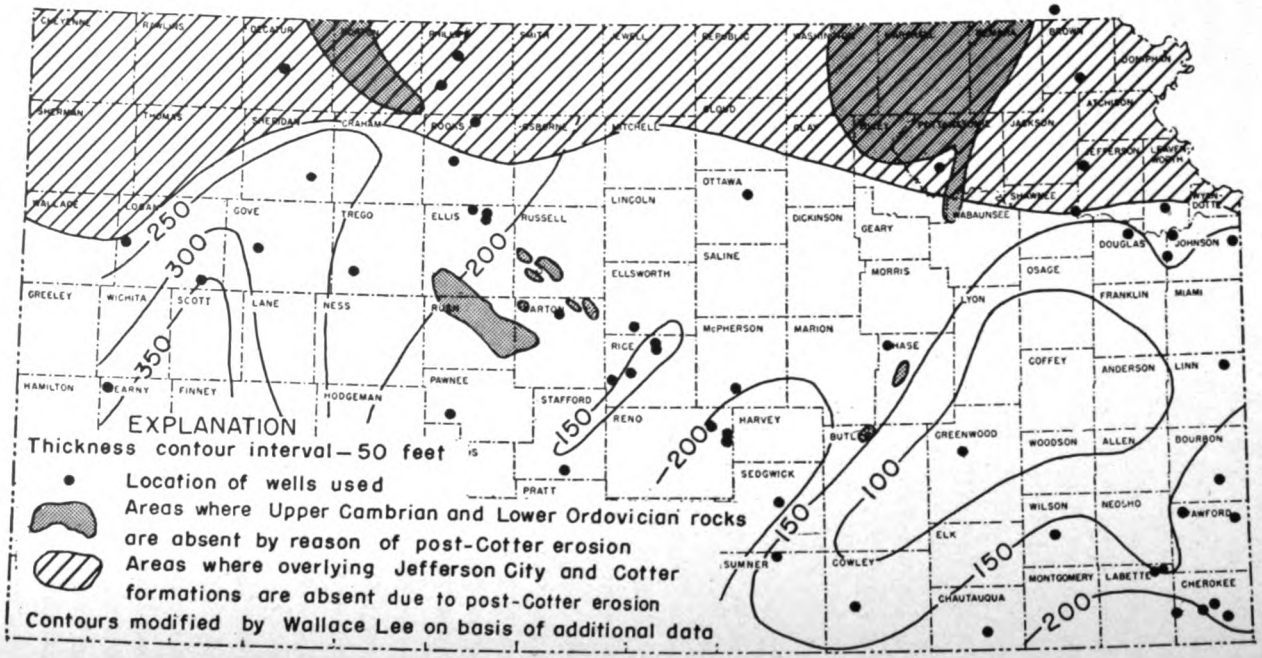

FIG. 8—Thickness of the Roubidoux dolomite in Kansas at the close of Cotter time.

variation throughout the section, whereas the dolomites of the Jefferson City and Cotter are varied both in texture and in color.

The Roubidoux dolomite is the oldest formation of the Upper Cambrian and Lower Ordovician strata that extends uninterruptedly across the State from east to west. The continuity of the sandstone of the Roubidoux dolomite throughout the State has helped in the correlation of the older formations that are not so widely distributed.

Distribution and thickness.—The distribution and thickness of the Roubidoux dolomite in Kansas are shown in Figure 8. A line extending from northern Leavenworth County to western Logan County roughly represents the northern limit of the Jefferson City-Cotter sequence. North of this line the Roubidoux dolomite was exposed and thinned by post-St. Peter erosion and in places it was entirely removed. This beveling is reflected by the absence of the Roubidoux dolomite from the Turner No. 1 Umschied well in Pottawatomie County (well 34). It also is indicated by the removal of all but 22 feet of the Roubidoux dolomite at the Phillips Petroleum Company No. 1 Vernon well in Decatur County (well 37). A normal section more than 200 feet thick is found in near-by wells.

Over a large area in the southeastern part of the State the thickness of the Roubidoux dolomite is relatively constant within the limits of 150 to 200 feet. An interesting exception is the Burge, Trott, et. al. No. 1 Breitkreutz well in Greenwood County (well 15) in which 72 feet of sandy Roubidoux dolomite rests on the dark-brown dolomite associated with the silty, sandy, and glauconitic residue typical of the Bonneterre dolomite. The absence of approximately 100 feet of lower beds of the Roubidoux as well as the Gasconade and Eminence dolomites is believed to indicate a locally high area at that place at the beginning of Roubidoux deposition.

In west-central Kansas the relatively thin section of Roubidoux (between 100 and 150 feet thick) underlain by Pre-Cambrian rocks indicates a high area on the pre-Roubidoux surface. In the central part of the State a thickness of Roubidoux greater than 200 feet indicates a pre-Roubidoux shallow basin in an area extending from southern McPherson County to central Sedgwick County between the "high" in west-central Kansas and the "high" shown by the well in Greenwood County.

The increase in thickness of the Roubidoux dolomite west of the high area in central Kansas indicates a basin filled by the Roubidoux sediments. The maximum thickness noted was 350 feet of sandstone of the Roubidoux dolomite in the Alma-McNeeley No. 1 Watchorn well (well 22) in Logan County. Approximately 30 miles west of this well, however, the Roubidoux dolomite thins to 235 feet in the Morgan-Flynn Cobb No. 1 McMillen well in Logan County (well 23). The Roubidoux is thinner also in the Stanolind Oil and Gas Company No. 1 Judd well in Kearny County (well 12). It is believed that this thinning is due to a local relatively high area that extended in a north-south direction through western Logan County and Kearny County at the beginning of Roubidoux deposition.

JEFFERSON CITY-COTTER SEQUENCE

The Roubidoux dolomite in Kansas is overlain by beds correlated with the Jefferson City and Cotter dolomites of Missouri. These beds are separated at the outcrop and have been differentiated in the subsurface by characteristics of their insoluble residues (McQueen, 1931, pp. 121-124). Although a persistent sand zone that may represent the base of the Cotter dolomite has been correlated in several wells in southeastern Kansas, the lack of sufficient well control makes unreliable an attempt to differentiate these formations in the subsurface of western Kansas.

The Jefferson City and Cotter dolomites crop out in a broad belt encircling the structural center of the Ozark region. The dolomite of these formations at the outcrop is chiefly of two kinds: a fine-grained argillaceous earthy-textured variety and a more massive dolomite with a hackly surface. Intercalated commonly thin beds of chert, lenses of sandstone, and green shale partings are contained in the dolomite. The Jefferson City and Cotter dolomites are reported by McQueen (quoted by Lee, 1943, p. 20) to be 210 feet thick in Jackson County, western Missouri.

Lithology in Kansas.—The dolomites of the Jefferson City-Cotter sequence in the subsurface of Kansas are variable in character. Beds that are only a few feet thick may differ greatly from those above and below both in color and in texture. The lithological character changes rapidly in a lateral direction, also.

This lateral and vertical variability is a characteristic that serves to distinguish the dolomite of the Jefferson City-Cotter sequence from those of lower formations of Late Cambrian and Early Ordovician age.

In Kansas, a white to gray, dense, somewhat argillaceous soft dolomite, which probably is the equivalent of the "cotton rock" of Missouri geologists, is the most common type of dolomite in the Jefferson City-Cotter sequence. A light-tan medium coarsely crystalline dolomite is also very common. Brown dolomite occurs in the lower part of the sequence above the contact with the Roubidoux dolomite in most wells. It is commonly very dark and very coarsely crystalline. However, light-brown, gray-brown, or buff fine-grained dolomites occur in this zone in some areas.

The dolomite of the Jefferson City-Cotter sequence in Kansas contains a considerable amount of insoluble material of which cherts are the chief constituent. These cherts are characterized by their great variety. White dense and bluish translucent or brown cherts are the most common types. The white chert is dense with a smooth, porcelaneous surface and a vitreous luster. Veinlets and encrustations of crystalline quartz may give the chert fragments a quartzose appearance. The translucent chert is bluish to opalescent with a glassy, resinous, or paraffinlike luster. In some areas, the translucent chert may grade into a quartzose chert that resembles milky quartz. Much of this chert contains oölites that commonly are white or translucent, but some are brown. Both of these types of chert are found in all parts of the Jefferson City-Cotter strata and may be associated with any of the other types of chert common to the formation.

Quartzose and vitreous brown cherts are abundant in the lower part of the formation, usually associated with the brown dolomites. Some brown chert occurs in fine drusy clusters resembling brown sugar. Large brown oölites up to 0.8 mm, in diameter, for the most part darker than the cherty matrix, are common in the brown cherts. Some of the oölites are opaque and others consist of alternating bands of opaque and translucent brown chert, or brown and white chert. Brown oölites that are free in the sample commonly are coated with a drusy quartz. McQueen (1931, p. 122) has found these brown oölites characteristic of the Cotter dolomite in Missouri, but in Kansas they are most common near the contact with the Roubidoux dolomite.

White oölitic chert may occupy the same stratigraphic position as brown oölitic chert in near-by wells and is thought to be a variant of the brown oölitic chert.

The presence of brown oölites in samples is used by many midcontinent geologists as a guide in identifying the top of the "Siliceous lime" because brown oölites seem to be more common in Upper Cambrian and Lower Ordovician strata than in younger formations. This criterion is unreliable because (1) in Kansas brown oölites are abundant in the lower part of the Jefferson City-Cotter sequence but not in the upper part, and (2) the Jefferson City-Cotter beds have been removed from large areas in Kansas.

Brown dense chert mottled with white chert was noted in many wells in southeastern and south-central Kansas. This type of chert was noted in samples from wells in Kansas, Missouri, and Oklahoma by McQueen (1931, p. 123) who assigns it to the lower part of the Cotter dolomite.

Dolocastic chert occurs in the insoluble residue of samples from all parts of the Jefferson City-Cotter sequence but is particularly abundant in the middle part of the sequence above the brown chert. It is associated with white dense and bluish translucent chert. A small amount of the chert is coarsely dolocastic and lacy. The greater part, however, consists of soft tripolitic chert matrix, with fine dolocasts that give the chert a spongy texture. Scattered large dolocasts occur in a white dense chert with a rough hackly surface.

A soft lusterless white finely porous tripolitic chert is found throughout the Jefferson City-Cotter sequence. McQueen (1931, p. 121) found it near the contact with the Roubidoux. Such chert is particularly abundant in wells in central and western Kansas but is not persistent laterally and may not be found in offset wells.

A small amount of chert with included sand grains, similar to chert found in the Roubidoux dolomite, is present in residues of the Jefferson City and Cotter dolomites. The association of oölites with the sand grains and the glassy centers of some oölites suggest that some of the white and bluish oölitic chert may be the result of replacement of the sand grains by secondary silica. The most common types of chert found in the Jefferson City-Cotter unit in Kansas wells are shown in Plate 5A.

Thin beds of sand or dolomitic sandstone occur in all parts of the Jefferson City-Cotter unit in Kansas but particularly near the

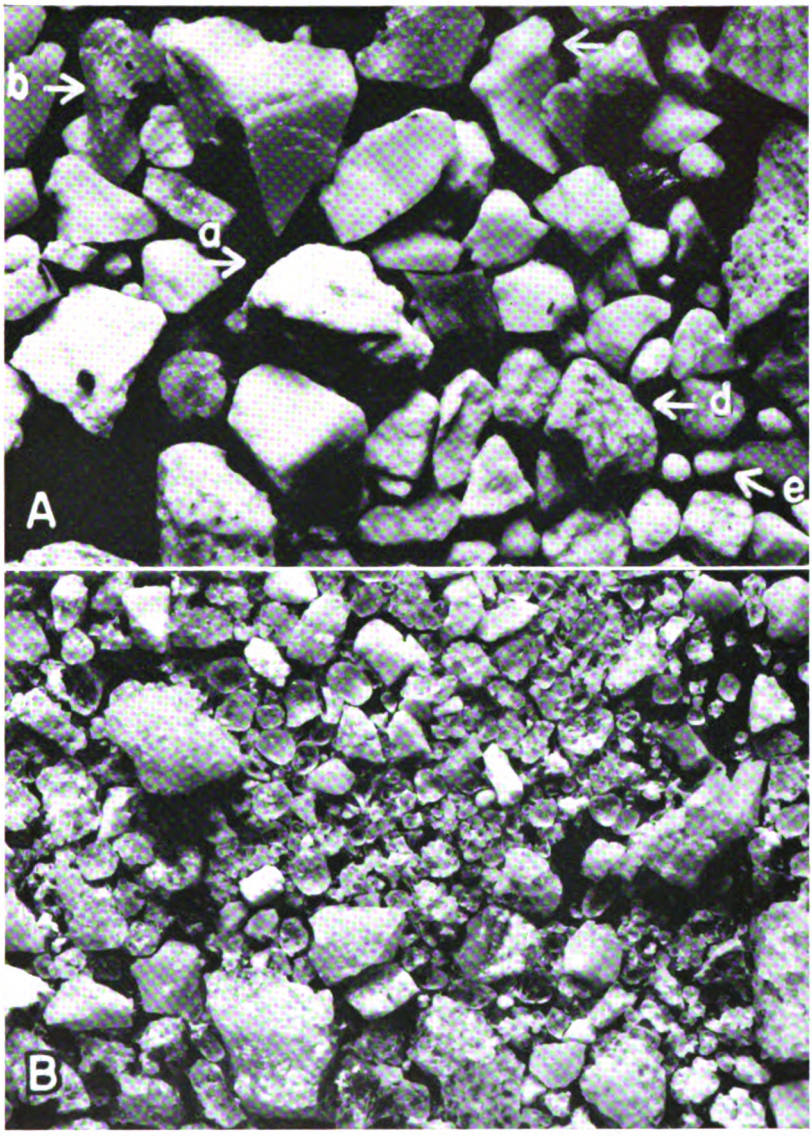

PLATE 5. Insoluble residues from the Jefferson City-Cotter sequence and Gunter sandstone member of the Van Buren formation. *A*, Assemblage of cherts from the Jefferson City-Cotter sequence showing (a) soft white lusterless tripolitic chert; (b) brown quartzose chert; (c) white vitreous chert; (d) brown and white oölites in chert; and (e) free chert (x10). This sample is from the Texas Co. No. 13-A Bemis well in SE¼ NW¼ NE¼ sec. 28, T. 11 S., R. 17 W., Ellis County, Kansas (a rotary drilled well), from a depth of 3542-57 feet. *B*, Well-rounded highly polished sand grains sorted into distinct coarse and fine sizes and sand grains in chert characteristic of the Gunter sandstone member of the Van Buren formation (x10). This sample is from the No. 1 Clark well, sec. 13, T. 33 S., R. 21 E., Cherokee County, Kansas, from a depth of 1529-36 feet.

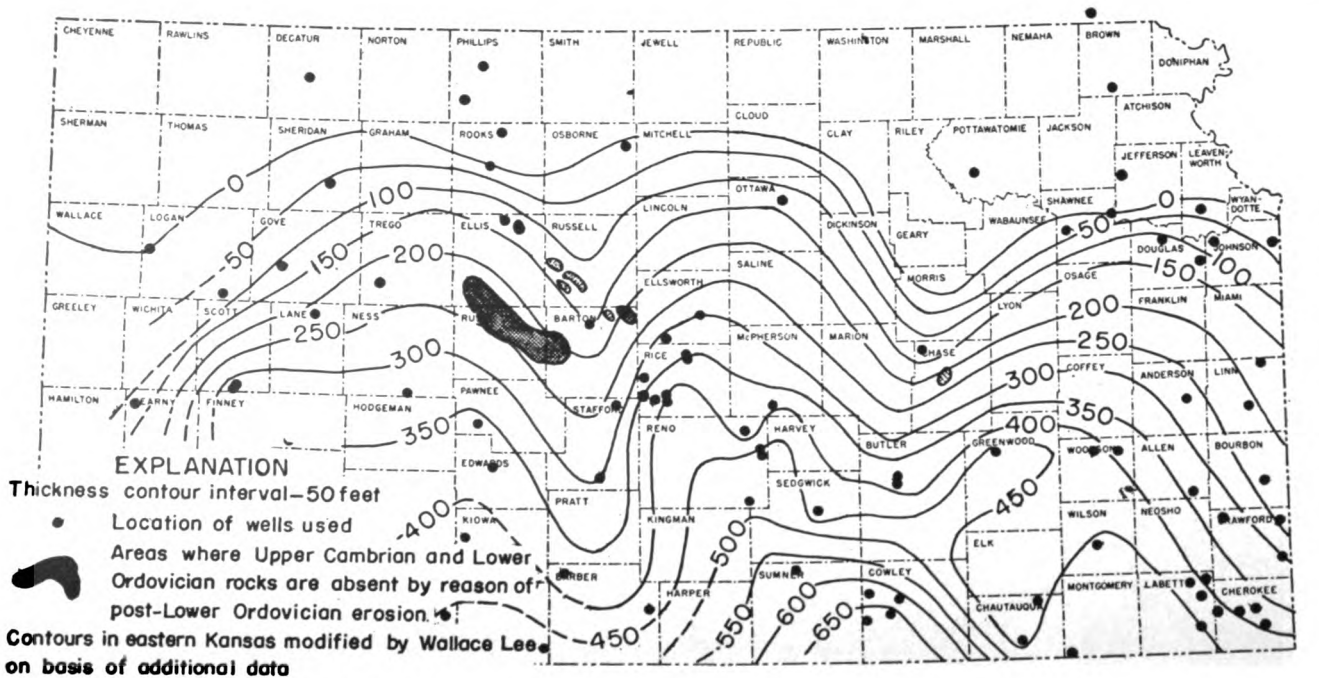

FIG. 9—Thickness of the Jefferson City-Cotter sequence in Kansas.

contact with the underlying Roubidoux dolomite. For the most part, they are poorly sorted and rather fine grained. Most of the larger grains are rounded and frosted, whereas the finer grains are bright and angular. Secondary quartz enlargement is common.

Pyrite, in finely porous spongy masses and aggregates of fine crystals, occurs throughout the unit. Flecks of bright-green shale were noted in the upper part of the unit.

A persistent bed of sandstone with a characteristic texture was traced over a considerable area in southeastern and south-central Kansas. It may represent the sandstone at the base of the Cotter dolomite which, in Missouri, serves to separate the Jefferson City and Cotter dolomites. The grains are well sorted and fine, averaging 0.2 mm in diameter, and are bright and angular. They occur both free and in loosely cemented clusters. The sand bed is approximately 10 feet thick in southeastern Kansas. It reaches its maximum development in Kansas in Cowley and Sumner Counties, where it is 30 feet thick. In Reno and McPherson Counties this sand probably is the uppermost zone of the Jefferson City-Cotter sequence. Westward it has been removed by post-Ordovician erosion.

Few wells in southwestern Kansas penetrate Upper Cambrian and Lower Ordovician beds more than a few feet. The few samples available consist of a fine angular sand and sandy dolomite which may be either the sand at the base of the Cotter dolomite or a sand higher in the section.

Stratigraphic relations and distinguishing characteristics.—The Jefferson City-Cotter sequence in Kansas overlies the Roubidoux dolomite and is overlain unconformably by beds ranging in age from the St. Peter sandstone at the top of the Lower Ordovician to Pennsylvanian. The great variety of the cherts and dolomites offers considerable contrast to the white, coarsely crystalline, sandy, and comparatively noncherty dolomite of the Roubidoux.

Distribution and thickness.—The distribution and thickness of the Jefferson City-Cotter sequence in Kansas are shown in Figure 9. A maximum thickness of 667 feet of these beds is found in Cowley County. Thicknesses of 350 to 400 feet prevail in the southernmost part of the State. Thinning is rapid to the north. In Douglas County the beds are 106 to 135 feet thick. They are absent entirely from wells in Jefferson County and farther north.

In north-central Kansas the beds have thinned to approximately 122 feet in Ottawa County (well 26) and are absent from the one well studied in Osborne County (well 35). In western Kansas, the Jefferson City-Cotter sequence is known to be 382 feet thick in a well in Pawnee County (well 11). The unit is present in wells to the south and west but because the base of the unit has not been reached in the wells available for study, the maximum thickness in this region is unknown. Northward, the beds have thinned to only slightly more than 200 feet in a well in Trego County and are absent from wells in Rooks, Decatur, and Logan Counties.

GEOLOGIC CROSS SECTIONS

The cross sections published with this report are arranged to give as complete coverage of the State as possible. Diagrammatic summaries and index maps showing location of the cross sections are given in Figures 10 to 13. Four sections originating at as many points near the Kansas-Missouri boundary and extending into western Kansas are arranged at fairly regular intervals from Oklahoma to Nebraska. These intersect five sections which extend from the southern boundary of Kansas to northern Kansas or Nebraska and are arranged at intervals from east to west across the State.

General Discussion

The importance of a well to this type of investigation is almost proportional to the percentage of the total thickness of the rocks penetrated. Therefore, the significance of some of the wells studied necessarily is much greater than that of others.

The wells studied in the western part of the State, for the most part, are those that penetrate all or nearly all of the Upper Cambrian and Lower Ordovician beds that are present at the location of the well. Most of the wells that penetrate the entire Paleozoic section are dry holes or wells drilled on the margin of pools and abandoned early in the life of the pool. The evidence indicates that the uppermost deposits of pre-St. Peter age are absent in Kansas and the well logs probably do not include the maximum thickness of the pre-St. Peter sedimentary rocks once present.

Comparison of all the logs of wells that penetrate all or the greater part of the Upper Cambrian and Lower Ordovician beds present shows no outstanding characteristic of the dolomite that persists over a distance of more than a few miles. The insoluble residues, however, exhibit very persistent characteristics and can be identified across the State. These persistent zones are correlated with similar zones identified at the outcrop and in the subsurface of Missouri.

The persistent and diagnostic features of each of the subdivisions which are the basis of most of the correlations are shown in the plotted logs (Pl. 6) by different patterns.

1. Sand in the Lamotte sandstone.
2. Fine glauconitic sand in the Bonneterre dolomite.
3. Quartzose chert, green shale, and pyrite in the Eminence dolomite (components of the Eminence residue not distinguished on the cross sections.)
4. Sand in the Gunter sandstone member of the Van Buren formation.
5. Chert in the Van Buren-Gasconade sequence.
6. Sand in the Roubidoux dolomite.
7. Chert in the Jefferson City-Cotter sequence and at the base of the Cotter sand.

These patterns serve to draw attention to outstanding features of the insoluble residues of each of the major subdivisions recognized in the subsurface of Kansas and emphasize the continuity of lithologic zones across the State.

Although sand may be the predominant constituent of the insoluble residue, it is commonly too small a percentage of the total sample to be plotted. Therefore, for those subdivisions that are identified on the basis of characteristic sand residues, the percentage of sand both in the insoluble residue (right hand column) and in the total sample (left hand column) are shown.

For subdivisions that are identified by a relatively large amount of residue consisting predominantly of chert, the percentage of chert in the total sample is plotted in the left hand column. The right hand column is left blank where cherty dolomites are indicated. The dotted pattern that generalizes the position of the sand zone at the base of the Cotter is an exception.

The space representing the material in the residue that was not found to be diagnostic of the subdivision was left blank in

both columns of the logs represented on the cross section. No attempt has been made to show differences in character of the dolomites (1) because few dolomite types were persistent enough laterally or vertically to afford a criterion for correlation, and (2) because correlations were based for the most part on diagnostic material in the insoluble residue. Therefore, the space in the left hand column in which symbols representing dolomite types on the original log were plotted is left blank on the cross sections.

More detailed examination of samples from closely spaced wells doubtless would provide data that would permit recognition of the point of contact between some of the beds more precisely than is possible in the present report. However, it is believed that the contacts as indicated in the accompanying plotted logs are consistent with the purpose of the study and with the control available for it. Data for drawing the cross sections have been derived principally from the wells shown on each. The thicknesses of the formations between wells and the points at which the formations wedge out were determined from the maps, showing the thickness and distribution.

Cross Section on Line A-A′ (Fig. 11 and Pl. 6)

Section A-A′ extends from Cherokee County in the extreme southeastern corner of the State northwestward to Kearny County, passing in westward order through Chautauqua, Cowley, Sumner, Sedgwick, Reno, Rice, Stafford, and Pawnee Counties. The section covers a total distance of 427 miles, although the straight-line distance between the Cherokee County well (well 1) and the Kearny County well (well 12) is 370 miles.

The formations immediately overlying the Pre-Cambrian surface are progressively younger from the eastern margin toward central Kansas. Older beds reappear in the section in the western part of the State.

From Cherokee to Chautauqua Counties (wells 2, 3, and 4), moderate thicknesses of Lamotte sandstone, overlain by Bonneterre dolomite, rest on the Pre-Cambrian surface. In Reno, Rice, and Pawnee Counties (wells 8, 9, and 11) the Roubidoux dolomite is the oldest formation in contact with the Pre-Cambrian rocks. The Lamotte sandstone is absent and the Bonneterre dolomite immediately overlies the granite in well 12 in Kearny County and probably in Stafford County (well 10).

The Bonneterre and Eminence dolomites thin westward to Chautauqua County and are absent from wells farther west in Rice and Pawnee Counties. Bonneterre dolomite is present in Stafford and Kearny Counties but beds of the Eminence and probably beds of the upper part of the Bonneterre dolomite are absent. The Van Buren formation, including its basal Gunter sandstone member, and the overlying Gasconade dolomite are present in Cherokee, Labette, and Chautauqua Counties where they overlie the Eminence, but in Sumner and Sedgwick Counties (wells 6 and 7) the Gunter overlaps onto the granite. No differentiation that permits the determination of what parts of the sequence are lost as the beds thin and disappear to the west has been made in the subsurface of Kansas.

The sandstone at the base of the Van Buren-Gasconade sequence in Sumner and Sedgwick Counties, which here constitutes the basal Paleozoic sandstone, overlaps the older beds onto the granite and, therefore, may be younger than the Gunter sandstone member of the Van Buren elsewhere. These beds are not present in wells on this cross section northwest of Sedgwick County (well 7). The cross section, however, shows an inlier between wells 8 and 9. This inlier is not revealed by wells on this cross section, but distribution maps based on wells in McPherson County and cross section B-B′ strongly suggest the presence of such a structural feature on the line of cross section A-A′.

The Roubidoux dolomite overlies the Gasconade dolomite in wells as far west as Sedgwick County (well 7). In Reno, Rice, and Pawnee Counties (wells 8, 9, and 11), the Roubidoux dolomite and a basal sandstone which probably is Roubidoux in age are in contact with the Pre-Cambrian surface and all beds older than Roubidoux are absent. In Kearny County (well 12) the Roubidoux dolomite rests on the Bonneterre dolomite.

Irregularities in the thickness and regional westward thinning of Jefferson City-Cotter deposits are the result of upwarping and removal of the deposits. In some areas this occurred at the end of Arbuckle time, in other areas it preceded the deposition of the Chattanooga shale, and in still others it preceded deposition of the Pennsylvanian. The Jefferson City-Cotter sequence thickens from Cherokee County westward to a maximum of 667 feet

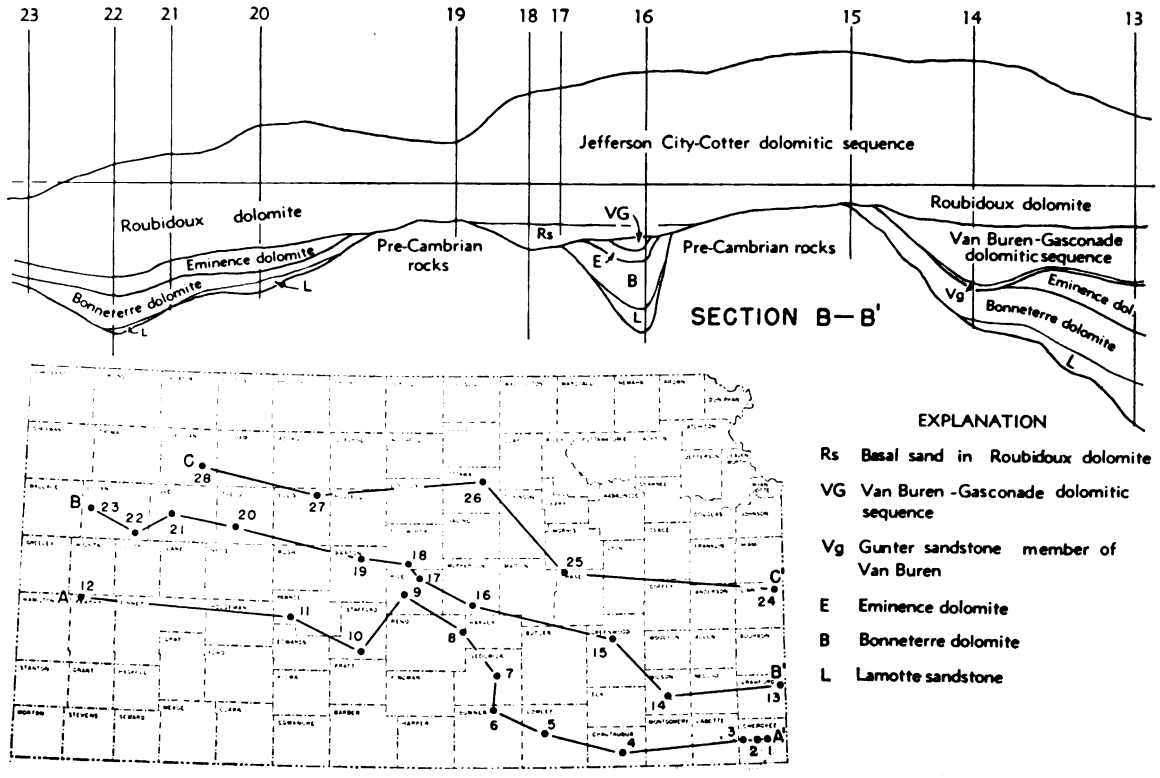

FIG. 10—Diagrammatic cross section on line B-B' and index of sections.

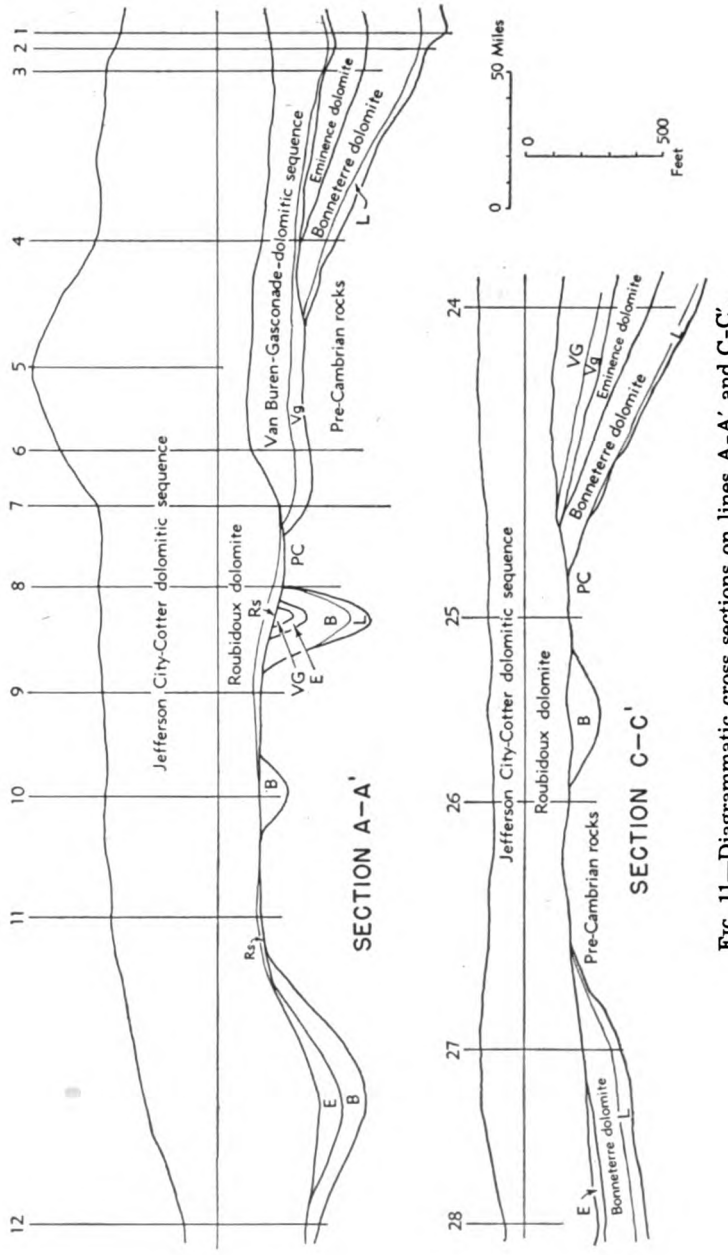

FIG. 11—Diagrammatic cross sections on lines A-A' and C-C'.

in Cowley County, but farther west the beds again become thinner. They are especially thin in Kearny County (well 12).

Cross Section on Line B-B′ (Fig. 10 and Pl. 6)

Section B-B′ extends from eastern Crawford County to western Logan County passing through Wilson, Greenwood, McPherson, Rice, Ellsworth, Barton, Trego, and Gove Counties. The section covers a total distance of 400 miles. The air line distance between the extremes is approximately 375 miles.

Beds ranging in age from Lamotte to Roubidoux rest on the Pre-Cambrian surface in section B-B′. The Lamotte sandstone rests on the Pre-Cambrian surface in Crawford, Wilson, and McPherson Counties (wells 13, 14, and 16). The basal bed of well 15 in Greenwood County, which is 17 feet thick, may represent the uper part of the Bonneterre dolomite overlying the Pre-Cambrian granite, the lower part of the Bonneterre dolomite and Lamotte sandstone being absent as result of overlap of upper beds of the Bonneterre onto the high area in the central part of the State. On the other hand, the cross section suggests strongly that the Bonneterre was leveled during pre-Roubidoux exposure. Where Lamotte is absent it is probable that the basal Bonneterre rocks are also absent due to overlap on high areas of the surface. Some of the upper part of the Bonneterre dolomite was removed by post-Bonneterre erosion. In the McPherson County well (well 16) the presence of pre-Roubidoux formations that are thin or absent in near-by wells may indicate a local basin of sedimentation but the older rocks were almost certainly beveled before Roubidoux time.

In a well in Rice County (well 9 of A-A′) 30 miles northwest of the McPherson County well, and in Ellsworth and Barton Counties (wells 18 and 19) the Roubidoux dolomite or a basal sand probably of Roubidoux age rests on the Pre-Cambrian surface and all older beds are absent. To the west in Trego and Gove Counties and eastern Logan County (wells 20 and 22) increasing thicknesses of Bonneterre dolomite and Lamotte sandstone are found. The Lamotte sandstone is absent from western Logan County (well 23) and only a thin section of Bonneterre dolomite rests on the Pre-Cambrian surface. This indicates that this area had slightly greater elevation than the surrounding area at the beginning of Lamotte deposition.

The Eminence dolomite thins from 172 feet in Crawford County (well 13) to a feather edge before reaching well 14 in Wilson County, 60 miles to the west. Cherty dolomite beds of relatively constant thickness between the Bonneterre dolomite and the Roubidoux dolomite, in western Kansas (wells 20 to 23 of cross section B-B′) are correlated with the Eminence dolomite. The Van Buren-Gasconade sequence is present in Crawford, Wilson, and McPherson Counties (wells 13, 14, and 16). It has not been determined whether the thinning of this sequence in McPherson County is due to loss of the upper or of the lower beds. The Van Buren-Gasconade sequence is absent from wells to the west.

The Roubidoux dolomite in cross sections B-B′ is in contact with all the older formations from Gasconade to Pre-Cambrian. The Roubidoux rests on Gasconade dolomite in Crawford, Wilson, and McPherson Counties (wells 13, 14, and 16). It overlies the Eminence dolomite in Trego, Gove, and Logan Counties (wells 20 to 23). Roubidoux deposits 72 feet thick that compose the upper part of the formation rest on the upper part of the Bonneterre dolomite in a well in Greenwood County (well 15). The intervening lower formations are absent. The Roubidoux dolomite and a basal sand of probable Roubidoux age rest directly on the Pre-Cambrian surface in Rice, Ellsworth, and Barton Counties (wells 17, 18, and 19). A greater thickness of Roubidoux sediments is found in wells in Trego, Gove, and Logan Counties than in wells to the east.

Beds of the Jefferson City-Cotter sequence thin to the west and are especially thin in Barton and Gove Counties (wells 19 and 21) and in eastern Logan County (well 22) as the result of post-Cotter erosion. The Jefferson City-Cotter sequence and the upper part of the Roubidoux dolomite have been removed from the well in western Logan County (well 23) by post-Cotter erosion.

Cross Section on Line C-C′ (Fig. 11 and Pl. 6)

Cross section C-C′ extends from Linn County near the eastern boundary of Kansas westward to Sheridan County, passing through Chase, Ottawa, and Ellis Counties. The total distance covered is 328 miles. The airline distance between the two ends of the section is 309 miles.

The Bonneterre dolomite and Eminence dolomite which are present in the Linn County well (well 24) wedge out toward the west in relations similar to those noted farther south in cross sections A-A′ and B-B′. They reappear to the west in wells in Ellis County and probably in Sheridan County (wells 27 and 28), although beds older than Roubidoux were not penetrated in well 28.

The Roubidoux dolomite overlies Gasconade dolomite in wells in Linn County (well 24), Pre-Cambrian granite and quartzite in Chase and Ottawa Counties (wells 25 and 26), and Bonneterre dolomite in Ellis County (well 27).

Post-Cotter erosion of exposed beds of the Jefferson City-Cotter sequence resulted in the removal of much of the upper part of the sequence, probably including all the Cotter deposits. The presence of Bonneterre dolomite between wells 25 and 26 and in well 28 is inferred from the distribution maps.

Cross Section on Line D-D′ (Fig. 13)

Section D-D′ extends westward from Johnson County near the Kansas-Missouri boundary to Decatur County in northwestern Kansas, passing through Douglas, Shawnee, Pottawatomie, Ottawa, Osborne, and Phillips Counties. The total distance covered is 332 miles. The airline distance between the two ends of the section is 314 miles.

Beds ranging in age from Lamotte to Roubidoux are found in contact with the Pre-Cambrian surface in section D-D′. Lamotte sandstone immediately overlies the Pre-Cambrian rocks in wells in Johnson, Douglas, and Shawnee Counties (wells 29 to 32). The variation in thickness of the Lamotte sandstone is presumably the result of irregularities on the surface of the Pre-Cambrian rocks upon which it was deposited. In Ottawa County Pre-Cambrian quartzite is overlain by Roubidoux dolomite (well 26). The Osborne County well (well 35) did not reach the Pre-Cambrian rocks. Westward, in Phillips County (well 36), Lamotte sandstone is absent and Bonneterre dolomite rests on the Pre-Cambrian rocks. Lamotte sandstone overlain by Bonneterre dolomite is present in Decatur County (well 37).

The Van Buren-Gasconade sequence, with the well-developed Gunter sandstone member of the Van Buren at the base, overlies a thick Eminence dolomite in Johnson and Douglas Counties

(wells 29 to 31). A green shale residue between the sand zone of the Bonneterre dolomite and the Gunter in a Shawnee County well (well 32) may represent either Eminence dolomite or the upper part of the Bonneterre dolomite. Eminence dolomite and the Van Buren-Gasconade sequence are absent from wells west of the Shawnee County well (well 32).

In section D-D′ the Roubidoux dolomite rests on Gasconade dolomite, Bonneterre dolomite, and Pre-Cambrian rocks. It overlies the Van Buren-Gasconade sequence in Johnson, Douglas, and Shawnee Counties (wells 29 to 32). The Roubidoux dolomite is in contact with the Bonneterre dolomite in western Kansas in wells in Phillips and Decatur Counties (wells 36 and 37). In Ottawa County the Roubidoux dolomite immediately overlies Pre-Cambrian quartzite (well 26). The Bonneterre between wells 26 and 34 is inferred from the distribution map of the Bonneterre dolomite.

Post-Cotter erosion has resulted in the removal of the Cotter dolomite and probably the upper part of the Jefferson City dolomite from all the wells. A detrital zone above the Roubidoux dolomite in Johnson County (well 30) may represent a pre-St. Peter river channel, where more beds of the Jefferson City and Cotter were removed than in near-by wells. All these beds and considerable amounts of the upper part of the Roubidoux dolomite are absent from wells in Shawnee, Ottawa, Phillips, and Decatur Counties. All the Upper Cambrian and Lower Ordovician strata that may have been deposited in the area of the Pottawatomie County well (well 34) were removed with the exception of 25 feet of Bonneterre dolomite and Lamotte sandstone.

Cross Section on Line E-E′ (Fig. 12 and Pl. 6)

Section E-E′ extends from Cherokee County, Kansas, to Richardson County, Nebraska, passing through Crawford, Linn, Douglas, Shawnee, Jefferson, and Brown Counties, Kansas. The total distance covered is 220 miles. The airline distance between the two ends of the section is 200 miles.

The Bonneterre dolomite thins regularly from 187 feet in Cherokee County (well 2) to 79 feet in Richardson County (well 41). The Eminence dolomite increases in thickness from 122 feet in Cherokee County to 172 feet in Crawford County (well 13). It remains fairly constant in thickness in Linn and Douglas

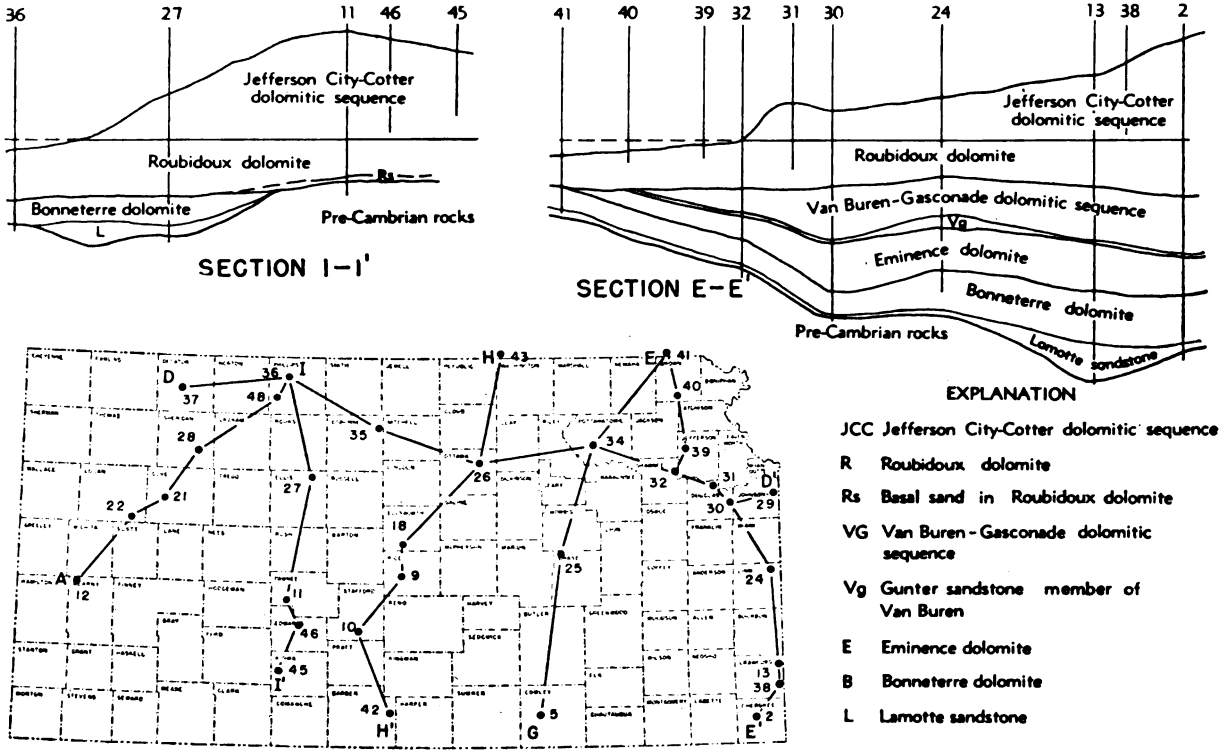

FIG. 12—Diagrammatic cross sections on lines E-E' and I-I' and index of sections.

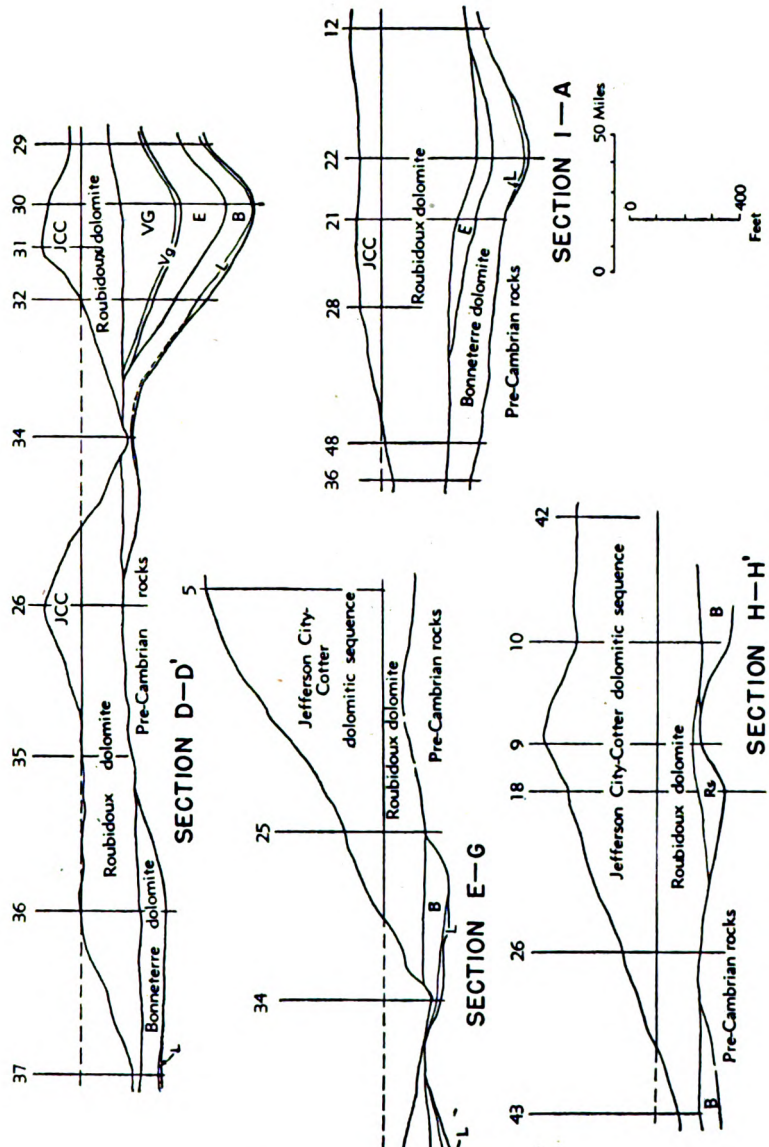

FIG. 13.—Diagrammatic cross sections on lines D-D', E-G, H-H' and I-A.

Counties (wells 24 and 30) but thins to 80 feet in Shawnee County (well 32) and is absent in the Nebraska well (well 41).

The Van Buren-Gasconade dolomitic sequence is present as far north as Shawnee County (well 32). It has not yet been determined whether the thin section in this well represents the upper part of the formation, in which case the sand at the base is younger than Gunter sand elsewhere, or whether the upper beds were removed by pre-Roubidoux erosion. Beds of both the Eminence and Gasconade dolomites are absent from the Nebraska well, in which the Roubidoux dolomite rests on Bonneterre dolomite.

Section E-E′ admirably illustrates the southward tilting of the Upper Cambrian and Lower Ordovician beds and removal by erosion after Cotter time of progressively greater thicknesses of Cotter and Jefferson City strata in a northward direction. In northern Kansas and southern Nebraska an undetermined thickness of upper beds of the Roubidoux dolomite also has been removed.

Cross Section on Line E-G (Fig. 13 and Pl. 6)

Section E-G extends from Cowley County, Kansas, to Richardson County, Nebraska, passing through Chase and Pottawatomie Counties, Kansas. Both the total distance covered and the airline distance between the two ends of the section are approximately 210 miles.

The pre-Roubidoux high area in central Kansas is indicated by the absence of beds older than Roubidoux in the Chase County well (well 25). To the north, in Pottawatomie County (well 34), the Roubidoux dolomite overlies Bonneterre dolomite, which has a thin bed of Lamotte sandstone at the base.

In Cowley County (well 5), post-Arbuckle erosion removed an undetermined thickness of Cotter and younger rocks. In Chase County (well 25) probably all the Cotter deposits and some of the upper beds of the Jefferson City are gone. The upper part of the Roubidoux dolomite was eroded in Richardson County, Nebraska (well 41).

Cross Section on Line H-H′ (Fig. 13 and Pl. 6)

Section H-H′ extends from Barber County, Kansas, to Jefferson County, Nebraska, passing through Stafford, Rice, Ellsworth,

and Ottawa Counties, Kansas. The total distance covered is 216 miles. The airline distance between the two ends of the section is 200 miles.

No formations older than Cotter or Jefferson City were penetrated by the well in Barber County (well 42). The Stafford County well (well 10) and the Nebraska well (well 43) passed through Roubidoux dolomite into Bonneterre dolomite but did not reach the Pre-Cambrian. Roubidoux or a basal sandstone probably of Roubidoux age is the oldest formation in contact with Pre-Cambrian rocks in the remaining wells in the section in Rice, Ellsworth, and Ottawa Counties (wells 9, 18, and 26). These wells are on the crest of the centrally located pre-Roubidoux high area.

The northward thinning of the Cotter-Jefferson City sequence as indicated in section H-H′ is the result of post-Arbuckle tilting and erosion.

Cross Section on Line I-I′ (Fig. 12 and Pl. 6)

Section I-I′ extends from Clark County to Phillips County, Kansas, passing northward through Kiowa, Edwards, Pawnee, Ellis, and Rooks Counties. The total distance covered is 187 miles.

The wells in the extreme southern part of the cross section (wells 45 and 46) penetrate beds older than Cotter or Jefferson City. In Pawnee County (well 11) the Pre-Cambrian rocks are overlain by a basal sandstone of probable Roubidoux age. To the north, in Ellis and Rooks Counties (wells 27 and 47), considerable thicknesses of Lamotte sandstone overlain by Bonneterre dolomite rest on the granite. In Phillips County (well 36), Lamotte sandstone is absent and Bonneterre dolomite overlies the Pre-Cambrian rocks.

The Roubidoux formation thickens northward from 137 feet in Pawnee County (well 11) to more than 200 feet in Rooks County (well 47).

Post-Arbuckle tilting and erosion have resulted in the removal of progressively greater thicknesses of Cotter and Jefferson City dolomites and younger beds from the area represented by the northern end of the section. In Rooks and Phillips Counties (wells 47 and 36) the upper part of the Roubidoux dolomite was also eroded.

Cross Section on Line I-A (Fig. 13 and Pl. 6)

Section I-A extends from Kearny County to Phillips County, Kansas, passing northward through Logan, Gove, and Sheridan Counties. Both the total distance covered and the airline distance between the two ends of the section are 160 miles.

The basin between the pre-Roubidoux high area in western Kansas and the pre-Roubidoux high area in central Kansas is crossed by this section. The Roubidoux dolomite found in the Kearny County well (well 12) which is located on the crest of the pre-Roubidoux high in western Kansas, overlies a thin section of Bonneterre dolomite beneath which the Lamotte sandstone is missing. The Eminence dolomite also is absent from this well. Similar relations are found in the wells in Rooks and Phillips Counties (wells 36, 47, and 48) located on the border of the pre-Roubidoux structurally high area of central Kansas. In the basin between these two "highs" the Eminence dolomite is well developed, as shown by wells in southeastern Logan and Gove Counties (wells 21 and 22), where it overlies a thickened section of Bonneterre dolomite. Lamotte sandstone is present at the base of the Logan County well (well 22).

Presumably the original thickness of Cotter and Jefferson City and younger strata in this area was nearly as great as in areas to the south and east. The thinning or absence of these formations in this section is due to post-Arbuckle erosion.

SUMMARY OF GEOLOGIC HISTORY

Detailed discussion of broadly regional tectonic features that may have affected the distribution and stratigraphic relations of Upper Cambrian and Lower Ordovician beds in Kansas is not within the scope of this study. The relationship of the formations, however, reveals the geologic history of the older formations in general terms.

General Considerations

The following summary of the depositional history of the Upper Cambrian and Lower Ordovician beds in Kansas is based upon an interpretation of the variations in thickness and distribution of the stratigraphic units composing that part of the geologic sec-

tion. The variation in thickness and the distribution may in part reflect changing extent of seaways; in part it may be the result of deformation due to tectonic activity and of topographic relief of the land surface upon which the beds were laid down; or it may result from a combination of these.

Tectonic activity may change the composition, texture, thickness, and distribution of clastic sediments by elevating new areas to an altitude at which erosional processes may become effective or by lowering old areas that have been supplying sediments below the altitude where erosion is effective. It may thus bring about environmental changes that are either favorable or unfavorable for the deposition of the nonclastic precipitates, evaporites, and organic deposits.

The composition of clastic sediments is dependent upon the composition of the source rock. The elevation of new areas and consequent exposure to erosional processes may bring about changes in the composition of clastic deposits. The texture of sediments is affected by the competency of transporting agents and by the distance detritus is carried, both of which reflect differences in elevation of the land surface. The total thickness of sediments that may be deposited is determined mainly by the amount of source material available, the effectiveness of the geological processes, and the length of time those processes are effective.

The original distribution of sediments is influenced by the character of land surface. Deposits normally will accumulate in basins and be absent from high areas. The original distribution may be modified by erosion following change in elevation. Sediments tend to be removed or thinned in uplifted areas and to be preserved in depressed areas. The presence or absence of stratigraphic units may therefore be an important key to the interpretation of structure.

Erosion probably has shaped the surface upon which some of the beds have been deposited. Thinner accumulations of sediment generally will extend over high areas and thicker accumulations over low areas. In any case, some form of tectonic activity is necessary to bring about conditions favorable to effective local erosion.

If it is unknown whether the upper or lower part of a sedimentary sequence is missing, it is uncertain whether beds are

absent or thin because of nondeposition or because of erosion following deposition.

The relationship and character of stratigraphic units within the Upper Cambrian and Lower Ordovician sequence indicate that a relatively high area of broad extent occupied the central part of Kansas at the beginning of Cambrian deposition.* Its location in relation to the present more recently formed structural features may be described as including the east and south flank of the Central Kansas uplift and all of the Salina basin.

In Arbuckle time the center of subsidence was in the Ozark region of Missouri, but the western margin of the basin extended into eastern Kansas. The high central part of Kansas may have formed the western boundary of Late Cambrian deposition belonging to the Ozark province. On the other hand, the absence of Upper Cambrian and some Lower Ordovician strata in the central Kansas area may reflect pre-Roubidoux stripping of deposits that once were extensively distributed. A broad basin in the western part of the State probably received deposits that were eastward extensions of the Sawatch quartzite of the Rocky Mountains and the Deadwood formation of the Black Hills.

A relatively high area in western Kansas near the Colorado boundary that extends from Gove County through western Logan County into Kearny County is indicated by absence of Lamotte sandstone, thinness of Bonneterre dolomite, and absence of the Eminence dolomite. Its western margin has not been determined. The Lamotte is present in well 22 in Logan County and well 20 in Trego County, although absent in well 21 in Gove County.

Such structural features as the Central Kansas uplift and the Nemaha anticline from which the upper parts of the Arbuckle sequence are now absent were not formed until later geologic time.

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*The absence of the Lamotte beneath the Bonneterre in some wells in central Kansas suggests topographic elevation of the Pre-Cambrian rocks in this area. However, the occurrence of Lamotte sandstone beneath the Bonneterre in the downwarped area of McPherson County (cross section A-A') and the beveling of the pre-Roubidoux surface reveal that the Lamotte was originally more widespread than now. The widespread occurrence of the Bonneterre in north-central Kansas and south-central Nebraska, in many wells that have been drilled since the completion of this report, indicate that the elevation was not high. The only wells in which the Bonneterre does not occur are in areas in which the Roubidoux overlies the beveled surface of the Pre-Cambrian rocks.

Kansas well samples indicate, as in Missouri (Lee, 1943, p. 104), that four epochs of deposition are to be recognized in Late Cambrian and Early Ordovician time. The successive groups of deposits, which are separated by major unconformities, include the following:

(1) Unconformable deposition of Lamotte sandstone on the Pre-Cambrian surface, followed by conformable deposition of the Bonneterre dolomite, Davis formation, and Derby and Doe Run dolomites, and closing with the upwarping and erosion of Doe Run and older deposits.

(2) Deposition of the Potosi, Eminence, and Proctor dolomites. The interruption of sedimentation at the end of Proctor time corresponds to the unconformity between the Cambrian and Ordovician Systems as defined in the upper Mississippi Valley.

(3) Deposition of the Van Buren formation, including the basal Gunter sandstone member and the Gasconade dolomite. This is followed by a conspicuous unconformity, for the overlying Roubidoux in different places overlies the Pre-Cambrian, Bonneterre, Eminence, and Gasconade. This unconformity is scarcely perceptible in Missouri but is pronounced in Kansas.

(4) Deposition of the Roubidoux dolomite, Jefferson City dolomite, Cotter dolomite, and possibly the Powell dolomite and Smithville limestone. The interruption of sedimentation at the end of Smithville time corresponds to the unconformity at the base of the Chazy group of Early and Middle Ordovician age. In Kansas this unconformity occurs at the base of the St. Peter sandstone.

The distribution and unconformable relationships of these will be discussed in order from oldest to youngest.

First Depositional Cycle, Lamotte to Doe Run

The Lamotte sandstone was laid down on an irregular Pre-Cambrian surface, and accumulation of sediment served to level off many inequalities in the surface. Probably this sedimentation was confined mainly to topographic depressions in eastern and western Kansas.

Deposition of Lamotte sediments gave way without interruption to widespread Bonneterre deposition, overlapping on the Pre-Cambrian surface where it was too high to be covered by Lamotte sandstone. The clastic character of the Bonneterre in

some wells, as in Chautauqua, Wilson, and McPherson Counties, may be the result of nearness to weathering granite. The Davis formation and the Derby and Doe Run dolomites probably were restricted to the deeper parts of the Ozark basin and were not deposited in Kansas.

The lithologic differences in the Bonneterre in eastern and western Kansas may be due to a facies change. Areas of thick Bonneterre in northern and southern McPherson County and the presence of Roubidoux in the Salina basin indicate more widespread deposition than indicated by areas at present underlain by Bonneterre. The absence of Bonneterre beneath the Roubidoux on structurally high areas in central Kansas has been interpreted by some geologists as indicating an area of nondeposition, but these areas were certainly beveled before the deposition of the Roubidoux and probably earlier. There was no barrier toward the north where the Bonneterre is continuous into western Kansas.

An area of moderate elevation in western Kansas at the beginning of Late Cambrian time is indicated by the absence of Lamotte sandstone and probably lower beds of the Bonneterre from wells in Kearny and Gove Counties and in western Logan County (wells 12, 21, and 23), although the Lamotte is present in southeastern Logan County and in Trego County (wells 20 and 22).

The unconformity at the end of the first cycle of deposition is represented by the absence of the Davis formation and the Derby and Doe Run dolomites. Either they were not deposited in Kansas or they were removed by post-Doe Run erosion.

Second Depositional Cycle, Potosi to Eminence

Deposition of the Potosi dolomite, which initiated the second depositional cycle, seemingly was restricted to the deeper parts of the Ozark basin in Missouri. It may have extended into southeastern Kansas although it has not been positively identified there. The Eminence dolomite, which conformably overlies the Potosi dolomite, extended westward and overlapped unconformably onto the Bonneterre dolomite in Kansas. Nowhere in Kansas is the Eminence dolomite known to lie directly on the Pre-Cambrian surface. This indicates either that the Eminence was restricted to eastern and western Kansas and was not deposited upon the

areas of uplift that were subsequently beveled by the Roubidoux, or that it was deposited broadly on the eroded surface of the Bonneterre and was removed by subsequent erosion from the crests of uplifted areas. Slight differences in the Eminence in eastern and western Kansas suggest that the rocks of this unit did not extend across the belts of uplifted Pre-Cambrian rocks in the central part of the State, but the occurrence of Eminence in the syncline in southern McPherson County suggests that it was originally more widely distributed than now.

It is not possible to determine the original distribution of the Eminence dolomite or what thickness of beds has been removed. The presence of a thin section of Eminence dolomite in western Logan County indicates that the formation probably was deposited in the extreme western part of the State and that upwarping and erosion at the close of the second depositional cycle removed all the Eminence dolomite from the area represented by wells in Kearny and Gove Counties.

Third Depositional Cycle, Van Buren to Gasconade

The third cycle of sedimentation extends from the deposition of the Gunter sandstone member of the Van Buren to the close of Gasconade time. In Missouri, the Van Buren-Gasconade sequence normally overlies the Proctor or Eminence. In Kansas, the sequence (as shown in cross sections A-A′ and B-B′) bevels the older rocks from the Eminence to the Pre-Cambrian. In southern McPherson County it overlies a thin section of Eminence. The relations are interpreted as indicating the continued growth of broad anticlines trending east of north with beveling of their crests by the Van Buren. In view of the presence of the Eminence beneath the Van Buren in southern McPherson County (well 16) it is presumed that that area was part of a pre-Roubidoux syncline in which the Van Buren-Gasconade sequence and the Eminence and Bonneterre, which were originally more widespread, were preserved although stripped from the crests of the adjacent anticlines. If the Van Buren-Gasconade sequence once overlay the Eminence in the basin of western Kansas, it was removed from that area by pre-Roubidoux erosion.

The Van Buren-Gasconade sequence overlaps unconformably across the beveled edges of the Eminence and Bonneterre dolomites onto the Pre-Cambrian surface in Sumner and Sedgwick

Counties (cross section A-A′). The coarsely clastic character of the basal beds of the Van Buren in Sedgwick and Sumner Counties (wells 6 and 7) is probably due to the nearness of exposed granite.

In Missouri, the Roubidoux formation everywhere overlies Gasconade dolomite. Upper beds of the Gasconade are absent locally in southeast Missouri, and their absence has been explained as resulting from post-Roubidoux solution (Dake, 1930, p. 158). Although the unconformity in Missouri is obscure, the Roubidoux dolomite in Kansas is conspicuously unconformable on the underlying rocks and rests in turn on each of the older formations and on Pre-Cambrian rocks in a considerable area in the central part of the State (Fig. 7).

Fourth Depositional Cycle, Roubidoux to Smithville

The widespread distribution of the Roubidoux, Jefferson City, and Cotter dolomites in Kansas, except where removed by post-Arbuckle erosion, indicates that the greatest westward extension of Ozark deposition probably occurred in the fourth depositional cycle, Roubidoux to Smithville.

In eastern Kansas, the Roubidoux dolomite unconformably overlies the Van Buren-Gasconade sequence and the Bonneterre dolomite. That some areas of the pre-Roubidoux eroded surface retained considerable relief is suggested by the absence of the lower part of the Roubidoux in well 15 (cross section B-B′), where it is only 72 feet thick and overlies an elevated thin body of Bonneterre on the crest of a structural arch. Local variations in the thickness of the Roubidoux occur elsewhere (well 6 of cross section B-B′). Its thickness reaches 350 feet in western Kansas.

In the central part of the State, the Roubidoux unconformably overlies the Pre-Cambrian rocks on structurally high areas, as shown in well 8 of cross section B-B′, and on a more well-defined arch farther west in wells 9, 18, and 19 in Rice and Barton Counties. Between these structural arches the well in southern McPherson County reveals a relatively deep and sharp syncline across which the Roubidoux overlies the Van Buren-Gasconade sequence and older rocks. In western Kansas the Roubidoux overlies the Eminence in a broad structural basin on the margin of which the Roubidoux overlies Bonneterre (cross sections A-A′ and B-B′).

The widespread deposition of Jefferson City and Cotter deposits in Kansas followed Roubidoux deposition. Although a minor break between the Jefferson City and Cotter dolomites is recognized in Missouri by some geologists, it has not been identified in Kansas.

The Powell dolomite and Smithville limestone succeeded the Cotter dolomite in parts of Missouri and probably in Kansas with only minor interruptions in sedimentation. Originally they were distributed widely, but if they reached Kansas they were removed from most of the State prior to St. Peter time. That remnants of these beds may survive in southwestern Kansas is indicated by meager samples from wells in Clark, Kiowa, Meade, and Gray Counties.

At the close of the fourth cycle of deposition, the beds were elevated in northern Kansas and truncated. Slight northward convergence of beds below the Roubidoux dolomite indicates that some deformation in this direction may have preceded the warping that took place before St. Peter deposition. All the Jefferson City and Cotter deposits and part or all of the Roubidoux dolomite were removed from northern Kansas during this extensive period of erosion. The Cotter dolomite probably was removed from all but the most southern part of the State. That the northward truncation of beds and overlap of the St. Peter sandstone continued into Nebraska is indicated by the absence of post-Gasconade beds from the Union Stock Yards Company No. 3 well at Omaha, Nebraska, as determined by McCracken of the Missouri Geological Survey (McQueen and Greene, 1938, p. 44).

The high area in western Kansas also seems to have received additional warping at the end of early Ordovician time, as indicated by the removal of all the Jefferson City and Cotter and upper part of the Roubidoux deposits from wells in western Logan County (well 23) and Kearny County (well 12), whereas these formations are present in wells to the east.

DESCRIPTIONS OF INSOLUBLE RESIDUES

Detailed descriptions of insoluble residues of cuttings of pre-St. Peter rocks in 15 representative wells are given below. These wells are shown on Plate 6.

La Salle Oil Company No. 1 Gobl, SE cor. NW¼ sec. 20, T. 28 S., R. 25 E., Crawford County, Kansas. No. 13, cross sections B-B' and E-E' (Figs. 10 and 12).

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
Eroded top of Cotter-Jefferson City sequence, 725.		
725 -30	12	Chert, bluish, semitranslucent, 30%; chert, fine, dolocastic, some of the fragments having a nondolocastic core, 30%; shale, caved, gray, 30%; pyrite, massive, some of it pitted and rather spongy in appearance, 10%.
730 -40	20	Chert, white to tan, semitranslucent, vitreous, 100%; trace massive pyrite.
740 -50	20	Chert, white, dense to semitranslucent, vitreous, 70%; chert, dolocastic (dolocasts are coarse, 0.2 mm diameter, and matrix is soft, porous), 30%; trace massive pyrite.
750 -60	10	Chert, bluish-white, semitranslucent, vitreous to somewhat quartzose, 95%; aggregates of quartz crystals, 5%.
760 -70	10	Chert, blue and brown, translucent, with large brown oölites approximately 0.8 mm diameter, banded and ringed with white dense chert, 100%.
770 -80	25	Chert, tan to bluish, semitranslucent, vitreous, with scattered dolocasts, 80%; shale, greenish-gray, soft, with scattered pyrite crystals, 15%; chert, medium fine, dolocastic, 5%.
780 -90		Samples missing.
790 -800	12	Chert, white, dense to semitranslucent, vitreous, with veinlets of crystalline quartz and scattered white oölites, 85%; chert, fine, soft, porous, dolocastic, 15%.
800 -810	15	Chert, white, vitreous, porcelaneous, grading into a semitranslucent, vitreous chert, 80%; chert, very finely dolocastic, 10%; sand, extremely well sorted, in clusters (grains average 0.2 mm diameter; some secondary quartz enlargement has taken place) 10%.
810 -20	2	Chert, white, dense, porcelaneous, with scattered white banded oölites, grading to white semitranslucent vitreous chert, 98%; sand, as above, 2%.
820 -30	25	Chert, white, semitranslucent, with small white banded oölites, 70%; chert, medium fine, dolocastic, soft and porous, dolocasts closely spaced, walls thin, unbroken, 20%; chert, white to cream, porcelaneous, 10%.
830 -40	20	Chert, bluish white, semitranslucent, 40% chert, cream to white, porcelaneous, 26%; chert, light tan, semitranslucent, with numerous brown translucent oölites ringed with dense white chert, 20%; chert, dolocastic, as above, 10%; sand, clusters of fine, bright, angular, well sorted, 2%; sand, medium coarse, rounded, frosted, showing secondary quartz enlargement, 2%; trace bright green shale.
840 -50	10	Chert, white to bluish, semitranslucent, vitreous, with very fine pyrite crystals scattered over the surface, 85%; chert, medium fine, dolocastic (walls are thin and broken; some fragments have dense chert at the core), 10%; chert, white, porcelaneous, 5%.

850 -60	15	Chert, medium fine, dolocastic (matrix is porous, walls thin but unbroken, and chert has a mealy appearance), 50%; chert, white porcelaneous, 20%; chert, bluish white, semitranslucent, vitreous, 20%; chert, quartzose, and aggregates of quartz crystals, 10%; trace of green shale.
860 -70	25	Chert, tan to cream, semitranslucent, with scattered large, brown, translucent and white, clear oölites, 85%; chert, quartzose, and aggregates of quartz crystals, 10%; chert, dolocastic, as above, 5%.
870 -80	25	Chert, light tan to cream, semitranslucent, vitreous, with scattered large brown oölites, 85%; chert, cream, vitreous, porcelaneous, 10%; chert, quartzose, and aggregates of quartz crystals, 5%.
880 -90	10	Chert, tan to bluish, semitranslucent, vitreous, containing clear glassy oölites or included sand grains, 75%; chert, coarse, dolocastic, walls thick and unbroken, 10%; quartz, crystalline, aggregates, and quartzose chert, 10%; chert, cream, vitreous, porcelaneous, 5%.
890 -900	10	Chert, tan with brown oölites, as above, 40%; sand, bright, angular, averaging 0.2 mm diameter, (larger grains, approximately 0.5 mm diameter, may be rounded and frosted), 30%; chert, tan, quartzose, 20%; chert, white, vitreous, porcelaneous, 10%; trace green shale.
900 -10	15	Chert, light tan to bluish, semitranslucent, vitreous, 80%; chert, tan, quartzose, as above, 20%.
910 -20	12	Chert, tan to bluish, semitranslucent, with scattered dark brown oölites, 85%; quartz, drusy, medium dark brown crystalline, 10%; quartz fragments, crystalline, clear, 5%.
920 -30	20	Chert, very finely dolocastic, fragments having a mealy appearance, 95%; chert, white, vitreous, porcelaneous, with scattered pyrite crystals on surface, 5%.
930 -40	20	Chert, light tan, semitranslucent, vitreous, with fine pyrite crystals scattered on surface, 65%; chert, finely dolocastic, as above, 20%; quartz, drusy, medium brown, crystalline, 10%; quartz fragments, milky, 5%.
940 -50	15	Chert, cream to tan, dense, somewhat granular, 40%; chert, bluish to tan, translucent, opalescent, 35%; chert, fine, dolocastic, as above, 15%; quartz, drusy, brown, as above, 10%.
950 -60	18	Chert, tan to bluish, semitranslucent, vitreous, with numerous white dense and brown translucent oölites, 70%; chert, cream to white, vitreous, porcelaneous, 15%; quartz fragments, angular, 10%; sand, fine, bright, angular, 5%.
960 -70	15	Chert, tan to bluish, semitranslucent, vitreous, with numerous dark brown oölites, 85%; quartz, crystalline, fragments, and a few terminated quartz crystals, 10%; sand, poorly sorted, rounded, frosted, 5%.

Top Roubidoux dolomite, 970.

970 -75	20	Chert, tan to bluish, as above, 60%; chert, light tan, drusy, 25%; sand bright angular averaging 0.2 mm diameter, 15%.

La Salle Oil Company No. 1 Gobl, SE cor. NW¼ sec. 20, T. 28 S., R. 25 E., Crawford County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
975 -80	10	Chert, tan to bluish, as above, 65%; chert, tan, drusy, and fragments brown quartzose chert, 20%; sand, medium coarse, bright, angular, averaging approximately 0.4 mm diameter (trace of doubly terminated quartz crystals), 15%.
980 -90	20	Sand, bright, angular, averaging 0.3 mm diameter and secondarily enlarged (few grains 1.0 mm diameter rounded and frosted), 30%; chert, quartzose, 30%; chert, white, vitreous, porcelaneous, 20%; chert, cream to tan, semitranslucent, 20%.
990 -1000	10	Sand, as above, 50%; chert, bluish-white, semitranslucent, 30%; chert, quartzose, 20%.
1000 -30	15	Sand, as above, 50%; chert, bluish-white, translucent, with numerous large white oölites which may be included sand grains, 50%.
1030 -40	5	Sand as above, 75%; chert, bluish-white, as above, oölites less numerous, 25%.
1040 -50	1	Sand, as above, 50%; chert, white, dense, with numerous large included sand grains, 50%.
1050 -60		Samples missing.
1060 -65	12	Sand, as above, 80%; chert, bluish-white, translucent, 20%.
1065 -70	10	Chert, bluish-white, translucent, with a few included sand grains, 50%; sand, as above, 30%; chert, tan, semitranslucent to quartzose, 20%; white oölites which may be coated sand grains are free in the sample; trace of bright green shale.
1070 -1110	30	Sand, as above, 100%.
1110 -15	1	Sand, as above, 75%; chert, white, dense, dull to quartzose, 25%.
1115 -35	25	Sand, as above, 100%.
Top Gasconade-Van Buren sequence, 1135.		
1135 -45	10	Chert, blue to tan, semitranslucent, vitreous, 50%; quartz, drusy, white to medium dark gray, brown, and light green, 25%; sand as above, 25%.
1145 -1200		Samples missing.
1200 -20	20	Chert, cream to white, dense, vitreous, 90%; chert, lacy, dolocastic, 10%.
1220 -30	15	Chert, cream to white, as above, 80%; chert, tripolitic, 20%.
1230 -40	10	Chert, white, dense to semitranslucent, vitreous, 60%; chert, tripolitic, 40%.
1240 -50	12	Chert, tripolitic, 50%; chert, white, vitreous, porcelaneous, grading to semitranslucent, vitreous, 50%.

1250	-70	10	Chert, tripolitic, 40%; chert, porcelaneous, as above, 30%; chert, light tan, semitranslucent, semiquartzose, 30%.
1270	-1310	10	Chert, porcelaneous, as above, 100%. The surface of many of the fragments is altered to tripolitic chert.
1310	-20	5	Chert, porcelaneous, as above, 45%; chert, very coarsely dolocastic (0.4 mm diameter), lacy-appearing, white, 30%; chert, quartzose, 20%; sand, ranging from 0.5 to 0.1 mm diameter, mostly rounded, 5%; considerable amount spongy pyrite.
1320	-30	10	Chert, porcelaneous, as above, 35%; chert, quartzose, and aggregates of crystalline quartz, 30%; chert, dolocastic, as above, 20%; chert, tripolitic, 15%.

Top Gunter sandstone member of the Van Buren formation, 1330.

1330	-40	5	Sand, ranging from 1.0 mm to 0.1 mm in diameter (all but finest grains are rounded and frosted, some grains being perfectly spherical), 80%; chert, porcelaneous, 15%; chert, dolocastic, 5%.

Top Eminence dolomite, 1340.

1340	-50	5	Sand, as above, except many grains are bright and angular due to secondary quartz enlargement, 70%; chert, white to cream, porcelaneous, 30%; aggregates of pyrite crystals present.
1350	-60	8	Sand, as above, 40%; chert, bluish-white, semitranslucent, opalescent, 30%; chert, white, porcelaneous, 20%; chert, light tan, translucent, quartzose, 10%.
1360	-70	3	Sand, as above, 50%; chert, white, dense to semitranslucent, vitreous, 35%; chert, coarse, lacy, dolocastic, 10%; chert, tripolitic, 5%; trace angular fragments milky and crystalline quartz.
1370	-80		No residue.
1380	-1400	8	Sand, as above, 70%; chert, bluish-white, semitranslucent, vitreous, 30%.
1400	-10	0.5	Chert, white, dense, vitreous, 40%; sand, as above, 40%; chert, drusy, and angular crystalline quartz fragments, 20%; considerable amount of pyrite in aggregates of fine crystals.
1410	-20	0.2	Chert, white, dense to semitranslucent, 80%; sand, fine, approximately 0.2 mm diameter, rounded and frosted, 10%; masses of fine pyrite crystals, 10%.
1420	-30	1	Chert, bluish-white, semitranslucent, 60%; sand, as above, 30%; quartz, angular fragments, milky, 10%; considerable amount of crystalline pyrite.
1430	-40	2	Chert, white, as above, 65%; sand, as above, 25%; chert, light tan, drusy, 10%.
1440	-50	1	Chert, quartzose and drusy, 90%; pyrite, in spongy and finely crystalline masses, 10%.
1450	-60	2	Chert, white, dense to semitranslucent, 45%; chert, light tan, translucent to quartzose, 25%; sand, bright, angular, 1.0 mm to 0.1 mm diameter but averaging 0.7 mm diameter, 20%; chert, finely dolocastic, porous, 10%; considerable amount of pyrite in masses of fine crystals, some of them in the shape of tiny balls.

La Salle Oil Company No. 1 Gobl, SE cor. NW¼ sec. 20, T. 28 S., R. 25 E., Crawford County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
1460 -70	3	Chert, white, semiquartzose, 55%; sand, as above, 30%; chert, tan, quartzose, as above, 15%; considerable amount spongy pyrite.
1470 -80	2	Chert, tan to bluish, semitranslucent, vitreous, 50%; sand, as above, 40%; chert, finely dolocastic, porous, 10%; considerable amount of pyrite in balls in fine crystal aggregates.
1480- 90	3	Chert, light tan, semitranslucent, semiquartzose, with numerous scattered large dolocasts 0.2 mm diameter, 90%; sand, as above, 10%; considerable amount of spongy pyrite and pyrite balls.
1480 -90 (duplicate sample)	0.1	Chert, white, drusy, 50%; chert, bluish-white, semitranslucent, 20%; pyrite, both massive and in aggregates of fine crystals, 15%; chert, tan, as above, 15%.
1490 -1500	3	Chert, tan, with scattered dolocasts as above, 100%.
1500 -07	0.1	Chert, tan, with scattered dolocasts, as above, 75%; pyrite, spongy, tarnished, 25%.
1507 -12	0.1	Chert, very finely dolocastic, mealy-textured, 100%; considerable amount spongy pyrite.
Top Bonneterre dolomite, 1512.		
1512 -67	5	Shale, brown, spongy, sandy, 100%; considerable amount massive pyrite.
1567 -73	3	Shale, brown, spongy, sandy, 100%; considerable amount glauconite grains and massive pyrite fragments.
1573 -87	8	Shale, light brown, spongy, sandy, 100%; considerable amount of massive pyrite.
1587 -1605	15	Shale, brown, spongy, sandy, becoming clusters of very fine sand, 100%; minor amount of pyrite.
1605 -35	30	Sand, very fine (75% in clusters and 25% free), 100%; minor amount of pyrite; trace glauconite.
1635 -55	25	Sand, very fine, approximately 50% free, 100%; fine grains of glauconite are associated with the sand clusters and free sand.
1655 -68	23	Sand, very fine, in clusters and free, associated with a very great deal of glauconite in fine and very large grains, 100%.
1663 -85	25	Sand, micaceous, fine, in clusters and free, associated with fine grains of glauconite, 100%.
1685 -90	25	Sand, fine, associated with a very great deal of glauconite in fine and large grains, some of which measure 1.0 mm across, and small fragments of mica, 100%.
1690 -99	37	Sand, as above, 100%.
1699 -1710		Samples missing.
Top Lamotte sandstone, 1710.		

1710 -13	45	Sand, coarse, averaging 0.8 mm diameter, and rounded and frosted, 100%.
1713 -20	72	Sand, coarse, both rounded frosted and bright angular, 100%.
1720 -25	100	Sand, coarse, bright, angular, averaging 1.0 mm diameter, 100%; quartz crystal faces and crystal terminations common.
1725 -30	100	Sand, as above, but including large flaky and sharp needlelike fragments of quartz, 100%.
1730 -60	100	Sand, as above, 100%; some grains appear to be derived from amethyst quartz.
1760 -1842	100	Sand, coarse, basal, as above, with numerous flaky grains, 100%; few pieces weathered feldspar.

Top Pre-Cambrian granite, 1840.

T. D. Pink granite.

Holeman and Edwards No. 9 Pollman, SE¼ SE¼ sec. 35, T. 19 S., R. 24 E., Linn County, Kansas. No. 24, cross section C-C′ (Fig. 11).

Samples start 882

Eroded top of the Cotter-Jefferson City sequence, 889.

889 -96	44	Chert, bluish-white, semitranslucent, waxy, 40%; chert, light, tan, translucent, semiquartzose, with a few large brown oölites, 40%; chert, cream, dense, with altered tripolitic surface, 20%.
896 -900	34	Chert, bluish-white, translucent, semiquartzose, 60%; sand, bright, angular, averaging 0.4 mm diameter, 20%; chert, white, vitreous, porcelaneous, with some altered surfaces tripolitic and dolocastic, 20%; trace spongy pyrite.
900 -05	20	Chert, bluish-white, as above, 60%; chert, cream, porcelaneous, with scattered medium fine dolocasts, 25%; sand, as above, 15%.
905 -10	16	Chert, bluish, translucent, opalescent, 75%; sand, as above, 20%; chert, porcelaneous, with scattered dolocasts, 5%.
910 -15	6	Chert, bluish, as above, 70%; chert, white, porcelaneous, 15%; sand, as above, 15%.
915 -20	40	Chert, white to tan, semitranslucent, vitreous to semiquartzose, showing occasional bandings, 70%; chert, cream, very finely dolocastic, mealy-textured, 30%.
920 -25	40	Chert, white to tan, as above, 70%; chert, dolocastic, as above, 25%; sand, bright, angular, 5%.
925 -30	48	Sand, bright, angular, ranging from 1.0 to 0.1 mm diameter with flaky grains and quartz crystal faces indicative of secondary enlargement, 95%; chert, white, as above, 5%.
930 -35	64	Chert, medium dark gray and white semitranslucent, vitreous, 100%.
935 -40	26	Sand, bright, angular, secondarily enlarged, 50%; chert, white to tan, semitranslucent, vitreous, 50%.
945 -60	10	Chert, white, as above, 100%.

Holeman and Edwards No. 9 Pollman, SE¼ SE¼ sec. 35, T. 19 S., R. 24 E., Linn County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
960 -65	30	Chert, white, as above, 87%; chert, cream, dull, dense to finely porous, 8%; chert, drusy, brown, 5%.
965 -70	8	Chert, white, as above, 90%; chert, dense to porous, as above, 10%.
970 -75	10	Chert, white, as above, 87%; chert, dense to porous, 8%; chert, tan, drusy, 5%.
975 -80	14	Chert, white, as above, 80%; chert, brown, drusy, 10%; chert, dense to porous, as above, 5%; sand, fine, bright, angular, 5%.
980 -85	10	Chert, white as above, 85%; sand, fine, bright, angular, 10%; chert, brown, drusy, 5%.
985 -90	8	Chert, white, as above, 70%; sand, fine, bright, angular, averaging 0.2 mm diameter, with flaky grains and quartz crystal faces indicative of secondary enlargement, 20%; chert, brown, drusy, 10%.
990 -95		Samples missing.
995 -1000	14	Chert, blue to tan, semitranslucent, vitreous, 60%; chert, finely dolocastic, mealy-textured, 30%; sand, 0.8 to 0.1 mm diameter, angular, bright, rounded, frosted, 10%.
1000 -05	4	Chert, drusy, brown, 50%; chert, bluish, as above, 30%; chert, cream, porcelaneous, 20%.
1005 -15	10	Chert, drusy, brown, 75%; chert, bluish, as above, 25%.
1015 -20	34	Sand, bright, very angular, 1.0 to 0.1 mm diameter, 50%; chert, bluish, as above, 30%; chert, white, with included sand grains, 20%.
1020 -25	12	Sand, bright, angular, and sand grains in chert, 50%; chert, bluish, as above, 40%; chert, tan, dense, with scattered oölites, 10%.
1025 -30	28	Chert, cream, porous to tripolitic, 75%; chert, bluish as above, 25%.
1030 -35	2	Chert, bluish, as above, 40%; chert, porous, as above, 30%; chert, dark brown, drusy, 30%.
1035 -40	12	Chert, bluish, as above 55%; sand, fine, bright, angular, 0.3 to 0.8 mm diameter, rounded, frosted, 25%; chert, porous, as above, 20%.
1040 -45	26	Chert, bluish, as above, 70%; chert, porous, as above, 30%.
1045 -50	22	Chert, bluish, as above, 80%; chert, tripolitic, white, dense, 20%.
1050 -55	58	Chert, white, quartzose, 80%; sand, bright, angular, 20%; trace of oölites or sand grains encrusted with drusy quartz.
Top Roubidoux dolomite, 1055.		
1055 -60	38	Sand, bright, angular, 1.0 to 0.1 mm diameter, and sand grains in chert, 80%; chert, white, dense to semitranslucent, 20%.

1060 -65	30	Sand, as above, 80%; chert, bluish, translucent, 20%.
1065 -70	30	Sand, averaging 0.5 mm diameter, 100%. Approximately 70% is rounded, frosted and 30% bright, extremely angular.
1070 -75	12	Sand, bright, angular, (few grains 1.0 mm diameter, rounded, frosted), 80%; chert, bluish, translucent, 20%.
1075 -80	28	Sand, fine, bright, angular, averaging 0.1 mm diameter, 45%; sand, poorly sorted, 1.0 to 0.1 mm diameter, the larger grains rounded and frosted, 45%; chert, bluish, as above, 10%.
1080 -85	46	Sand, poorly sorted, as above, 100%.
1085 -90	34	Chert, blue to tan, dense, with numerous included sand grains, 75%; sand, fine, bright, angular, 25%.
1090 -95	22	Sand, bright, angular, averaging 0.5 mm diameter, 90%; chert, bluish-white, translucent, 10%.
1095 -1100	28	Sand, fine, bright, angular, averaging 0.2 mm diameter, 70%; chert, gray, quartzose, 30%.
1100 -10	28	Sand, bright, angular, 65%; sand, rounded, frosted, 20%; chert, gray, quartzose, 15%.
1110 -15	22	Sand, bright, angular, 55%; chert, bluish-white to tan, semitranslucent, vitreous, 45%.
1115 -20	8	Sand, 100% (50% is fine, averaging 0.2 mm diameter, and 50% coarse, rounded, frosted, ranging up to 0.8 mm diameter); considerable amount of spongy pyrite.
1120 -25	8	Sand, as above, 100%.
1125 -30	4	Sand, as above, 60%; chert, bluish, translucent, with numerous included sand grains, 40%.
1130 -35	4	Sand, very fine, bright, angular, averaging less than 0.1 mm diameter, 75%; chert, bluish-white, translucent, 25%.
1135 -40	30	Chert, bluish, as above, 70%; sand, as above, 30%.
1140 -55	14	Chert, bluish, as above, 50%; sand, as above, 50%.
1155 -60	10	Sand, as above, 80%; chert, bluish, as above, 20%.
1160 -65	2	Sand, bright, angular, poorly sorted, ranging from 0.1 to 0.8 mm diameter, 100%; considerable amount crystalline pyrite.
1165 -70	10	Chert, bluish-white, translucent, 30%; sand, as above, 30%; chert, dark brown, drusy, 20%; chert, gray quartzose to vitreous, 20%.
1170 -75	80	Sand, coarse, bright, angular, averaging 1.0 mm diameter, 100%; Conchoidal fracture, flaky grains and quartz crystal faces in evidence.
1175 -80	18	Sand, bright, angular, averaging 0.8 mm diameter, with trace rounded, frosted grains, 90%; chert, bluish-white, translucent, 10%.
1180 -85	8	Sand, bright, angular, averaging 0.3 mm diameter, with flaky grains and quartz crystal faces common, 75%; chert, as above, 25%.
Top Gasconade-Van Buren sequence, 1190.		
1185 -95	4	Chert, blue to tan, semitranslucent, semiquartzose, 60%; sand, as above, 40%.
1195 -1200	28	Chert, as above, 100%.

Holeman and Edwards No. 9 Pollman, SE¼ SE¼ sec. 35, T. 19 S., R. 24 E., Linn County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
1200 -05	4	Chert, as above, 65%; sand, coarse to fine, bright, angular, 20%; chert, brown, drusy, 15%.
1205 -08	1	Chert, as above, 90%; sand, as above, 10%.
1208 -20	1	Sand, bright, angular, averaging 0.1 mm diameter, 50%; chert, as above, 50%; considerable amount of crystalline pyrite.
1220 -22	72	Chert, tan to medium dark brown, semitranslucent, semiquartzose to vitreous, with encrustations of quartz crystals, 100%.
1222 -25	48	Chert, white, dull, dense, 50%; chert, cream, tripolitic, 50%.
1225 -30	28	Same as above.
1230 -35	36	Chert, bluish-white, semitranslucent, vitreous, 90%; chert, tripolitic, with scattered dolocasts, 10%.
1235 -45		Samples missing.
1245 -50	52	Chert, bluish-white, as above, 100%.
1250 -55	36	Chert, as above, 90%; chert, white, dull, dense, 10%.
1255 -60	28	Chert, bluish, as above, 80%; chert, white, dense, rough, 20%.
1260 -65	10	Chert, bluish, as above, 70%; chert, rough, as above, with scattered medium fine dolocasts, 30%.
1265 -70	8	Chert, cream, dense, smooth, porcelaneous, 50%; chert, cream, rough, dense, 50%.
1270 -76	8	Chert, bluish, translucent, 80%; chert, rough, as above, 20%; trace fragments of crystalline quartz.
1276 -82	12	Chert, white, smooth, vitreous, porcelaneous, with scattered large brown translucent oölites, 100%.
1282 -86	24	Chert, as above, 100%.
1286 -92	14	Chert, as above, 100%.
1292 -94		Samples missing.
1294 -97	18	Chert, white, dense, quartzose, with veinings and encrustations of crystalline quartz, 70%; chert, white, dense, rough, with scattered medium large dolocasts, 30%.
1297 -1303	16	Chert, rough, as above, 50%; chert, tan, smooth, vitreous to quartzose, with scattered tan dense oölites and veinings of crystalline quartz, 50%.
1303 -10	10	Chert, as above, 100%.
1310 -24	34	Chert, as above, 100%.
Top Gunter sandstone member of the Van Buren formation, 1324.		
1324 -30	24	Sand, bright, angular, ranging from 1.0 to 0.1 mm diameter (quartz crystal faces indicate secondary enlargement), 75%; chert, white, dense, smooth to rough, 25%; trace white oölites free in sample.
1330 -35	18	Sand, as above, 60%; chert, smooth to rough, as above, 40%.

1335 -40	12	Ozokerite (?) 100%.
1340 -45	2	Sand, bright, angular, ranging from 0.5 to 0.1 mm diameter, averaging 0.2 mm diameter, 70%; chert, white, semitranslucent, 30%; trace spongy pyrite.
1345 -50	2	Chert, light tan, smooth, dense to semitranslucent, 80%; sand, as above, 20%.
1350 -55	2	Sand, mostly rounded and frosted, averaging 0.2 mm diameter, 70%; chert, light tan, semitranslucent, with scattered large light tan translucent oölites, 30%; considerable amount of crystalline pyrite.
1355 -60	18	Chert, tan, smooth, semitranslucent to dense, 70%; chert, cream, dense, rough, 30%.
1360 -72	14	Sand, bright, angular, secondarily enlarged, ranging from 0.9 to 0.1 mm diameter, 80%; chert, white, dense, vitreous, 20%; trace white oölites free in sample.

Top Eminence dolomite, 1370.

1372 -78	16	Chert, tan, smooth, dense, 90%; sand, as above, 10%.
1378 -84	22	Chert, blue to tan, translucent, grading to medium gray, translucent, 60%; chert, white, smooth, dense, 25%; sand, bright, angular, and angular fragments crystalline quartz, 10%; quartz, drusy, dark brown, 5%.
1384 -90	4	Chert, blue to tan, translucent, semiquartzose, 60%; chert, white, smooth, dense, 25%; sand, bright, angular, 15%.
1390 -1400	2	Chert, blue to tan, as above, 70%; chert, white, smooth, as above, 20%; quartz, drusy, very dark brown, 10%.
1400 -05	1	Chert, white to tan, semitranslucent, quartzose, 50%; chert, white, dense, smooth to rough, 30%; aggregates fine pyrite crystals, 10%; sand, bright, angular, and rounded, frosted, 10%.
1405 -15	1	Chert, bluish-white, semitranslucent, 70%; quartz, drusy, brown, 20%; sand, as above, 10%.
1415 -30	-1	Trace sand and chert.

Top Bonneterre (?) dolomite, 1430? Samples 1430-88 may represent an upper shaly phase of the Bonneterre dolomite.

1430 -78	1	Shale, greenish-brown, waxy, smooth, 100%; trace sand and quartzose material; considerable amount of crystalline and spongy pyrite.
1478 -88	6	Shale, very waxy, smooth, laminated, dolocastic, green, 100%.

Top Bonneterre dolomite, 1510.

1488 -1527	2	Pyrite, massive, spongy, 50%; shale, green, as above, 50%.
1527 -37	4	Quartz, drusy, white, 70%; sand, rounded, averaging 0.8 mm diameter, blue color suggesting derivation from blue translucent chert, 30%; much massive pyrite.
1537 -42	4	Sand grains, blue, 70%; shale, waxy, green, 20%; chert, quartzose, 10%; much massive and spongy pyrite.
1542 -47	4	Sand grains, blue, 6%; pyrite, massive, spongy, 30%; shale, waxy, green, 10%.
1547 -52	4	Sand, blue, 65%; pyrite, spongy, 30%; shale, waxy, green, 5%.

Holeman and Edwards No. 9 Pollman, SE¼ SE¼ sec. 35, T. 19 S., R. 24 E., Linn County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
1552 -65	28	Sand grains, bright, angular, blue, 1.5 to 0.1 mm diameter, 100%; trace amethyst quartz.
1565 -81	48	Sand, as above, 100%; trace green shale.
1581 -1600	52	Sand, as above, 100%; trace green shale.
T. D. 1601		

R. F. Duffens et al. No. 1 Stanley, NW¼ NE¼ NW¼ sec. 3, T. 14 S, R. 21E., Douglas County, Kansas. No. 30, cross sections D-D' and E-E' (Figs. 12 and 13)

Eroded top of the Cotter-Jefferson City sequence, 1712.

1712 -16	80	Sand, coarse, poorly sorted, 1.0 to 0.1 mm diameter, mostly rounded and frosted, 60%; chert, bluish, semitranslucent, with included sand grains, 25%; chert, light tan, translucent, quartzose, 15%.
1716 -24	70	Sand, as above, 30%; chert, bluish, semitranslucent, vitreous, 30%; sand, extremely fine, 0.1 mm to fine powder, 20%; chert, brown, semitranslucent, quartzose, 20%.
1724 -30	55	Sand, rounded, frosted, averaging 0.6 mm diameter, 75%; chert, white, dense to semitranslucent, 25%.
1730 -33	70	Sand, as above, 75%; chert, white, dense, rough, 25%.
1733 -37	55	Sand, as above, 90%; chert, white, dense to translucent, 10%; a considerable amount of crystalline pyrite.
1737 -44	40	Sand, as above, 90%; chert, white to bluish, translucent, 10%.
1744 -50	40	Sand, as above, 70%; chert, white, dense, rough to semitranslucent, vitreous, 30%.
1750 -53	70	Sand, as above, 70%; chert, white to bluish, semitranslucent, 30%.
1753 -57	80	Sand, as above, 75%; chert, white, dense, vitreous, 25%.
1757 -61	80	Sand, as above, 65%; chert, white, as above, 25%; chert, brown, semitranslucent, 10%.
1761 -63	70	Sand, as above, 75%; chert, white, dense to bluish, semitranslucent, 25%.
1763 -66	50	Sand, as above, 75%; chert, white to tan, semitranslucent, 25%.
1766 -73	70	Sand, as above, 40%; chert, white, soft, very finely dolocastic, 30%; chert, white, semitranslucent, 30%.
1773 -77	75	Sand, as above, 70%; chert, blue to tan, translucent, 20%; chert, cream, dense, rough, 10%.
1777 -80	60	Chert, white to tan, semitranslucent, 50%; sand, as above, 50%.
1780 -82	75	Sand, as above, less pyritic, 80%; chert, bluish-white, semitranslucent, 20%.
1782 -84	55	Sand, as above, 85%; chert, as above, 15%.

1784 -88	60	Sand, as above, 70%; chert, white, dense, soft, tripolitic, 20%; chert, bluish-white, translucent, 10%.
1788 -92	50	Sand, as above, 90%; chert, translucent, as above, 5%; chert, tripolitic, as above, 5%.
1792 -97	65	Sand, as above, 90%; chert, white, semitranslucent, 10%.
1797 -1802	65	Sand, as above, 85%; chert, white, dense, smooth to rough, 10%; chert, as above, 5%.
1802 -05	65	Sand, as above, 90%; chert, white, dense to bluish, translucent, 10%.
1805 -10	35	Sand, as above, 90%; chert, as above, 10%.
1810 -14	30	Sand, as above, 95%; chert, white, dense, smooth to bluish, translucent, 5%.

Top Roubidoux dolomite, 1818.

1814 -23	25	Sand, coarse, rounded, frosted, to fine, bright, angular, 90%; chert, white, dense to bluish, translucent, 10%.
1823 -26	65	Sand, as above, 85%; chert, white, dense, smooth to rough, 10%; chert, tan, semitranslucent, 5%.
1826 -30	40	Sand, with a greater proportion of subrounded grains 0.1 mm diameter, 90%; chert, as above, 10%.
1830 -34	32	Sand, as above, 80%; chert, white, dense, granular, 20%.
1834 -37	25	Sand, mostly fine, bright, angular grains, and few rounded, frosted and secondarily enlarged grains 0.5 mm diameter, 75%; chert, white, dense, dull, with included sand grains, 25%.
1837 -38	25	Sand, bright, angular, 0.3 mm diameter, 75%; chert, white, dense, 25%.
1838 -49	50	Sand, as above, 75%; chert, as above, 25%.
1849 -52	45	Chert, white, dense, dull, and trace free white oölites, 90%; sand, fine, bright, angular, as above, 10%.
1852 -56	5	Chert, white dense to semitranslucent, 50%; sand, as above, 50%.
1856 -61	30	Sand, as above, 90%; chert, as above, 10%.
1861 -66	5	Sand, as above, 90%; chert, as above, 10%.
1866 -70	12	Sand, bright, extremely angular, 0.3 mm diameter, 55%; chert, white, dense to semitranslucent, 40%; quartz, drusy, brown, 5%.
1870 -75	18	Sand, as above, 70%; quartz, drusy, brown, 20%; chert, white to bluish, semitranslucent, 10%.
1875 -80	15	Sand, as above, 60%; chert, bluish-white, translucent, 25%; quartz, drusy, brown, 10%; chert, white, dense, rough, 5%.
1880 -85	25	Sand, as above, 90%; chert, bluish, translucent, 10%.
1885 -1900	32	Sand, as above, pyritic, 65%; chert, white, dense to semitranslucent, 25%; quartz, drusy, brown, 10%.
1900 -02	40	Chert, white, semitranslucent, 100%.
1902 -05	40	Chert, as above, 90%; sand, fine, bright, angular, 10%.
1905 -23	32	Sand, fine, bright, angular, as above, with trace rounded, frosted grains, 75%; chert, white, dense to translucent, 25%.

R. F. Duffens et al. No. 1 Stanley, NW¼ NE¼ NW¼ sec. 3, T. 14 S, R. 21E., Douglas County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
1923 -28	60	Sand, bright, angular and rounded, frosted, averaging 0.5 mm diameter, 70%; chert, bluish, translucent, 30%.
1928 -33	40	Sand, as above, 75%; chert, very finely dolocastic, quartzose, 15%; chert, as above, 10%.
1933 -36	30	Sand, as above, but with greater proportion fine powdery grains less than 0.1 mm diameter, 85%; chert, bluish, translucent, 15%.
1936 -39	30	Sand, as above, 80%; quartz, drusy, gray, 10%; chert, bluish-white, dense to semitranslucent, 10%.
1939 -41	40	Quartz, drusy, gray, 50%; sand, as above, 50%.
1941 -43	35	Sand, as above, 60%; chert, bluish-white, semitranslucent, 40%.
1943 -47	40	Sand, as above, 50%; quartz, drusy, gray, 30%; chert, as above, 20%; trace ozokerite?
1947 -54	50	Sand, as above, 70%; chert, as above, 20%; quartz, drusy, gray, 10%.
1954 -56	50	Sample too small to make residues.
1956 -60	50	Sand, as above, 80%; chert, bluish, translucent, 20%.
1960 -70		Samples missing.
1970 -73	15	Sand, as above, 50%; chert, bluish, translucent, semiquartzose, 40%; chert, white, soft, coarsely dolocastic, 10%.
1973 -76	8	Sand, as above, 70%; chert, bluish, translucent, semiquartzose, 20%; chert, cream, soft, crumbly, tripolitic, 10%.
1976 -83	10	Sand, coarse, 1.0 mm diameter, and fine, bright angular, averaging 0.3 mm diameter, 70%; chert, bluish, translucent, 20%; chert, white, dense, porcelaneous, 10%.
1980 -84		Samples too small to make residues.
Top Gasconade-Van Buren sequence, 1985.		
1984 -92	25	Sand, as above, 80%; chert, bluish-white, semitranslucent to translucent, 20%.
1992 -2009		Samples too small to make residues.
2009 -11	10	Sand, coarse and fine, with grains less than 0.1 mm diameter, 75%; chert, bluish-white, translucent, 25%.
2011 -19	40	Sand, as above, 90%; chert, bluish, translucent, 10%.
2019 -25	10	Sand, as above, 90%; chert, as above, 10%.
2025 -29	20	Sand, medium coarse, rounded, frosted, 90%; chert, white, dense to bluish, translucent, 10%.
2025 -32	30	Chert, white, dense, vitreous, 50%; chert, white, semitranslucent, quartzose, 30%; sand grains, large, rounded, frosted, 20%.
2032 -36	20	Chert, bluish-white, semitranslucent, 50%; chert, white, dense, rough, 40%; chert, soft, white, crumbly, tripolitic, 10%.

2036 -45	25	Chert, bluish-white, semitranslucent, 100%.
2045 -48	40	Sand, coarse to fine, rounded, frosted, 60%; chert, white, dense to semitranslucent, 40%.
2048 -51	50	Sand, as above, 80%; chert, bluish, semitranslucent to dense, 20%.
2051 -56	30	Sand, pyritic, as above, 60%; chert, white, dense to bluish, translucent, 40%.
2056 -61	20	Chert, as above, 60%; sand, as above, 40%.
2061 -65	20	Chert, as above, 80%; sand, as above, 20%.
2065 -72	15	Chert, white, dense, vitreous to bluish, semitranslucent, 80%; sand, as above, 20%.
2072 -75		Samples too small to make residues.
2075 -82	25	Sand, as above, 70%; chert, white, dense, vitreous, 30%.
2082 -87	30	Sand, as above, 55%; chert, as above, 45%.
2087 -90	15	Sand, as above, 80%; chert, white, dense, smooth to semiquartzose, 20%.
2090 -94		Samples too small to make residues.
2094 -99	20	Chert, white, dense, vitreous, 85%; sand, pyritic, as above, 15%.
2099 -2106	10	Chert, as above, 85%; sand, as above, 15%.
2106 -11	5	Sand, coarse, rounded, frosted, averaging 0.5 mm diameter, 40%; sand, bright, angular, averaging 0.1 mm diameter, 40%; chert, white, dense to semitranslucent, 20%.
2111 -25	10	Sand, well sorted, bright, angular, averaging 0.2 mm diameter, 70%; chert, white, dense, dull, 30%.
2125 -34	10	Sand, fine, bright, angular, well sorted, 40%; chert, white, dense, dull, 30%; chert, bluish, semitranslucent, 30%.
2134 -41		Samples too small to make residues.
2141 -55	50	Chert, white, semitranslucent, quartzose, 65%; sand, as above, and quartz, crystalline, angular fragments, 20%; chert, cream, soft, crumbly, rough, 15%.
2155 -61		Samples too small to make residues.
2161 -66	10	Chert, white, translucent, quartzose, 65%; sand, bright, angular, 0.3 to 0.1 mm diameter, 25%; chert, cream, rough, crumbly, 10%.
2166 -70	10	Chert, bluish-white, translucent, quartzose, 50%; sand, as above, 35%; chert, white, dense, dull, 10%; chert, white, soft, tripolitic, 5%.
2170 -80		Samples too small to make residues.
2180 -84	5	Chert, bluish-white, translucent, quartzose, 60%; sand, as above, 40%.

Top Gunter sandstone member of the Van Buren, 2185.

2184 -91	20	Sand, poorly sorted, subrounded, ranging from 0.8 to 0.1 mm diameter, 80%; chert, as above, 20%.

Top Eminence dolomite, 2191.

2191 -94	5	Chert, bluish-white, semitranslucent, quartzose, 65%; sand, medium fine, bright, angular, 30%; chert, cream, soft, tripolitic, 5%.

R. F. Duffens et al. No. 1 Stanley, NW¼ NE¼ NW¼ sec. 3, T. 14 S, R. 21E., Douglas County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
2194 -2200	5	Chert, bluish-white, translucent, quartzose, 50%; chert, white, dense, vitreous, 25%; sand, as above, 25%.
2200 -05		No sample.
2205 -13	5	Chert, bluish-white, semitranslucent, 75%; sand, pyritic, as above, 25%.
2213 -17	5	Chert, bluish-white, semitranslucent, 60%; sand, medium coarse, rounded, frosted, to fine, bright, angular, 30%; chert, white, dense, vitreous, 10%.
2217 -28		Samples too small to make residues.
2228 -31	5	Sand, as above, 80%; chert, white, dense, vitreous, 10%; chert, blue, semitranslucent, 10%.
2231 -72		Samples too small to make residues.
2272 -75	5	Sand, as above, 60%; chert, bluish, translucent, 20%; chert, white, translucent, quartzose, 10%; chert, white, dense, vitreous, 10%.
2275 -83		Samples too small to make residues.
2283 -87	16	Sand, as above, 80%; chert, white, dense, vitreous, 10%; chert, bluish-white, semitranslucent, 10%.
2287 -96		Samples too small to make residues.
2296 -98		Sand, as above, 75%; chert, white, dense to bluish, translucent, 25%.
2298 -2300	5	Quartz, drusy, white, 40%; chert, white, dense, vitreous, 30%; sand, as above, 20%; chert, bluish, translucent, 10%.
2300 -01	10	Quartz, drusy, as above, 50%; chert, bluish, translucent, 30%; chert, white, dense, vitreous, 20%.
2301 -08		Samples too small to make residues.
2308 -10	7	Sand, medium coarse, rounded, frosted, to fine, bright, angular, 70%; chert, white, dense, vitreous, 20%; chert, bluish, translucent, 10%.
2310 -14	16	Sand, as above, 70%; chert, white, dense to semitranslucent, 30%.
2314 -17	5	Sand, fine, bright, angular, averaging 0.2 mm diameter, 70%; chert, white to bluish, semitranslucent, 30%.
2317 -19		Samples too small to make residues.
2319 -23	30	Sand, medium coarse, poorly sorted, rounded, frosted, to fine, bright, angular, 80%; chert, white to tan, dense, vitreous, 20%.
2323 -35		Samples too small to make residues.
2335 -37	20	Sand, as above, 70%; chert, white, dense, rough, 10%; chert, bluish, translucent, 10%; chert, white, semitranslucent, 10%.
2337 -42	15	Sand, as above, with trace rounded feldspar grains, 90%; chert, white, semitranslucent, 10%.
2342 -46	8	Chert, white, semitranslucent, quartzose, 90%; sand, very fine, bright, angular, 10%.

2346 -48	15	Chert, buff, soft, crumbly, porous, 70%; chert, blue to tan, dense, vitreous, 20%; sand, medium coarse, rounded, frosted, 10%.
2348 -52	20	Chert, finely dolocastic, 80%; chert, white, dense, porcelaneous, 10%; sand grains, rounded, coarse, 5%; chert, bluish-white, translucent, 5%.
2352 -54	25	Chert, dolocastic, as above, 80%; sand, fine, bright, angular, 15%; chert, white, dense, porcelaneous, 5%.
2354 -56		Samples too small to make residues.
2356 -60	10	Chert, bluish-white, semitranslucent, 40%; chert, finely dolocastic, as above, 20%; sand, fine, bright, angular, 20%; chert, white, dense, porcelaneous, 20%.

Top Bonneterre dolomite, 2366.

2360 -67	10	Chert, white, translucent, quartzose, 60% sand, as above, with quartz, crystalline, angular fragments, 30%; chert, white, medium finely dolocastic, 10%.
2367 -72	5	Quartz, drusy, light tan, 80%; sand and quartz, as above, 20%.
2372 -75	5	Quartz, drusy, brown, 90%; sand grains, rounded frosted, and fragments, 10%; quartz, crystalline, angular.
2375 -83	1	Quartz, drusy, tan, with much pyrite, 75%; sand and quartz, as above, 25%.
2383 -89	1	Quartz, crystalline, angular fragments, 50%; quartz, drusy, brown, 35%; chert, white, dense, dull, 10%; chert, dolocastic, 5%.
2389 -95	1	Chert, brown, dense to semitranslucent, 40%; chert, blue, translucent, 25%; pyrite, 25%; quartz, crystalline, angular fragments, 10%.
2395 -98	1	Chert, white, dense, semiquartzose, 45%; shale, cream, soft, waxy, (cavings?), 20%; pyrite, 20%; sand, bright, angular, and angular fragments quartz, 15%.
2398 -2400	1	Shale, slightly dolocastic, brown, 20%; sand, rounded, frosted, and bright, angular, 20%; chert, brown, dense to semitranslucent, 20%; pyrite, 15%; chert, bluish-white, translucent, 15%; chert, white, dense, porcelaneous, 10%.
2400 -02	1	Chert, brown, semitranslucent, quartzose, 50%; pyrite, 25%; chert, white, dense, porcelaneous, 15%; sand, bright, angular, 10%.
2402 -03	1	Sand, rounded, frosted, 2.0 mm diameter, to bright, angular grains less than 0.1 mm diameter, 50%; chert, white, dense, porcelaneous, 25%; chert, tan, quartzose, 25%.
2403 -04	1	Shale, light brown, dolocastic, with glauconite inclusions, 50%; sand, coarse, rounded, frosted, and angular fragments crystalline quartz, 25%; quartz, drusy, brown, 15%; chert, white, dense, porcelaneous, 10%; much crystalline and massive pyrite.
2404 -05	4	Sand, well sorted, secondarily enlarged, averaging 0.2 mm diameter, 80%; chert, tan to white, dense, 20%; much pyrite.
2405 -08	2	Sand, pyritic, as above, 100%.

R. F. Duffens et al. No. 1 Stanley, NW¼ NE¼ NW¼ sec. 3, T. 14 S, R. 21 E., Douglas County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
2408 -09	1	Sand, fine, as above, 100%.
2409 -11	8	Quartz, drusy, tan, 70%; sand, coarse, rounded, frosted, 30%.
2411 -15	2	Chert, tan, quartzose, 85%; sand, coarse, as above, 10%; chert, bluish, semitranslucent, 5%; many rounded glauconite grains and much crystalline pyrite.
2415 -18	5	Quartz, drusy, tan, 90%; chert, bluish, translucent, 5%; sand, as above, 5%; much massive and crystalline pyrite.
2418 -20	3	Sand, very fine, in clusters, with large glauconite grains, 80%; sand, as above, 10%; pyrite, massive and finely crystalline, 10%.
2420 -28	5	Sand, fine, glauconitic, as above, 100%.
2428 -33	10	Sand, glauconitic, fine, as above, 50%; shale, greenish-gray to brown, dolocastic, 50%.
2433 -37	20	Shale, as above, 80%; sand, fine, glauconitic, brown, shaly aggregates, 20%.
2437 -43	30	Shale, dolocastic, as above, 50%; sand, as above, 50%.
2443 -50	15	Shale, brown to green with fine dolocasts and included glauconite grains, 100%.
2450 -56	10	Shale, dolocastic, as above, 90%; glauconite, large grains, 10%.
Top basal sandstone (Lamotte), 2457.		
2456 -60	35	Sand, bright, angular, and round, frosted, averaging 0.6 mm diameter, 100%; much glauconite.
Top Pre-Cambrian granite, 2463.		
2460 -95	100	Pink granite.
T. D. 2503.		

Glower No. 1 Forkner, NW¼ SE¼ NE¼ sec. 17, T. 33 S., R. 23 E., Cherokee County, Kansas. No. 2, cross section A-A' (Fig. 11).

Eroded top of the Jefferson City-Cotter sequence, 685.		
685 -89	45	Chert, bluish, translucent, contains oölites which appear as darker gray translucent areas, 85%; chert, medium fine, mealy-textured, dolocastic, 15%.
689 -95	25	Chert, white, dense to semitranslucent, 90%; chert, dolocastic as above, 10%.
695 -700	12	Sand, medium coarse, poorly sorted (0.8 to 0.1 mm diameter), mostly rounded and frosted and secondarily enlarged, 65%; chert, white, as above, 30%; chert, dolocastic, as above, 5%.

700 -05	25	Chert, smooth, dense, white, vitreous, with scattered faint brown oölites, 93%; chert, dolocastic, as above, 5%; quartz, crystalline, angular fragments, 2%.
705 -10	6	Chert, bluish translucent, containing a few brown translucent oölites, 75%; chert, dolocastic, as above, 15%; chert, white, dense, as above, 10%.
710 -15	10	Chert, smooth, white, dense, vitreous, 76%; chert, dolocastic, as above, 20%; quartz, crystalline, angular fragments, 2%; sand grains in chert, 2% .
720 -26	30	Chert, semitranslucent, blue to tan, faintly oölitic, 97%; chert, dolocastic, as above, 3%.
726 -32	30	Chert, as above, with numerous brown banded oölites, 60%; chert, dolocastic, somewhat coarser than previous sample, 40%; a considerable amount of spongy pyrite.
732 -37	40	Chert, as above, 85%; chert, dolocastic, 15%.
737 -43	60	Chert, as above, 80%; chert, dolocastic, very fine, 20%.
743 -45	25	Chert, bluish, translucent, opalescent, 70%; chert, dolocastic, as above, 20%; sand, fine, bright, angular, 10%.
745 -55		Sample too small to make residues.
755 -62	20	Chert, blue to brown, translucent, 75%; chert, soft, white, dolocastic, 15%; quartzose material, dark gray, 5%; sand, fine, angular, 5%.
762 -67	35	Chert, very fine, mealy-textured, dolocastic, 80%; sand grains in chert, 10%; chert, white to bluish, translucent, 10%.
767 -75	25	Chert, blue to brown, semitranslucent, 77%; sand, medium coarse, averaging 0.5 mm diameter, rounded, frosted and bright and angular, 20%; spongy pyrite, 2%; quartzose material, black to green, 1%.
773 -79	25	Chert, bluish, translucent, 79%; chert, very finely, dolocastic, porous, 20%; quartzose material, 1%.
779 -85	8	Chert, smooth, white, dense, vitreous, 92%; chert, white, soft, rough, porous, 5%; chert, dolocastic, as above, 2%; quartzose material, dark green to black, 1%.
785 -93	3	Chert, white to buff, smooth, dense, vitreous, 50%; chert, bluish, translucent, 25%; quartzose material, yellow-green to gray, 10%; quartz, milky, angular fragments, 5%; chert, dolocastic, as above, 5%; spongy pyrite, 5%.
793 -800	25	Sand, very well sorted, medium fine, free and in friable aggregates, averaging 0.2 mm diameter, and bright and angular, 100%.
800 -05	5	Quartz, milky, angular fragments, 50%; chert, tan, semitranslucent, vitreous to quartzose, 50%.
805 -10	2	Chert, white, smooth, dense, vitreous, 50%; chert, blue to tan, translucent, 25%; sand, fine, bright, angular, poorly sorted, 25%. Larger grains 0.5 mm diameter are rounded, frosted, and secondarily enlarged.
810 -17	3	Chert, white, smooth, dense, vitreous, 75%; chert, blue to tan, translucent, opalescent, 20%; sand, as above, 5%.
817 -23	30	Chert, bluish, semitranslucent, 70%; chert, white, dense, 20%; chert, very finely dolocastic, mealy-textured, 10%.

Glower No. 1 Forkner, NW¼ SE¼ NE¼ sec. 17, T. 33 S., R. 23 E., Cherokee County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
823 -28	50	Chert, white, semitranslucent, opalescent, 95%; sand, as above, 5%; much finely crystalline pyrite.
828 -32	35	Chert, white to buff, faintly oölitic, semitranslucent, with veinings and bandings of crystalline quartz, 100%.
832 -37	25	Chert, blue to tan, translucent, opalescent, 85%; chert, finely dolocastic, mealy-textured, 15%.
837 -45	10	Chert, translucent, as above, 75%; sand, medium coarse, angular to rounded, frosted, 0.5 to 1.0 mm diameter, 25%.
845 -49		Sample too small to make residues.
849 -52	85	Chert, finely dolocastic, 100%.
852 -58	25	Chert, dolocastic, as above, 75%; chert, blue to tan, translucent, opalescent, 25%.
858 -61	5	Chert, dolocastic, as above, 50%; chert, translucent, as above, 50%; much spongy pyrite.
864 -70	20	Chert, blue to brown, translucent, containing numerous brown quartzose to translucent oölites, 100%.
870 -76	35	Chert, translucent, blue to brown, opalescent, 75%; chert, white, smooth, dense, vitreous, 25%.
876 -81	40	Chert, white, dense, smooth, vitreous, with numerous large brown translucent oölites, 100%.
881 -88	20	Chert, smooth, white, dense, vitreous, with scattered large brown oölites, 80%; sand, medium fine, bright and angular due to secondary quartz enlargement, 15%; chert, brown, translucent, 5%.
888 -94	25	Chert, brown, dense to translucent, containing scattered banded and translucent oölites, 100%.
894 -900	12	Chert, as above, 98%; chert, soft, porous, slightly dolocastic, white, 2%.
900 -05	15	Chert, white, dense, with numerous included sand grains, 80%; chert, white to bluish, translucent, 10%; sand, fine, angular, 10%.
905 -10	35	Chert, tan to buff, very finely dolocastic, mealy-textured, 55%; chert, light brown, semitranslucent, waxy-lustered, 25%; sand, medium coarse, poorly sorted, bright, angular, 15%; quartz, crystalline, angular fragments, 5%.
910 -16	35	Chert, brown, translucent, waxy-lustered, grading to light tan semitranslucent vitreous chert, 90%; sand, as above, 5%; chert, dolocastic, as above, 5%.
916 -22	25	Chert, brown, as above, 90%; sand, as above, 10%.
922 -28	25	Chert, tan, semitranslucent, vitreous, 70%; shale (?), cream, finely dolocastic, 25%; quartz, crystalline, angular fragments, 5%.
928 -34	20	Chert, brown to bluish, semitranslucent, containing numerous translucent brown oölites, 80%; sand, medium coarse, secondarily enlarged, poorly sorted (0.7 to 0.1 mm diameter), 20%.

934 -41	50	Chert, light tan, dense to semitranslucent, 85%; chert, finely dolocastic, 15%.
941 -47	25	Chert, white to buff, dense, smooth, vitreous, 75%; chert, brown, dense, with numerous small brown oölites (0.1 mm diameter), 20%; shale, dark brown, dolocastic, 5%.
947 -53	25	Chert, cream to brown, finely dolocastic, mealy-textured, 50%; chert, brown to tan, waxy-lustered, containing faint darker brown translucent oölites.
953 -60	15	Chert, brown, as above, 85%; shale, cream, dolocastic, 15%.
960 -65	25	Chert, brown, as above, 85%; chert, cream to light brown, quartzose, dolocastic, 15%.
965 -70	20	Chert, tan, dense, containing numerous dark brown translucent oölites (many oölites are free), 100%.
970 -76	50	Chert, light tan to buff, dense, vitreous, non-oölitic, 100%.
976 -82	45	Chert, tan, dense, as above, 60%; chert, cream, finely dolocastic, porous, 40%.
982 -87	10	Chert, tan, dense, with numerous brown translucent banded oölites, 75%; chert, white, rough, 15%; chert, soft, finely dolocastic, porous, 10%.
987 -92	10	Chert, white, rough, 80%; chert, oölitic, as above, 20%.
992 -98	30	Chert, tan to buff, dense, vitreous, 75%; sand, medium fine, bright, angular, 25%.
998 -1004	30	Chert, dense, as above, 90%; shale, brown to white, dolocastic, 5%; sand, angular, 5%.
1004 -10	25	Chert, cream to brown, dense, vitreous, 95%; sand, angular, as above, 5%.
1010 -17	18	Chert, as above, 90%; shale, cream to brown, dolocastic, 10%.
1017 -24	6	Chert, buff, dense, with scattered fine, brown oölites, 100%.
1024 -30	15	Chert, white, dense, granular, mottled with dark gray, and covered with fine pyrite cyrstals, 63%; chert, tan, semitranslucent, 30%; chert, white, soft, rough, 5%; oölites, tan, dense, in crystalline matrix, 2%.
1030 -35	6	Chert, cream to brown, dense, 60%; chert, gray mottled, with fine pyrite crystals on surface, 38%; shale, brown, spongy, dolocastic, 2%.
1035 -41	30	Sand, bright, angular, poorly sorted, ranging from 0.5 to -0.1 mm diameter, 60%; chert, white to tan, dense, vitreous, 40%.
1041 -46	40	Chert, dense, as above, 70%; chert, white to brown, medium finely dolocastic, spongy-textured, 30%.
1046 -52	30	Chert, dolocastic, as above, 60%; chert, gray to brown, dense, grainy, with scattered dolocasts, 40%; much pyrite.
1052 -59	25	Chert, cream, dense, vitreous, with numerous brown translucent oölites, 65%; chert, dolocastic, as above, 30%; quartz, crystalline, angular fragments, 5%.

Glower No. 1 Forkner, NW¼ SE¼ NE¼ sec. 17, T. 33 S., R. 23 E., Cherokee County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
1059 -62	60	Chert, oölitic, as above, 60%; chert, dolocastic, as above, 40%.
1062 -65	12	Chert, dolocastic, as above, 50%; chert, tan to brown, semitranslucent, vitreous, 50%; much pyrite.
Top Roubidoux dolomite, 1065.		
1065 -70	30	Chert, white to tan, translucent, with brown translucent oölites, 55%; chert, smooth, white, dense, vitreous, 25%; sand, fine bright, angular, 15%; quartz, crystalline, angular fragments, 5%.
1070 -75	35	Chert, smooth, white, dense, vitreous, 40%; chert, oölitic, as above, 30%; sand, fine, bright, angular, averaging 0.3 mm diameter, 30%.
1075 -80	30	Sand, bright, angular, averaging 0.1 mm diameter, 60%; chert, white, semitranslucent, 20%; chert, tan, translucent, faintly oölitic, 20%.
1080 -85	30	Sand, coarser (0.3 to 1.0 mm diameter), mostly bright, angular but larger grains rounded and frosted, 70%; chert, white, dense to bluish, translucent, 20%; chert, oölitic, as above, 10%.
1085 -90	15	Sand, as above, 75%; chert, white, dense, with smooth vitreous rough surface, 15%; chert, oölitic, as above, 10%.
1090 -96	25	Sand, as above, 90%; chert, white, dense, smooth, vitreous, with numerous large brown translucent oölites, 10%.
1096 -1102	10	Sand, as above, 80%; chert, white, dense, smooth, vitreous, 20%.
1102 -07	10	Sand, as above, 90%; chert, bluish, translucent, with scattered brown translucent oölites, 10%.
1107 -19	30	Sand, as above, 75%; chert, white, dense to bluish, translucent, non-oölitic, 25%.
1119 -25	20	Sand, as above, 95%; chert, as above, 5%.
1125 -30	10	Sand, as above, 100%.
1130 -36	30	Chert, white to bluish, semitranslucent, 75%; sand, as above, 25%; scattered free white oölites.
1136 -41	15	Sand, as above, 80%; chert, white, dense to blue, translucent, 20%.
1141 -70		Samples too small to make residues.
1170 -75	15	Sand, as above, 50%; chert, as above, 50%.
1175 -79	70	Chert, white, smooth, dense, vitreous to quartzose, faintly oölitic, with crystalline quartz veining, 95%; sand, as above, 5%.
1179 -85	25	Chert, as above, 75%; sand, as above, 25%; trace ozokerite?
1185 -89	15	Sand, as above, 70%; chert, as above, 30%.

1189 -92	5	Sand, as above, 90%; chert, bluish, translucent, opalescent with scattered brown translucent oölites, 10%.
1192 -1202	60	Sand, bright, angular, poorly sorted, 1.0 to 0.1 mm diameter, but averaging 0.2 mm diameter, 100%.
1202 -08	75	Sand, as above, 100%.
1207 -14	15	Sand, as above, 90%; chert, white, dense, smooth, vitreous, 10%.
1208 -14	65	Sand, as above, 100%.
1214 -19	35	Sand, as above, 100%.
1219 -24	10	Sand, as above, 100%.
1224 -34	30	Sand, as above, 100%.
1234 -50	15	Sand, as above, 100%.
1250 -56	25	Sand, as above, 100%.
1256 -63	10	Sand, as above, 90%; chert, bluish white, semitranslucent, 10%.

Top of the Gasconade-Van Buren sequence, 1263.

1263 -69	15	Chert, white, dense, smooth, vitreous, 90%; sand, as above, 10%.
1269 -75	45	Chert, as above, 90%; sand, as above, 10%.
1275 -81		Samples missing.
1281 -87	15	Sand, bright, angular, 60%; chert, as above, 40%.
1287 -94		Samples missing.
1294 -99	30	Sand, fine, bright, angular, averaging 0.2 mm diameter, fairly well sorted, 80%; chert, bluish white, semitranslucent, with white banded oölites, 20%.
1299 -1304	30	Sand, as above, 95%; chert, soft, white, porous, 5%.
1304 -10	40	Sand, as above, 90%; chert, white to bluish, semitranslucent, 10%.
1310 -17	20	Sand, as above, 90%; chert, soft, white, porous, 5%; chert, bluish white, semitranslucent, 5%.
1317 -22	25	Sand, 50%; chert, bluish, as above, 50%.
1322 -28	20	Sand, 75%; chert, as above, 25%.
1328 -31	60	Chert, white, dense, smooth, vitreous, 90%; sand, 10%.
1331 -37	15	Sand, 60%; chert, as above, 40%.
1337 -43	15	Sand, 75%; chert, bluish white, semitranslucent, 20%; chert, soft, white, porous, 5%.
1343 -55	12	Chert, white, dense, smooth, vitreous, 75%; sand, 25%.
1355 -60	40	Chert, as above, 95%; sand, 5%.
1360 -63	60	Sand, 50%; chert, white, dense to bluish, semitranslucent, vitreous, 50%.
1363 -68	3	Sand, 80%; chert, as above, 20%.
1368 -74	3	Chert, soft, white, porous, 50%; sand, 40%; chert, bluish white, semitranslucent, 10%.
1374 -80	45	Chert, white, dense, smooth, vitreous, 100%.
1380 -85	20	Chert, as above, 85%; chert, soft, white, porous, 15%.
1385 -90	30	Chert, white to buff, dense, vitreous, 80%; chert, porous, as above, 20%.
1390 -95	15	Chert, porous, as above, 75%; chert, white, dense, smooth, vitreous, 25%.

Glower No. 1 Forkner, NW¼ SE¼ NE¼ sec. 17, T. 33 S., R. 23 E., Cherokee County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
1395 -1408	6	Chert, porous, as above, 70%; chert, dense, as above, 20%; sand, fine, bright, angular, 10%.
1408 -16	25	Chert, dense, as above, 95%; sand, 5%.
1416 -21	15	Chert, white, dense, smooth, vitreous, with numerous white oölites, faint because they are only slightly more translucent than matrix, 95%; sand, 5%.
1421 -26	10	Chert, oölitic, as above, 90%; quartzose material, yellow green, 10%.
1426 -43	25	Chert, white, smooth, dense, vitreous, 80%; sand, 10%; chert, soft, white, porous, 10%.
1443 -48	15	Quartz, crystalline, angular fragments, 50%; chert, white, semitranslucent to dense, 30%; chert, porous, as above, 20%. Free white oölites also are soft and porous.
1448 -55	10	Chert, tan to gray, dense, granular, 90%; quartz, crystalline, angular fragments, 10%; soft, porous, white, free oölites numerous.
1455 -60	60	Chert, white to tan, dense to semitranslucent, 95%; chert, soft, white, porous, 5%.
1460 -65	5	Chert, tan to bluish, semitranslucent, 80%; sand, fine, bright, angular, 10%; chert, porous, as above, 10%.
1465 -71	2	Chert, semitranslucent, as above, 85%; chert, porous, as above, 10%; sand, bright, angular, 5%.
1471 -77	1	Chert, translucent, as above, 75%; sand, fine, bright, angular, 15%; chert, porous, as above, 10%.
Top Gunter sandstone member of the Van Buren formation, 1478.		
1477 -84	15	Sand, poorly sorted, ranging from 0.6 to -0.1 mm diameter, but averaging 0.3 mm diameter (larger grains are rounded, frosted, or secondarily enlarged, smaller grains bright and angular), 85%; chert, porous, as above, 15%.
1484 -90	5	Sand, as above, 90%; chert, porous, as above, including free white porous oölites which are brown at core, 10%.
1490 -96	5	Sand, as above, 85%; chert, bluish, translucent, 10%; chert, porous, as above, 5%.
Top Eminence dolomite, 1498.		
1496 -1508	1	Sand, as above, 90%; chert, bluish, semitranslucent, 5%; chert, porous, as above, 5%.
1508 -15		Samples missing.
1515 -19	2	Sand, as above, 59%; chert, bluish-white, translucent, 40%; chert, medium fine, lacy, dolocastic, 1%.
1519 -24	1	Sand, as above, 50%; chert, white, dense, smooth, vitreous, 25%; chert, bluish, translucent, 15%; quartzose material, 10%.
1524 -42	2	Chert, bluish- white, semitranslucent to semiquartzose, 75%; sand, as above, 25%.

1542 -53	-1	Chert, white, dense, smooth, vitreous, 90%; sand, 10%.
1553 -58	5	Chert, bluish-white, semitranslucent, 50%; sand, 50%.
1558 -64	1	Sand and angular fragments, quartz, 70%; chert, bluish, as above, 20%; chert, white, smooth, dense, vitreous, 10%.
1564 -73	1	Sand and angular fragments, quartz, 70%; chert, white, dense to semitranslucent, 30%.
1573 -79	2	Sand and angular fragments of crystalline quartz as above, 60%; chert, white, milky, quartzose to drusy, 40%.
1579 -1602		Samples too small to make residues.
1602 -06	5	Sand and angular fragments crystalline, quartz, 40%; chert, medium fine, lacy, dolocastic, 25%; chert, bluish, translucent, 25%; pink feldspar, (?) 10%.
1606 -11	3	Sand and angular fragments of crystalline quartz, 45%; chert, bluish, translucent, 25%; chert, dolocastic, as above, 15%; feldspar (?), 15%.
1611 -17		Samples missing.

Top Bonneterre dolomite, 1620.

1617 -22	6	Sand and angular fragments of crystalline quartz, 40%; shale, dark brown, spongy, dolocastic, 30%; chert, dark brown, translucent, vitreous to quartzose, 20%; chert, white, dense, vitreous, 10%; much crystalline pyrite.
1622 -26	5	Shale, spongy, brown, as above, 50%; chert, brown, as above, 20%; chert, white, dense to semitranslucent, 20%; feldspar (?), 5%; quartz fragments, angular, 5%; much spongy pyrite.
1626 -35	1	Chert, white, dense to semitranslucent, quartzose, 60%; shale, brown, spongy, as above, 20%; quartz fragments, angular, and sand, 20%; much spongy pyrite.
1635 -40	8	Shale, brown, spongy, 90%; chert, white, quartzose, 10%; much spongy pyrite.
1640 -45	5	Shale, yellow-brown, porous, spongy, 95%; chert, white, quartzose, 5%.
1645 -68	8	Shale, brown, coarsely spongy, finely sandy, 100%; much bright, massive pyrite.
1668 -85	12	Shale, sandy brown, as above, 100%.
1685 -1708	15	Shale, light buff, very sandy, spongy, and aggregates of very fine sand, all less than 0.1 mm diameter, 100%.
1708 -21	30	Shale, spongy, and sand aggregates, very fine, as above, 100%.
1721 -30	60	Shale, spongy, and sand aggregates, very fine, as above, 100%.
1730 -40	40	Shale, spongy, and sand aggregates, very fine, as above, 100%.
1740 -60	50	Sand aggregates, very fine, bright, angular, shaly, associated with fine grains of glauconite, 100%.
1760 -75	55	Sand, light colored aggregates, angular, bright, somewhat coarser than previous samples, averaging 0.2 mm diameter and associated with considerable yellow-green to brown glauconite.

Glower No. 1 Forkner, NW¼ SE¼ NE¼ sec. 17, T. 33 S., R. 23 E., Cherokee County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
1775 -1800	35	Sand, as above, in loose aggregates and free, associated with much glauconite, 100%.
1800 -06	15	Sand, as above, 100%.
Top Lamotte sandstone, 1807.		
1806 -10	50	Sand, coarse, poorly sorted, bright, angular, 1.5 mm diameter, 85%; sand, fine, bright, glauconitic, as above, 15%.
1810 -14	75	Sand, coarse, as above, 100%.
1814 -18	100	Sand, coarse, as above, 100%.
Top Pre-Cambrian ? (prob. quartzite), 1831.		
1818 -37	100	Sand, coarse, as above, grading into large angular fragments crystalline quartz 2.0 to 3.0 mm diameter, 100%.
1837 -57	100	Sand, coarse, angular, as above, with arkosic material, 100%.
Top Pre-Cambrian granite.		
1857 -62	100	Pink granite.
T. D.		

Prairie Oil and Gas Company No. 9 Brown, SE¼ SW¼ NW¼ sec. 26, T. 34 S., R. 11 E., Chautauqua County, Kansas. No. 4, cross section **A-A'** (**Fig. 11**).

Eroded top of the Cotter-Jefferson City sequence, 2208.		
2208 -18	25	Chert, cream, coarsely dolocastic, 95%; white, banded, 5%.
2218 -22	12	Chert, dolocastic, as above, 90%; quartz, crystalline, angular fragments, 10%.
2222 -28	20	Chert, cream to brown, finely dolocastic, spongy, 95%; chert, white, dense, vitreous, 5%.
2228 -34	10	Chert, lacy dolocastic, semiquartzose, 95%; chert, dark brown, quartzose, 5%.
2234 -40	2	Sand, bright, angular, well sorted, averaging 0.3 mm diameter, 65%; chert, dolocastic, as above, 25%; chert, white, dense, vitreous, 10%.
2240 -49	18	Chert, light tan, very quartzose, with scattered medium coarse dolocasts, 100%.
2249 -56	4	Chert, tan, quartzose, as above, 75%; sand, poorly sorted, fine, bright, angular, 25%.
2256 -60	24	Chert, tan, translucent, with faint translucent brown to bluish oölites, 75%; chert, tan, finely dolocastic, spongy, 25%.
2260 -65	4	Chert, tan, oölitic, as above, 85%; chert, white, dense, smooth, 10%; sand and angular fragments crystalline quartz, 5%.

2265 -70	4	Shale, spongy, dolocastic, brown, 50%; chert, brown, translucent, opalescent, 20%; shale, brown, 15%; chert, white and tan, dense, mottled, 15%.
2270 -77	20	Chert, cream, dense, with brown translucent oölites, 80%; chert, buff, coarsely dolocastic, spongy, 10%; chert, brown, translucent, as above, 10%.
2277 -84	4	Chert, white, dense, vitreous, 75%; chert, tan to bluish, translucent, 25%.
2284 -90	8	Chert, blue to tan, translucent, opalescent, containing numerous translucent oölites, 85%; sand and angular fragments crystalline quartz, 15%.
2290 -96		Samples missing.
2296 -2302	24	Chert, brown, semitranslucent, oölitic, 55%; sand, fine (0.2 mm diameter), bright, angular, 20%; chert, soft, porous to quartzose, dolocastic, 15%; quartz, milky, angular fragments, 10%; much spongy pyrite.
2302 -08		Samples missing.
2308 -15	8	Chert, white to buff, dense, with blue to brown translucent oölites, 90%; sand, as above, 10%.
2315 -20	10	Chert, white to bluish, translucent, 65%; chert, brown, coarsely dolocastic, 25%; shale (cavings?), dark brown, 10%.
2320 -26	22	Chert, bluish, as above, 75%; chert, dolocastic, as above, 25%.
2326 -34	14	Chert, light tan to brown, translucent, with faint translucent brown oölites, 60%; chert, white, dense to semitranslucent, 25%; sand, medium coarse, rounded, frosted, 10%; shale, green to brown pyritiferous, 5%; much dark spongy pyrite.
2334 -41	10	Chert, white, soft, rough, 50%; chert, white, dense, smooth, vitreous, 25%; chert, oölitic, as above, and free tan oölites coated with drusy quartz.
2341 -49	4	Chert, bluish-white, translucent, with small white oölites, 35%; chert, white, dense, vitreous, 20%; quartz, milky, angular fragments, 20%; sand, coarse, rounded, frosted, 15%; chert, brown, translucent, and free brown oölites, 10%.
2349 -55	4	Sand, coarse (0.8 to 0.1 mm diameter), poorly sorted, rounded, frosted, 75%; chert, white, dense, smooth, vitreous, with some included sand grains, 25%.
2355 -60	10	Chert, white, with numerous included sand grains, 65%; sand, fine, bright, angular, secondarily enlarged, 30%; chert, brown, porous, dolocastic, 5%.
2360 -68	28	Chert, blue to white, semitranslucent, 75%; sand, well sorted, bright, angular, free and in aggregates, 25%.
2368 -76	8	Chert, white, semitranslucent, as above, 50%; sand, as above, 40%; chert, white, rough, 10%.
2376 -83	18	Chert, white, dense to semitranslucent, 50%; drusy quartz, brown, 25%; chert, cream to brown, quartzose, finely dolocastic, 25%.
2383 -93	6	Sand, 0.5 to 0.1 mm diameter, mostly bright and angular but larger grains rounded, frosted, 75%; chert, white, dense, vitreous, 15%; chert, white, rough, 5% (with scattered large dolocasts); chert, blue, translucent, 5%.

Prairie Oil and Gas Company No. 9 Brown, SE¼ SW¼ NW¼ sec. 26, T. 34 S., R. 11 E., Chautauqua County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
2393 -99	5	Sand, as above, 55%; sandstone, shaly, laminated, fine, 25%; chert, white, dense, smooth, vitreous, 20%.
2399 -2407	22	Sand and angular fragments crystalline quartz, 50%; chert, brown, quartzose, very finely dolocastic, 25%; chert, white to tan, translucent, 25%.
2407 -13	18	Sand and angular fragments crystalline quartz, 40%; chert, white, dense, slightly rough, 35%; chert, dolocastic, as above, 15%; drusy, quartz, tan, 10%.
2413 -19	20	Chert, white to tan, dense, vitreous, 80%; chert, dolocastic, as above, 15%; shale, greenish-gray, 5%.
2419 -27	16	Chert, white to buff, dense, rough, associated with much spongy and crystalline pyrite.
2427 -34	26	Chert, cream, dense, vitreous, 80%; chert, cream, finely dolocastic, quartzose, 15%; quartz, crystalline, angular fragments, 5%; much pyrite.
2434 -47	64	Sand, fine, bright, angular, well sorted, averaging 0.2 mm diameter, and with a frosty look due to secondary quartz enlargement, 100%.
2447 -50	12	Sand, as above, 70%; chert, cream, dense, vitreous, 20%; quartz, crystalline, angular fragments, 10%.
2450 -56	12	Sand, as above, 50%; chert, white to tan, dense, vitreous, 25%; quartz, crystalline and milky, angular fragments, 25%.
2456 -59	12	Chert, cream, dense, dull, with numerous dark brown, translucent to quartzose oölites and free brown oölites, 50%; sand, as above, 35%; quartz, crystalline, large fragments, 15%; much spongy pyrite.
2459 -65	6	Chert, oölitic, as above, 40%; sand, as above, 40%; quartz, crystalline, as above, 20%; much spongy pyrite.
2465 -72	14	Chert, cream, dense, rough, 50%; quartz, crystalline and milky, angular fragments, 50%; much spongy pyrite.
2472 -79	38	Chert, tan to brown, dense, rough, 90%; quartz, crystalline, as above, 10%.
2479 -84	6	Chert, dense, as above, 85%; sand, bright, angular, and angular fragments crystalline quartz, 15%.
2484 -93	16	Chert, white, semitranslucent, showing some banding, 40%; sand and quartz, as above, 30%; chert, dense, as above, 20%; chert, brown, semitranslucent, vitreous, 10%.
2493 -99	36	Chert, cream, dense, rough 50%; chert, bluish-white, translucent, 40%; sand and quartz, as above, 10%.
2499 -2507	22	Chert, cream, dense, rough, 45%; chert, cream, spongy, finely dolocastic, 25%; chert, bluish-white to tan, translucent, 20%; chert, brown, translucent, with scattered medium fine dolocasts, 10%.

2507 -14	16	Chert, tan, semitranslucent, with darker brown, translucent oölites, 40%; sand, fine, well-sorted, bright, angular, averaging 0.2 mm diameter, 35%; chert, tan, finely dolocastic, appears to be sandy and laminated with a brown shale, 25%.
2514 -21	26	Chert, brown, dense, with numerous brown oölites and free brown oölites, 90%; chert, white, dense, rough, 10%.
2521 -23	30	Chert, oölitic, as above, 90%; chert, cream, dense, rough, 10%.
2523 -29	26	Chert, light tan, semitranslucent, vitreous to quartzose, some fragments containing numerous brown oölites, 80%; chert, bluish-white, translucent, 20%.
2529 -35	26	Chert, white to tan, semitranslucent, 60%; chert, brown, translucent, semiquartzose, 20%; chert, rough, soft, dolocastic, 10%; chert, white, dense, with a rough, hackly surface, 10%.
2535 -38		Samples missing.
2538 -41	28	Chert, buff to gray, quartzose, finely dolocastic, 50%; chert, white to tan, semitranslucent, 50%.
2541 -48	26	Chert, cream, dense to semitranslucent, vitreous to quartzose, 100%.
2548 -54	38	Quartz, crystalline, angular fragments, 50%; chert, white, dense to semitranslucent, 50%.
2554 -61	20	Chert, as above, 75%; quartz, crystalline, 25%.
2561 -72	4	Chert, as above, 75%; sand and quartz, crystalline, angular fragments, 25%.
2572 -78	8	Chert, as above, 55%; chert, finely dolocastic, quartzose, 20%; sand and quartz as above, 15%; shale, gray to greenish (caved from higher beds?), 10%.
2577 -87	2	Sand, fine, bright, angular, 50%; chert, bluish-white, translucent, 50%.
2587 -93	4	Chert, brown, semitranslucent, with faint, darker brown, translucent oölites, 75%; chert, white, dense to translucent, 25%.
2593 -2600	10	Chert, bluish-white, translucent, 40%; chert, white, very finely dolocastic, 35%; chert, tan to brown, translucent, 25%.
2600 -08	24	Chert, tan to blue, semitranslucent, 40%; chert, brown, semitranslucent, with large brown oölites and free brown oölites, 35%; chert, white, dense, rough, 15%; sand, white to gray and brown aggregates, very fine, 10%.
2608 -15	10	Chert, light tan, semitranslucent, with large brown, translucent oölites ringed with white dense chert, 75%; chert, white, dense to bluish, translucent, 25%.
2615 -22	8	Chert, cream, finely dolocastic, 50%; chert, tan to brown, semitranslucent, 25%; chert, bluish-white, semitranslucent, 25%.
2622 -29	5	Chert, bluish-white, semitranslucent, banded, 45%; chert, white, rough, 25%; chert, brown, as above, 25%; sand, bright, angular, and quartz, angular fragments, crystalline, 5%.
2629 -2635		Samples missing.

Prairie Oil and Gas Company No. 9 Brown, SE¼ SW¼ NW¼ sec. 26, T. 34 S., R. 11 E., Chautauqua County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
2635 -41	16	Chert, brown, semitranslucent, with numerous brown translucent oölites ringed with white dense chert, 70%; sand and quartz, as above, 30%; much finely crystalline pyrite.
2641 -49		Samples missing.
2649 -55	15	Chert, white, dense, smooth, vitreous to rough, 75%; sand and quartz, as above, 25%.
Top Roubidoux dolomite, 2655.		
2655 -62	20	Chert, bluish-white to tan, semitranslucent, finely oölitic, 70%; sand, bright, angular, averaging 0.2 mm diameter (many grains irregular to flaky in shape), 30%.
2662 -69		Samples missing.
2669 -76	1	Sand, as above, 75%; chert, as above, 25%.
2676 -82	4	Sand as above, 75%; chert, white, dense, rough, 15%; chert, white to tan, dense, mottled, 10%.
2682 -88	2	Sand, as above, 70%; chert, bluish-white, translucent, 20%; chert, white, dense, rough, 10%.
2688 -94	20	Sand, as above, 90%; chert, white, semitranslucent, 10%.
2694 -2701	2	Sand, as above, 90%; chert, as above, 10%.
2701 -07	8	Sand, as above, 90%; chert, white, semitranslucent, 10%.
2707 -33	20	Sand, coarser than previous samples (grains range from 0.8 to 0.1 mm diameter and fragments of angular quartz measure 1.0 mm plus; larger grains are rounded and frosted), 90%; chert, white, dense to bluish, translucent, 10%.
2733 -46	8	Sand, as above, 90%; chert, white, dense, with gray, dense to translucent oölites, 10%.
2746 -54	16	Sand, as above, 50%; chert, white, dense to semitranslucent, 50%.
2754 -67	6	Sand, as above, 75%; chert, white, dense to bluish, translucent, 25%.
2767 -80	10	Sand, as above, 90%; chert, white, dense to semitranslucent, 10%.
2780 -87	6	Sand, as above, 50%; chert, white, dense, vitreous, 25%; drusy quartz, 25%.
2787 -93	6	Sand, ranging from 1.0 to 0.1 mm diameter (grains 0.2 mm or less are bright and angular; larger grains rounded, frosted), 90%; chert, white, dense, vitreous, 10%; much spongy pyrite.
2793 -2800	46	Sand, as above, 100%.
2800 -07	34	Sand, as above, 100%.
2807 -20		Samples missing.

Top Gasconade-Van Buren sequence, 2820.

2820 -27	12	Chert, white, dense, vitreous to quartzose, 90%; sand, as above, 10%.
2827 -41	24	Chert, white, dense, smooth, vitreous, 100%; trace angular fragments of crystalline quartz.
2841 -47	10	Chert, as above, 100%.
2847 -52	48	Chert, white, dense, smooth, vitreous, with quartz veinings, 50%; quartz, clear, drusy, 35%; sand, fine, bright, angular, secondarily enlarged, 15%.
2852 -61	84	Chert, white, as above, 90%; sand, as above, 10%.
2861 -70	2	Chert, as above, 90%; sand, as above, 10%.
2870 -77	4	Sand, poorly sorted, ranging from 0.8 to 0.1 mm diameter (larger grains are rounded, frosted; smaller grains are bright, angular), 75%; chert, bluish-white to tan, semitranslucent, 25%.
2877 -85	4	Chert, white, dense, vitreous to quartzose, 85%; sand, as above, 15%.
2885 -92	10	Chert, as above, 90%; sand, as above, 10%.
2892 -2917	22	Chert, as above, 90%; sand, as above, 10%.
2917 -35	10	Chert, cream, dense, smooth to rough, 65%; quartzose material, 25%; sand, as above, 10%.
2935 -39		Samples missing.

Top Gunter sandstone member of the Van Buren formation, 2939.

2939 -42	20	Chert, as above, 65%; sand (larger grains up to 1.0 mm diameter are rounded, frosted; smaller grains average 0.2 mm diameter, are bright, angular), 35%; trace mica.
2942 -47	10	Chert, cream to tan, dense to semitranslucent, 75%; sand, as above, 25%.
2947 -56	30	Chert, as above, 75%; sand, as above, 25%.

Top Eminence dolomite, 2955.

2956 -61	12	Chert, buff, dense, smooth to slightly rough, 70%; sand, fine, bright, angular, and drusy quartz, 30%.
2961 -70	4	Sand and drusy quartz, as above, 50%; chert, as above, 50%.

Top Bonneterre (?) dolomite, 2970.

2970 -91	8	Sand, fine, bright, angular, and drusy quartz, (grains are irregular in shape, some flaky and some needle-like, and range from 0.5 to 0.1 mm diameter), 75%; chert, as above, 25%.
2991 -3002	4	Sand, as above, 90%; chert, white, dense, dull, with white oölites, 10%.
3002 -18	2	Sand, as above, 90%; chert, white, dense, semiquartzose, 10%.
3018 -23	16	Sand, as above, 80%; shale, greenish-gray, 20%.
3023 -44	10	Sand, as above, 100%.
3044 -50	8	Sand, as above, 50%; chert, dark gray, drusy, 30%; chert, white, dense, semiquartzose, 20%.
3050 -59		Samples missing.

Top Lamotte sandstone, 3059.

Prairie Oil and Gas Company No. 9 Brown, SE¼ SW¼ NW¼ sec. 26, T. 34 S., R. 11 E, Chautauqua County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
3059 -64	54	Sand, as above, 90%; quartz, drusy, gray, as above, 10%.
3064 -79		Samples missing.
3079 -85	64	Sand, fine, in well indurated aggregates, associated with finely crystalline pyrite, 75%; sand, as above, 25%.
Top Pre-Cambrian granite, 3085.		
3085 -91	100	Pink granite.
T. D.		

D. R. Lauck No. 1 McLean, SW cor. SE¼ sec. 1, T. 27 S., R. 1 W., Sedgwick County, Kansas. No. 7, cross section A-A' (Fig. 11).

Eroded top of the Cotter-Jefferson City sequence, 3601.		
3601 -07		Samples too small to make residues.
3607 -17	18	Chert, white, dense, porcelaneous, 85%; sand, angular, fine, bright, 15%.
3617 -23	25	Chert, as above, 90%; sand, angular, fine, bright, 10%.
3623 -30	10	Simpson shale, caved, 80%; chert, white, dense, 10%; sand, as above, 10%.
3630 -36	50	Simpson shale, caved, 90%; quartz, crystalline, angular fragments, 5%; sand, bright, angular, 5%.
3636 -67		Samples too small to make residues.
3667 -79	10	Chert, tan to brown, translucent, oölitic, 70%; chert, white, dense, porcelaneous, 15%; pyrite, massive, 15%.
3679 -97		Samples missing.
3697 -3705	12	Chert, white, dense, with translucent oölites, 85%; chert, tan, as above, 15%.
3705 -13	5	Pyrite, bright, spongy, 50%; chert, tan, quartzose, 30%; chert, white, dense, oölitic, as above, 20%.
3713 -19		Samples too small to make residues.
3719 -25	5	Quartz, crystalline, angular fragments, 90%; chert, tan, quartzose, 5%; pyrite, spongy, 5%.
3725 -33	3	Chert, soft, white, crumbly, tripolitic, 85%; quartz, drusy, light tan, 15%.
3733 -43	3	Quartz, crystalline, angular fragments, 75%; chert, light tan, dense, vitreous, 15%; chert, tripolitic, as above, 10%.
3743 -50	1	Sand, poorly sorted, secondarily coated, 1.0 to 0.1 mm diameter, 100%.
3750 -55	10	Quartz, drusy, brown, 80%; sand, bright, angular, medium fine, 20%.
3755 -68		Samples too small to make residues.
3768 -73	5	Chert, bluish, translucent, 55%; sand, as above, 40%; quartz, drusy, brown, 5%.

3773 -78	3	Chert, bluish, translucent, 65%; sand, as above, 30%; quartz, drusy, brown, 5%.
3778 -83	5	Quartz, drusy, brown, 50%; chert, bluish, translucent, 30%; sand, as above, 20%.
3783 -86	6	Chert, white, dense, porcelaneous, 85%; sand, fine, bright, angular, 15%.
3786 -91		Samples too small to make residues.
3791 -98	20	Chert, white, dense, porcelaneous, 100%.
3798 -3803		Samples too small to make residues.
3803 -09	15	Sand, well sorted, bright, angular, averaging 0.2 mm diameter, 80%; chert, white, dense, porcelaneous, 20%.
3809 -14	5	Sand, as above, 90%; chert, white, dense, porcelaneous, 10%.
3814 -20	20	Chert, white, semitranslucent, 100% .
3820 -26	5	Chert, white, dense, porcelaneous 65%; sand, fine, bright, angular, 25%; quartz, drusy, brown, 10%.
3826 -32	5	Chert, porcelaneous, as above, 60%; chert, buff, dense, vitreous, 15%; sand, as above, 15%; chert, dolocastic, 10%.
3832 -36	25	Chert, bluish, translucent, 95%; chert, soft, white, tripolitic, 5%.
3836 -41	33	Chert, bluish, translucent, 75%; chert, tripolitic, as above, 15%; sand, fine, bright, angular, 10%.
3841 -51	40	Chert, bluish, translucent, 85%; chert, tripolitic, as above, 10%; sand, as above, 5%.
3851 -55	10	Chert, bluish, translucent, 65%; chert, tripolitic, as above, 25%; sand, as above, 10%.
3855 -61	15	Chert, bluish, translucent, 60%; sand, as above, 25%; chert, tripolitic, as above, 15%.
3861 -66	37	Chert, white, dense to semitranslucent, 85%; chert, tripolitic, as above, 15%.
3866 -71	3	Chert, white, as above, 85%; chert, tripolitic, as above, 15%.
3871 -77	45	Chert, white, dense, with numerous white and brown oölites and white oölites free in sample, 85%; chert, tripolitic, as above, 10%; chert, translucent, tan, 5%.
3877 -82	43	Chert, white, dense to semitranslucent, with scattered brown oölites, 95%; chert, tripolitic, as above, 5%.
3882 -90	30	Chert, white, dense to semitranslucent, 90%; chert, tripolitic, as above, 10%.
3890 -97	20	Chert, as above, containing brown oölites and white coated brown oölites free in the sample, 90%; chert, tripolitic, as above, 10%.
3897 -3907	15	Chert, white, dense, rough, 100%.
3907 -11	20	Chert, white, dense, 80%, chert, light tan, translucent, semiquartzose, 20%.
3911 -21	9	Chert, white, dense to semitransucent, 85%; chert, tan, as above, 10%; sand, fine, bright, angular, 5%.
3921 -26	10	Chert, white, as above, 80%; quartz, crystalline, angular fragments, 15%; chert, dolocastic, 5%.
3926 -33	25	Chert, white, as above, 92%; sand, fine, bright, angular, 5%; chert, very finely dolocastic, 3%.

D. R. Lauck No. 1 McLean, SW cor. SE¼ sec. 1, T. 27 S., R. 1 W., Sedgwick County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
3933 -38	15	Chert, bluish-white, translucent, with scattered brown oölites, 60%; chert, light tan, translucent, 15%; sand, as above, 15%; chert, white, soft, crumbly, tripolitic, 10%.
3938 -43	20	Sand, bright, angular, averaging 0.5 mm diameter, 85%; chert, tripolitic, 15%.
3943 -53	4	Chert, white, dense to bluish, translucent, 50%; sand, as above, 30%; quartz, drusy, brown, 20%.
3953 -59	20	Chert, light tan, semitranslucent, 95%; chert, tripolitic, 5%.
3959 -64	25	Chert, tan, as above, 70%; sand, medium coarse, bright, angular, 20%; chert, white, dense, porcelaneous, 10%.
3964 -74	5	Chert, white, dense, porcelaneous, 95%; chert, tan, as above, 5%.
3974 -85	2	Chert, white, dense, porcelaneous, 40%; chert, white, semitranslucent, 30%; sand, fine, bright, angular, 20%; quartz, drusy, brown, 10%.
(Residues 3985-4703 T.D. are estimated from examination of original samples because samples are too small to make residues).		
3985 -92	25	Chert, bluish, semitranslucent, 100%.
3992 -97	10	Chert, white to bluish, semitranslucent, 75%; sand, bright, angular, averaging 0.4 mm diameter, with few angular fragments crystalline quartz, 25%.
3997 -4002	10	Chert, as above, 50%; sand, as above, 50%.
4002 -08	1	Chert, white to bluish, semitranslucent, 100%.
4008 -13	1	Sand, fine, bright, angular, 100%.
4013 -19	20	Chert, bluish-white, semitranslucent, 100%.
4018 -25	6	Chert, white, dense to bluish, translucent, vitreous, 100%.
4025 -30		Sample not usable.
Top Roubidoux dolomite, 4030.		
4030 -35	1	Chert, bluish-white, semitranslucent, 70%; sand, fine, bright, angular, 30%.
4035 -47	20	Sand, bright, angular, 0.2 mm diameter, 80%; chert, white, dense, rough, 20%.
4047 -56	5	Sand, as above, 80%; chert, as above, 20%.
4056 -60	1	Sand, as above, 100%.
4060 -65	10	Sand, as above, 70%; chert, bluish, semitranslucent, 30%.
4065 -70	5	Sand, as above, 80%; chert, white, dense to bluish, translucent, 20%.
4070 -76		Samples missing.
4076 -83	25	Chert, blue, translucent, 100%.
4083 -97	1	Chert, as above, 100%.
4097 -4103	15	Sand, bright, angular, 0.6 to 0.1 mm diameter, with angular fragments crystalline quartz, 100%.

4103	-09	25	Sand, bright, angular, 1.5 to 0.1 mm diameter, with much angular crystalline quartz and aggregates of quartz crystals (quartz faces on sand indicate secondary enlargement), 100%.
4109	-19	10	Sand, bright, angular, 1.0 to 0.1 mm diameter, averaging 0.4 mm diameter, 100%; no crystalline quartz.
4119	-24	1	Chert, bluish, translucent, 60%; sand, fine, bright, angular, 40%.
4124	-28		Samples missing.
4128	-35	10	Chert, as above, 60%; sand as above. 40%.
4135	-38	1	Chert, as above, 60%; sand, as above, 40%.
4138	-41	1	Sand, fine, bright, angular, 100%.
4141	-50	10	Sand, as above, 100%.
4150	-58	1	Sand, as above, 100%.
4158	-66	10	Sand, as above, 80%; chert, white, dense, soft, tripolitic, 20%.
4166	-86	1	Sand, as above, 100%.
4186	-4203	10	Sand, bright, angular, averaging less than 0.1 mm diameter, 100%.
4203	-13	20	Sand, as above, 100%.
4213	-24	25	Sand, as above, with few coarse grains and flecks green shale, 100%.
4224	-29	20	Sand, as above, 90%; chert, white, dense, rough, 10%.
4229	-35	20	Sand, as above, 100%.
4235	-43	10	Sand, as above, 100%.
4243	-48	20	Sand, as above, 100%.

Top Gasconade-Van Buren sequence, 4248.

4248	-70	40	Chert, white, dense, semiquartzose, 60%; sand, bright, angular, averaging 0.3 mm diameter, 40%.
4270	-82		Samples missing.
4282	-89	15	Chert, white, dense, semiquartzose, 75%; sand, as above, with flecks black mica, 20%; chert, soft, white, tripolitic, 5%.
4289	-98	25	Chert, as above, 50%; sand, as above, 50%.
4298	-4310	25	Sand, as above, 100%.

Top basal sand (Gunter?), 4310.

4310	-43	100	Sand, bright, angular, fairly well sorted, averaging 0.5 mm diameter, 100%.
4343	-50	100	Sand, coarser, with grains 1.0 mm diameter, 100%.
4350	-57	100	Sand, coarser, with grains 2.0 mm diameter, 100%.
4357	-63	100	Sand, as above, 50%; shale, green (may be cave), 50%.

Top Pre-Cambrian metamorphic rocks, 4363.

4363	-70		Samples missing.
4370	-4703		Quartzite and schist.

T. D.

Babcock Oil Company No. 1 Copeman, S½ S½ SE¼ sec. 7, T. 10 S., R. 2 W., Ottawa County, Kansas. No. 26, cross sections C-C', D-D', and H-H' (Figs. 11 and 13).

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
Eroded top of the Cotter-Jefferson City sequence, 3723.		
3723 -27	10	Quartz, crystalline, angular fragments, 75%; sand, fine, bright, angular, 20%; chert, white, dense, rough, 5%; trace spongy pyrite.
3727 -29	17	Sand, fine, bright, angular, 80%; quartz, drusy, gray, 10%; chert, white, dense, rough, 10%.
3729 -30	17	Chert, white, dense, rough, 50%; sand, as above, 45%; chert, finely dolocastic, porous, 5%; trace brown oölites in chert.
3730 -40	8	Sand, as above, 60%; chert, dolocastic, as above, 30%; chert, white, dense, rough, 10%.
3740 -44	9	Chert, light tan to brown, semitranslucent, quartzose, 50%; chert, dolocastic, as above, 40%; sand, as above, 10%.
3744 -47	11	Chert, white, dense, rough, with hackly fracture, 100%.
3747 -50	17	Chert, as above, with numerous white soft oölites which are brown and translucent at core, 100%.
3750 -67		Samples too small to make residues.
3767 -77	20	Chert, white, as above, 70%; sand grains, fine, bright, angular, 30%; trace fine pyrite crystals.
3777 -90		Samples too small to make residues.
3790 -95	40	Chert, blue to brown, translucent, opalescent, 100%.
3785 -3800	80	Chert, as above, 80%; chert, white, dense, porcelaneous, 20%.
3800 -15		Samples too small to make residues.
3815 -18	10	Chert, bluish, translucent, vitreous, 90%; sand, bright, angular, 10%.
3818 -45		Samples too small to make residues.
Top Roubidoux dolomite, 3845.		
3845 -50	20	Chert, white, dense to semitranslucent, 90%; sand, as above, 10%.
3850 -60	10	Chert, as above, 75%; sand, as above, 25%.
3860 -68	10	Chert, as above, 60%; sand, fine, bright, angular, 40%.
3868 -76		Samples too small to make residues.
3880 -92	10	Chert, as above, 60%; sand, as above, 40%.
3892 -3900	15	Sand, 0.8 to 0.1 mm diameter, mostly bright, angular but some larger grains rounded, frosted, 100%; trace waxy, olive drab shale.
3900 -05	20	Sand, as above, 100%.
3905 -16	35	Sand, as above, 100%.
3916 -25	18	Sand, as above, 50%; drusy?, quartz, 30%; chert, white, dense to semitranslucent, 20%.
3925 -34		Samples too small to make residues.

3934 -62	10	Sand, as above, 70%; quartz, drusy?, 30%.
3962 -67	10	Sand, as above, 100%.
3967 -77	65	Sand, as above, 100%; some grains have pinkish color.
3977 -91	55	Sand, as above, 100%.
3992 -97	65	Sand, as above, 100%.
3997 -4001½	85	Sand, as above, with trace weathered feldspar, 100%.
4001½-09	90	Sand, arkosic, fine, bright, angular, grains averaging 0.2 mm diameter, 100%.

Top Pre-Cambrian rocks, 4009?

4009 -21		Samples missing.
4021 -4114	100	Sand, as above, 75%; feldspar, weathered, 25%; trace mica flakes and black mineral which may be hornblende. Some of sand and feldspar occurs in loose aggregates.

T.D. 4135

Shell Petroleum Corporation and Olson Drilling Company No. 7 Blake, NE cor. SW¼ sec. 23, T. 23 S., R. 4 W., Reno County, Kansas.
No. 8, cross section A-A' (Fig. 11).

Eroded top of the Cotter-Jefferson City sequence, 3815.

3815 -25	7	Sand, fine, bright, angular, averaging 0.1 mm diameter, with drusy, secondary quartz enlargement, 70%; chert, buff, finely dolocastic, quartzose, 30%.
3825 -35	4	Sand, free, as above, 45%; sand grain aggregates, well indurated, 30%; chert, dolocastic, as above, 15%; chert, white, dense, porcelaneous, 10%.
3835 -40	7	Sand, as above, 70%; tan, semitranslucent, semiquartzose, 20%; chert, white, finely dolocastic, semiquartzose, 10%.
3840 -45	5	Sand, as above, 65%; chert, dolocastic, as above, 25%; chert, tan, semiquartzose, as above, 10%.
3845 -50	14	Quartz, drusy, tan, 30%; chert, dolocastic, as above, 25%; chert, white, dense, rough, 20%; sand, as above, with much spongy pyrite, 15%; chert, white, dense, porcelaneous, 10%.
3850 -55	13	Shale, buff, finely dolocastic, porous, 50%; sand, as above, 20%; chert, tan, semitranslucent, vitreous, 15%; quartz, drusy, tan, 15%.
3855 -60	7	Shale, (cavings?), dolocastic, white, 50%; shale, brown, finely dolocastic, porous, 25%; chert, white, dense, porcelaneous, 20%; sand aggregates, well indurated, 5%.
3860 -65	6	Shale, white, dolocastic, as above, 50%; sand, subrounded, fine, averaging 0.2 mm diameter, 45%; chert, blue, translucent, quartzose, 5%.
3865 -70	3	Shale, dolocastic, white, as above, 75%; sand, as above, free and in aggregates, 15%; chert, white, dense, porcelaneous, 10%.
3870 -80	5	Sand, as above, free, 70%; shale, brown, porous, finely dolocastic, 30%.

Shell Petroleum Corporation and Olson Drilling Company No. 7 Blake, NE cor. SW¼ sec. 23, T. 23 S., R. 4 W., Reno County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
3880 -90	21	Chert, blue to white, translucent, vitreous, 30%; chert, tan, translucent, quartzose, 30%; chert, white, rough, dense, 30%; shale, brown (cavings?), 10%.
3890 -3900	18	Sand, subrounded to angular, well sorted, averaging 0.2 mm diameter, 60%; chert, white to buff, semitranslucent, vitreous, 25%; chert, tan, quartzose, as above, 10%; chert, white, dense, rough, 5%.
3900 -10	15	Sand, as above, 30%; chert, white to bluish, semitranslucent, vitreous, 20%; chert, tan, translucent, quartzose, 20%; quartz, crystalline, angular fragments, 15%; shale, brown, porous (caved from higher beds?), 15%.
3910 -20	53	Chert, blue to tan, translucent, vitreous, with veinings of crystalline quartz, 90%; chert, cream, dense, rough, 10%.
3920 -30	37	Chert, blue to tan, as above, 100%.
3930 -60	19	Chert, white to tan, semitranslucent, vitreous, with scattered oölites, large brown and small white, translucent, 80%; chert, white, coarse and finely dolocastic, quartzose, 20%.
3960 -70	25	Chert, bluish-white, semitranslucent, vitreous, 80%; quartz, crystalline and milky, angular fragments, 20%.
3970 -4000	12	Chert, bluish, as above, with scattered large dolocasts, 60%; quartz, angular fragments, as above, 20%; chert, finely dolocastic, mealy-textured, white, 10%; chert, tan, semitranslucent, vitreous, 10%.
4000 -10	31	Chert, bluish, as above, 40%; chert, dolocastic as above, 30%; chert, white, dense porcelaneous, 20%; quartz, angular fragments, as above, 10%.
4010 -30	21	Chert, bluish, as above, 35%; chert, tan, translucent, fairly oölitic, 30%; chert, dolocastic, as above, 20%; chert, porcelaneous, 10%; quartz, angular fragments, 5%.
4030 -40	27	Chert, bluish, as above, 95%; chert, dolocastic, as above, 5%.
4040 -60	14	Chert, bluish, as above, 100%.
4060 -70	18	Chert, white to gray, semitranslucent, vitreous, 50%; chert, tan, quartzose, 40%; quartz, milky and crystalline, angular fragments, 10%.
4070 -90	13	Chert, white to bluish, semitranslucent, vitreous, 70%; quartz, drusy, tan, 20%; chert, dolocastic, as above, 10%.
4090 -4100	10	Chert, bluish-white, semitranslucent, 50%; chert, dolocastic, as above, 20%; chert, tan, quartzose, as above, 15%; chert, tan, translucent, 10%; quartz, crystalline and milky, angular fragments, 5%.
4100 -30	9	Quartz, drusy, tan to dark brown, 85%; chert, bluish, as above, 15%.

4130 -40	7	Quartz, drusy, brown, 70%; chert, bluish, as above, 30%.
4140 -50	14	Quartz, drusy, brown, 40%; chert, white, semitranslucent, vitreous, 30%; chert, blue to tan, faintly oölitic, translucent, 30%.
4150 -60	14	Chert, blue to tan, as above, 40%; quartz, drusy, brown, 30%; chert, white, as above, 20%; sand, coarse, round, frosted, and fine, bright, angular, 10%.
4160 -70	16	Chert, bluish-white, semitranslucent, vitreous, 75%; quartz, drusy, brown, 15%; chert, white, fine-grained, dense, 10%.
4170 -4200	11	Quartz, drusy, brown, 50%; chert, bluish, as above, faintly oölitic, 40%; quartz, crystalline, angular fragments, 10%.
4200 -20	13	Quartz, drusy, brown, 40%; chert, white, dense, porcelaneous, 30%; chert, bluish, as above, 30%.
4220 -30	10	Chert, blue to tan, translucent, vitreous, with scattered large brown oölites; 50%; chert, white, dense, rough to porcelaneous, 30%; sand, coarse, rounded, pitted grains and fine bright angular sand, 20%.
4230 -40	13	Chert, white to tan, quartzose, 70%; chert, white to bluish, semitranslucent, vitreous, 20%; chert, brown, quartzose, with scattered faint brown oölites, 10%.

Top Roubidoux dolomite, 4240.

4240 -60	14	Sand, extremely angular, 1.0 to 0.1 mm diameter (may be angular fragments crystalline quartz), 50%; chert, white to tan, semitranslucent, vitreous, with scattered faint brown oölites, 50%.
4260 -70	10	Sand, as above, 50%; chert, white to bluish, semitranslucent, vitreous, 20%; quartz, drusy, tan, 20%; chert, coarsely dolocastic, 10%.
4270 -80	7	Sand, as above, 50%; chert, bluish, as above, 25%; quartz, drusy, tan, 20%; chert, white, tripolitic, as above, 5%.
4280 -4300	10	Sand, as above, 60%; chert, white to tan, semitranslucent, vitreous, 25%; chert, dolocastic, as above, 10%; quartz, drusy, brown, 5%.
4300 -20	11	Sand, as above, 85%; chert, bluish, semitranslucent, 15%.
4320 -30	13	Sand, as above, 45%; chert, brown, quartzose, 30%; chert, bluish, as above, 25%.
4330 -40	10	Chert, bluish, as above, 50%; sand, as above, 30%; chert, tan, quartzose, 10%; quartz, crystalline, angular fragments, 10%.
4340 -70	5	Sand, as above, 70%; chert, bluish, as above, 20%; quartz, drusy, white to tan, 10%.
4370 -80	2	Sand, as above, 55%; chert, bluish-white, semitranslucent, 25%; chert, white, quartzose, 20%.
4380 -90	3	Sand, as above, 75%; chert, white, dense, porcelaneous, 25%.
4390 -4400		Samples missing.

Shell Petroleum Corporation and Olson Drilling Company, No. 7 Blake, NE cor. SW¼ sec. 23, T. 23 S., R. 4 W., Reno County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
4400 -20	4	Chert, white, dense, rough, 25%; chert, white, semi-translucent, vitreous, 25%; chert, white, quartzose, and quartz, crystalline, angular fragments, 25%; sand, as above, 25%.
4420 -30	13	Sand, rounded to subrounded, 0.5 mm diameter, free and in clusters, 100%.
4430 -50	12	Sand, as above, 90%; chert, bluish-white, semitranslucent, vitreous, 10%.
Top basal sand (Roubidoux?), 4450.		
4450 -60	42	Sand, bright, angular (secondarily enlarged?), fairly well sorted, averaging 0.5 mm diameter, 100%.
4460 -80	78	Sand, as above, 100%.
4480 -90	57	Sand, as above, with trace grains 2.0 mm diameter, 100%.
4490 -4510		Cement.
Top Pre-Cambrian granite, 4498.		
4510 -60		Pink granite.
T. D. is 4709.		

Mid-Continent Petroleum Corporation No. 9 Hartle, SW¼ NE¼ SW¼ NW¼ sec. 15, T. 20 S., R. 9 W., Rice County, Kansas, No. 9, cross sections A-A' and H-H' (Figs. 11 and 13).

Eroded top of the Cotter-Jefferson City sequence, 3240.		
3240 -70		Samples too small to make residues.
3270 -80	33	Chert, white, finely dolocastic, mealy-textured, 50%; chert, tan, translucent, vitreous, 50%.
3280 -90	17	Chert, tan, as above, 50%; quartz, drusy, brown, 20%; chert, lacy, dolocastic, 20%; sand, subrounded, ranging from 0.4 to 0.1 mm diameter, 10%.
3290 -3300	25	Chert, bluish-white, translucent, vitreous, 70%; chert, tan, as above, 20%; sand, subrounded, averaging 0.1 mm diameter, 10%.
3300 -10	33	Chert, blue to brown, translucent, vitreous, 90%; quartz, drusy, white to brown, 10%.
3310 -20	33	Chert, blue to brown, as above, 85%; sand, subrounded, averaging 0.1 mm diameter, 5%; quartz, drusy, white to brown, 5%; chert, soft, white, finely dolocastic, 5%.
3320 -40	25	Chert, blue to brown, as above, 75%; quartz, drusy, brown, (oöcasts?), 25%.
3340 -50	17	Chert, blue to tan, translucent, with scattered faint brown oölites, 100%.

3350 -70	22	Chert, blue to tan, semitranslucent, vitreous, 90%; chert, lacy, coarsely dolocastic, 10%.
3370 -80		Samples missing.
3380 -90	33	Chert, blue to tan, as above, 60%; chert, white, soft, finely dolocastic, 40%.
3390 -3400	20	Chert, white, dense, rough, 50%; sand, bright, angular, averaging 0.1 mm diameter, 20%; chert, dolocastic, as above, 20%; chert, white, dense, porcelaneous, 10%.
3400 -10	25	Chert, white to blue, semitranslucent, vitreous, 60%; chert, dolocastic, as above, 40%.
3410 -20	33	Chert, dolocastic, as above, 50%; chert, blue to tan, semitranslucent, 40%; chert, white, finely porous, 10%.
3420 -30	40	Chert, blue to tan, as above, 70%; chert, dolocastic, as above, 30%.
3430 -40	50	Chert, blue to tan, as above, 90%; chert, very finely dolocastic, quartzose, 10%.
3440 -50	22	Chert, white to buff, semitranslucent, 70%; chert, white, lacy, coarsely dolocastic, 30%.
3450 -55		No sample.
3455 -60	12	Quartz, drusy, brown, 55%; chert, bluish-white, translucent, 25%; sand, bright, angular, averaging 0.1 mm diameter, 20%.
3460 -90		Samples missing.
3490 -95	2	Sand, as above, 90%; drusy, brown, quartz, 10%.
3495 -3500	18	Chert, white to buff, semitranslucent, 80%; quartz, drusy, brown, 20%.
3500 -10	20	Chert, white, translucent, with numerous brown oölites 0.3 mm diameter, 100%.
3510 -20	9	Chert, blue, translucent, opalescent, 55%; quartz, drusy, brown, 45%.
3520 -25		Samples missing.
3525 -30	18	Chert, blue, as above, 80%; quartz, drusy, brown, 20%.
3530 -35		Samples too small to make residues.
3535 -40	10	Chert, blue, as above, 80%; quartz, drusy, brown, 20%.
3545 -55	33	Chert, blue, as above, 50%; quartz, drusy, brown, 50%.
3555 -65		Samples missing.
3565 -70	18	Chert, blue to white, semitranslucent to translucent, 70%; sand, bright, angular, averaging 0.3 mm diameter, 20%; quartz, drusy, brown, 10%.
3570 -76	25	Chert, white, soft, finely dolocastic, mealy-textured, 50%; chert, blue to tan, semitranslucent, vitreous, 50%.
3576 -3610		Samples too small to make residues.
3610 -15	14	Sand, bright, angular, 0.5 to 0.1 mm diameter, 75%; chert, blue, translucent, 25%.
3615 -35	14	Chert, blue, translucent, with waxy luster, 80%; sand, as above, 20%.
3635 -50	27	Chert, blue, as above, 90%; sand, as above, 10%.

Top Roubidoux dolomite, 3650.

3650 -60	7	Sand grains, subrounded, averaging 0.3 mm diameter, 50%; chert, blue, as above, 50%; flecks bright green shale common.

Mid-Continent Petroleum Corporation No. 9 Hartle, SW¼ NE¼ SW¼ NW¼ sec. 15, T. 20 S., R. 9 W., Rice County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
3660 -65	7	Sand, as above, 75%; chert, blue, as above, 25%.
3665 -80	10	Sand, as above, 60%; chert, blue, as above, 40%.
3680 -85	6	Chert, white to blue, semitranslucent, vitreous, 70%; sand, as above, 30%; numerous flecks green waxy shale.
3685 -90	8	Sand, as above, 50%; chert, as above, 50%.
3690 -95	9	Sand, bright, angular to subrounded, ranging from 0.8 to 0.1 mm diameter, associated with flecks green shale, 70%; chert, light tan, translucent, quartzose, 30%.
3695 -3705	8	Chert, as above, 50%; sand, as above, 50%.
3705 -15	6	Sand, as above, 75%; chert, as above, 25%.
3715 -35		Samples too small to make residues.
3735 -40	4	Sand, bright, angular, well-sorted, averaging 0.2 mm diameter, 100%.
3740 -50		Samples too small to make residues.
3750 -55	9	Sand, as above, 100%.
3755 -60		Samples too small to make residues.
3760 -70	7	Sand, as above, 75%; chert, blue to tan, semitranslucent, semiquartzose, 25%.
3770 -75		Samples too small to make residues.
3775 -80	11	Sand, as above, 100%.
3780 -85		Samples too small to make residues.
Top basal sand (Roubidoux?), 3785.		
3785 -90	55	Sand, angular to subrounded, 0.5 to 0.1 mm diameter, 100%.
3790 -3800		Samples too small to make residues.
3800 -10	64	Sand, angular to subrounded, averaging 0.4 mm diameter.
3810 -15		Samples too small to make residues.
Top Pre-Cambrian granite, 3815.		
3815 -55		Pink granite, somewhat weathered in appearance.
3855 -3905		Fresh granite.
T. D.		

The Texas Company No. 4 Dees, SE cor. NW¼ sec. 23, T. 17 S., R. 9 W., Ellsworth County, Kansas. No. 18, cross sections B-B' and H-H' (Figs. 10 and 13).

Eroded top of the Cotter-Jefferson City sequence, 3208.		
3208 -20	12	Sand, ranging from rounded grains 2.0 mm diameter to bright, angular grains 0.1 mm diameter, 50%; chert, tan, dense, with scattered light tan oölites, 50%.
3220 -25	8	Quartz, drusy, brown, 75%; sand grains, subrounded, averaging 0.3 mm diameter, 25%.
3225 -35	17	Sand, as above, 70%; quartz, drusy, brown, 30%.
3235 -60	28	Sand, as above, 75%; chert, white, dense, rough, 10%; chert, tan to blue, translucent, vitreous, 10%; chert, white, soft, finely dolocastic, 5%.
3260 -72		Samples missing.
3272 -82	21	Quartz, drusy, brown, 50%; sand, as above, 50%.
3282 -92	5	Quartz, drusy, brown, 100%.
3292 -3300	21	Chert, blue to tan, semitranslucent, vitreous, with scattered large tan opaque oölites and few free oölites, 50%; sand, ranging from rounded, frosted grains 0.5 mm diameter to bright, subangular grains 0.1 mm diameter, 25%; quartz, drusy, brown, 20%; chert, finely dolocastic, 5%.
3300 -08	10	Quartz, drusy, brown, with numerous tan oölites coated with drusy quartz and oöcasts lined with drusy quartz, 100%.
3308 -18	15	Chert, blue to tan, dense, vitreous, with numerous brown and white oölites, coated with drusy quartz, 70%; sand, as above, 30%.
3318 -26	9	Quartz, drusy, brown, as above, 50%; sand, bright, angular, averaging 0.2 mm diameter, 50%.
3326 -40	19	Chert, blue to tan, dense, vitreous, 50%; chert, white, finely dolocastic, mealy-textured, 30%; sand, as above, 20%.
3340 -48	10	Chert, blue to tan, semitranslucent, vitreous, 65%; chert, dolocastic, as above, 25%; chert, white, dense, rough, 10%.
3348 -62	25	Chert, light tan, semitranslucent, vitreous, 50%; chert, dolocastic, as above, 25%; sand, fine, bright, angular, 25%.
3362 -78	8	Chert, blue to tan, semitranslucent, vitreous, 70%; chert, dolocastic, as above, 20%; sand, as above, 10%.
3375 -83	18	Chert, blue to tan, as above, 75%; chert, dolocastic, as above, 10%; chert, white, dense, rough, 10%; sand, as above, 5%.
3383 -88	12	Chert, white to buff, dense, porcelaneous, with scattered included sand grains, 55%; sand, as above, 25%; quartz, drusy, white, 20%.
3388 -95	18	Chert, white to buff, dense, vitreous, 50%; sand, as above, 25%; quartz, crystalline, angular fragments, 10%; quartz, drusy, white, 10%; chert, dolocastic, 5%.
3395 -3405	4	Chert, white, dense to tan, translucent, vitreous, 40%; chert, white, finely dolocastic, mealy-textured, 20%; sand, fine, as above, 20%; quartz, drusy, white to tan, 20%.

The Texas Company No. 4 Dees, SE cor. NW¼ sec. 23, T. 17 S., R. 9 W., Ellsworth County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
3405 -07		Samples missing.
3407 -19	1	Sand, as above, 50%; quartz, drusy, brown, 25%; chert, white, dense, porcelaneous, 25%.
3417 -35	29	Chert, white to tan, dense, vitreous, with brown opaque oölites, 90%; sand, as above, 10%.
3435 -43	8	Sand, as above, 60%; chert, oölitic, as above, and drusy, free oölites coated with drusy quartz, 40%.
3442 -55	62	Chert, white to tan, dense, vitreous, 100%.
3455 -68	13	Quartz, drusy, brown, 45%; chert, white, dense, vitreous, with included sand grains, 45%; sand, as above, 10%.
3468 -75	9	Sand, as above, 50%; chert, bluish-white, semitranslucent, vitreous, with scattered included sand grains broken across the grain, 30%; quartz, drusy, brown, 20%.
3475 -3517		Samples too small to make residues.
3517 -25	14	Quartz, drusy, 100%.
Top Roubidoux dolomite, 3525.		
3525 -33	7	Sand, bright, angular, averaging 0.1 mm diameter, but with few coarse, rounded, frosted grains 1.0 mm diameter, 50%; chert, white, dense to tan, translucent, vitreous, 40%; quartz, drusy, 10%.
3533 -45	6	Sand, as above, 50%; chert, blue to tan, translucent, semiquartzose, 40%; chert, white, dense, porcelaneous, 10%.
3545 -65	10	Sand, as above, 70%; chert, blue to tan, as above, 20%; chert, white, dense, porcelaneous, 10%.
3565 -80	10	Sand, as above, 85%; chert, blue to tan, as above, 15%.
3580 -3600	8	Sand, as above, 70%; chert, tan, semitranslucent, semiquartzose, 30%.
3600 -34	6	Sand, as above, 90%; chert, tan, as above, 10%.
3634 -57	2	Sand, with angular to subrounded, pitted grains up to 1.0 mm diameter, 100%.
3657 -70	6	Quartz, crystalline, angular fragments, 50%; sand, fine, bright, angular (0.2 mm diameter), 50%; terminated quartz crystals common.
Top basal sand (Roubidoux ?), 3670.		
3670 -82	12	Sand, bright, angular, averaging 0.3 mm diameter, 100%.
3682 -3710	65	Sand, as above, but with few rounded, frosted and pitted grains 1.0 mm diameter, 100%.
3710 -15		Samples missing.
3715 -33	58	Sand, free, as above, 90%; sand grains, coarse, in aggregates, 10%.
3733 -48		Samples too small to make residues.

3748 -58	95	Sand, as above, 100%.
3758 -72	89	Sand, as above, with the addition of some arkosic material, 100%.

Top Pre-Cambrian (?) quartzite, 3772.

3772 -95	100	Sand, coarse, as above, 75%; feldspar, weathered, 25%.
3795 -3810	100	Quartz, angular fragments, up to 3.0 mm diameter, 100%; traces mica and much weathered feldspar.
3810 -3845	100	Sand, finer, bright, angular, ranging from 1.0 to 0.1 mm diameter, and with small amount arkosic material, 100%.
3845 -3915	100	Sand, fine, bright, angular, averaging 0.3 mm diameter, 75%; arkosic material, 25%.
3915 -25	100	Sand, as above, but with coarse grains up to 2.0 mm diameter, 75%; arkosic material, 25%.
3925 -65	100	Quartzite or granite, angular fragments.
3965 -4097		Pink granite(?).

T. D. is 4100.

Stanolind Oil and Gas Company No. 5 Riemann, SW¼ SW¼ NW¼ sec. 34, T. 16 S., R. 13 W., Barton County, Kansas. No. 19, cross section B-B' (Fig. 10).

Eroded top of the Cotter-Jefferson City sequence, 3406.

3406 cir.	25	Chert, blue to tan, translucent, 40%; chert, cream, dense, rough, 40%; sand, fine, bright, angular, averaging 0.1 mm diameter, 20%.
3412 -15	7	Sand, as above, 70%; chert, buff, translucent to dense, porcelaneous, 30%.
3415 -16	10	Sand, ranging from 0.4 to 0.1 mm diameter, rounded and frosted, 100%.
3416 -18	11	Sand, rounded, frosted, as above, 90%; chert, light, brown, translucent, with brown, translucent oölites, 10%.
3418 -21½	10	Sand, as above, 60%; chert, light tan, translucent, with faint translucent oölites and oöcasts, 40%; flecks light green shale.
3421½-23½	13	Sand, as above, 40%; chert, tan, translucent, 30%; chert tan, dense, porcelaneous, mottled, 30%.
3423½-26	11	Chert, light tan, translucent, semiquartzose, 25%; quartz, drusy, tan, 25%; chert, white, dense, rough, containing white dense oölites, partly weathered out, 25%; sand, as above, 20%; quartz, crystalline, angular fragments, 5%.
3426 -27	12	Sand, as above, 65%; chert, tan, as above, 20%; quartz, drusy, tan, 10%; chert, white, dense to translucent, with white oölites, 5%.
3427 -28	24	Sand, as above, 75%; chert, tan, as above, 10%; chert, white, dense, rough, 5%; chert, white, dense, porcelaneous, with large brown translucent oölites, 5%; quartz, drusy, tan, 5%.
3428 -29	9	Sand, very coarse, rounded, frosted, ranging from 1.0 to 0.1 mm diameter, 87%; drusy, tan, 8%; chert, tan, as above, 5%.

Stanolind Oil and Gas Company No. 5 Riemann, SW¼ SW¼ NW¼ sec. 34, T. 16 S., R. 13 W., Barton County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
3429 -30	13	Sand, as above, 75%; chert, light tan, translucent, with faint white translucent oölites, 15%; quartz, drusy, tan, 10%; considerable amount spongy pyrite.
3430 -33	9	Chert, blue to tan, semitranslucent, 30%; sand, as above, 25%; chert, tan, as above, with large brown translucent oölites, 25%; chert, cream, dense, rough, 20%.
3433 -35	10	Sand, as above, 50%; chert, blue to tan, as above, 40%; chert, rough, as above, 10%.
3435 -36	10	Chert, blue to tan, as above, 50%;; sand, as above, 50%.
3436 -36½	12	Chert, blue to tan, semitranslucent to translucent, 40%; chert, cream, dense, porcelaneous, with brown, translucent oölites, 30%; sand, as above, 20%; chert, cream, spongy, finely dolocastic, 10%; much light green, waxy shale.
3436½-36'8"	6	Sand, coarse, rounded, frosted, and fine, bright, angular, 50%; chert, white, dense, porcelaneous, 20%; chert, white, semiquartzose, 10%; chert, bluish, translucent, 10%; chert, brown, translucent, banded with white dense chert, 10%; much tarnished spongy pyrite.
3436'8"-38	6	Chert, tan, translucent, semiquartzose, with white dense oölites, 40%; sand, as above, 35%; chert, bluish, translucent, 20%; quartz, milky, angular fragments, 5%; much spongy pyrite.
3438 -44	21	Sand, as above, 50%; chert, tan, oölitic, as above, 25%; chert, cream, dense, porcelaneous, with scattered brown translucent oölites, 15%; chert, bluish, translucent, 5%; chert, white, dense, rough, 5%.
3444 -48	13	Sand as above, 40%; chert, tan, oölitic, as above, 25%; chert, blue to tan, translucent, 25%; chert, fragile, white, rough, coarsely dolocastic, 10%.
3448 -55	9	Chert, tan, dense to translucent, faintly mottled, 40%; sand, fine, bright, angular, averaging 0.2 mm diameter, few large rounded, frosted grains, 30%; chert, blue, to tan, with veins of crystalline quartz, 15%; chert, white, dense, rough, 15%.
3455 -65	14	Sand, as above, 50%; chert, tan to bluish, translucent, 25%; chert, white, porcelaneous, with large brown translucent oölites, 15%; chert, white, rough, dense, 10%.
3465 -70	12	Sand, as above, 38%; chert, white, dense, porcelaneous, oölitic, as above, 20%; chert, white to tan, dense, porcelaneous, 20%; chert, blue to tan, translucent, semiquartzose, 15%; chert, white, dense, rough, 5%; oölite aggregates, coated with drusy, quartz, 2%.
3470 -75	5	Sand, as above, 65%; chert, tan to bluish, translucent, 15%; chert, white, quartzose, 10%; chert, tan to brown, translucent, 10%.

3475 -80	8	Sand, as above, 50%; chert, tan, translucent to dense, porcelaneous, 25%; chert, white, dense, rough, 15%; chert, white, dense, porcelaneous, 10%.
3480 -85	8	Chert, white, dense to tan, translucent, 40%; sand, subrounded, averaging 0.3 mm diameter, with few grains 1.0 mm diameter, rounded and frosted, 40%; chert, tan, semitranslucent, vitreous, with traces of oölites, and bands and veins of crystalline quartz, 20%.
3485 -90	13	Sand, as above, 70%; chert, white, dense, dull to rough, 15%; chert, tan, semitranslucent, with numerous brown oölites, 15%.
3490 -95	11	Sand, as above, with flakes mica, 35%; chert, blue to tan, semitranslucent, vitreous, 35%; chert, tan, oölitic, as above, 20%; chert, white, porcelaneous, 5%; chert, white, dense, rough, 5%.
3495 -3500	11	Sand, angular to subrounded, averaging 0.2 mm diameter, 30%; chert, white, dense, with altered rough surface and trace oölites, partly weathered out, 20%; chert, white, dense, porcelaneous, 20%; chert, tan, translucent, quartzose, oöcasts lined with drusy quartz, and scattered large brown translucent oölites ringed with white dense chert, 15%; chert, blue to tan, as above, 15%.
3500 -06½	9	Chert, light tan, translucent, 50%; sand, as above, 50%.
3506½-15	10	Sand, as above, 40%; chert, blue to tan, translucent, 30%; chert, white, dense, porcelaneous, with large brown translucent and white dense oölites, 30%.
3515 -18	6	Sand, as above, 60%; chert, blue to tan, translucent, 20%; chert, tan, translucent, with included sand grains, 20%.
3518 -23	9	Sand, as above, 30%; chert, white, dense, porcelaneous, 30%; chert, blue to tan, translucent, 30%; chert, dark brown, dense, mottled, 10%.
3523 -28	8	Chert, tan, translucent, 50%; sand, as above, with flecks green shale, 50%.
3528 -32	12	Sand, as above, 35%; chert, tan, translucent, with numerous included sand grains and sand grain cavities and scattered pyrite crystals on surface, 30%; chert, white to buff, dense, porcelaneous, 30%; chert, white, finely dolocastic, fragile, 5%.
3532 -36	11	Sand, as above, 30%; chert, white, dense, dull to vitreous, 25%; chert, white, dense to brown, translucent, mottled, with fine pyrite crystals on surface, 25%; chert, white, dense, rough, 20%.
3536 -40	5	Sand, as above, 95%; chert, white, dense, with faint brown translucent oölites, 5%.
3540 -45	10	Sand, as above, 50%; chert, oölitic, as above, 50%.
3545 -50	6	Sand, as above, 60%; chert, tan, translucent, veined and encrusted with crystalline quartz, 20%; chert, bluish-white, semitranslucent, 10%; chert, cream, dense, porcelaneous, 10%.

Top Roubidoux dolomite, 3550.

3550 -55	6	Sand, angular to subrounded, averaging 0.2 mm diameter, but with large rounded, frosted grains 2.0 mm diameter, 95%; chert, white, semitranslucent, 5%.

Stanolind Oil and Gas Company No. 5 Riemann, SW¼ SW¼ NW¼ sec. 34, T. 16 S., R. 13 W., Barton County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
3555 -60	7	Sand, as above, 90%; chert, bluish, semitranslucent, 10%.
3560 -80	8	Sand, as above, with traces weathered feldspar, 100%.
3580 -85	15	Sand, as above, 75%; sand grains in chert, 25%.
3585 -95	18	Sand, as above, with considerable amounts of mica and weathered arkosic material, 80%; sand grains in chert, 10%; sand grains in well-indurated clusters, 10%.
3595 -3605	20	Sand, as above, 80%; sand grains in chert, 20%.
3605 -3650	13	Sand, as above, 100%.
3650 -75	16	Sand, as above, 100%.
3675 -90	9	Sand, as above, with mica flakes 2.0 mm diameter, 100%.
Top Pre-Cambrian granite, 3690.		
3690 -3760		Pink granite.
T. D. is 3762.		

Phillips Petroleum Company No. 1 Vernon, NE¼ NE¼ sec. 32, T. 3 S., R. 28 W., Decatur County, Kansas. No. 37, cross sections D-D', I-A and I-I' (Figs. 12 and 13).

Eroded top of the Roubidoux dolomite, 4275.		
4275 -80	60	Chert, tan, translucent, vitreous, 50%; chert, blue, translucent, milky, 25%; sand, fine, bright, angular, averaging 0.1 mm diameter, secondarily coated, and associated with much glauconite or green shale, 25%.
4280 -84		Samples missing.
4284 -90	38	Sand, as above, 80%; chert, tan, translucent, vitreous to quartzose, 20%.
4290 -95	25	Sand, as above, 85%; feldspar, weathered, 15%.
4295 -97		Sample missing.
Top Bonneterre dolomite, 4297.		
4297 -4300	14	Sand, fine, well sorted, with much glauconite, 100%.
4300 -05	19	Sand, as above, associated with numerous glauconite grains 0.5 mm diameter, 100%.
4305 -10	20	Sand, as above, 75%; sand, coarse, subrounded, averaging 0.5 mm diameter, 25%.
4310 -35	23	Sand, fine, as above, 60%; sand, coarse, as above, 40%; much glauconite.
4335 -40	13	Sand, fine, as above, 55%; glauconite, bright green, large shiny grains, (1.0 mm diameter), 25%; sand, coarse, as above, 20%.
4340 -55	18	Glauconite, 50%; sand, coarse, as above, 50%.
4355 -60	20	Sand, bright, angular, ranging from 0.5 to 0.1 mm diameter, 90%; glauconite, 10%; trace mica flakes.

Top Lamotte sandstone, 4363.

4360 -65	27	Sand, as above, free and in aggregates, 90%; glauconite, 10%.
4365 -70	38	Sand, well sorted, averaging 0.2 mm diameter and in aggregates, 50%; sand, coarse, 0.5 to 0.2 mm diameter, free, 50%; minor amount glauconite.
4370 -80	83	Sand, as above, in aggregates, 75%; sand, coarse, free, as above, 25%.

Top Pre-Cambrian granite, 4380.

4380 -4400	100	Pink granite.

T. D.

Cities Service Oil Company No. 1 Victory Life Insurance Company, W½ W½ NW¼ sec. 36, T. 13 S., R. 30 W., Gove County, Kansas.
No. 21, cross sections B-B' and I-A (Figs. 10 and 13).

Eroded top of the Cotter-Jefferson City sequence, 4600 or 4601 (company top)

4600 -4615		Samples too small to make residues.
4615 -20	6	Sand, well sorted, subrounded, averaging 0.3 mm diameter, free and in well-indurated clusters resembling sand grains in chert, 30%; chert, tan, semitranslucent, semiquartzose, with faint brown oölites, 30%; chert, white to gray blue, dense, mottled, 30%; chert, white, rough, 10%; much crystalline pyrite.
4620 -25	8	Sand, rounded, frosted, averaging 0.5 mm diameter, 30%; quartz, drusy, brown, 20%; chert, tan, as above, 20%; chert, white, dense, mottled with dark blue veinlets, 20%; chert, bluish, translucent, waxy-lustered, 10%.
4625 -30	9	Chert, white, dense, vitreous, 75%; quartz, drusy, brown, 15%; chert, dolocastic, quartzose, 10%.
4630 -35	25	Chert, bluish, translucent, 55%; chert, white, rough, with cavities due to removal of sand grains or oölites, 20%; chert, tan, translucent, quartzose, 10%; chert, white dense, porcelaneous, 5%; druse, tan, 5%; chert, dolocastic, as above, 5%.
4635 -40	13	Chert, tan, dense, semiquartzose, with faint brown translucent oölites, 60%; chert, white, rough, finely dolocastic, 30%; sand, fine, bright, angular, 0.2 mm diameter, 10%; much tarnished spongy pyrite.
4646 -50	11	Chert, white, dense, porcelaneous, 20%; sand, as above, 20%; chert, tan, translucent, quartzose, 20%; chert, bluish, semitranslucent, vitreous, with scattered brown translucent oölites, 15%; chert, white, rough, dense, 15%; chert, tan, oölitic, as above, 10%.
4650 -55	3	Sand, as above, 50%; chert, dolocastic, quartzose, 15%; chert, white, porcelaneous, with tan translucent oölites, 10%; chert, tan, oölitic, as above, 10%; quartz, drusy, brown, 10%; quartz, drusy, 5%.
4655 -60	6	Chert, white, dense, rough, mottled with brown dense chert, 35%; chert, white, dense, rough, 35%; chert, blue to tan, semitranslucent, 20%; sand, as above, 10%.

Cities Service Oil Company No. 1 Victory Life Insurance Company, W½ W½ NW¼ sec. 36, T. 13 S., R. 30 W., Gove County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
4660 -65	20	Chert, blue to tan, as above, 30%; chert, white, dense, porcelaneous, with scattered white oölites, 30%; chert, white, dense, finely dolocastic, 15%; sand, fine, subangular, 15%; chert, bluish, semitranslucent, quartzose, with oöcasts, lined with drusy quartz, 10%; minor amount spongy pyrite.
4665 -70	10	Chert, white to buff, dense, vitreous, with finely dolocastic, lacy surface, 20%; chert, blue to brown, semitranslucent, vitreous, 20%; chert, white, porcelaneous, 20%; sand, fine, as above, 20%; quartz, drusy, brown, 10%; quartz, crystalline, angular fragments, 10%.
4670 -75	10	Chert, white to buff, dense as above, 75%; sand, fine, bright, angular, 0.1 mm average diameter, 25%.
4675 -80	6	Chert, tan, semitranslucent, semiquartzose, 30%; chert, lacy, dolocastic, quartzose, 30%; sand, as above, 30%; chert, blue to tan, dense, vitreous, mottled, 10%.
4680 -85	5	Chert, tan, semiquartzose, as above, 40%; chert, dolocastic, as above, 40%; sand, rounded, frosted grains 0.8 mm diameter, grading into bright, angular grains 0.2 mm diameter, 20%.
4685 -90	6	Chert, tan, semiquartzose, as above, 75%; sand, as above, 25%.
4690 -93	6	Sand, as above, 30%; chert, bluish, semitranslucent, 30%; chert, tan, translucent, quartzose, oöcastic, 30%; chert, dolocastic, as above, 10%.
4693 -4700	6	Sand, as above, 50%; chert, dark gray to blue and tan, mottled, banded, semitranslucent, 25%; chert, white, dense, with dark blue oölites, 10%; chert, white to cream, finely dolocastic, quartzose, 10%; chert, tan, translucent, quartzose, 5%.
4700 -05	20	Chert, mottled, as above (may be cave), 50%; sand, as above, 20%; chert, white, dense, porcelaneous, 15%; chert, white, dense, rough, 15%; much pyrite.
Top Roubidoux dolomite, 4705.		
4705 -10	5	Chert, blue to tan, semitranslucent, with scattered brown, translucent oölites, 40%; sand, fine, bright, angular, averaging 0.3 mm diameter, 40%; chert, quartzose, with oöcasts and free oölites, crusted with drusy quartz, 20%.
4710 -15	7	Sand, as above, 40%; chert, light tan, semitranslucent, semi-quartzose, 35%; chert, blue, dense, mottled, 20%; chert, finely dolocastic, quartzose, 5%.
4715 -20	6	Chert, white to tan, semitranslucent, vitreous, with scattered dark brown, translucent oölites, 80%; sand, as above, 20%.
4720 -25	15	Sand, rounded, frosted, averaging 0.4 mm diameter, 50%; chert, tan, as above, with scattered white, dense oölites, 25%; sand grains in chert, 15%; chert, gray, dense, vitreous, (caved from higher beds ?), 10%.

4725 -30	14	Sand, as above, 85%; chert, tan, as above, non-oölitic, 15%.
4730 -35	8	Sand, as above, 75%; chert, white, with numerous included sand grains, 15%; chert, white, dense, porcelaneous, 5%; chert, tan, as above, 5%.
4735 -40	8	Sand, coarse, poorly sorted, ranging from coarse rounded, frosted grains 1.0 mm diameter to bright, angular grains 0.1 mm diameter, 80%; sand grains in chert, 15%; chert, tan, as above, with white, dense oölites, 5%; trace green shale and glauconite.
4740 -43	5	Sand, as above, 90%; chert, white, dense, mottled with brown, 10%; numerous flecks bright green shale.
4743 -50	7	Sand, as above, 90%; chert, blue to tan, dense, vitreous, 10%.
4750 -55	11	Sand, as above, 65%; sand in well-indurated aggregates, 25%; chert, blue to tan, as above, 5%; chert, brown, wtih numerous dark brown dense oölites, 5%.
4755 -65	5	Sand, with much drusy quartz coating, 100%.
4765 -70	7	Sand, finer, averaging 0.1 mm diameter, mostly bright, angular, 90%; chert, white, translucent, with included sand grains, 10%.
4770 -75	16	Sand, as above, 100%.
4775 -90	5	Sand, as above, 100%.
4790 -4800	4	Sand, as above, 80%; chert, white, soft, coarsely dolocastic, 20%; considerable green dolocastic, pyritic shale.
4800 -10	6	Chert, dolocastic, as above, 50%; sand, as above, 50%; much lacy, dolocastic green shale.
4810 -25	6	Sand, as above, 55%; drusy, quartz, 25%; chert, dolocastic, as above, 20%.
4825 -30	2	Sand, subangular, averaging 0.2 mm diameter, with flecks bright green shale, 100%.
4830 -45	4	Sand, as above, 80%; chert, soft, white, lacy, dolocastic, 10%; quartz, crystalline, angular fragments, 10%.
4845 -50	4	Sand, as above, 65%; chert, white, dense, rough, with scattered large dolocasts, 25%; chert, white, translucent, faintly oölitic, 10%.
4850 -70	3	Sand, as above, 95%; chert, bluish, semitranslucent, 5%.
4870 -75	3	Sand, as above, 85%; chert, coarse, lacy, dolocastic, 15%.
4875 -85	3	Sand, as above, 80%; chert, tan, dense, vitreous, 15%; chert, dolocastic, as above, 5%.
4885 -95	3	Sand, as above, 90%; chert, soft, white, lacy, dolocastic, 10%.
4895 -4900	4	Sand, as above, 60%; chert, blue to tan, semitranslucent, 25%; chert, white to buff, dense, dull, 10%; chert, dolocastic, as above, 5%.
4900 -05	3	Sand, fine, bright, angular, averaging 0.1 mm diameter, 75%; sand, coarse, rounded, frosted grains, averaging 0.8 mm diameter, 25%.
4905 -20	2	Sand, as above, 80%; chert, white to tan, semitranslucent, vitreous, 10%; chert, soft, white, lacy, dolocastic, 10%,

Cities Service Oil Company No. 1 Victory Life Insurance Company, W½ W½ NW¼ sec. 36, T. 13 S., R. 30 W., Gove County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
4920 -50	3	Sand, very fine, bright, angular, averaging 0.1 mm diameter, 100%.
4950 -75	3	Sand, as above, 75%; chert, white, soft, medium finely dolocastic, 25%.
4975 -80	2	Sand, as above, with drusy coatings, 75%; chert, dolocastic, as above, 25%.
Top Eminence dolomite, 4980.		
4980 -85	8	Sand, as above, 85%; chert, coarse, dolocastic, lacy, 15%.
4985 -95	3	Sand, as above, 55%; chert, dolocastic, as above, 45%.
4995 -5000	4	Sand, as above, 45%; chert, dolocastic, as above, 45%; chert, white to buff, semitranslucent, vitreous, 10%.
5000 -05	6	Chert, dolocastic, as above, 40%; chert, white, dense, rough, with scattered large dolocasts, 30%; sand, as above, 20%; chert, buff, as above, 10%.
5005 -25	4	Chert, dolocastic, as above, 50%; sand, as above, 40%; chert, white, rough, as above, 10%; much dark spongy pyrite.
5025 -30	4	Chert, white, quartzose to soft, dense, coarsely dolocastic, 60%; chert, brown, coarsely dolocastic, 40%.
5030 -50	6	Chert, brown, spongy, dolocastic, 70%; sand, fine, bright, angular, 20%; chert, dense, vitreous tan, 10%.
Top Bonneterre dolomite, 5050.		
5050 -55	10	Sand, coarser, rounded, frosted, averaging 0.5 mm diameter, 50%; chert, dolocastic, as above, 30%; chert, tan, as above, 20%.
5055 -98	11	Sand, as above, with flecks bright green shale or glauconite, 75%; chert, brown, dolocastic, as above, 25%.
5098 -5103	15	Sand, as above, 100%.
5103 -15	16	Sand, as above, with few large grains 3.0 mm diameter, 100%.
5115 -25	28	Sand, as above, 100%.
5125 -35	20	Sand, as above, approximately half in aggregates associated with a considerable amount of glauconite, 100%.
5135 -40	36	Sand, as above, 100%.
5140 -60	48	Sand, as above, approximately 75% in aggregates and associated with mica flakes, 100%.
Top Pre-Cambrian granite, 5160.		
5160 -69	100	Pink granite.

T. D.

Alma Oil Company and Robert McNeeley No. 1 Watchorn, SW¼ NE¼ sec. 13, T. 15 S., R. 33 W., Logan County, Kansas. No. 22, cross sections B-B' and I-A (Figs. 10 and 13).

Eroded top of the Cotter-Jefferson City sequence, 5050.		
5050 -65		Samples too small to make residues.
5065 -70	25	Chert, finely dolocastic, mealy-textured, 80%; chert, tan, translucent, vitreous, 15%; quartz, crystalline, angular fragments, 5%.
5070 -75	2	Pyrite, spongy, 25%; chert, dolocastic, as above, 25%; sand, fine, bright, angular, averaging 0.1 mm diameter, 25%; chert, cream, soft, finely porous, with cavities due to removal of microfossils (caved from higher beds?), 25%.
5075 -80	11	Chert, dolocastic, as above, 75%; sand, as above, 25%.
5080 -85	9	Chert, tan, dense to semitranslucent, vitreous, 40%; sand, coarse, rounded, frosted grains, ranging to angular subrounded grains 0.1 mm diameter, 40%; chert, dolocastic, as above, 20%.
5085 -95		Samples too small to make residues.
5095 -5105	5	Sand, fine, bright, angular, averaging 0.1 mm diameter, 40%; chert, blue to tan, semitranslucent, vitreous, 30%; chert, blue to tan, translucent, with large translucent oölites, 30%.
5105 -10		Sample too small to make residues.
5110 -15	2	Sand, as above, 75%; chert, tan, dense, vitreous, 25%.
Top Roubidoux dolomite, 5120.		
5115 -25		Sample too small to make residues.
5125 -30-	5	Sand, as above, 50%; chert, white to cream, rough, dolocastic, 25%; chert, tan, translucent, wtih dark brown oölites, 25%.
5130 -35	14	Chert, white, dense, with brown translucent oölites, 80%; sand, as above, 20%.
5135 -40	7	Sand, as above, 40%; chert, cream, dense, rough, 30%; chert, tan, semitranslucent, semiquartzose, 30%.
5140 -45	5	Chert, blue to tan, semitranslucent, vitreous, 75% sand, as above, 25%.
5145 -50	3	Sand, as above, 50%; chert, white to tan, dense, vitreous, with brown translucent oölites, 50%.
5150 -55	5	Sand, as above, 55%; chert, white, quartzose, medium finely dolocastic, 15%; chert, tan, translucent, quartzose, 15%; chert, blue, dense, vitreous, 15%.
5155 -60	9	Sand, as above, 60%; chert, tan, dense, vitreous, with brown oölites, 40%.
5160 -65	4	Sand, as above, 75%; chert, bluish white, vitreous, with dark brown to gray oölites, 20%; chert, tan, translucent, quartzose, 5%.
5165 -70		Samples too small to make residues.
5170 -75	6	Sand, fine, averaging 0.2 mm diameter and with secondary quartz enlargement, 100%.
5175 -85		Samples missing.

Alma Oil Company and Robert McNeeley No. 1 Watchorn, SW¼ NE¼ sec. 13, T. 15 S., R. 33 W., Logan County, Kansas, continued.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
5185 -90	9	Chert, tan, translucent to dense, vitreous, with numerous brown translucent oölites, 50%; sand, as above, 50%.
5190 -95	14	Sand, coarse, rounded, frosted, averaging 0.5 mm diameter, 85%; chert, buff, dense, rough, finely dolocastic, 15%.
5195 -5200	12	Sand, as above, 70%; chert, tan, translucent, quartzose, with oöcasts lined with drusy quartz, 25%; chert, white, dense, porcelaneous, 5%.
5200 -5220		Samples too small to make residues.
5220 -25	14	Sand, as above, 70%; chert, tan, dense, vitreous, with scattered brown oölites and few dolocasts, 25%; chert, brown, spongy, finely dolocastic, 5%.
5225 -30		Sample too small to make residues.
5230 -35	4	Sand, as above, 80%; chert, tan, semitranslucent, vitreous, 10%; chert, white, dense, rough, 10%.
5235 -40	14	Sand, as above, 80%; chert, tan, 10%; chert, rough, 10%.
5240 -45	7	Sand, as above, 75%; chert, white, dense, rough, 25%.
5245 -55	8	Sand, as above, 85%; chert, white, dense, porcelaneous, 15%.
5255 -60	11	Sand, as above, 80%; chert, white, dense, rough, 20%.
5260 -85	6	Sand, fine, bright, angular, well-sorted, averaging 0.1 mm diameter, approximately one-third in drusy clusters.
5285 -90	9	Sand, bright, angular, well sorted, coarser than previous samples, averaging 0.3 mm diameter, 70%; chert, white, dense, rough, with scattered fine dolocasts, 30%.
5290 -5300	4	Sand, as above, 100%.
5300 -05		Sample too small to make residues.
5305 -10	7	Sand, fine, bright, angular, averaging 0.1 mm diameter, 50%; sand, coarse, subrounded and frosted, averaging 0.5 mm diameter, 50%.
5310 -20	2	Sand, fine, as above, 80%; chert, light tan, semitranslucent, 20%.
5320 -25	4	Sand, as above, 100%.
5325 -35		Samples too small to make residues.
5335 -40	8	Sand, as above, 80%; chert, white, quartzose, coarsely dolocastic, 20%.
5340 -65	2	Sand, fine, well sorted, subrounded, averaging 0.1 mm diameter, 100%.
5365 -70	2	Sand, bright, angular, averaging 0.3 mm diameter, 80%; oölites, cream, dense, rough, hollow, 20%.
5370 -85	5	Sand, as above, 100%.
5385 -90	3	Sand, as above, 48%; sand, drusy aggregates, secondarily enlarged, 25%; chert, white, semitranslucent,

		20%; chert, brown, dense, mottled, 5%; oölites, tan, coated with white porous chert, 2%.
5390 -95	4	Sand, as above, with much spongy pyrite, 80%; chert, white, dense, faintly mottled, 10%; chert, tan, translucent, 5%; chert, cream, spongy, finely dolocastic, 5%.
5395 -5410	5	Sand, as above, 55%; chert, white, dense, dull, 15%; chert, tan to blue, dense, with scattered brown oölites, 15%; chert, tan, semitranslucent, vitreous, 15%.
5410 -25		Samples too small to make residues.
5425 -35	2	Sand, as above, associated with flecks of dolocastic green shale, 75%; chert, white, semitranslucent, 25%.
5435 -40	1	Sand, as above, 95%; quartz, crystalline, angular fragments, 5%.
5440 -45	3	Sand, as above, associated with much green shale or glauconite, 95%; chert, tan, translucent, vitreous, 5%.
5445 -55	2	Sand, as above, 95%; quartz, milky, angular fragments, 5%.
5455 -65		Samples too small to make residues.
5465 -70	3	Sand, as above, 70%; chert, white, dense, rough, medium fine to very fine, dolocastic, 25%; chert, blue, translucent, vitreous, 5%; trace coarse, round, frosted sand grains up to 1.5 mm diameter.

Top Eminence dolomite, 5470.

5470 -75	2	Sand, as above, 90%; chert, white, lacy, coarsely dolocastic, 10%.
5475 -80	17	Chert, tan, dense, vitreous, mottled, 30%; chert, white, dense, rough, dolocastic, 30%; sand, as above, 30%; drusy, quartz, 10%.
5480 -85		Samples too small to make residues.
5485 -90	13	Chert, tan, faintly mottled, with scattered dolocasts, 40%; chert, tan, dense, vitreous, 30%; sand, fine, as above 20%; sand grains, large, 3.0 mm diameter, 10%.
5490 -95	7	Chert, blue to tan, semitranslucent vitreous, 25%; chert, tan, quartzose, with vugs(?), 25%; chert, blue, dense, faintly mottled, 25%; sand, as above, 25%.
5495 -5500	9	Sand, as above, 40%; chert, white, dense, rough to vitreous, coarsely dolocastic, 30%; chert, white, dense, porcelaneous, 30%.
5500 -05	5	Chert, dolocastic, as above, 25%; chert, tan, semitranslucent, with cavities lined with drusy quartz, 25%; sand, as above, with flecks of dolocastic green shale, 25%; chert, dense, porcelaneous, 15%; chert, white, dense, rough, porous, 10%.
5505 -10	5	Sand, as above, 30%; chert, white, dense, porcelaneous, 30%; chert, tan, mottled, (caved?), 30%; quartz, crystalline, angular fragments, 5%; chert, dolocastic, as above, 5%.
5510 -15	7	Sand, as above, 70%; chert, white, dense, rough, porous, 10%; chert, white, semitranslucent, vitreous, 10%; chert, dolocastic, as above, 10%.
5515 -25	6	Sand, as above, 60%; chert, gray to brown, spongy, coarsely dolocastic, 15%; quartz, crystalline, angular fragments, 10%; chert, white, dense, rough, 10%; chert, tan to blue, semitranslucent, 5%.

Alma Oil Company and Robert McNeeley No. 1 Watchorn, SW¼ NE¼ sec. 13, T. 15 S., R. 33 W., Logan County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
5525 -30	8	Sand, as above, 70%; chert, dolocastic, as above, 30%.
5530 -35	14	Sand, as above, 60%; chert, dolocastic, as above, 40%.
Top Bonneterre dolomite, 5535.		
5535 -40	10	Sand, rounded, frosted, averaging 0.5 mm diameter, associated with a considerable amount of glauconite. 100%.
5540 -45	20	Sand, as above, 100%.
5545 -50	7	Sand, as above, 100%.
5550 -55	8	Sand, as above, 75%; quartz, milky, angular fragments, 25%; minor amount spongy pyrite and glauconite.
5555 -60	9	Sand, as above, 100%.
5560 -85	24	Sand, as above, 100%; trace mica flakes; few glauconite grains.
5585 -90	33	Sand, as above, 100%.
5590 -95		Sample too small to make residues.
5595 -5605	20	Sand, as above, 100%.
Top Lamotte sandstone, 5650.		
5605 -65		Samples too small to make residues. Examination of samples indicates presence of sand, as above, with much glauconite. Top Reagan sand also reported at 5647. Top Pre-Cambrian granite reported at 5662.
5665 -5750 T. D.		Pink granite.

Stanolind Oil and Gas Company No. 5 Judd, SE¼ SE¼ sec. 15, T. 21 S., R. 38 W., Kearny County, Kansas. No. 12, cross sections A-A' and I-A (Figs. 11 and 13).

Eroded top of the Cotter-Jefferson City sequence, 5550.		
5550 -55	10	Chert, white, dense, porcelaneous, 100%.
5555 -60	8	Chert, lacy, coarsely dolocastic, 50%; chert, white, dense, dull to vitreous, 50%; flecks green shale.
5560 -65	9	Chert, white, as above, 50%; chert, light tan, translucent, with brown, translucent oölites, 50%.
5566 -71	6	Sand, rounded, frosted, ranging from 1.0 to 0.1 mm diameter, 50%; chert, lacy, coarsely dolocastic, 35%; chert, white, dense, porcelaneous, 10%; chert, brown, translucent, 5%.
5571 -76	7	Chert, white, dense, dull-lustered, with faint brown oölites, 80%; sand, as above, 20%.
5577 -80	13	Chert, white, dense, vitreous, with inclusions of brown crystalline quartz, 65%; chert, brown, translucent, with

		scattered coarse dolocasts, 20%; sand, as above, 10%; chert, brown, translucent, with included sand grains, 5%.
5580 -84	14	Chert, white, dense, porcelaneous, 60%; sand, as above, 30%; chert, brown, with included sand grains, as above, 10%.
5584 -90	11	Sand, as above, 50%; chert, white, dense to semi-translucent, 50%.
5590 -95	10	Chert, light tan, semitranslucent, quartzose, grading to a dark brown drusy quartz, 40%; chert, white, dense, porcelaneous, 35%; sand, as above, 20%; chert, dolocastic, 5%.
5595 -5600	14	Chert, white, dense, porcelaneous, 75%; sand as above, 20%; quartz, drusy, brown, 5%.
5600 -05	6	Chert, white to buff, dense, rough, 60%; chert, bluish white, semitranslucent, 40%.
5605 -10	10	Chert, white, dense, rough, 55%; sand, rounded, frosted, 30%; chert, gray, finely porous, dolocastic, 10%; quartz, drusy, dark brown, 5%.
5610 -15	14	Chert, white, dense, porcelaneous, 50%; chert, light tan, semitranslucent, quartzose, 40%; sand, as above, 10%.
5615 -20	8	Chert, white, dense, porcelaneous, with trace included sand grains, 45%; chert, bluish-white, translucent, 30%; chert, brown translucent, 20%; sand, as above, 5%.
5620 -25	15	Chert, porcelaneous, as above, 30%; sand, as above, 20%; chert, white, dense, rough, 20%; chert, bluish white, as above, 20%; chert, brown, dense to translucent, quartzose, 10%.
5625 -30	8	Chert, porcelaneous, as above, 70%; chert, white, dense, rough, 20%; chert, light tan, translucent, 10%.
5630 -35	9	Quartz, crystalline, angular fragments, 75%; chert, porcelaneous, as above, with inclusions of brown crystalline quartz, 20%; quartz, drusy, brown, 5%.
5635 -40	6	Chert, porcelaneous to rough, white, dense, 65%; chert, white dolocastic, quartzose, 20%; sand, rounded, frosted, 10%; quartz, drusy, clear, 5%.
5640 -45	7	Quartz, crystalline, angular fragments, 45%; chert, porcelaneous, 45%.
5645 -50	9	Quartz, milky, angular fragments, 40%; chert, white, dense, porcelaneous, 30%; chert, white, dense, rough, 10%; chert, brown to tan, translucent, 10%; chert, finely dolocastic, quartzose, 5%; sand, rounded, frosted, 5%.
5650 -55	3	Sand, as above, 40%; chert, white, dense, rough, 40%; quartz, milky, angular fragments, 10%; quartz, drusy, tan to brown, 10%.
5655 -60	9	Quartz, milky, angular fragments, 45%; sand, as above, 20%; chert, tan semitranslucent, quartzose, 20%; chert, white to buff, dense, vitreous, 10%; chert ,white, dense, rough, 5%.
5660 -65	8	Chert, tan, semitranslucent, with scattered, coarse dolocasts, 60%; chert, tan, semitranslucent, vitreous, 20%; quartz, milky, angular fragments, 10%; sand, as above, 10%.

Stanolind Oil and Gas Company No. 5 Judd, SE¼ SE¼ sec. 15, T. 21 S., R. 38 W., Kearny County, Kansas, concluded.

Depth, feet	Residue, percentage of sample	Description and percentage of insoluble residues
5665 -70	9	Chert, tan, translucent, vitreous, 70%; sand, as above, 30%.
5670 -75	7	Chert, white, dense, rough, with scattered large dolocasts and fine pyrite crystals on surface, 40%; chert, tan, translucent to white, dense, with tan quartzose inclusions which may be oölites, 40%; chert, white, dense, porcelaneous, 20%; considerable amount crystalline pyrite.
Top Roubidoux dolomite, 5675.		
5675 -80	7	Sand, ranging from rounded, frosted grains 0.7 mm diameter to bright, angular grains less than 0.1 mm diameter, 75%; chert, white, dense, porcelaneous, 25%.
5680 -85	5	Sand, as above, 65%; quartz, drusy, tan, may be aggregates of coated sand grains, 25%; chert, tan to white, dense, vitreous, with faint brown opaque oölites, 10%.
5685 -90	8	Chert, light tan, translucent, 50%; sand, as above, 50%.
5690 -95	10	Sand, as above, 85%; chert, white, dense, vitreous to quartzose, 10%; quartz, crystalline, angular fragments, 5%.
5690 -95	6	Sand, as above, 80%; chert, white, dense, porcelaneous, with few fossil (?) cavities, 20%.
5695 -5700	7	Sand, as above, 80%; chert, semitranslucent, tan, 20%.
5700 -05	9	Sand, rounded, frosted, averaging 0.5 mm diameter, 60%; chert, white, dense, porcelaneous (one fragment has fine brown oölites), 30%; quartz, milky, angular fragments, 10%.
5705 -10	3	Sand, as above, 75%; chert, tan, translucent, with scattered coarse dolocasts, 20%; chert, tan, translucent, vitreous to quartzose, 5%.
5710 -15	7	Sand, as above, 65%; chert, white, dense, vitreous to quartzose, 30%; chert, brown, semitranslucent, 5%; considerable amount spongy pyrite.
5715 -20		Samples too small to make residues.
5720 -25	6	Sand, rounded, frosted, ranging from 0.7 to 0.1 mm diameter, 50%; chert, tan, semitranslucent, quartzose, with scattered large brown,, translucent oölites, 30%; chert, white, dense, porcelaneous to quartzose, 20%.
5720 -25	10	Sand, as above, 40%; chert, light brown, translucent, quartzose, with numerous included sand grains and/or oölites, 40%; chert, white, dense, porcelaneous, 20%.
5725 -30	8	Sand, as above, 60%; chert, white, dense, vitreous, with numerous white and brown oölites, 40%.
5730 -35	9	Sand, as above, 85%; chert, white, dense, porcelaneous, 10%; chert, tan, translucent, quartzose, 5%.
5735 -50	7	Sand, as above, 85%; chert, white, dense, rough, with white, opaque oölites partly weathered out, 15%.

5750 -55	6	Sand, as above, 80%; chert, white, finely dolocastic, mealy-textured, 10%; chert, white, dense, porcelaneous, 5%; chert, brown, translucent, oölitic, 5%.
5755 -5800	7	Sand, as above, 100%.
5800 -50	4	Sand, rounded, frosted, 0.6 mm to less than 0.1 mm diameter, with flecks green shale, 90%; chert, white, dense, porcelaneous, 10%.
5850 -55	4	Sand, as above, 80%; chert, white, dense, porcelaneous, 10%; chert, brown, translucent, quartzose, 10%.
5855 -60	5	Sand, as above, 80%; chert, lacy, dolocastic, quartzose, 10%; chert, white, dense, porcelaneous, 10%.
5860 -65	3	Sand, as above, 70%; chert, dolocastic, as above, 20%; quartz, drusy, brown, 10%.
5865 -70	4	Sand, as above, 90%; chert, dolocastic, as above, 10%.
5870 -5900	5	Sand, as above, 100%.
5900 -6000	6	Sand, bright, angular, averaging less than 0.1 mm diameter, with few large, rounded, frosted grains, 100%.

Top Bonneterre dolomite, 6000.

6000 -10	4	Sand, fine, as above, 90%; sand grains, coarse, rounded, frosted, 10%; trace glauconite.
6010 -15	9	Sand, fine, bright, angular, free and in clusters, 90%; shale, dark brown, spongy, 10%; considerable amount of spongy pyrite.
6015 -20	5	Sand, coarse, averaging 0.5 mm diameter, mostly bright and angular, 100%.
6020 -25	4	Sand, as above, 95%; chert, lacy, coarsely dolocastic, quartzose, 5%; considerable amount glauconite and green shale.
6025 -50	6	Sand, glauconitic, as above, 100%.

Pre-Cambrian granite, 6050.

6050 -60		Gray granite, with dark gray and pink feldspar visible.
6060 -65		Granite, as above; amethyst quartz present.
6065 -69		Fresh pink granite..

T. D. is 6071.

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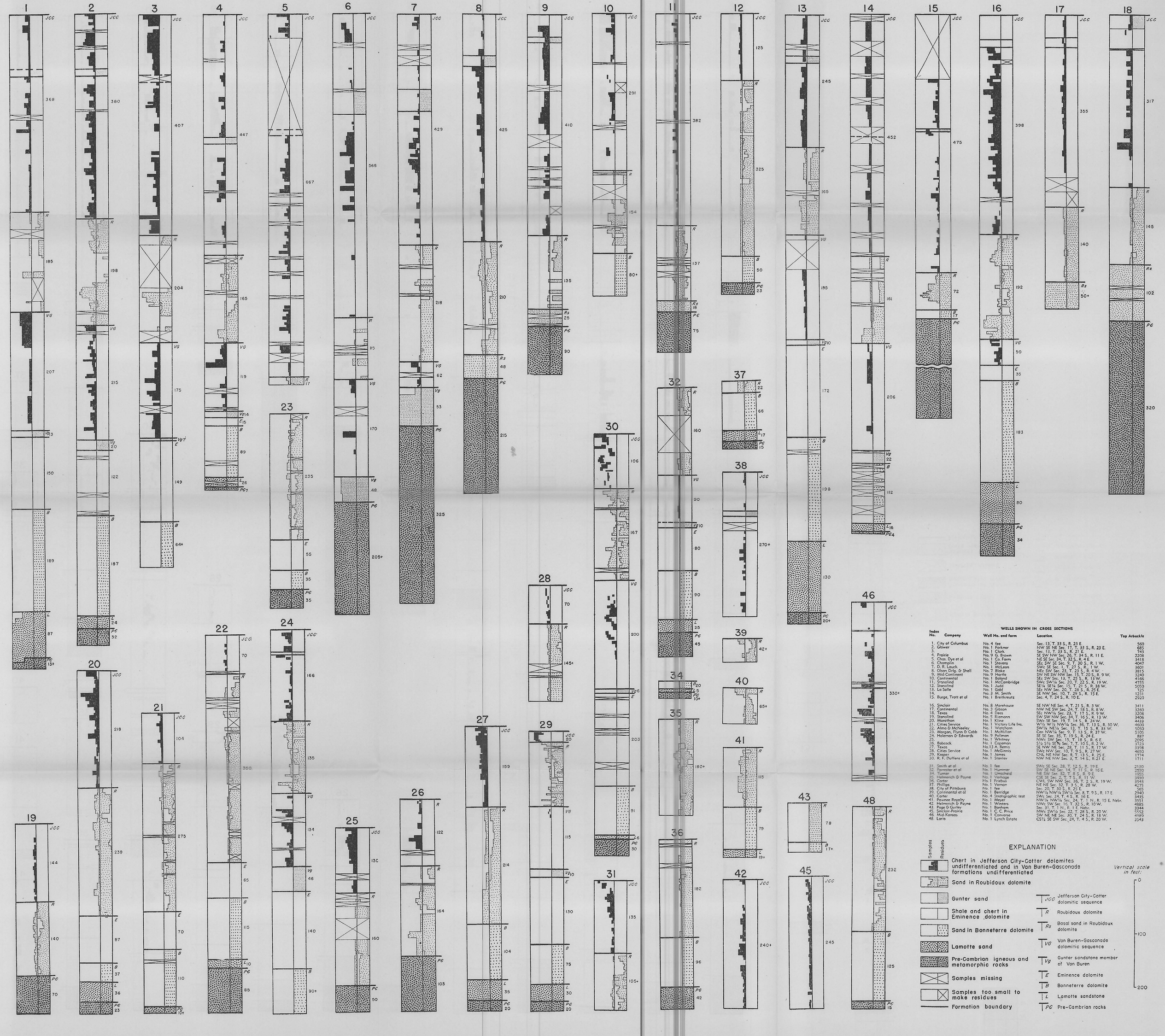
GRAPHIC SAMPLE LOGS OF WELLS USED IN CROSS SECTIONS

State Geological Survey of Kansas

By Raymond Keroher and Jewel Kirby, 1947

Bulletin 72, Plate 6



WELLS SHOWN IN CROSS SECTIONS

Index No.	Company	Well No. and farm	Location	Top Arbuckle
1.	City of Columbus	No. 4 fee	Sec. 13, T. 33 S., R. 23 E.	560
2.	Glower	No. 1 Forkner	NW SE NE Sec. 17, T. 33 S., R. 23 E.	685
3.		No. 1 Clark	Sec. 13, T. 33 S., R. 21 E.	743
4.	Prairie	No. 9 G. Brown	SE SW NW Sec. 26, T. 34 S., R. 11 E.	2208
5.	Chas. Dye et al	No. 1 Co. Farm	NE SE Sec. 34, T. 32 S., R. 4 E.	3418
6.	Champlin	No. 1 Stevens	SE SW SE Sec. 9, T. 30 S., R. 1 W.	4047
7.	D. R. Lauck	No. 1 McLean	SW SE Sec. 1, T. 27 S., R. 1 W.	3601
8.	Olsen Drlg. & Shell	No. 7 Blake	NE SW Sec. 23, T. 23 S., R. 4 W.	3815
9.	Mid-Continent	No. 9 Hartle	SW NE SW NW Sec. 15, T. 20 S., R. 9 W.	3240
10.	Continental	No. 1 Boland	SE SW Sec. 13, T. 25 S., R. 13 W.	4166
11.	Stanolind	No. 1 McCambridge	SW SW ¼ Sec. 20, T. 22 S., R. 19 W.	4755
12.	Stanolind	No. 1 Judd	SE¼ SE¼ Sec. 15, T. 21 S., R. 38 W.	5050
13.	La Salle	No. 1 Gobl	SEc NW Sec. 20, T. 28 S., R. 25 E.	725
14.		No. 3 M. Smith	SE NW Sec. 10, T. 29 S., R. 15 E.	1231
15.	Burge, Trott et al	No. 1 Breitkreutz	Sec. 4, T. 24 S., R. 10 E.	2920
16.	Sinclair	No. 8 Morehouse	SE NW NE Sec. 4, T. 21 S., R. 3 W.	3411
17.	Continental	No. 3 Gibson	NW NE SW Sec. 24, T. 18 S., R. 8 W.	3260
18.	Texas	No. 4 Dees	SEc NW¼ Sec. 23, T. 17 S., R. 9 W.	3208
19.	Stanolind	No. 5 Riemann	SW SW NW Sec. 34, T. 16 S., R. 13 W.	3406
20.	Marathon	No. 1 Kline	SW SE Sec. 19, T. 14 S., R. 24 W.	4434
21.	Cities Service	No. 1 Victory Life Ins.	W½ W½ NW¼ Sec. 36, T. 13 S., R. 30 W.	4600
22.	Alma & McKeeley	No. 1 Watchorn	SW¼ NE¼ Sec. 13, T. 15 S., R. 33 W.	5050
23.	Morgan, Flynn & Cobb	No. 1 McMillen	Cen NW¼ Sec. 7, T. 13 S., R. 37 W.	5105
24.	Holeman & Edwards	No. 9 Pallman	SE SE Sec. 35, T. 19 S., R. 24 E.	887
25.		No. 1 Whitney	NW SW Sec. 15, T. 18 S., R. 6 E.	2095
26.	Babcock	No. 1 Copeman	S½ S½ SE¼ Sec. 7, T. 10 S., R. 2 W.	3723
27.	Texas	No. 13 A. Bemis	SE NW NE Sec. 28, T. 15 S., R. 17 W.	3398
28.	Cities Service	No. 1 McGinnis	SWc NW Sec. 10, T. 9 S., R. 27 W.	4650
29.	Kasper	No. 1 James	CNL NE NW Sec. 8, T. 13 S., R. 25 E.	1774
30.	R. F. Duffens et al	No. 1 Stanley	NW NE NW Sec. 3, T. 14 S., R. 21 E.	1711
31.	Smith et al	No. 1 fee	SW SE Sec. 28, T. 12 S., R. 19 E.	2130
32.	Forrester et al	No. 1 Hummer	SW SE NE Sec. 14, T. 11 S., R. 16 E.	2550
34.	Turner	No. 1 Umscheid	NE SW Sec. 32, T. 8 S., R. 9 E.	1955
35.	Helmerich & Payne	No. 1 Vinnage	CSE SE Sec. 2, T. 31 S., R. 1 W.	3990
36.	Carter	No. 1 Friebus	CWL SW NW Sec. 36, T. 2 S., R. 19 W.	3543
37.	Phillips	No. 1 Vernon	NE NE Sec. 32, T. 3 S., R. 28 W.	4075
38.	City of Pittsburg	No. 1 fee	Sec. 20, T. 30 S., R. 25 E.	565
39.	Continental et al	No. 1 Berridge	NW¼ NW¼ SW½ Sec. 8, T. 9 S., R. 17 E.	2940
40.	Carter	No. 4 Stratigraphic test	SWc Sec. 24, T. 4 S., R. 16 E.	3435
41.	Pawnee Royalty	No. 1 Meyer	NW¼ NW¼ Sec. 24, T. 1 N., R. 15 E. Nebr.	3551
42.	Helmerich & Payne	No. 1 Winters	NWc SW Sec. 16, T. 32 S., R. 10 W.	4885
43.	Page & Gurley	No. 1 Banham	Sec. 31, T. 1 N., R. 1 E. Nebr.	3944
45.	Sinclair-Prairie	No. 1 C. C. Price	NW¼ SW¼ Sec. 22, T. 28 S., R. 20 W.	5552
46.	Mid-Kansas	No. 1 Converse	SW NE NE Sec. 20, T. 24 S., R. 18 W.	4089
48.	Lario	No. 1 Lynch Estate	CS½ SE SW Sec. 24, T. 4 S., R. 20 W.	3543

EXPLANATION

Samples / Residues

- Chert in Jefferson City-Cotter dolomites undifferentiated and in Van Buren-Gasconade formations undifferentiated
- Sand in Roubidoux dolomite
- Gunter sand
- Shale and chert in Eminence dolomite
- Sand in Bonneterre dolomite
- Lamotte sand
- Pre-Cambrian igneous and metamorphic rocks
- Samples missing
- Samples too small to make residues
- Formation boundary

- JCC Jefferson City-Cotter dolomitic sequence
- R Roubidoux dolomite
- Rs Basal sand in Roubidoux dolomite
- VG Van Buren-Gasconade dolomitic sequence
- Vg Gunter sandstone member of Van Buren
- E Eminence dolomite
- B Bonneterre dolomite
- L Lamotte sandstone
- PC Pre-Cambrian rocks

Vertical scale in feet: 0, 100, 200