BUREAU OF ECONOMIC GEOLOGY
The University of Texas
Austin 12, Texas

JOHN T. LONSDALE, Director

Report of Investigations—No. 26

Lead Deposits in the Upper Cambrian of Central Texas

By

VIRGIL E. BARNES

May 1956

BUREAU OF ECONOMIC GEOLOGY
The University of Texas
Austin 12, Texas

JOHN T. LONSDALE, Director

Report of Investigations — No. 26

Lead Deposits in the Upper Cambrian of Central Texas

By

VIRGIL E. BARNES

May 1956

Contents

Illustrations

Tables

Lead Deposits in the Upper Cambrian of Central Texas

VIRGIL E. BARNES

ABSTRACT

The lead and zinc deposits in the Upper Cambrian rocks of central Texas are reviewed in the light of new detailed information. Included are analytical data for all deposits, detailed stratigraphic sections of the Cambrian rocks, and maps at a scale of 4 inches to the mile.

Igneous rocks of Carboniferous or younger age in the area are recognized for the first time. It is concluded that a magmatic hydrothermal origin of the lead is more probable than a leaching-meteoric origin through ground water moving laterally then upward along buried knobs.

The solution history of the carbonate rocks of the Llano uplift is reviewed in connection with the possibility of a ground-water origin; and new data are presented, the most important of which are the recognition for the first time of extensive solution of Precambrian marble during the Paleozoic, the finding of Marble Falls limestone deposited in a sink at the level of the Hickory sandstone, and the recognition that the dips about the granite knobs are caused predominantly by intrastratal solution of Cap Mountain limestone.

GENERAL SETTING

The lead and zinc deposits discussed in this paper are in Blanco, Burnet, and Gillespie counties, Texas (fig. 1). Reported occurrences of lead in Llano and Mason counties have been investigated, but no lead was found. Production of lead in the Llano uplift has been almost nil, and the literature gives very little encouragement that commercial deposits are present.

However, within the United States, lead and zinc are in short supply, and since World War II, interest has been expressed in the possibility of commercial deposits in the Llano uplift. In geologic mapping about the Llano uplift from 1939 to 1951, the writer has become well acquainted with the part of the geologic section in which the lead occurs. A reinvestigation of the lead deposits of central Texas is desirable at this time to see if their mode of origin can be outlined, as well as to give analytical and mineralogical data on the known deposits and provide modern geologic maps of the vicinity of each occurrence.

The writer wishes to express his appreciation to Mr. John S. Brown, Chief Geologist of the St. Joseph Lead Company, for critically reading portions of the manuscript, for planning the very instructive tour of the southeast Missouri deposits under the guidance of Mr. W. W. Weigel, and for the very helpful suggestions from his geological staff, especially from Mr. E. L. Ohle and Mr. R. E. Wagner; to Mr. John W. Chandler of the Eagle-Picher Company for permission to publish logs of churn drill holes drilled in 1925; to Mr. Tom O'Donnell for pointing out the location of the holes drilled in the Fairland area, and to Mr. L. G. Henbest, of the U. S. Geological Survey, for examining material from the collapse structure near Streeter.

In the sampling and examination of the deposits the writer was assisted by H. L. Ellinwood and P. L. Dixon; in the geologic mapping he was assisted at different

times by H. L. Ellinwood, L. E. Warren, A. R. Palmer, T. M. Anderson, J. T. Twining, and Louis Dixon. The chemical analyses were made by R. M. Wheeler.

So far as known, the date of the first discovery of lead in central Texas is not recorded. Shumard (1886, p. 143) mentioned that a "remarkably rich sample of ore had been received from Fort San Saba" and that "In Llano County occurs an interesting ore, the molybdate of lead." Comstock (1890, pp. 339–344) described some of the lead deposits of central Texas, and again in 1891 (pp. 583–594) reviewed and amplified his descriptions. He reported that from 1889 to 1891, G. C. Gage was engaged in testing the outcrops in Silver Mine Hollow and Beaver Creek Canyon and that no profitable accumulation of lead had been discovered. He also mentioned galena deposits north of Hye, presumably those in the vicinity of Iron Rock Creek of the present paper. Another area described as the Caylor tract is on the divide between Honey and Little Bluff creeks, Mason County, and of the four assays reported, lead and zinc were present as a trace in only one sample.

Phillips (1904) stated that assays showed between 10 and 20 percent lead with no silver or gold in strata 6 to 12 feet thick in Silver Creek. Paige (1911, pp. 75–77, and 1912, p. 14) described the lead deposits on Beaver Creek and Silver Creek and noted similarities to deposits in southeast Missouri. Baker (1933) described an additional deposit 4 miles north of Marble Falls and suggested that the deposits are syngenetic. Tarr (1933) refuted the syngenetic origin and suggested "an epigenetic origin, which might very well be magmatic." Baker (1935) recorded the production from the Silver Creek prospect by the Frank Pavitte Mining Company during 1930 of 29 tons of galena averaging 66.45 percent metallic lead from 736 tons of ore. This is the only recorded production of lead from central Texas.

Howell and Lochman (1938) noted small amounts of galena associated with trilobites in the *Cedaria* and *Crepicephalus* zones of the Cap Mountain limestone in the Llano uplift but did not give the specific localities where it is found.

Progress of geologic mapping in the eastern portion of the Llano uplift is shown in figure 1. The lead deposits in the vicinity of Iron Rock Creek and part of the deposit on the Scott Klett ranch are mapped in the North Grape Creek quadrangle (Barnes, 1952b), and the rest of the Scott Klett deposit is mapped in the Sandy P.O. quadrangle (Barnes, MS.). The deposit north of Marble Falls is near the boundary of the Longhorn Cavern quadrangle (partly mapped) and the Granite Mountain quadrangle, the mapping of which has been completed and manuscript prepared. Mapping is not contemplated at present of the Fall Creek and Buchanan Lake quadrangles in which the Beaver Creek and Silver Creek deposits lie, but an area of Cambrian and Ordovician rocks (Cloud and Barnes, 1948) in the Fall Creek quadrangle has been mapped.

General information about the stratigraphy of the Llano uplift is contained in publications by Paige (1911, 1912). Recent publications dealing in more detail with the stratigraphy of various groups of rocks in the Llano uplift are: Precambrian rocks (Barnes, Shock, and Cunningham, 1950; Stenzel, 1932, 1935); Cambrian rocks (Bridge, Barnes, and Cloud, 1947; Barnes and Bell, 1954; Palmer, 1954; Wilson, 1949) ; Ordovican rocks (Cloud and Barnes, 1948, and Barnes, Cloud, and Duncan, 1953); Devonian rocks (Barnes, Cloud, and Warren, 1947); Carboniferous rocks (Plummer, 1950; Barnes, 1952c); and Cretaceous rocks (Barnes, 1948).

EXPLANATION OF FIG. 1. Index map of the eastern part of the Llano uplift, central Texas, showing (dotted pattern) location of areas mapped for this paper and progress of recent mapping. Horizontal line pattern represents quadrangles for which maps have been published; vertical line pattern represents areas that are mapped and for which manuscript is essentially complete; diagonal line pattern represents quadrangles which have been mapped in part only.

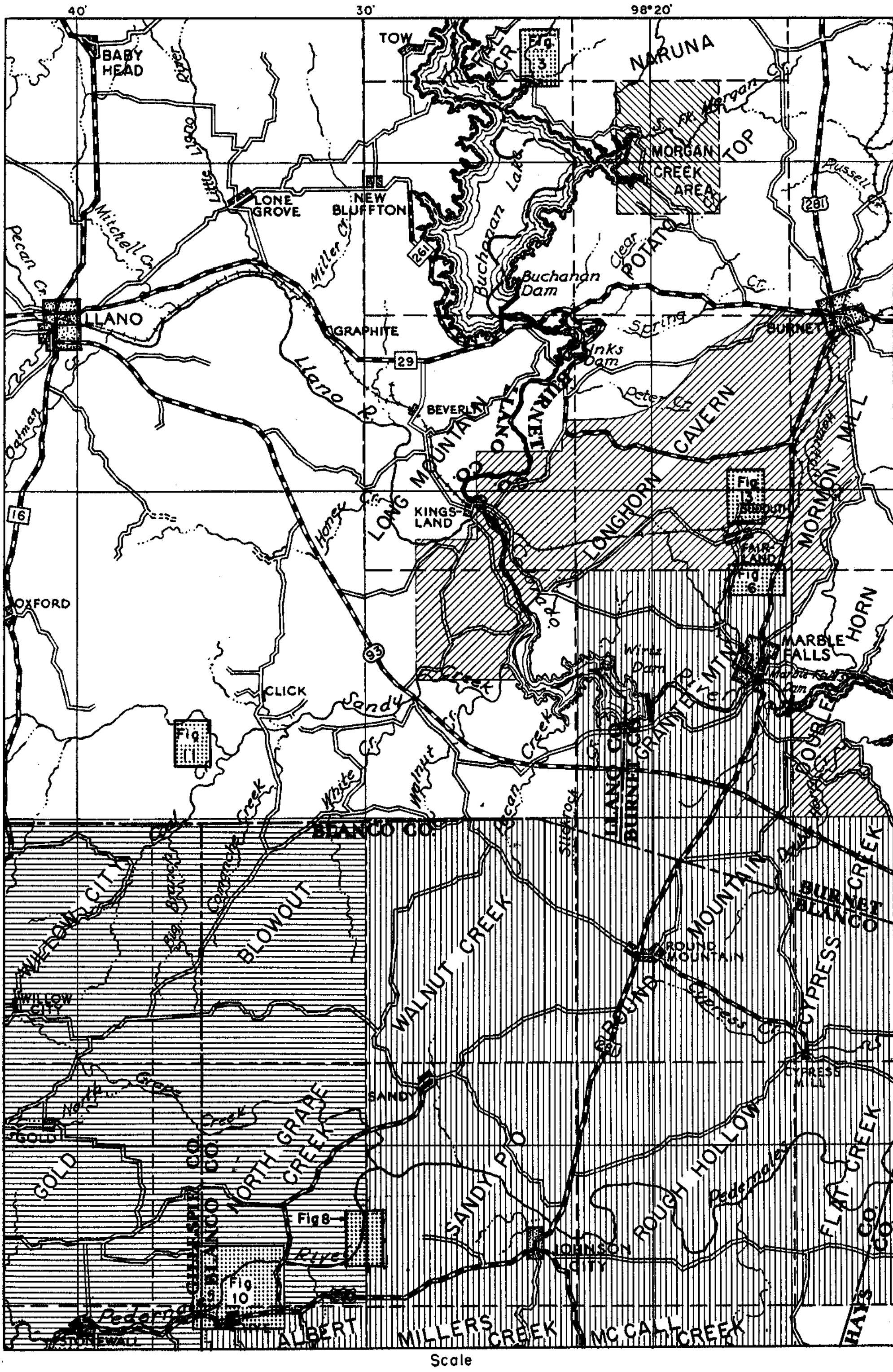

Fig. 1. Index map of the eastern part of the Llano uplift.

GEOLOGIC HISTORY OF THE LLANO REGION

A review of the geologic history of the Llano area aids in a better understanding of the lead deposits. The Precambrian part of the geologic history has been reviewed by Barnes, Shock, and Cunningham (1950, pp. 7–8). About half a billion years elapsed from the emplacement of the Town Mountain granites to the deposition of the Cambrian sediments of the Llano uplift, and it seems unlikely that any residual magmatic materials from any Precambrian source were available for mineralization of the Cambrian rocks. However, there is a definite relation between the location of the known deposits and the Precambrian rocks. Without exception the lead deposits are in Cambrian sedimentary rocks on the flanks of buried hills of Precambrian rock. These hills are of either Town Mountain or Oatman Creek granite.

The surface upon which the Cambrian sediments were deposited has a relief of about 800 feet, and the buried hills are mostly silicious rocks resistant to weathering, such as aplogranite and Valley Spring gneiss. The margins of a few of the Town Mountain granite masses have large exfoliation domes which are resistant to weathering, and a few of the dioritic and amphibolitic rocks stand high.

The Cambrian units recognized in the Llano uplift are as follows:

- Upper Cambrian—
  - Wilberns formation—
    - San Saba member—
      - Dolomitic facies
      - Calcitic facies
    - Point Peak shale member
    - Morgan Creek limestone member
    - Welge sandstone member
  - Riley formation—
    - Lion Mountain sandstone member
    - Cap Mountain limestone member
    - Hickory sandstone member

The Hickory sandstone contains dreikanters at its base in some areas and in its lower part is without fossils; some of it is even devoid of burrows and other evidence of organisms. This part of the sandstone, though grouped with overlying sandstone that contains Upper Cambrian fossils, may not be Upper Cambrian in age. The Hickory sandstone grades upward into the Cap Mountain limestone, which in turn grades upward into the Lion Mountain sandstone.

The source of the Cambrian sediments will be discussed more fully (p. 12). Dreikanters are especially common in the basal portion of the Hickory sandstone in the western part of the Llano uplift and many of them rest on the Precambrian surface. The bases of these dreikanters are not wind-abraded so that they probably have not been moved since being wind-blasted. This suggests that a blanket of wind-blown sand protected them as the Cambrian sea encroached on the central Texas area. It is likely that a large Precambrian surface in the eastern part of the uplift was not protected by a sand blanket, and the weathering products were incorporated into the lower portion of the Hickory sandstone. After the greater part of the Precambrian surface was buried by sediment, additional sand was brought in from a northwesterly direction.

Much of the sand, especially in the upper part of the Hickory and higher, is thought to have been derived from the north, northwest, or west. During Cambrian sedimentation the pre-Cambrian surface in general sloped upward in these directions. The Hickory sandstone is quite variable in thickness throughout the Llano uplift but in any local area attains about the same maximum thickness, indicating that conditions were rather uniform as the sea transgressed. The Cap Mountain limestone extends in the subsurface about 60 miles northward from its outcrop. It thins by lateral transition from limestone to sandstone, as shown by fossil zones which are in sandstone to the north and limestone to the south. The Lion Mountain and Welge sandstones both thin southeastward, indicating that the sand source was in the opposite direction. The rest of the Cambrian is without sand units except for the westernmost outcrop areas of the San Saba member, the sand probably coming from the west.

The Lower Ordovician rocks are cherty to non-cherty dolomites and limestones up to 1,826 feet thick in the southeastern part of the uplift and as little as 830 feet in the northwestern part of the uplift. The Lower Ordovician units in the Llano uplift are as follows:

Lower Ordovician—
- Ellenburger group—
  - Honeycut formation
  - Gorman formation—
    - Calcitic facies
    - Dolomitic facies
  - Tanyard formation—
    - Staendebach member—
      - Calcitic facies
      - Dolomitic facies
    - Threadgill member
      - Dolomitic facies
      - Calcitic facies

The Threadgill is predominantly non-cherty, and the Staendebach is predominantly cherty. The formations are of rather uniform thickness; the difference in total thickness for the Ellenburger group is caused by erosion which in the northwestern area has removed all of the Honeycut and part of the Gorman.

The truncation of the Ellenburger was almost complete by the beginning of the Devonian and perhaps was accomplished much earlier. Upper Ordovician (Barnes, Cloud, and Duncan, 1953) and Lower, Middle, and Upper Devonian rocks (Barnes, Cloud, and Warren, 1947) are now recognized in the Llano uplift, mostly preserved in collapsed areas in the Ellenburger. Only a part of the upper contact of the Ellenburger has been mapped in detail, and other units of the Devonian, Mississippian, or even the Silurian and Ordovician may be found along this boundary in the future.

Rocks of Mississippian age recognized in the Llano uplift are the Ives breccia, the Chappel limestone, and the Barnett formation. The Mississippian rocks probably do not exceed 200 feet in thickness anywhere in their outcrop area and are absent in places in the eastern part of the uplift, where Pennsylvanian rocks rest directly on the Ellenburger. The Pennsylvanian rock units are more widespread and more uniformly distributed. The lowest unit is the Marble Falls limestone, which is about 400 feet thick in the eastern part of the uplift. The Marble Falls grades upward into the Smithwick shale which Plummer (1950, p. 80) measured as 301 feet at its type locality. The Smithwick shale, and locally the Marble Falls limestone, is overlain by the Strawn group of sandstones and shales. Other Pennsylvanian rocks cropping out in the northwestern part of the Llano uplift belong to the Canyon group but are probably without significance so far as the lead deposits are concerned.

During the Strawn the rocks in the Llano uplift were highly disturbed by normal faulting related to the Ouachita orogeny (Barnes, 1948). The Ouachita foldbelt composed of Smithwick rocks crops out in a small area along the Colorado River within 15 miles of the lead deposit north of Marble Falls. The Canyon rocks in the northwestern part of the Llano uplift are not faulted, indicating that the orogeny occurred chiefly during the Strawn.

Sometime during the interval from the Pennsylvanian to the Cretaceous, the Llano uplift was domed and eroded to expose Precambrian rocks. Cretaceous rocks, which are still essentially undisturbed, accumulated until they covered the uplift perhaps during the Edwards. The Cretaceous rocks recognized in the Llano uplift area are of Lower Cretaceous age and are as follows:

Fredericksburg group (or formation) —
- Edwards limestone formation (or member)
- Comanche Peak limestone formation (or member)
- Walnut clay formation (or member)

Shingle Hills formation—
- Glen Rose limestone member
- Hensell sand member

Travis Peak formation—
- Cow Creek limestone member
- Sycamore sand member

The Cretaceous rocks are extensively faulted (Balcones fault zone) in a belt swinging around the eastern and southern sides of the Llano uplift. The main disturbance of the Balcones fault zone is from 35 to 50 miles from the lead deposits, but minor faults are much closer. In the Cain City quadrangle (Barnes, 1952a) one fault is mapped within 15 miles of the lead deposits north of Hye, toward which it trends. The Balcones period of faulting is undated, except that it is younger than the Tertiary rocks which are involved in the vicinity of San Antonio. As the faulting follows the Ouachita belt of weakness, it may have been progressive, starting during the Cretaceous or even at an earlier date and continuing late into the Tertiary. Igneous activity, some of which is dated as Austin chalk in age (Hill, 1890) and some as early Tertiary (Lonsdale, 1927), follows the Balcones fault zone. The nearest known outcropping igneous rock belonging to this group is 25 miles to the south of the lead deposits north of Hye. These rocks are mostly basaltic and in general had little effect upon the rocks which they intrude.

Diabase dikes intruded along the Marble Falls fault were discovered in 1951. The dikes were mapped for a distance of 3 miles from Backbone Creek southwestward to a point one-quarter mile southwest of Colorado River, and the maximum thickness seen is close to 70 feet. The dikes are mostly highly weathered with the development of the typical spheroidal weathering of a fine-grained diabasic rock. In the outcrop along Backbone Creek slight brecciation indicates movement along the fault following the solidification of the intrusive. Dr. P. T. Flawn identified the rock as an altered diabase. It contains 75 percent plagioclase (about labradorite) in subophitic arrangement, 6 percent carbonate, 8 percent chlorite probably altered from pyroxene, 6 percent magnetite or ilmenite, 4 percent leucoxene, and about 1 percent rutile.

The diabase cannot be older than the main period of faulting, which is probably Strawn in age. It could have been intruded at about the time the Strawn faulting ceased, or much later. It is possible that the diabase is related to the more basic igneous rocks of the Balcones fault zone. This discovery of igneous rocks of Carboniferous or later age in the Llano uplift reveals a period of igneous activity not previously recognized. The outcrop on Backbone Creek is 2.5 miles from the nearest lead and zinc deposit near Slaughter Gap.

STRATIGRAPHY OF THE UPPER CAMBRIAN

Detailed information about the Cambrian stratigraphy of the eastern portion of the Llano uplift is given in two sections described in Appendix A. One, the Morgan Creek composite section (fig. 1), is about 3.5 miles east of the Silver Creek lead deposit and shows the normal sequence of rocks. The other (fig. 8) includes a portion of the Scott Klett lead deposit, and gives about the maximum deviation from the norm shown by the Cambrian rocks at the surface in the Llano uplift. The bottom of the Klett-Walker section is near a granite—Cap Mountain limestone contact on a tall, buried hill, where much of the Cap Mountain limestone and all of the Hickory sandstone is missing. Figure 2 is a graphic representation of these sections and also shows the amount of insoluble residue contained in the rock.

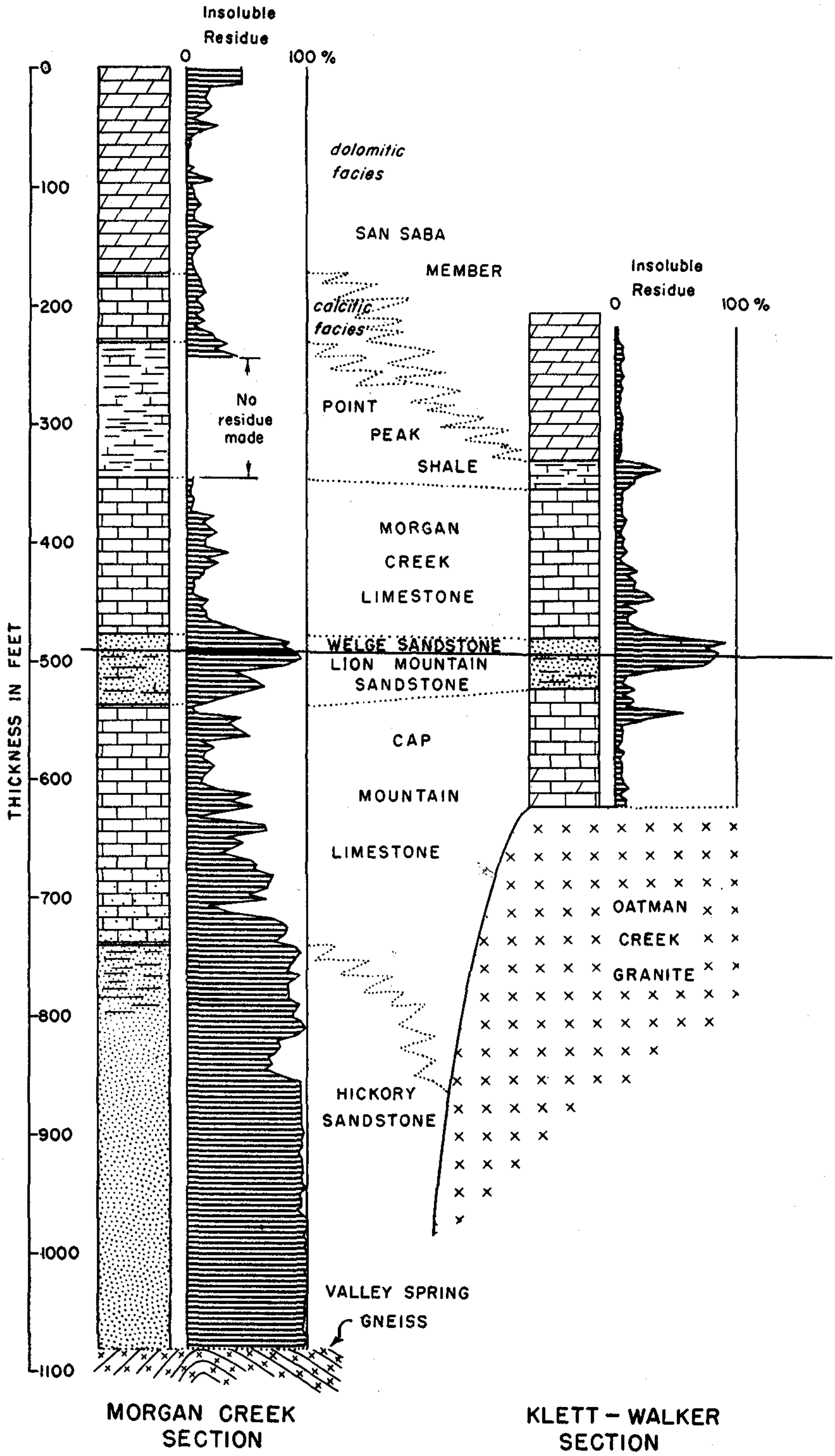

FIG. 2. Diagram showing gross lithology and amount of insoluble residue in the Morgan Creek and Klett-Walker Upper Cambrian sections, Llano uplift.

STRUCTURE IN THE UPPER CAMBRIAN ROCKS

STRUCTURE CAUSED BY BURIED TOPOGRAPHY

Steep quaquaversal dips flank buried hills in central Texas, and for many years the writer considered them to be original depositional features. Mapping for the present paper revealed, however, that these dips are caused mostly by intrastratal solution and resultant thinning of limestone units. The evidence for this conclusion is as follows:

(1) The buried hills are small isolated features and contributed almost nothing to the encircling sediments except for coarse detritus in a few places resting directly on the flanks of the buried hills.

(2) The terrigenous material in the Cap Mountain limestone and above is mostly derived beyond the present area of outcrop.

(3) The limestones of the Upper Cambrian are formed predominantly from limesands composed of oöids and comminuted fossils.

(4) The Welge sandstone and Lion Mountain sandstone are above some of the buried hills and are little thinned.

(5) Stylolites are very abundant and prove that intrastratal solution was very important, especially in the Cap Mountain limestone and the Morgan Creek limestone.

The hills in the Llano area furnished little sediment after the Hickory sandstone was deposited and thus were unlike actively growing organic reefs where steep initial dips are common in the flanking sediments derived from the reef. As mentioned above, the terrigenous material in the Cap Mountain limestone and younger rocks was derived from a northwesterly direction many miles distant, and the calcareous material was limesand composed of oöids and comminuted fossils. It does not seem plausible that clastic material of this type could be deposited on hills several hundred feet high on the sea floor in layers of uniform thickness and with a uniformly steep dip. Some steep dips, however, are caused by currents upsweeping sediment against such hills. Actually many of the buried hills in central Texas are elliptical to nearly circular and during sedimentation acted as obstructions to the sediment-carrying currents causing the formation of secondary currents which scoured in places and deposited in others. Under this condition sand would accumulate in the lee of the buried hills and be massively cross-bedded.

As soon as the level of the sediment reached the top of the buried hills the hills would cease to have any effect, and additional units deposited would be of uniform thickness, as appears to be true for the Lion Mountain sandstone and the Welge sandstone. It is also believed that the structure, as we see it now, was, at least in part, formed as late as the Middle Ordovician or even later, and that it was formed mostly by intrastratal solution of the Cap Mountain limestone. Because the sediments are clastic it is believed that compaction had very little to do with the formation of the structure.

Baker (1935) pointed out that the geological conditions in central Texas are similar to those in the lead belt of southeastern Missouri. Ohle (1952, p. 477) described the lead-belt area and gave the following stratigraphic information concerning the Cambrian rocks in southeastern Missouri:

> The first formation deposited was the Lamotte sandstone; it is successively overlain by the Bonneterre dolomite, the principal lead-producing formation, then the Davis shale, the Derby-Doerun limestone, and a succession of Cambro-Ordovician cherty dolomites. Several of these formations may be found in direct contact with the pre-Cambrian as their deposition progressively overlapped the older rocks on the flanks of the igneous knobs and ridges.
>
> Immediately overlying the pre-Cambrian there is, not uncommonly, a thin basal conglomerate of granite or porphyry boulders, which is incorporated into the overlying sediments. Deposition of the lower part of the rock section was fairly continuous, and the Lamotte sometimes grades almost imperceptibly into the lower sandy Bonneterre. Since the sediments were deposited on an uneven floor, they tend to reflect the irregularities in that floor. Most of the steep dips found in the district, that is, dips in excess of 10°, are original dips and not caused by deformation. Such domelike structures in the sedimentary rocks around the igneous knobs have localized a considerable number of the ore-bodies in the district and particularly those in the Fredericktown area.

If the steep dips in the southeast Missouri area are original dips, as Ohle thinks and as Bridge (1930) and Dake and Bridge (1928, 1932) before him thought, the Llano and southeast Missouri areas are not similar. Mr. John S. Brown in a letter of May 12, 1953, stated:

> The steep dips in the Bonneterre are by no means restricted to the perimeter of knobs. Many ridges and internal structures within the formation show intricate angular bedding with dips of 5 to 25 degrees, which often are superimposed vertically in divergent and opposed directions, usually with planes of submarine scour or unconformity between. These affect markedly the thickness of individual units of the Bonneterre but not measurably its overall thickness of about 400 feet.

If the writer interprets the above paragraph correctly as to scale, then conditions are indeed different in the two areas. The Cap Mountain limestone is in well-defined beds, and these beds dip steeply only in the vicinity of buried hills and where structurally disturbed. However, within individual beds cross-bedding is very common and, of course, the foreset beds dip steeply, but seldom does any one set of cross-beds exceed a foot in thickness.

In southeast Missouri steep dips about buried hills have been accepted as initial dips for more than 20 years, and apparently no recent attempt has been made to re-examine the evidence. Some ore-bodies are situated where the contact between the Lamotte and Bonneterre intersects buried hills, and stratigraphically higher ore-bodies are said to be in part localized above these intersections. Differential subsidence about buried hills should produce a permeable joint system. Could such a system have developed at the right time in southeast Missouri to be invaded by a wave of mineralizing solutions? A study of central Texas cannot result in the final answer to a problem in Missouri, but a comparison of the two areas might stimulate new thought on the Missouri district.

NORMAL FAULTING

A channel trending around the eastern and southern sides of the Llano area collected sediment during part of the Paleozoic, during the early Pennsylvanian the channel became a trough of geosynclinal accumulation of sediment, and about the middle of the Pennsylvanian the sediments in the trough were folded, producing the Ouachita foldbelt. At this time the Llano uplift was extensively faulted, the faults all being normal and dipping between 60 and 90 degrees. The fault blocks are tilted in various directions mostly less than 10 degrees, but some small blocks along main faults are more steeply tilted. All of the lead and zinc prospects examined are in fault blocks of various size and of various tilt. The tilt accentuates the dips on one side of buried hills and decreases them on the other.

COLLAPSE STRUCTURES IN THE PALEOZOIC ROCKS OF THE LLANO UPLIFT

In the Llano uplift, rocks of many ages have been found collapsed into strata of Lower Ordovician and Cambrian ages and as fillings in solution features near the top of the Ellenburger. Many other zones of collapse have been mapped within these rocks, especially along contacts. The solution and collapse continued, probably spasmodically, during a long period of time, and each new unit recognized indicates another cycle of submergence and emergence.

To date, excluding units that have not been described, the following formations have been found:

Lower Pennsylvanian
- Unnamed formation of Morrow equivalence (Cloud and Barnes, 1948; Barnes, 1954)

Upper (?) Devonian
- Zesch formation (Barnes, Cloud, and Warren, 1947)

Middle Devonian
- Bear Spring formation (Barnes, Cloud, and Warren, 1947)

Middle or Lower Devonian
- Stribling formation (Barnes, Cloud, and Warren, 1947)

Lower Devonian
- Pillar Bluff limestone (Barnes, Cloud, and Warren, 1947)

Upper Ordovician
- Burnam limestone (Barnes, Cloud, and Duncan, 1953)

Each of these units records a period when the Llano uplift, or at least part of it, was submerged and solution in the underlying units was probably at a minimum. Between the times successive units were deposited, the Llano uplift emerged one or more times, and solution with its attendant collapse became active, trapping portions of the formations before they could be entirely stripped away. Of these formations the only ones seen in place in normal stratigraphic position are the Stribling formation and the Morrow equivalent.

In addition the Ives breccia, Chappel limestone, and Barnett formation of Mississippian age have been seen individually and collectively in collapse structures in the Ellenburger, indicating other periods of emergence. Marble Falls limestone of Pennsylvanian age has been mapped in positions where it has apparently collapsed with the Barnett shale, and near Streeter, Mason County, Pennsylvanian limestone probably of Marble Falls age has descended to a depth of 1,800 feet beneath the base of the Marble Falls limestone.

Solution and collapse occurred along many of the contacts in the Llano uplift. Limestone of the Threadgill member of the Tanyard formation has collapsed into limestone of the San Saba member of the Wilberns formation. Dolomite of the Staendebach member of the Tanyard formation has collapsed into both the dolomitic and calcitic facies of the Threadgill member. The Honeycut formation has collapsed into the calcitic facies of the Gorman and perhaps to some extent into the dolomitic facies of the Gorman, and collapse areas have been mapped within the calcitic facies of the Gorman.

Solution and collapse appear almost to have ceased about the time of the Pennsylvanian faulting, perhaps due to interruption of essentially continuous aquifers such as the Hickory and Welge sandstones. During the denudation of the Llano uplift prior to deposition of Cretaceous sediments, some solution probably occurred—perhaps those collapse structures containing normal sequences of Mississippian and Pennsylvanian rocks formed at this time. Following the deposition of the Cretaceous rocks, solution effects appear to be minor, as Cretaceous rocks collapsed into Paleozoic rocks have not been recognized. The present cycle of erosion has produced a number of caverns, some of which have collapsed.

To form the collapse structures in the Streeter area, Precambrian marble had to be dissolved beneath about 2,200 feet of sedimentary cover consisting predominantly of carbonate rocks, but the source of the water to dissolve the Precambrian marble is a problem. It seems unlikely that the water could cross 2,200 feet of section downward and still have dissolving power; in fact, water following such a path should rapidly become saturated and with deeper penetration should precipitate calcite because of increasing temperature.

Ohle (1951, p. 908) pointed out that practically all rocks are permeable to some degree and made the following statement:

> Permeability tests on carbonate rocks from several mining districts and on a few igneous rocks lead to the conclusion that probably no rocks, except possibly volcanic glasses, are truly impermeable. All of the rocks tested showed a finite ability to transmit fluid. Over geologic time and under reasonable pressure, the flow will be in considerable volume.

It seems likely, therefore, that some water would be lost upward, even though some shale is present in the Cambrian of central Texas.

The intrastratal solution of the Cap Mountain limestone producing quaquaversal dips about the granite knobs is demonstrated to have occurred after some other geologic units had been deposited (p. 23). This solution may have been accomplished by water moving upward. The resultant stylolites and wavy bedding in the Cap Mountain limestone may therefore have been produced over a period extending from the Lower Ordovician to the middle of the Pennsylvanian. During the same time additional water moving upward from the Welge sandstone might have accentuated the development of stylolites in the Morgan Creek limestone. If intrastratal solution started late, the beds should have been competent enough to have developed joints as they were flexed over the granite knobs. Such a joint system would tend to increase the permeability above the knobs and might be responsible for collapse structures such as those at the Silver Creek prospect.

If intrastratal solution occurred to the extent indicated and if joint systems formed over buried topographic features, it seems likely that many of the collapse structures in the upper portion of the Ellenburger may be related to buried topography. Such a reflection of buried hills may possibly have a bearing on petroleum accumulation in the Ellenburger group of rocks.

JOINTS

The joint patterns in the Paleozoic rocks of the Llano uplift have not been examined in detail. Joints are well developed in some of the units, especially in the Cap Mountain limestone; the joints widened by solution show very well on aerial photographs.

It has been generally assumed that the widely distributed joint system in the Cap Mountain limestone is related to the mid-Carboniferous faulting. However, a portion of the jointing may be related to subsidence about buried topographic features. Such subsidence should produce a joint system related to the configuration of the buried hills, and it is possible that a careful study of joints might indicate the position of buried hills.

SILVER CREEK—BEAVER CREEK AREA, BURNET COUNTY

The Silver Creek—Beaver Creek area (fig. 3) is about 13 miles airline northwest of Burnet (fig. 1). Both the Silver Creek and Beaver Creek prospects are on the R. D. Goodrich ranch.

Silver Creek prospect.—Paige (1911, pp. 75-77) described the Silver Creek prospect, including the general geologic setting, host rock, minerals, and the mine workings. He made some surmises about the genesis and compared the deposits to those in southwestern (probably southeastern) Missouri.

The Silver Creek prospect is situated on the western side of a granite dome which was an island at the start of Cambrian sedimentation in the Llano uplift area. The dome reached a little higher than the base of the Morgan Creek limestone because locally derived microcline cleavage fragments occur in the basal few feet of the Morgan Creek limestone on the eastern side of the dome. In the composite Morgan Creek section there is about 600 feet of sedimentary rock beneath this level, indicating that the island which is now a buried hill stood about 600 feet above the general level of the old erosion surface.

Originally the highest point on the dome appears to have been near the eastern edge within the present outcrop area but it has now been removed by erosion. The decomposing granite supplied coarse microcline and quartz grains to the sediments immediately adjacent to the dome, but these fragments did not move far. For example, along the eastern edge of the granite outcrop near the highest point on the dome, the Welge sandstone is very feldspathic; and where the Lion Mountain sandstone rests directly on the granite it is scarcely identifiable because of the coarse feldspar and quartz which it contains. On the opposite side of the dome and only 300 yards away, Cap Mountain limestone, highly feldspathic in its basal few feet, is overlain by Lion Mountain sandstone followed by Welge sandstone, both of which are entirely normal in appearance and free of locally derived detritus. A section of the upper portion of the Lion Mountain sandstone and the Welge sandstone exposed in the open cuts (fig. 4A) is as follows:

Description	*Thickness in feet* *Interval*	*Cumulative*	*Feet above base*
Wilberns formation: 21 feet measured			
Morgan Creek limestone member: present but not measured			
1. Limestone—coarse grained, grayish red to pale red, becoming less sandy upward, very sandy at base, somewhat glauconitic, similar to the Morgan Creek limestone described in the composite Morgan Creek section.			
Welge sandstone member: 21 feet thick			
2. Sandstone—medium grained, yellowish gray to olive gray, calcareous in upper part.	5	5	34 - 39
3. Sandstone—medium grained, olive gray, glauconitic.	4	9	30 - 34
4. Sandstone—medium grained, pale olive weathering to dusky yellow, contains galena.	1.5	10.5	28.5 - 30
5. Greensand—medium grained, olive gray weathering to dark reddish brown in streaks, composed mostly of glauconite and quartz sand.	2.5	13	26 - 28.5
6. Sandstone—medium grained, greenish gray to very light gray weathering to dusky yellow, in part slightly glauconitic, contains galena.	8	21	18 - 26
Riley formation: 18 feet measured			
Lion Mountain sandstone member: 18 feet measured			
7. Greensand—medium grained, dusky green, composed of glauconite and quartz sand, friable at base.	6	27	12 - 18

8. Sandstone—medium grained, non-glauconitic.	**2**	**29**	**10 – 12**
9. Greensand—similar to friable part of interval 7.	**1**	**30**	**9 – 10**
10. Sandstone—glauconitic.	**4**	**34**	**5 – 9**
11. Sandstone—medium grained, glauconitic, contains a few thin yellowish brown shale layers.	**5**	**39**	**0 – 5**

The total thickness of the Lion Mountain sandstone measured southeast of the mill is 25 feet. The thickness of the Cap Mountain limestone was not measured. It appears to thicken rapidly away from the dome and toward the dome laps on to and feathers out against the granite. About 54 feet of Morgan Creek limestone is beneath the *Irvingella* zone (€wm(i), fig. 4A), and only a few feet of Morgan Creek limestone is above this zone. Around the eastern side of the dome the rest of the Morgan Creek limestone, the Point Peak shale, the calcitic facies of the San Saba member, and part of the dolomitic facies of the San Saba member are present. To the west, Point Peak shale is downfaulted against Welge sandstone and Morgan Creek limestone, and limestone of the San Saba member against Morgan Creek limestone.

The sedimentary rocks dip away from the granite dome in all directions, and the dips, as explained on pages 13–15, are interpreted as caused chiefly by intrastratal solution in the Cap Mountain limestone and perhaps in small part by compaction. There is no evidence that any of the structure is caused by folding, as indicated by Paige, except that tilting has accentuated the dips on one side of the dome and decreased them on the other. A local sharp change in strike and dip at the northwest edge of the mill may be related to an irregularity on the side of the granite dome.

The lead and zinc mineralization in the workings is in the Welge sandstone and the Morgan Creek limestone, and none was seen beneath in the Lion Mountain sandstone and the Cap Mountain limestone or near the granite contact. From an examination of the Eagle-Picher drill hole logs, it appears that traces of lead were found in the Lion Mountain sandstone, and traces to "good lead" are common in the Cap Mountain limestone. Analyses also reveal slight mineralization in the Lion Mountain sandstone.

The mineralized Morgan Creek limestone is in and adjacent to a collapse structure in which the Morgan Creek limestone has subsided at least as low as the top portion of the Lion Mountain sandstone and perhaps even lower. In the vicinity of sample No. 24, *Linarsonella* were collected, which normally are found just beneath the *Irvingella* coquinite. This indicates that this particular block of limestone subsided about 60 feet below its normal level. The only unit beneath this level which could dissolve and allow the collapse of overlying material is the Cap Mountain limestone.

The area of collapse is 35 by 150 feet (fig. 4A). Mineralization extends outward from the collapse structure into the Welge sandstone at least 140 feet in one direction and into the Morgan Creek limestone at least 30 feet where exposed in the underground workings.

A small area of jumbled Morgan Creek limestone near the ore bin south of the mill suggests the presence of another collapse structure. The workings beneath this area are in undisturbed Welge sandstone. From 20 to 40 feet to the west, however, the rock underground is disturbed, and the western boundary of the disturbed area is bounded by a fault downthrown to the west. No surface expression of the fault was recognized.

The adit nearest the mill is in normally dipping undisturbed rock except near the Welge—Morgan Creek contact. The fault mentioned above possibly passes through this disturbed zone. No lead or zinc mineralization was seen even though the end of the adit is within 20 feet of the main collapsed area.

Mineralized Welge sandstone is exposed

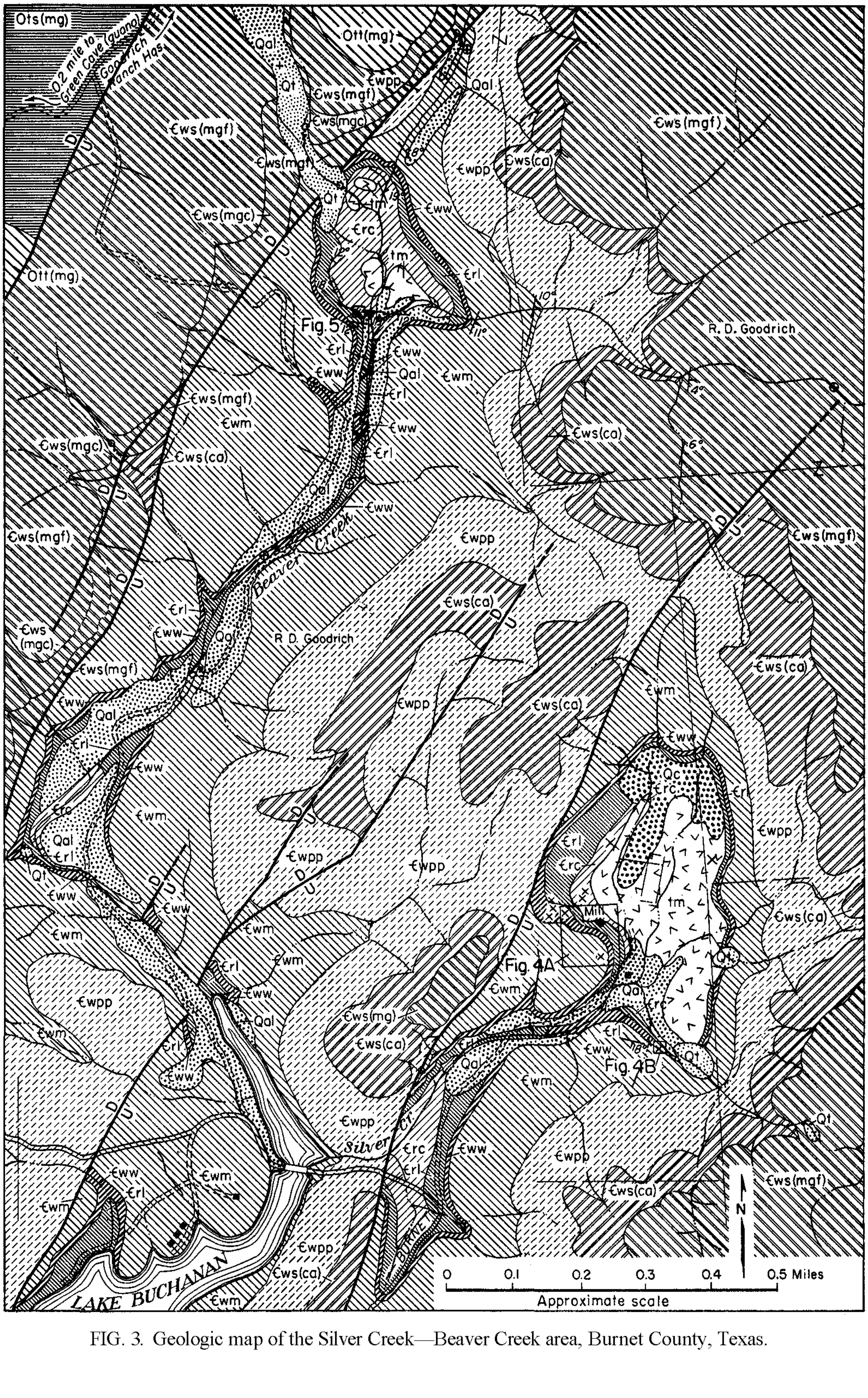

FIG. 3. Geologic map of the Silver Creek—Beaver Creek area, Burnet County, Texas.

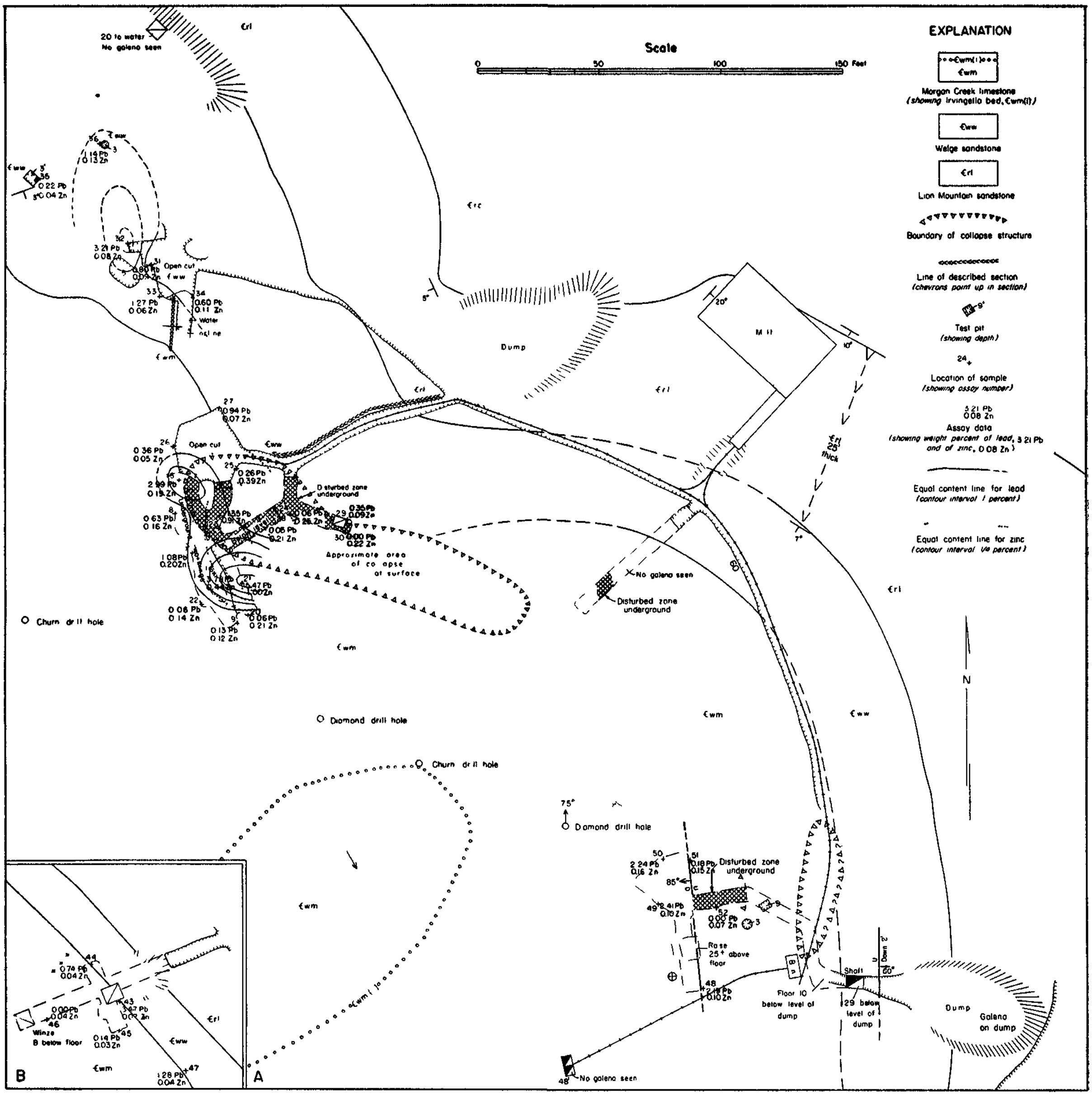

Fig. 4. Pace-compass map of the Silver Creek prospect, Burnet County, Texas.

EXPLANATION OF FIG. 3. Surficial deposits are shown by symbol, as follows: Qal, alluvium; Qt, travertine. The Lower Ordovician is represented by the Tanyard formation of the Ellenburger group, members of which are indicated by the following symbols: Ots(mg), dolomitic facies of the Staendebach member; Ott(mg), dolomitic facies of the Threadgill member. The Upper Cambrian is represented by two formations, comprised of six members, shown by the following symbols: Wilberns formation: €ws(mgf), fine-grained, and €ws(mgc), coarse-grained dolomitic facies, and €ws(ca), calcitic facies of the San Saba member; €wpp, Point Peak shale member; €wm, Morgan Creek limestone member; €ww, Welge sandstone member. Riley formation: €rl, Lion Mountain sandstone member; €rc, Cap Mountain limestone member. The Precambrian is represented by coarse-grained Town Mountain granite, tm. Base from U. S. Department of Agriculture, Soil Conservation Service, aerial photographs flown by Park Aerial Surveys, Inc., 1939-1940. Geology by Virgil E. Barnes and Howard L. Ellinwood, 1950.

in workings about one-quarter mile south-southeast of the mill (fig. 4B). Paige (1911, p. 76) stated:

> The tunnel is located a short distance south of Silver Creek on the western contact. It is run S. 68° W. in glauconitic sandstone. Thirty feet in, a crosscut is driven 7 feet northwest and 18 feet southeast. A bed of sandstone about 18 inches thick is here seen dipping 23° SW., and shows a little disseminated galena. At the end of the crosscuts and also at a point near the tunnel the drift has been widened, evidently for the purpose of following a body of ore which gave out. The tunnel was continued beyond the drift, but is reported to have struck no lead.

The mineralization is in the lower portion of the Welge sandstone. Forty feet southeast of the workings, the upper portion of the Welge is mineralized, and immediately to the west the basal portion of the Morgan Creek contains occasional crystals of galena.

The mineralized portion of the Silver Creek prospect was sampled. All the samples except Nos. 35 and 36 are 5-foot vertical channel samples. Samples 20, 21, 23 and 28 are from a part of the workings which have been excavated 5 feet below the floor of the level. Sample 21 is the richest, but this does not necessarily mean that the grade of mineralization increases with depth.

Figure 4 shows the location of each sample, and the amount of lead and zinc contained is shown by red overprint. Also in red are separate lines showing equal concentration for both lead and zinc. The main lead concentration is in the collapsed Morgan Creek limestone. A second concentration is indicated in the Welge sandstone, but there is little information on the intervening area, and the two concentrations may actually be part of one area. The areas of lead and zinc concentration are open to the east, indicating that mineralization may continue eastward in the collapsed area and the adjacent undisturbed Morgan Creek limestone.

The contours representing lead and zinc concentration essentially coincide in the Morgan Creek limestone, but in the Welge sandstone, zinc is deficient. This indicates that the Morgan Creek limestone is either more receptive to zinc mineralization or that in the Welge sandstone zinc minerals have been leached. The amount of lead and zinc contained in the samples collected from the Silver Creek prospect is given in Table 1.

Table 1. Lead, zinc, and insoluble residue in samples from Silver Creek prospect, Burnet County.

Sample No.	Lead (Percent)	Zinc (Percent)	Insoluble Residue (Percent)	Member*
15	2.99	0.19	68.70	€wm–€ww(tr)
16	3.78	0.44	68.22	€wm–€ww(tr)
17	1.08	0.20	59.13	€wm–€ww(tr)
18	0.63	0.16	59.00	€wm–€ww(tr)
19	0.13	0.12	31.24	€wm–€ww(tr)
20	0.06	0.21	41.02	€wm–€ww(tr)
21	5.47	1.00	49.00	€wm–€ww(tr)
22	0.06	0.14	58.12	€wm–€ww(tr)
23	1.35	0.91	49.00	€wm(d)
24	0.06	0.25	31.22	€wm(d)
25	0.26	0.39	30.80	€wm(d)
26	0.36	0.05	71.25	€ww
27	0.94	0.07	72.36	€ww
28	0.05	0.21	13.75	€wm(d)
29	0.35	0.09	93.71	€rl
30	0.00	0.22	35.80	€wm(d)
31	0.80	0.09	77.20	€ww
32	3.21	0.08	80.22	€ww
33	1.27	0.06	75.35	€ww
34	0.60	0.11	77.30	€ww
35	0.22	0.04	75.17	€ww
36	1.14	0.13	99.11	€ww
43	3.47	0.07	87.61	€ww and €rl
44	0.74	0.04	78.73	€ww and €rl
45	0.14	0.03	73.01	€ww
46	0.00	0.04	70.71	€ww
47	1.28	0.04	67.32	€ww
48	2.19	0.10	87.00	€ww
49	2.41	0.10	79.30	€ww
50	2.24	0.16	75.26	€ww
51	0.18	0.05	92.65	€rl
52	0.00	0.07	42.50	€wm(d)

*The following symbols are used: €wm, Morgan Creek limestone; €ww, Welge sandstone; €rl, Lion Mountain sandstone; (tr) transitional beds; (d) disturbed and collapsed beds.

Three of the samples have been analyzed more completely—including two of Morgan Creek limestone, one of which is high in lead and zinc and the other very low in lead and zinc; and one of Welge sandstone which contains the most lead and zinc. These analyses and one of a sample from the Lion Mountain sandstone (Barnes, Dawson, and Parkinson, 1947, p. 122) are given in Table 2.

The chemical analyses from Table 2 have been recast into the following possible mineral combinations (Table 3).

Minerals actually seen in thin sections

of samples from the Morgan Creek limestone and the Welge sandstone at this locality are quartz, calcite, galena, sphalerite, apatite, cerussite, dolomite, glauconite, limonite, muscovite (?), and zircon. Ilmenite, while not recognized in thin section, is common at this horizon. Kaolinite and albite are the only alumina minerals mentioned in the calculations, but some potash feldspar probably is present. Siderite and rhodochrosite are not actually present but make up a part of the dolomite molecule.

Table 2. Analyses of selected samples from Silver Creek prospect, Burnet County, and of Lion Mountain sandstone, Squaw Creek, Mason County.

	No. 21 (Percent)	No. 22 (Percent)	No. 32 (Percent)	Lion Mountain Sandstone (Percent)
SiO_2	29.47	42.91	70.04	69.24
Al_2O_3	1.95	1.79	0.75	2.23
Fe_2O_3	4.03	9.81	0.81	17.14
FeO	2.17	2.40	2.04	1.20
MgO	0.57	0.65	0.18	1.58
CaO	28.60	21.90	11.60	1.71
Na_2O	....	....	....	0.08
K_2O	....	....	....	2.99
H_2O+	....	....	....	1.82
H_2O-	....	....	....	0.52
CO_2	....	....	....	0.77
TiO_2	0.13	0.15	0.15	0.14
P_2O_5	1.15	0.35	0.47	0.69
S	1.66	0.29	0.17	0.03
MnO	0.38	0.43	0.23	0.03
BaO	....	....	....	0.00
Pb	5.47	0.06	3.21	....
Zn	1.00	0.14	0.08	....
Ignition loss	22.17	17.66	9.53	
Total	98.75	98.54	99.26	100.17
Less O	1.66	0.29	0.17	
Total	97.09	98.25	99.09	100.17

Table 3. Recast of analyses from Table 2 into possible minerals.

	No. 21 (Percent)	No. 22 (Percent)	No. 32 (Percent)	Lion Mountain Sandstone (Percent)
Quartz	27.3	40.8	69.3	49.0
Kaolinite	4.9	4.6	1.8	....
Albite	....	....	....	1.0
Ilmenite	0.3	0.3	0.3	0.3
Apatite	3.1	1.2	1.2	1.7
Galena	6.2	0.1	1.0	....
Sphalerite	1.5	0.2	0.1	....
Pyrite	1.3	0.8	0.0	0.1
Calcite	48.8	37.2	19.9	0.9
Dolomite	2.6	2.9	0.9	0.7
Siderite	2.0	2.8	3.0	....
Rhodochrosite	0.6	0.7	0.3	....
Cerussite	....	....	2.9	....
Goethite	4.4	10.8	0.9	....
Hematite	....	....	....	7.4
Glauconite	....			38.9
Total	103.0	102.4	101.6	

Calculated ignition loss			
S	1.7	0.3	0.2
H_2O	1.1	1.7	0.3
CO_2	23.7	19.1	11.0
Total	26.5	21.1	11.5
Excess	4.3	3.4	2.0

The mineral totals are well in excess of a hundred percent, but if iron were calculated as magnetite and hematite instead of limonite and siderite, the total would be about right. The calculated ignition loss would be improved also but would still be far in excess of that actually measured. Such mineral calculations from analyses are only approximations but help to visualize the amount of the various minerals present.

Thin sections show that the mineralized basal portion of the Morgan Creek limestone is sandy, actually nearly a calcareous sandstone. In addition to the well-rounded, coarse quartz grains, the rock contains many sieve-textured calcite fossil fragments; others which are phosphatic account for the apatite reported in the mineral calculation. The calcite fossil fragments in some sections are limonite impregnated, some wholly arid others peripherally. In such sections the large amount of secondary slightly cloudy, coarse-grained calcite is easily seen.

Small fractures are mostly filled by calcite, but in some, galena is also present showing that the galena is post-fracturing. Some of the secondary calcite crystals adjacent to fractures are deformed, indicating that the rock was cemented at the time it was fractured. However, in some fractures the calcite of the vein has crystal continuity with that of the wall rock.

The galena is mostly in the intergranular space between quartz grains and appears to show no preference for replacement between fossil-fragment calcite and secondary calcite.

Thin sections of the mineralized Welge sandstone show it to be mostly rather coarse, rounded quartz sand cemented by very coarse-grained calcite with, in some places, one crystal of calcite containing several quartz grains. Phosphatic shell fragments are rare. The galena is in both the intergranular space between quartz grains and in fractures which have in part granulated the quartz. The galena-quartz grain boundaries in a few places are very irregular and sutured, showing that the galena has replaced the quartz.

Some sphalerite is associated with the galena, and the galena is in part altered to and surrounded by cerussite. In one grain a dull, opaque material between the galena and the cerussite probably is partly altered galena.

The present investigation of the Silver Creek prospect is more detailed than previous investigations, but roughly the same conclusions are reached. However, for the first time it is recognized that the mineralization is in part associated with a collapse structure and that it extends outward in at least one direction from the collapse into the Welge sandstone and into the Morgan Creek limestone. Only about a 10-foot vertical section of the collapse is accessible for study, and nothing is known about the amount of mineralization beyond this, except in the workings near the ore bin south of the mill and the workings one-quarter mile south-southeast of the mill.

The base of the collapse is assumed to be in the Cap Mountain limestone perhaps extending to the granite. The rock is dropped so that *Linarsonella-bearing* Morgan Creek is opposite Lion Mountain sandstone, indicating about 60 feet of subsidence. The Lion Mountain sandstone is not visibly mineralized alongside the Morgan Creek limestone in the collapse, and for this reason it is assumed that it is not a favorable host. Because the Lion Mountain is beneath the Morgan Creek, there may be a barren zone in the collapse. Drilling by the Eagle-Picher Company in 1925 revealed that there is some mineralization in the Cap Mountain limestone, but unfortunately the map showing the location of the drill holes has been lost and the position of this mineralization in relation to the workings can not be ascertained. The logs of the drill holes are given in Appendix B, including the writer's interpretation of the members penetrated.

Any statement about the amount of mineralized rock and the amount of lead and zinc in the prospect can be only a guess. However, if in the area of the collapse, 35 by 150 feet, a thickness of 30 feet is assumed, about 13,000 tons of rock would be involved. If this contains an average of 2.5 percent lead and 0.5 percent zinc, about 330 tons of lead and about 65 tons of zinc would be present in the collapse.

The Welge sandstone is of even lower grade, and little is known about the areal extent of mineralization. If, however, half the Welge sandstone within 140 feet of the collapse is mineralized, and if, as indicated in the section, mineralization extends through 12 feet of section, about 20,000 tons of rock is involved; but if the assays are indicative, it contains only about 200 tons of lead.

Other collapsed areas may be present in the vicinity, and if the search for lead in this area is continued, such collapses should be especially sought. Rock exposures are good in this area, and collapse structures which come to the surface should be easily detected by the jumbled appearance of the rock.

Beaver Creek prospect.—The Beaver Creek prospect is situated on the southwestern side of a buried granite exfoliation dome breached by Beaver Creek. Paige (1911, Pl. V) showed a photograph of folded Cap Mountain limestone beds above the granite along Beaver Creek and on page 75 stated "... a similar occurrence is found on Beaver Creek, where again galena occurs in glauconitic sandstone near the base of the sandstone series..."

The granite dome is overlapped by rocks high in the Cap Mountain limestone, and the highest point of the dome probably did not quite reach the base of the Lion Mountain sandstone. The top of the dome is irregular and crops out in two areas about 500 feet apart. The northern area has two outcrops each a little over 100 feet in diameter, and the southern area likewise is in two exposures which, however, probably join beneath alluvium.

The northern area is especially instructive as the rock is well exposed, and the Cap Mountain limestone dips quaquaversally from each outcrop. The granite exposure is smooth and unfractured and could not have been deformed to produce folds in the overlying limestone, as thought by Paige. The present inclination of the strata is thought to be caused chiefly by post-depositional thinning modified by regional tilting.

The Lion Mountain and Welge sandstones appear to be of normal thickness and are composed of sand derived from many miles away, yet they dip away from the granite dome in all directions an average of 10 degrees. Evidently these sandstones were deposited on an essentially flat sea bottom and the sea bottom was just as flat above the granite dome. The Cap Mountain limestone likewise contains much clastic material derived from many miles away, and the same argument applies to it, except that the calcitic components could be derived locally.

The amount of thinning to produce the present inclination, subtracting the regional dip, is a minimum of 140 feet and may have been nearer 200 feet. In the near-by Morgan Creek section, the Cap Mountain limestone is 204 feet thick, which means that as originally deposited the member was between 340 and 400 feet thick, giving a thinning of 40 to 50 percent.

The same stratigraphic section is present in the vicinity of the Beaver Creek prospect as in the vicinity of the Silver Creek prospect. In addition the structural conditions are almost identical, with a fault a short distance to the west but with more throw dropping the dolomitic facies of the San Saba member against Morgan Creek limestone and Welge sandstone.

The galena in the Beaver Creek prospect is in the transitional zone from the Cap Mountain limestone to the Lion Mountain sandstone. Figure 5 is a pace-compass map of the workings, which consist of shallow pits, the deepest of which is barren. Galena was found in only one of the pits, and a channel sample from one corner of the pit assayed only 0.32 percent lead and no zinc and contained 48.80 percent insoluble residue. A small ore pile near by was chip sampled and found to contain 0.81 percent lead, no zinc, and 50.41 percent insoluble residue. The only other galena seen is in Cap Mountain limestone in Beaver Creek due east of the workings.

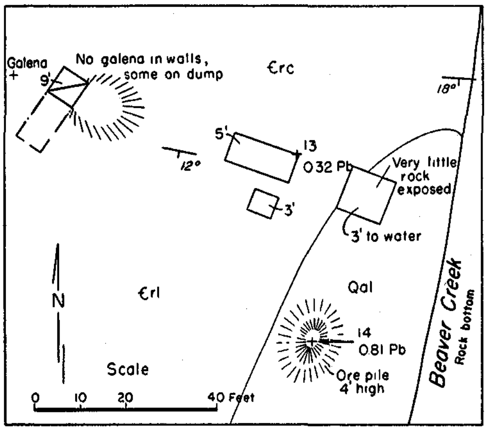

FIG. 5. Pace-compass map of the Beaver Creek prospect, Burnet County, Texas.

Three thin sections were made of the galena-bearing rock. All are highly sandy with quartz predominating; microcline abundant; plagioclase present; authigenic feldspar, chert (?), muscovite (?), and zircon rare; and in one section there is considerable glauconite. The sections are predominantly dolomite and calcite with the minerals in about equal amounts in two sections with calcite predominating in the other. The calcite was originally deposited as a limesand, and the grains have been secondarily enlarged. The dolomite is in well-zoned rhombs and where in contact with galena mostly retains its rhombic shape. Dolomite rhombs surrounded by galena suggest that the dolomite formed first and that galena replaced the surrounding calcite but did not replace the dolomite. Fragments of phosphatic brachiopod shells are common to abundant, and one section contains sporadic sphalerite grains.

The Beaver Creek prospect contains very

little lead and almost no zinc, and the control of the mineralization is not apparent. No collapse structure is present, and no structural disturbance was seen in the vicinity of the prospect. The surrounding area was not examined for collapse structures but such a search is recommended.

The log of a hole drilled near Beaver Creek by the Eagle-Picher Company is given in Appendix B. The hole started near the top of the Morgan Creek limestone and penetrated what appears to be a normal section of Cambrian rocks. No lead shows are logged. The position of this hole is unknown, but considering the thickness of Cambrian rocks penetrated it must be at least a quarter mile from the granite outcrop.

SLAUGHTER GAP AREA, BURNET COUNTY

Baker (1933) mentioned the presence of galena 4 miles airline north of Marble Falls (fig. 1). This deposit is about 1 mile northeast of Slaughter Gap and can be reached by road from Marble Falls by way of Slaughter Gap but perhaps more easily from U. S. Highway 281 at a point 3.45 miles north of Marble Falls by following a ranch road (fig. 6) west-northwestward about a mile. The prospect is situated on the Tom O'Donnell ranch and is in Cap Mountain limestone along the northern side of an exhumed exfoliation dome of Town Mountain granite.

The geology of an area in the vicinity of Slaughter Gap and about the prospect is shown in figure 6. Three northeast-trending faults divide the area into blocks and the rocks in the central two dip gently northeastward. The rocks in the southeastern block dip southwestward, and the northwestern block appears to be synclinal, with the axis of the syncline occupied by Hickory sandstone. The block in which the prospect is situated has granite exposed to the southwest beneath about 200 feet of Hickory sandstone. The granite dome near the prospect probably stands about 200 feet above the general level of the granite surface. Two other domes are exposed to the southeast, but only one reaches the base of the Cap Mountain limestone.

The Cap Mountain limestone dips steeply northward near the dome, but the dip flattens rapidly away from the dome. To the south where the Hickory sandstone is in contact with the granite, the attitude of the rocks cannot be seen, but from the configuration of the Cap Mountain limestone on the hill to the south, there appears to be little if any dip away from the dome in this direction.

Galena mineralization (fig. 7) extends along the strike for only a little more than a hundred yards. The workings consist of a short incline, a shaft about 20 feet deep, and three small prospect holes. The incline is along the bedding of the Cap Mountain limestone, which dips 18 degrees northward. About a foot of "granite wash" is interbedded with the limestone in the incline, and such beds probably have an initial depositional dip which helps to accentuate the dip caused by thinning of the Cap Mountain limestone through solution and compaction. Limestone on the dump from the shaft contains microcline cleavage fragments and quartz fragments. A few specks of galena are distributed through about 20 feet of beds above the incline. Mr. Tom O'Donnell (personal communication) reported some galena in the Cap Mountain limestone south of the granite (fig. 7) and in the limestone in Shin-bone ridge, which is a complex fault sliver along the Marble Falls fault in the vicinity of some of the diabase outcrops along the fault plane. The writer did not check these reported occurrences.

The Cap Mountain limestone in the vicinity of the prospect is mostly thickly bedded and pale yellowish brown to light olive gray tending toward yellowish gray. The more dolomitic beds are dark yellowish orange, and beds containing appreciable glauconite tend to weather to the same color. Much of the limestone is oolitic, glauconite is sparingly distributed throughout, and a few beds are highly glauconitic. Eastward from the prospect the basal portion of the Cap Mountain limestone con-

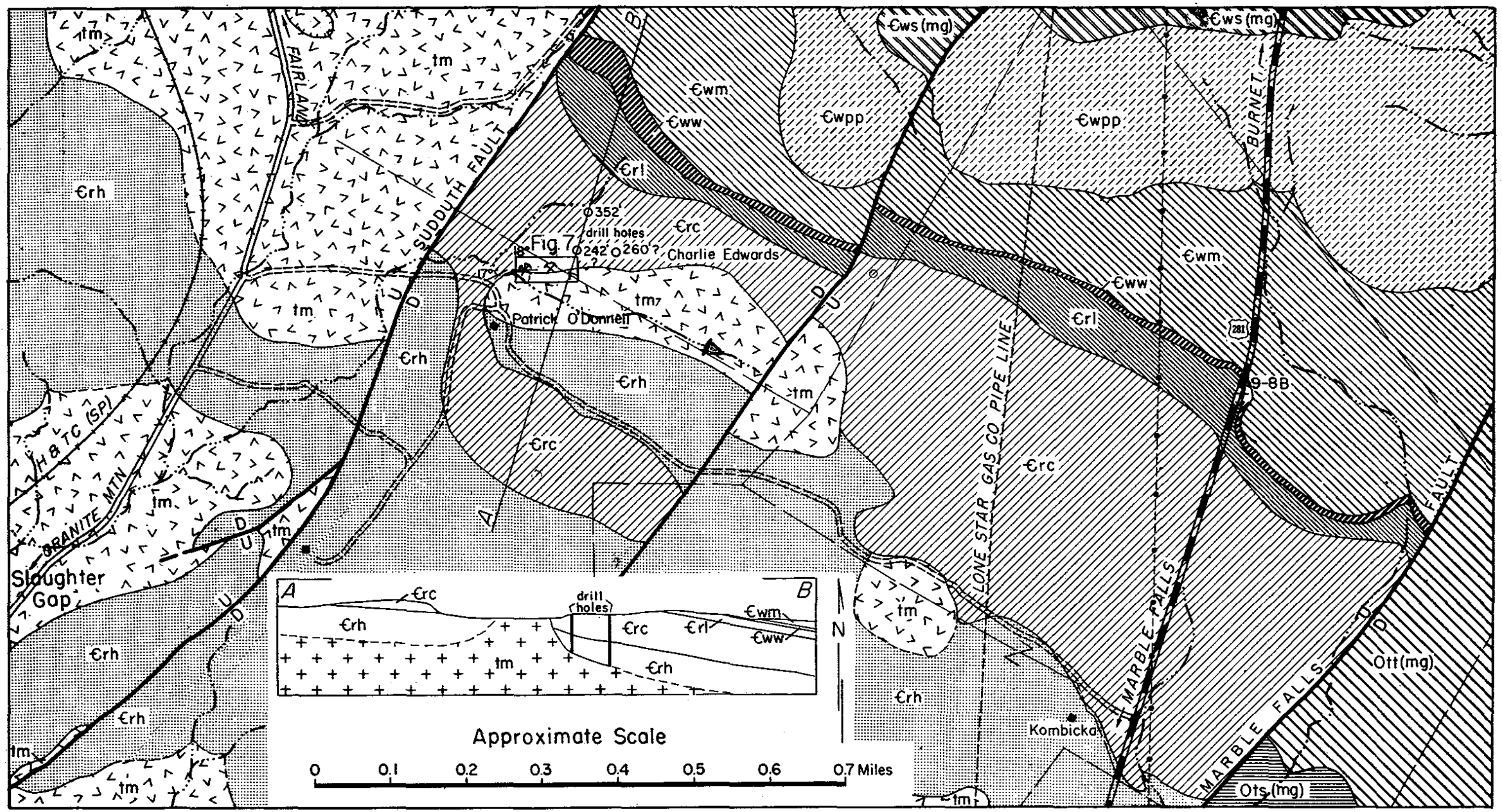

FIG. 6. Geologic map of an area in the vicinity of Slaughter Gap, Burnet County, Texas. The Lower Ordovician is represented by the Tanyard formation of the Ellenburger group, members of which are indicated by the following symbols: Ots(mg), dolomitic facies of the Staendebach member; Ott(mg), dolomitic facies of the Threadgill member. The Upper Cambrian is represented by two formations, comprised of seven members, shown by the following symbols: Wilberns formation: Ꞓws(mg), dolomitic facies of the San Saba member; Ꞓwpp, Point Peak shale member; Ꞓwm, Morgan Creek limestone member; Ꞓww, Welge sandstone member. Riley formation: Ꞓrl, Lion Mountain sandstone member; Ꞓrc, Cap Mountain limestone member; Ꞓrh, Hickory sandstone member. The Precambrian is represented by coarse-grained Town Mountain granite, tm. Base from U.S. Department of Agriculture, Soil Conservation Service, aerial photographs flown by Park Aerial Surveys, Inc., 1939–1940. Geology by Virgil E. Barnes and Lincoln E. Warren, 1945.

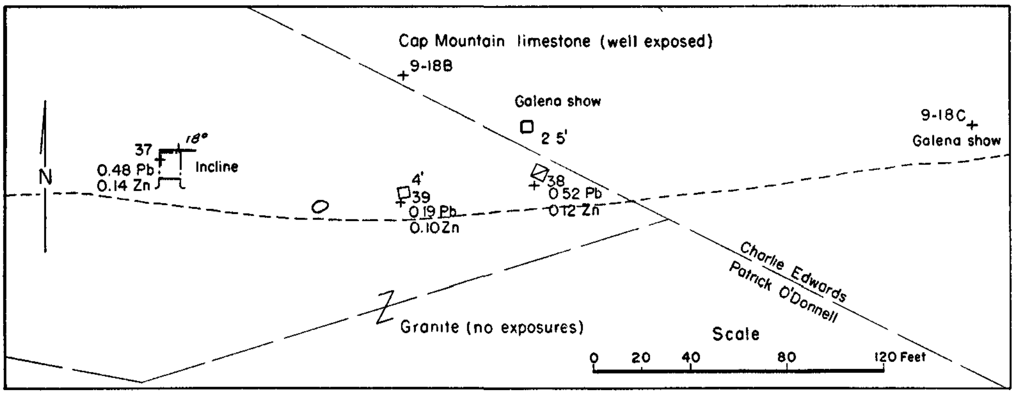

FIG. 7. Pace-compass map of the prospect near Slaughter Gap, Burnet County, Texas.

tains much microcline, and at several places girvanella-like objects are abundant. North of the prospect the joints of the Cap Mountain limestone are widened by solution, which is typical of its outcrop in much of the Llano uplift. The two fossil collections in the vicinity of the prospect contain typical Cap Mountain limestone trilobites.

A thin section of the galena-bearing limestone is mostly calcite containing quartz in very fine sand-silt-sized particles, the amount varying widely from bed to bed; a large grain of microcline; some authigenic feldspar; and rare biotite and glauconite grains. The calcite ranges from extremely fine grained and cloudy to coarse grained and clear, the latter filling cavities in fossils and forming veins. Fossils and fossil debris are common, and most of the material is probably from trilobites.

A sphere in the section resembles an oolite except that it is made up of a mosaic of calcite grains as if the sphere had been derived by the rounding of a rock particle. Stylolites are common but are not markedly suture-like. The galena has replaced calcite and included the quartz, producing a sieve texture. In one area of clear calcite the galena is cubic, indicating that it grew in an opening and that the clear calcite is later.

The eastern end of the granite dome is cut by a fault, and the upthrown side is to the southeast. No mineralization was seen in the vicinity of this fault nor along the Sudduth fault a short distance to the northwest of the prospect. Diabase crops out along the Marble Falls fault 2.5 miles south of the lead prospect and is the nearest post-Cambrian igneous rock known in the area. If mineralizing solutions accompanied the igneous activity, it might be expected that limestones along the fault would be mineralized unless the solutions spread out into the Hickory sandstone instead of continuing upward along the fault. If this happened the solutions might not reach the limestone in the upthrown block except where forced upward by an obstruction such as a buried granite dome. In the

EXPLANATION OF FIG. 8. Areas of alluvium are indicated by the symbol Qal. Both members of the Shingle Hills formation are present and are indicated by the symbols Kshgr, Glen Rose limestone, and Kshh, Hensell sand. The Lower Ordovician is represented by one member of the Tanyard formation of the Ellenburger group, namely, Ott(mg), dolomitic facies of the Threadgill member. The Upper Cambrian is represented by two formations, comprised of six members, shown by the following symbols: Wilberns formation: Ꞓws(mgf), fine-grained, and Ꞓws(mgc), coarse-grained dolomitic facies, and Ꞓws(ca), calcitic facies of the San Saba member; Ꞓwpp, Point Peak shale member; Ꞓwm, Morgan Creek limestone member; Ꞓww, Welge sandstone member. Riley formation: Ꞓrl, Lion Mountain sandstone member; Ꞓrc, Cap Mountain limestone member. The Precambrian is represented by coarse-grained Oatman Creek granite, oc. The location of the Klett-Walker section is shown by chevrons. Base from U. S. Department of Agriculture, Soil Conservation Service, aerial photographs flown by Park Aerial Surveys, Inc., 1939-1940. Geology by Virgil E. Barnes and Lincoln E. Warren, 1943.

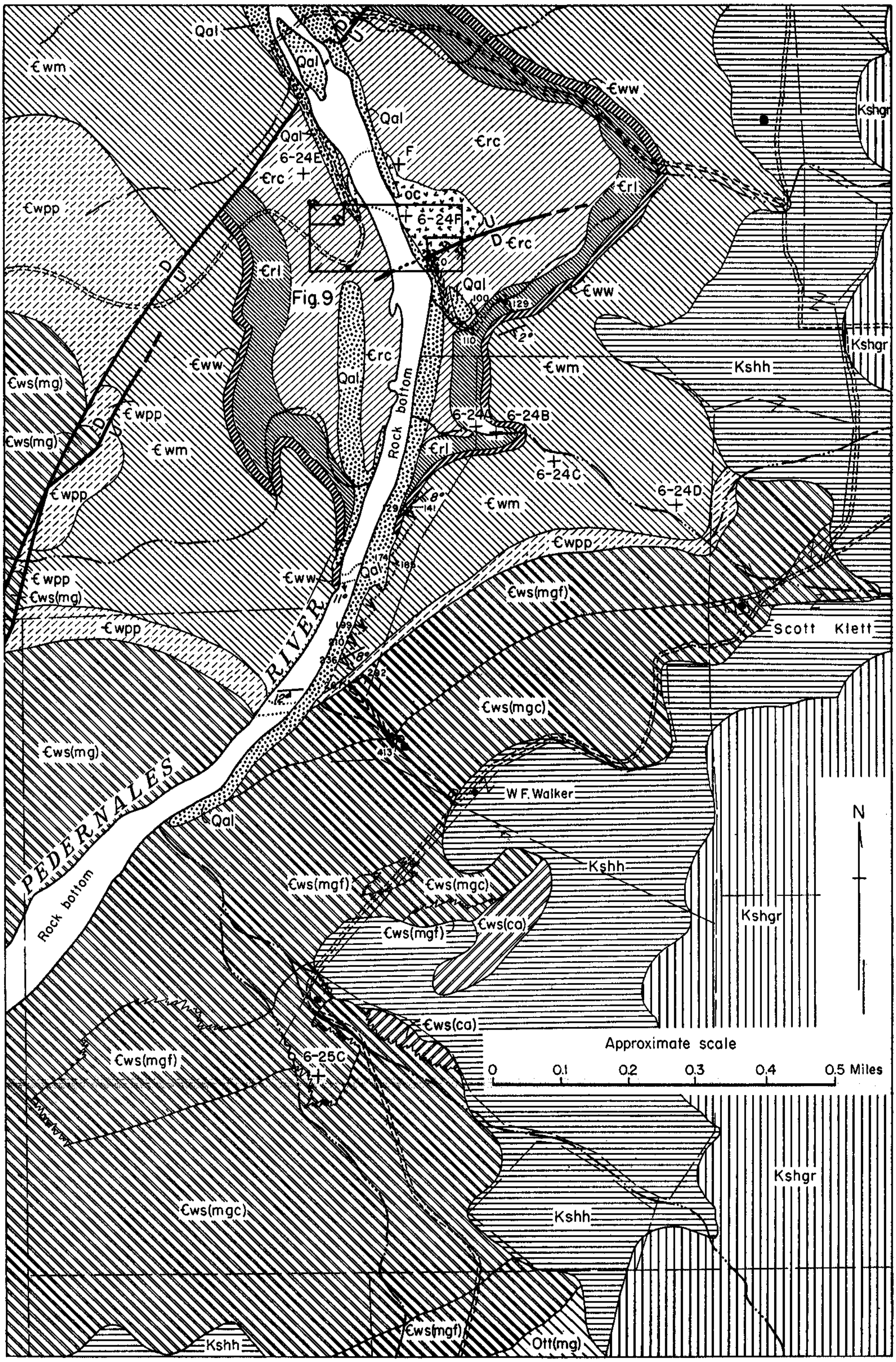

FIG. 8. Geologic map of an area in the vicinity of the Scott Klett prospect, Blanco County, Texas.

downthrown block the top of the Cap Mountain limestone is about 2,800 feet deep. It might be more plausible for ore deposits to form in the downthrown block, if the mineralizing solutions have an igneous source, as the first limestone would be encountered in the downthrown blocks.

The amount of lead and zinc contained in three samples is shown in Table 4.

Table 4. Lead, zinc, and insoluble residue in samples from Slaughter Gap area, Burnet County.

Sample No.	Lead (Percent)	Zinc (Percent)	Insoluble Residue (Percent)	Length of Channel Sample
37	0.48	0.14	13.51	4 feet
38	0.52	0.12	61.91	From dump
39	0.19	0.10	19.73	From dump

The amount of mineralization is very small and little was seen to encourage prospecting in this area.

The Eagle-Picher Company drilled four holes in the Fairland area and the logs are given in Appendix B. The three holes drilled on the Edwards tract are shown in figure 6, and of these the two southernmost ones encountered lead. The logs could not be matched with these two holes.

The hole drilled on the O'Donnell property is 2 miles north of Fairland, and no lead mineralization was encountered. Mr. Tom O'Donnell told the writer that some lead was found in the Cap Mountain limestone to the south, but no attempt was made by the writer to verify this report. A map of the area (fig. 13) is given in Appendix B.

SCOTT KLETT AREA, BLANCO COUNTY

The prospect on the Scott Klett ranch is 5.4 miles airline slightly north of west from Johnson City (fig. 1), and figure 8 is a geologic map of the area.

The workings comprise 6 pits, 2 open cuts, and one incline (fig. 9) and, except for two of the pits west of the river, are in galena-bearing dolomite in the Cap Mountain limestone which surrounds an exhumed hill of Oatman Creek granite. The galena is in two areas about 250 yards apart, one being near the southern border of the granite and the other near its western border. The granite hill reaches within 100 feet or less of the top of the Cap Mountain limestone, and as much as 400 feet of unexposed Cap Mountain limestone may be along its flanks, if its thickness as measured in the White Creek section, 12 miles to the north, remains the same. The White Creek section contains 276 feet of Hickory sandstone, and if these thicknesses continue southward the granite hill possibly is 700 feet high.

The Cap Mountain limestone dips away

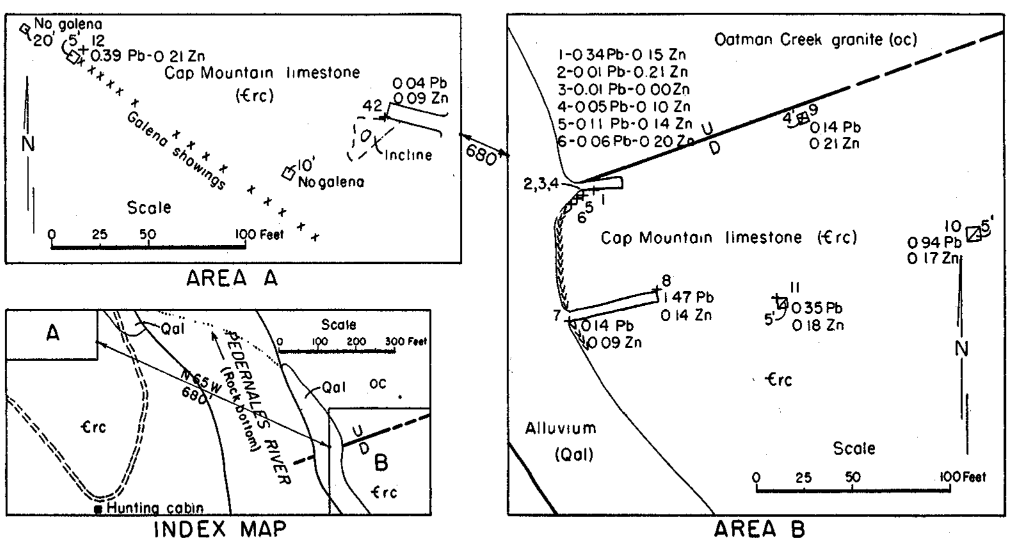

FIG. 9. Pace-compass map of the Scott Klett prospect, Blanco County, Texas.

from the granite in all directions, and, as explained above, most of this dip is probably caused by solution and some may be by compaction. Between 50 and 100 feet of thinning is necessary to produce the present structure. A northeast-southwest-trending fault has dropped Morgan Creek limestone opposite Cap Mountain limestone, Lion Mountain sandstone, and Welge sandstone a short distance to the northwest of the prospect. No mineralization was seen in the vicinity of the fault. A small fault is mapped at the southern end of the granite exposure, but actually this may be collapse from solution of Cap Mountain limestone along the granite contact, allowing some subsidence.

The granite (Barnes, Dawson, and Parkinson, 1947, pp. 51–52) has an average grain size of 10 mm and is composed predominantly of microcline microperthite and quartz with some hornblende and biotite. Accessory minerals are magnetite, apatite, and zircon. Plagioclase is extremely rare as individual crystals and is associated with femic minerals. Alteration products are mostly chlorite, an alteration producing cloudiness in the potassic portion of the microperthite, and a few flakes of sericite.

A chemical analysis and normative mineral composition show that the granite is not as silicic as some of the Oatman Creek granites but still probably should be classed as an aplogranite. The chemical analysis and normative mineral composition are given in Table 5.

The mineralized portion of the prospect was sampled; samples 1 to 6 inclusive represent the lower 25 feet of the Klett-Walker section and sample 7 represents the 34 to 38-foot portion of the section. The samples are either channel samples or chip samples from dumps, and the amount of lead and zinc contained is given in Table 6.

Table 5. Analysis and normative mineral composition of Oatman Creek granite, Scott Klett area, Blanco County.

Chemical Analysis*	Percent	Normative Mineral Composition	Percent
SiO_2	74.10	Quartz	29.16
Al_2O_3	12.75	Orthoclase	30.58
Fe_2O_3	0.83	Albite	33.54
FeO	1.88	Anorthite	1.67
MgO	0.16	Hypersthene	2.91
CaO	0.63	Magnetite	1.16
Na_2O	3.95	Ilmenite	0.46
K_2O	5.20	Apatite	0.07
H_2O+	0.10	Fluorite	0.31
H_2O-	0.04	Calcite	0.32
CO_2	0.14	Pyrite	0.04
TiO_2	0.24	Normative plagioclase	$Ab_{95}An_5$
P_2O_5	0.03		
MnO	0.05		
BaO	0.04		
F	0.12		
S	0.02		
Total	100.28		
Less O	0.06		
Total	100.22		

* Analyzed at the Minnesota Rock Analyses Laboratory, Minneapolis. Analysts: R. B. Ellestad (Fe_2O_3, FeO, CO_2, TiO_2, P_2O_5, MnO, and F); G. Kahan (all other determinations). Fluorine determination by Willard and Winter method.

Table 6. Lead, zinc and insoluble residue in samples from Scott Klett area, Blanco County.

Sample No.	Lead (Percent)	Zinc (Percent)	Insoluble Residue (Percent)	Length of Channel Sample (Feet)
1	0.34	0.15	8.22	5
2	0.01	0.21	4.45	5
3	0.01	0.00	3.20	5
4	0.05	0.10	8.21	5
5	0.11	0.14	7.00	5
6	0.06	0.20	6.32	5
7	0.14	0.09	6.06	4
8	1.47	0.14	6.45	5
9	0.14	0.21	18.69	4
10	0.94	0.17	4.02	5
11	0.35	0.18	5.03	5
12	0.39	0.21	8.52	From dump
42	0.04	0.09	8.62	5

Two of the samples were analyzed somewhat more completely; these analyses are given in Table 7.

The chemical analyses have been recast into the following possible mineral combinations (Table 8).

Table 7. Analyses of selected samples from Scott Klett area, Blanco County.

	No. 1	No. 8
SiO_2	3.83	4.73
Al_2O_3	0.78	0.67
Fe_2O_3	0.84	2.00
FeO	4.29	5.00
MgO	14.70	13.54
CaO	31.20	30.20
TiO_2	0.05	0.12
P_2O_5	0.01	0.03
S	0.14	0.38
MnO	0.43	0.49
Pb	0.01	1.47
Zn	0.21	0.14
Ignition loss	43.80	39.21
Total	100.29	97.98
Less O	0.14	0.38
Total	100.15	97.60

Table 8. Recast of analyses from Table 7 into possible minerals.

	No. 1	No. 8
Quartz	2.9	3.9
Kaolin	2.1	1.8
Ilmenite	0.1	0.3
Apatite	tr	0.1
Galena	tr	1.7
Sphalerite	0.3	0.2
Pyrite	0.1	0.4
Calcite	19.1	20.2
Dolomite	67.4	62.0
Siderite	6.7	7.5
Rhodochrosite	0.7	0.8
Goethite	0.9	2.3
Total	100.3	101.2
Calculated ignition loss		
S	0.1	0.4
H_2O	0.2	0.5
CO_2	43.4	41.6
Total	43.7	42.5
Excess	0.1	3.3

Minerals seen in thin section are dolomite, calcite, quartz, glauconite, galena, and rare microcline and pyrite. As mentioned above, siderite and rhodochrosite are not actually present but make up part of the dolomite molecule. The chief chemical difference between the Cap Mountain limestone and the overlying members, except for differences caused by variation in the amount of sand, is the high MgO and low P_2O_5 content of the Cap Mountain limestone reflected by the high percentage of dolomite and the scarcity of apatite, the latter from phosphatic brachiopods.

A portion of the calcite is fossil debris, much of which has a brownish color. The dolomite varies widely in grain size; patches of different color and grain size are irregularly distributed. The dolomite is in rhombs, some of which are zoned, and is mostly brownish, indicating a high iron content and that it is ankeritic.

The galena is in coarse-grained aggregates, and one such grain has small pyrite particles bordering it on one side. The dolomite is clear along this side of the galena grain and contains a few pyrite particles, some of which are within rhombs. It appears that cloudy calcite and dolomite have been replaced by galena, that some galena has been deposited in cavities, and that pyrite and clear dolomite finished filling the cavities, both being deposited at the same time.

The amounts of lead and zinc shown by the analyses do not indicate that the deposit is of economic importance. However, only a very small portion of the thickness of the Cap Mountain limestone is represented by the samples. If the mineralizing solutions were from below, it is possible that the Cap Mountain limestone could harbor commercial ore where the Cap Mountain limestone—Hickory sandstone contact intersects the granite.

IRON ROCK CREEK AREA, BLANCO AND GILLESPIE COUNTIES

A small amount of galena is in the Cap Mountain limestone surrounding the two westernmost granite outcrops shown in figure 10. A series of seven granite outcrops roughly aligned in an east-west direction is distributed through a distance of 2.5 miles. The line of outcrop is about 2 miles north of Hye and crosses both Pedernales River and Iron Rock Creek. The granite represents exhumed hills with the three centrally located outcrops perhaps belonging to the same hill, thus limiting the number of buried hills to five.

The two easternmost hills are in contact with the base of the Lion Mountain sandstone, and it is possible that the others also extended this high in the Cambrian. The Cambrian rocks dip away from the line of hills, thus producing an anticline; not all

Fig. 10. Geologic map of the Iron Rock Creek area, Blanco and Gillespie counties, Texas.

the dip can be attributed to thinning of the Cap Mountain limestone by solution and compaction.

The configuration of the Welge and Lion Mountain sandstones on the Willi and Sultemeier ranches north of the granite exposures suggests that another buried hill is not far beneath the surface. The eastern end of the anticline is cut off by a northeast-southwest-trending fault downdropped to the southeast, and to the west the anticline swings northwestward and is cut off by an east-west fault downdropped to the north. It seems likely that the row of granite hills continues in each direction and that to the east it may even form an arc extending to or beyond the granite hill on the Scott Klett ranch. This possibility can be better visualized by examining the North Grape Creek quadrangle map (Barnes, 1952b).

Excavations in the vicinity of the granite hills are limited to three pits ranging from 4 to about 20 feet deep, all in Cap Mountain limestone. Two of the pits contained enough galena to make it desirable to obtain samples. The third pit, about 20 feet deep, was not entered, but the material on the dump contained only rare specks of galena.

A pit 4 feet deep and of irregular outline is situated on the A. A. Maurer ranch about 500 feet west of the westernmost granite outcrop. A churn drill hole in the bottom of the pit is of unknown depth. A 4-foot channel sample from the pit contains 0.04 percent lead, 0.23 percent zinc, and 14.40 percent insoluble residue. The Cap Mountain limestone exposed by the pit is dolomitic, medium light gray, and has weathered to a dark yellowish orange, whereas the rock on outcropping surfaces ranges from light to moderate brown. The dolomite is glauconitic and has a small amount of vuggy porosity. Elsewhere about the knob on the Maurer, Willi, and Reagan ranches the Cap Mountain is light to moderate brown and in places is highly limonitic. Farther away from the granite the limestone is medium light gray.

A thin section of the rock contains dolomite, calcite(?), quartz, galena, sphalerite, pyrite, limonite, glauconite, microcline, plagioclase, and authigenic feldspar. Some clouded, granular areas which grade out into rhombic dolomite may be calcite. The dolomite ranges from uniformly cloudy to clear with some of the latter well zoned, the banding in part being limonite (?). The clear dolomite forms a network and is younger than the cloudy dolomite, and both are cut by myriad stylolites, causing the section to have a brecciated appearance under low magnification. The detrital minerals are very fine grained and are concentrated in the more stylolitic areas. Some of the stylolites contain pyrite, but most of the pyrite has altered to limonite. Larger areas of pyrite have filled vuggy pores, and perfect rhombs of dolomite project into the pyrite. The galena likewise shows some evidence of having in part filled openings. A small amount of pyrite fringes one galena grain. The sphalerite is in subround grains and mostly associated with stylolites. None was found enclosed in first generation dolomite, and since detrital minerals occur in the first generation dolomite, it seems likely that the sphalerite is not detrital.

A prospect pit on the A. Willi ranch is about 8 by 10 feet and 10 feet deep. The top bed is about 4 feet thick in the pit and 15 to 20 feet to the west contains some galena. A small amount of pyrite is in the lower part of the pit, and the Cap Mountain throughout is medium light gray weathering to dark yellowish orange similar to that in the Maurer pit. A channel sample from the 4-foot galena-bearing bed in the pit contains 0.03 percent lead, 0.14 percent zinc, and 14.30 percent insoluble residue.

The third pit, also on the A. Willi ranch, is about 20 feet deep and 4 by 4 feet. It is estimated that 12 feet of the pit is in Cap Mountain limestone, and the rest is in granite. Specks of galena can be found in the limestone on the dump only with very careful search; therefore no sample was collected.

The Cap Mountain limestone around the rest of the granite masses was searched for galena but none was found. A pit about 2 feet deep on the western side of the southernmost granite mass on the Sultemeier ranch revealed no galena.

The granite probably served only in a mechanical way in localizing the galena and sphalerite. Barnes, Dawson, and Parkinson (1947, pp. 48–51) described the granite and gave an analysis of it. It forms low, boulder-strewn hills, is light salmon-pink, medium grained (7 mm ave.), joints are rather numerous, inclusions are absent, and pegmatites are scarce. The granite is composed predominantly of microcline, in part perthitic, quartz, and plagioclase. Biotite containing numerous pleochroic halos is common but not abundant. Accessory minerals are fluorite, magnetite, zircon, and in sample Bl-8 (p. 51) a small amount of rutile. The fluorite is in grains up to 3 mm in size, which is larger than normal for the granites of the Llano uplift. Alteration products are abundant, among which are chlorite, sericite, limonite, and decomposition products of feldspar. Tourmaline is common is the westernmost outcrop.

Very little lead and zinc are present in the surface rocks in the Iron Rock Creek area, and it is also possible that little more is present in depth along the flanks of the buried hills. However, the intersection of the Cap Mountain limestone—Hickory sandstone contact with the granite should be investigated by drilling since deposits of commercial importance could be present.

OTHER AREAS

CEDAR MOUNTAIN, LLANO COUNTY

Repeated rumors have been heard of the presence of a lead deposit in a canyon leading from Cedar Mountain into Sandy Creek. Such a canyon about 3 miles southwest of Click contains an exhumed hill of metadiorite (Paige, 1911), and since the known lead deposits of the Llano uplift are around buried hills, the area was mapped (fig. 11).

The diorite, locality 3–43A, reaches well up into the Cap Mountain limestone and is similar in appearance to the mass of diorite described by Barnes (1945, p. 58, loc. 3-37A). The diorite, locality 3-37A, is composed about equally of hornblende and labradorite-bytownite plagioclase with some titanite and zircon. Much of the feldspar has a granulated appearance between cross nicols, and the hornblende is in distinct crystals with ragged edges.

The Cap Mountain limestone is about 425 feet thick in two near-by sections (Bridge, Barnes, and Cloud, 1947), one to the south at the south end of Cedar Mountain (Cut Off Gap section), and the other to the north in the Riley Mountains (East Canyon section). The Hickory sandstone was measured in the northern section only, where it is about 340 feet thick. The average thickness of other units measured in both sections is Lion Mountain sandstone, 25 feet; Welge sandstone, 20 feet; and Morgan Creek limestone, 125 feet. Units measured only in the Riley Mountains (Moore Hollow section) are Point Peak shale, 215 feet; and calcitic facies of the San Saba member, 145 feet thick, not all of which is present in the area mapped in figure 11.

No galena was found within the map area; however, intensive search was confined to the vicinity of the diorite. Canyons farther west which drain into Sandy Creek were not explored.

BETWEEN LITTLE BLUFF AND HONEY CREEKS, MASON COUNTY

Comstock (1890, 1891) mentioned an occurrence of lead on the Caylor tract on the divide between Little Bluff and Honey Creeks in Mason County and indicated that the geology is almost too complex to be deciphered. In addition to many units of Cambrian and Ordovician age a great mass of Precambrian marble is situated in the area, and portions of it could easily be mistaken for some of the Paleozoic limestones. A fault zone passes through the area (fig. 12), producing many thin fault blocks containing one or more formations which are tedious to map but which are not especially difficult to identify as the stratigraphy of the area is now well known. In figure 12 the mapping of the fault zone

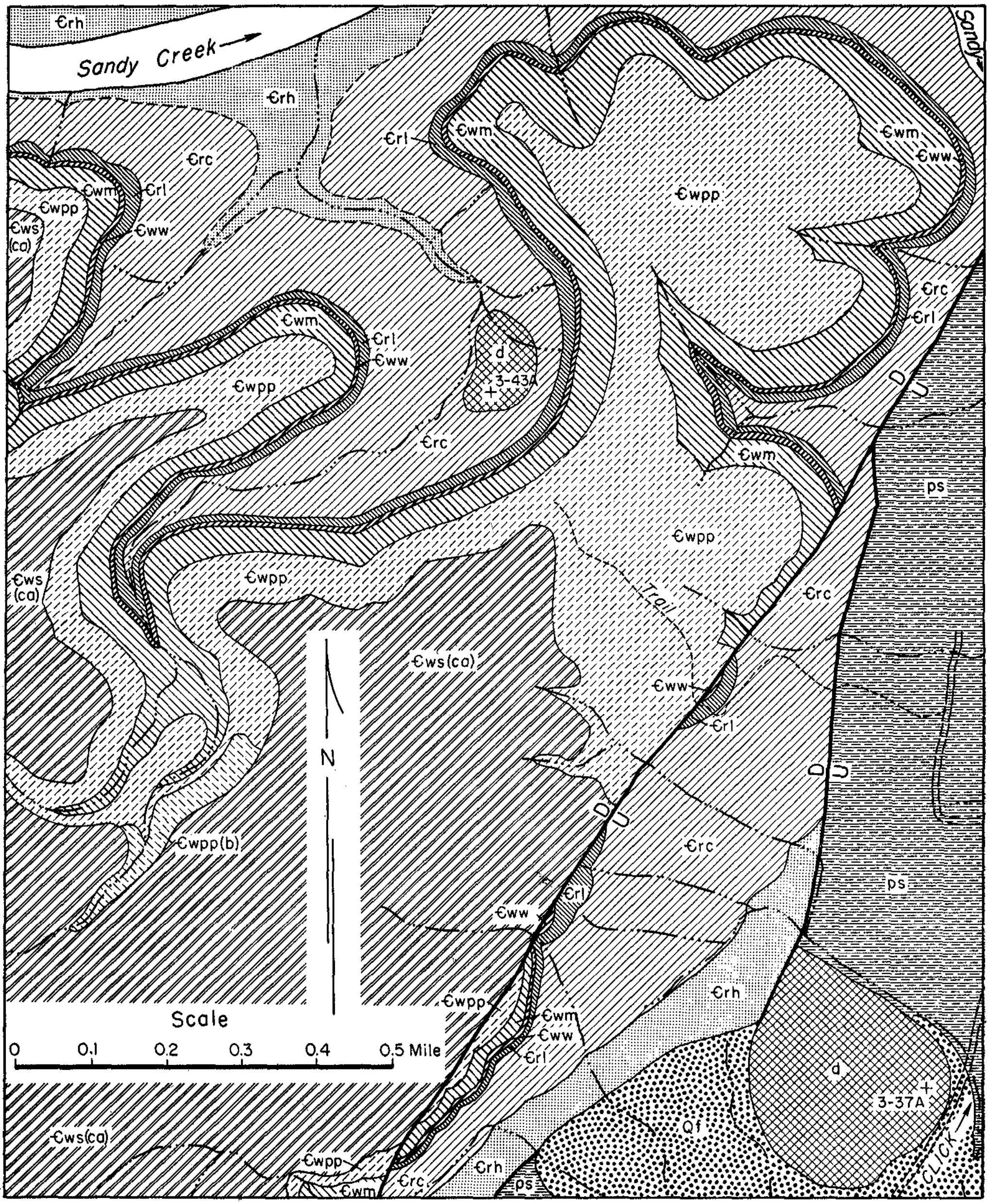

FIG. 11. Geologic map of a part of Cedar Mountain, Llano County, Texas. An area of fanglomerate is shown by the symbol Qf. The Upper Cambrian is represented by two formations, comprised of seven members, shown by the following symbols: Wilberns formation: €ws(ca), calcitic facies of the San Saba member; €wpp, Point Peak shale member containing a stromatolitic bioherm, €wpp(b) ; €wm, Morgan Creek limestone member; €ww, Welge sandstone member. Riley formation: €rl, Lion Mountain sandstone member; €rc, Cap Mountain limestone member; and €rh, Hickory sandstone member. The Precambrian is represented by Packsaddle schist, ps, and diorite, d. Base from U. S, Department of Agriculture, Soil Conservation Service, aerial photographs flown by Park Aerial **Sur-**veys, Inc., 1939-1940. Geology by Virgil E. Barnes and Lincoln E. Warren, 1943.

is generalized as none of the early prospecting was within the zone.

All of the prospect pits and shafts, except some recent pits in the Oatman Creek granite dug for topaz, are in the Packsaddle schist. One pit in non-mineralized schistose rock on the Eppler ranch was seen in 1941. The pit was not revisited during 1952; consequently it is not mapped. Pits on the Marvin Lange property have been filled recently, and no sulfide mineralization was seen in the waste that remains. The pits were situated on the marble-schist contact. Three pits in marble on the Bolt ranch and three small pits in one area on the Ernest Lange ranch are also barren. No sulfide mineralization, except for minute amounts of pyrite, was seen anywhere in the area mapped. The Caylor tract is presumably within the area shown in figure 12, as no other "diggings" are reported on the divide between Honey and Little Bluff Creeks.

Two samples of the marble were described by Barnes, Dawson, and Parkinson (1947, p. 100). The rock is composed predominantly of calcite with a small amount of dolomite, tremolite, talc, pyrite, graphite, and serpentine. The marble is mostly fine grained, but coarser grained portions are common. The marble weathers in part light gray and in part brown. Most of that which weathers brown is probably dolomitic and is light gray on freshly broken surfaces. The rest is brown on broken surfaces and is probably ankeritic. The brown-colored portion of the marble cuts at random structure interpreted as bedding. The marble is steeply dipping, in part crenulated, and apparently is also folded, on a larger scale. No attempt was made to outline the folds within the marble.

Barnes, Dawson, and Parkinson (1947, pp. 79–81) described the Oatman Creek granite within the map area, which in recent years has yielded considerable gem-grade topaz, probably from pegmatites within the granite. Cassiterite and tourmaline are also common, but not abundant, in the alluvial materials resting on the granite. The granite is composed predominantly of plagioclase, microcline, and quartz and a small amount of muscovite, biotite, fluorite, and zircon. The minerals appear to be in about 3 mm-sized grains, but in thin section it is seen that they are aggregate and that the grain size is nearer a millimeter. The Town Mountain granite has not been sampled within the map area, but to the east (p. 82) a sample was collected. This granite has about the same mineral composition as the Oatman Creek granite except that the Oatman Creek granite contains some muscovite and fluorite, and the Town Mountain granite contains magnetite and apatite. The grain size of the Town Mountain granite ranges from 4 mm for the biotite areas, about 7 mm for the quartz areas, and up to about 20 mm for the microcline phenocrysts.

The marble in the Packsaddle schist and the Oatman Creek granite appear to have formed a ridge which may have stood as much as 200 feet above the surrounding sea bottom at the advent of Cambrian sedimentation. Red Hickory sandstone which is normally about 200 feet above the base of the member overlaps the higher points of the marble ridge. Patches of Hickory sandstone are scattered indiscriminately on the marble from low in valleys to high on hills as if the marble ridge were being exhumed with very little additional erosion of the marble. Sporadic areas of jumbled

EXPLANATION OF FIG. 12. The Lower Ordovician is represented by the Tanyard formation of the Ellenburger group, members of which are indicated by the following symbols: Ots(mg), dolomitic facies of the Staendebach member, and Ott(ca), calcitic facies of the Threadgill member. The Upper Cambrian is represented by two formations, comprised of seven members, shown by the following symbols: Wilberns formation: €ws(ca), calcite facies of the San Saba member, including a stromatolitic bioherm, €ws(cab); €wpp, Point Peak shale member; €wm, Morgan Creek limestone member; €ww, Welge sandstone member. Riley formation: €rl, Lion Mountain sandstone member; €rc, Cap Mountain limestone member; €rh, Hickory sandstone member. The Precambrian is represented by Packsaddle schist, ps, with marble, ps(m), mapped separately; Oatman Creek granite, oc; Town Mountain granite, tm; and a small quartz mass in the Town Mountain granite, qz. Base from U. S. Department of Agriculture, Soil Conservation Service, aerial photographs flown by Park Aerial Surveys, Inc., 1939. Geology by Virgil E. Barnes and John T. Twining, May 1952.

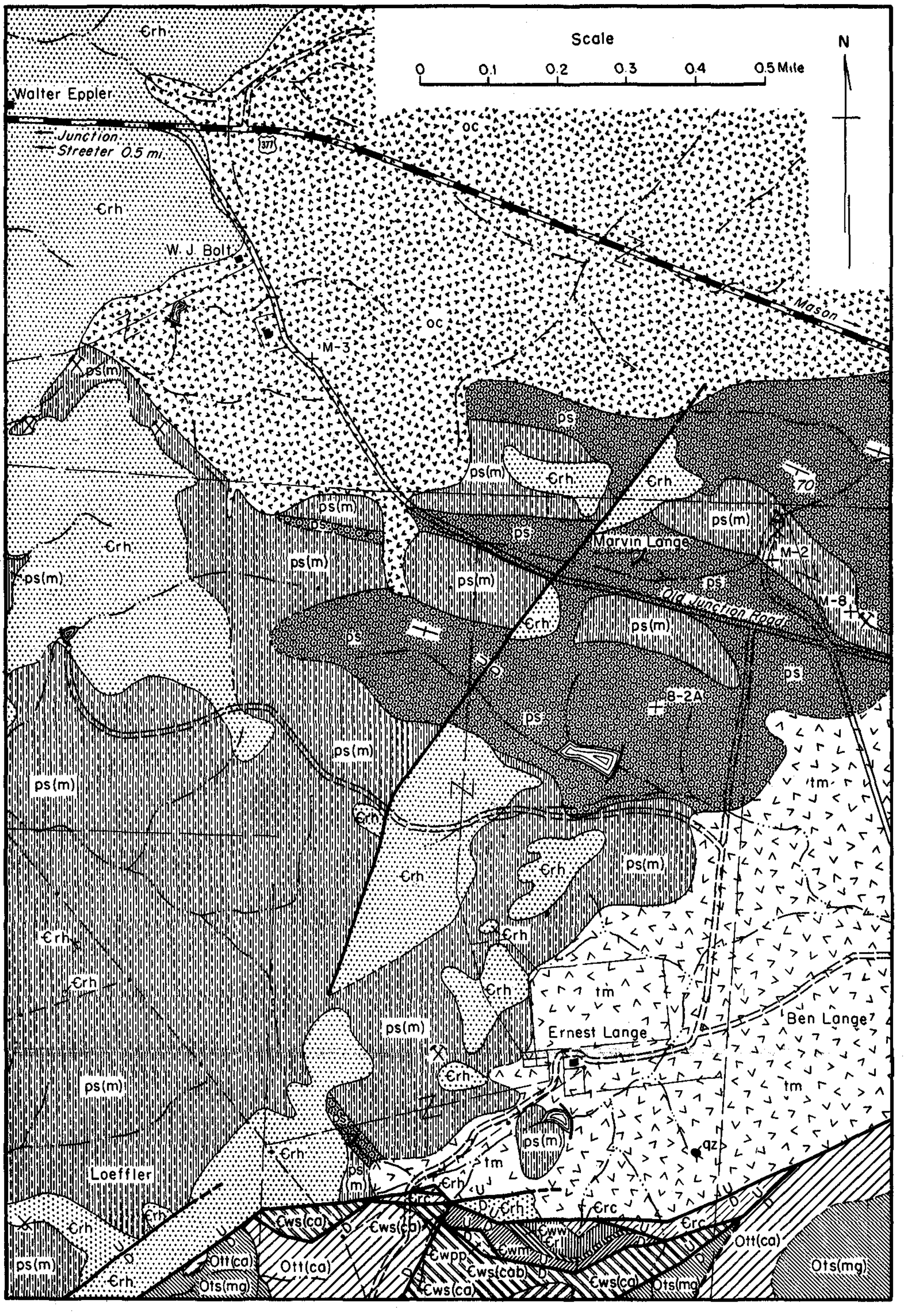

FIG. 12. Geologic map of an area east of Streeter, Mason County, Texas.

blocks of Hickory sandstone suggest that some collapse has taken place.

The mapping of this area was prompted as much by the solution and collapse history that might be revealed as by the reported presence of lead and zinc. The information gained is almost nil, but perhaps careful mapping of the remaining marble exposure to the west may give some additional information which can be applied to the interpretation of the very spectacular filled sink situated about 3 miles to the west along Bluff Creek about half a mile north of U. S. Highway 377. In this ancient sink, large blocks of Cap Mountain limestone have subsided to the level of the upper portion of the Hickory sandstone; surrounding the blocks is limestone containing fusulinids and other fossils which Dr. L. G. Henbest, of the U. S. Geological Survey, has determined to be definitely Pennsylvanian (Barnes, 1954, pp. 68–69).

Dr. Henbest notes also that the fossil-bearing material is composed of limesand and quartz sand in which fragments of dense limestone are scattered, and that microfossils occur in both the fragments and the sand. The fossils that are free are almost invariably abraded but without discoloration and so far as studied are not foreign to those in the fragments. The material looks like a conglomerate in many respects, but the features just described are not especially rare in Pennsylvanian limestones in the Rocky Mountain region that are not regarded as conglomerates.

The notations by Dr. Henbest suggest to the writer that perhaps the main collapse took place during the first emergence following the deposition of the Marble Falls limestone and before its complete lithification. Perhaps the limemuds were more indurated than the limesands and during the descent were not disaggregated as were the limesands.

The collapse was produced by the solution of Precambrian marble allowing at least 2,200 feet of the Paleozoic stratigraphic section to subside in order that Pennsylvanian sediments could reach a position about 1,800 feet beneath their normal level of deposition. It seems fantastic that a collapse only 100 feet in diameter at the level of observation could reach so far upward, as the Cap Mountain blocks have moved only a short distance downward. If, however, the solution cavern in the Precambrian marble was large enough to contain all the caving material, such a sink could develop. The cavern eventually must have filled in order to retain the Cap Mountain limestone blocks in their present position.

GENESIS OF CENTRAL TEXAS LEAD AND ZINC DEPOSITS

EARLIER THEORIES OF ORIGIN

Paige (1911, p. 77) stated: "Considering their proximity to the basal unconformity and the presence of the shales above, it is suggested that the deposits owe their origin to lead-bearing solutions more or less controlled by the relatively impervious pre-Cambrian floor below and the relatively impervious shale above, moving laterally in past time under artesian conditions, the lead in solution having been derived by leaching from many feet of higher strata perhaps many miles distant from the present deposit." Elsewhere he stated: "If the deposition be due to any inherent quality of the enclosing rock, one would suspect that the presence of glauconite might have played a part."

Baker (1933, pp. 164–165) stated: "So far as the writer has been able to determine, the galena of central Texas is syngenetic, having been deposited with the limestone and glauconite in the Upper Cambrian sea. The galena occurs as cubes that vary in size from microscopic up to one inch across. . . . In only two instances has the writer noted secondary or subsequently concentrated galena, one in a thin veinlet occupying a stylolite plane of solution and one in small solution cavities. With these exceptions, the galena occurs irregularly disseminated in the original dense, unaltered finely crystalline gray limestone, where it appears to be fully as syngenetic as the glauconite in the same limestone." And on page 170: "Because the Lipalian Interval of denudation preceding the Upper Cambrian incursion was of vast duration, residual or other surface deposits of lead compounds, derived from an original pre-Cambrian source, had ample chance to accumulate in appreciable quantities. These would go into solution or suspension in the Cambrian sea or be brought to it in either form, or else be carried in as detritals. Deposition of the galena would take place wherever conditions were favorable."

Tarr (1933) from the evidence cited by Baker pointed out that the two exceptions mentioned by Baker are certainly epigenetic, and that the faulting plus the geologic section involved "certainly makes feasible the suggestion of an epigenetic origin, which might very well be magmatic."

Howell and Lochman (1938, p. 2) in reference to galena associated with trilobites in the Llano uplift stated: "The galena has clearly undergone secondary concentration here at the Cambrian—Pre-Cambrian contact," but no evidence is cited by these authors.

SUMMARY OF OBSERVED DATA

Before a discussion of these or other modes of origin, the observed facts are summarized.

A. *Local field data*

(1) The ore minerals are in dolomite, dolomitic limestone, limestone, calcareous sandstone, and glauconitic sandstone.
(2) The ore minerals occur in four units of the Cambrian, namely, the Cap Mountain limestone and the Lion Mountain sandstone members of the Riley formation and the Welge sandstone and Morgan Creek limestone members of the Wilberns formation.
(3) The mineralization is in the immediate vicinity of exhumed granite hills, mostly on their southwestern and western sides.
(4) The beds dip quaquaversally about the granite hills.
(5) The ore minerals are galena, sphalerite, and cerussite.
(6) The galena is in aggregates, and crystal faces formed only where the galena grew freely in a cavity. Isolated cubes are rare.
(7) Glauconite is present in small amounts in the Cap Mountain and Morgan Creek limestone members and is essentially absent in the Welge sandstone member.
(8) The highly glauconitic Lion Mountain sandstone member is only slightly mineralized.
(9) Stylolites are abundant in the Cap Mountain limestone member and the Morgan Creek limestone member.
(10) The most highly mineralized area is in and adjacent to a collapse structure (Silver Creek prospect).
(11) The next most highly mineralized area is in a zone of disturbance—either a col-

lapse structure or a minor fault zone (Scott Klett prospect).

(12) The minor mineralization is in areas having little structural disturbance.

(13) Normal faults with more than 100 feet displacement are near all deposits.

B. *Petrographic data*

(14) The limestones were originally in large part fossil debris limesands containing ooids, glauconite, and some quartz and feldspar.

(15) The grains are cloudy and secondarily enlarged by the addition of clear calcite which also completely fills all voids.

(16) The galena and sphalerite are in contact with stylolites, fractures, and areas of second generation dolomite.

(17) No particle of galena or sphalerite was seen in undisturbed limestone, yet glauconite and detritals are common.

(18) The galena appears to have both replaced calcite and grown freely in cavities which were later filled by second generation dolomite and a minor amount of pyrite. First generation dolomite is not replaced by galena. A few quartz grains appear to be partly replaced by galena.

(19) Glauconite in contact with galena is rare and no glauconite grains enclosed by galena were seen in thin section.

(20) Much of the galena in the Silver Creek prospect is in veinlets.

(21) The periphery of many of the galena grains is incipiently altered, probably to anglesite.

C. *Regional data*

(22) The top portion of the Hickory sandstone is shaly; apparently it is less shaly toward the southeast part of the Llano uplift in the vicinity of the Scott Klett prospect.

(23) The Point Peak shale is stratigraphically above the position of the ore minerals and in the southern area contains very little shale.

(24) The Point Peak shale has not been analyzed for its metal content but is of a type normally very low in metals.

(25) The Llano region repeatedly alternated between emergence and submergence with important solution effects during each cycle from the Lower Ordovician to the lower Pennsylvanian.

(26) The erosion surface upon which Cretaceous rocks were deposited is estimated to have ranged from 100 feet in the Scott Klett area to 400 feet in the Silver Creek area, above the present site of the mineral deposits. This depth is within range of ground-water activity.

(27) Diabase which cannot be older than Pennsylvanian was intruded along the Marble Falls fault within 2.5 miles of the Slaughter Gap area.

(28) A basic dike southeast of Babyhead, Llano County, appears to cut llanite, which until now was thought to be the youngest igneous rock in the Llano region.

DISCUSSION OF THEORIES OF ORIGIN

The facts as outlined are insufficient to resolve positively the problem of the origin of these deposits. A magmatic origin is supported by evidence of post-Cambrian igneous activity in the Llano uplift. In view of the solution and collapse history of the Llano region, deposition from meteoric water cannot be eliminated. It is evident that water dissolved vast quantities of carbonate rock in the time interval from Lower Ordovician to lower Pennsylvanian and in so doing traversed the entire Paleozoic section and even portions of the Precambrian. Again during the cycle of erosion preceding the deposition of Cretaceous sediments the sites of these mineral deposits were near the surface and within reach of ground-water activity.

The role of glauconite as a precipitant for the galena—likewise for sphalerite hitherto unrecognized—is not supported by points 7, 8, and 19. The syngenetic origin suggested by Baker is not supported by points 6, 10, 16, 17, 18, and 20. The shale which Tarr thought might be of importance as a confining bed or impermeable barrier would seem to be of no importance in the southern area where very little shale exists, point 23.

The leaching-meteoric water theory.—Paige (1911) appears to have favored the hypothesis of leaching of lead from overlying sediments, lateral movement under artesian conditions, and deposition in areas brecciated by faulting. The brecciation which he observed is probably the collapse structure at the Silver Creek prospect. Shale is postulated as the main source for lead and zinc in such deposits as these, and if the Point Peak shale is considered to be the source, the grade of deposits in the Llano uplift is roughly correlative with the thickness of shale—the highest assay values and thickest shale being to the north. The Point Peak shale has not been analyzed for its metal content; however, it is of a type which appears to be extremely low in sulfides. If the deposits originated in this manner it is unlikely that lead and zinc could be present in quantities of commercial value.

A modification of Paige's leaching-meteoric water theory can be suggested, namely, solution of lead and zinc from the Precambrian rocks by meteoric water traversing the immediately overlying Hickory sandstone, and precipitation of lead and zinc minerals as the water moved upward along granite knobs. Post-Lower Ordovician erosion has removed the Ordovician rocks as well as some of the Cambrian rocks in several areas northwest of Streeter. Water entering the Cambrian may have traversed the sandstone to the Streeter area and still had ample power to dissolve the underlying Precambrian marble. This allowed a collapse of the overlying rocks and permitted the entry of more water into the Hickory sandstone. To reach the buried knobs around which the mineral deposits are situated, the water would have to traverse at least 70 miles of Hickory sandstone and in this distance, considering the probable slow rate of flow, time would have been available for solution of lead and zinc if present. With such an origin the deposits would have formed prior to the mid-Pennsylvanian faulting while water was free to move throughout the entire Hickory sandstone sheet.

Minor lead and zinc mineralization associated with fluorite is known in Precambrian rocks a few miles west of Burnet. These minerals are presumably of Precambrian age, but a later age is possible. If they are of Precambrian age it is possible that these and similarly mineralized rocks furnished all the lead and zinc that is present in the overlying Cambrian rocks.

Any lead and zinc dissolved by meteoric water passing through the Hickory sandstone came from the immediately underlying Precambrian rocks and not their residual products as suggested by Baker. Conditions were unfavorable at the start of Cambrian sedimentation in the Llano uplift for the accumulation of residual deposits except of very resistant material such as quartz. Furthermore, lead and zinc minerals are relatively unstable and are not found in thoroughly leached residuum such as that which accumulated on the Precambrian surface in central Texas.

Why the sediments in the vicinity of buried hills should be more permeable than elsewhere might be explained by the winnowing action of currents deflected by the buried hills. If a predominant current existed in the sea in which the shaly Hickory was deposited, the winnowing would tend to be in the same position on the various hills. This may explain the localization of the mineralization mostly on their southwestern and western sides. The carbonate rocks in subsiding about the buried hills should have developed a joint system, thus increasing their permeability. Increased permeability about the knobs would be as favorable to an origin from a magmatic source as to an origin from leaching and redeposition.

The magmatic theory.—If the deposits originated from a magmatic source they might be related to the diabasic rock found along the Marble Falls fault. The intrusion of diabase is not dated—it could be mid-Pennsylvanian in age, or later. Possibly it is related to the Balcones fault zone period of igneous activity. There is no evidence of igneous activity in the Llano uplift between the start of Cambrian deposition and the faulting of mid-Pennsylvanian age.

An objection to a period of mineralization during or following the faulting is the lack of mineralization along any of the faults. This, however, might be explained by high porosity in the lower portion of the Hickory sandstone. It is estimated that less than 1 percent of the base of the Cap Mountain limestone rests on Precambrian rocks, and the remainder rests on Hickory sandstone, the upper portion of which is shaly. Probably more than 90 percent of the solutions migrating upwards along a fault, no matter what the throw of the fault, would encounter porous Hickory sandstone first and perhaps be dissipated. No lead and zinc mineralization has been seen anywhere in the Hickory sandstone.

Any mineralized solution passing upward, which was not dissipated in the porous Hickory sandstone, would encounter Cap Mountain limestone in the downthrown block. If Cap Mountain limestone acted as a precipitant for lead and zinc minerals, the bulk of the mineral deposits should be in downthrown fault blocks. These have not been explored.

The faults in places cut buried hills which reach above the level of the Hickory sandstone. Solutions traveling upward along these portions of the faults would encounter Cap Mountain limestone first. All known mineralization is associated with buried hills, and at all prospects, near-by faults probably transect the hills where Cap Mountain limestone is in contact with granite.

CONCLUSIONS AND RECOMMENDATIONS

The lead-zinc deposits in the eastern part of the Llano uplift were probably deposited from upward moving magmatic solutions, perhaps related to the igneous activity during which diabase was intruded along the Marble Falls fault. If this be true the mineral deposits are mid-Pennsylvanian or later in age. An origin from meteoric water moving laterally through the Hickory sandstone dissolving lead and zinc from the subjacent Precambrian rocks followed by upward movement and precipitation around buried hills is not eliminated. However, as studies of this type of deposit continue about the world, more and more evidence is accumulating pointing to their origin from a magmatic source.

Lead and zinc deposits of the type in the Cambrian rocks of the Llano uplift are common in rocks composed of carbonate minerals or at least containing carbonate minerals. It is unlikely, therefore, that deposits will be found in the essentially carbonate-free Hickory sandstone. The lack of mineralization higher than the basal part of the Morgan Creek limestone suggests that either the volume of mineralizing solutions is small, or the progress of the solutions was so slow that all the lead and zinc was precipitated soon after limestone was encountered.

If the minerals were deposited from solutions derived from a magmatic source there is a distinct possibility that commercial lead-zinc ore deposits exist in the eastern portion of the Llano uplift. It is logical that the Cap Mountain limestone along the downthrown sides of faults should be more highly mineralized than on the upthrown sides. Before condemning the area a drilling program should be planned starting with the known areas of mineralization, progressing across the faults to investigate the Cap Mountain limestone in the downthrown blocks. The southern area appears to be the most likely area for finding mineral deposits.

In view of the localization of many deposits in the southeast Missouri area where the contact of the Lamotte sandstone and Bonneterre dolomite intersects buried hills, the intersection of the Cap Mountain limestone — Hickory sandstone contact with the buried hills in central Texas should be investigated by drilling.

Many buried hills which cannot be detected by surface geologic work must be present in the subsurface. Some of the shallower ones can possibly be detected with the aid of a gravity meter; the deeper ones can possibly be found with a seismograph.

REFERENCES

BAKER, C. L. (1933) Disseminated galena in the Upper Cambrian of the Central Mineral region, Texas: Econ. Geol., vol. 28, pp. 163–170.

——— (1935) Lead minerals and ores, *in* The geology of Texas, Vol. II, Structural and economic geology: Univ. Texas Bull. 3401, Jan. 1, 1934, pp. 503–504.

BARNES, V. E. (1945) Soapstone and serpentine in the Central Mineral region of Texas: Univ. Texas Pub. 4301, Jan. 1, 1943, pp. 55–91.

——— (1948) Ouachita facies in central Texas: Univ. Texas, Bur. Econ. Geol., Rept. Inv. 2, 12 pp.

——— (1952a) Geology of the Cain City quadrangle, Gillespie and Kendall counties, Texas: Univ. Texas, Bur. Econ. Geol., Geol. Quad. Map 13.

——— (1952b) Geology of the North Grape Creek quadrangle, Blanco and Gillespie counties, Texas: Univ. Texas, Bur. Econ. Geol., Geol. Quad. Map 10.

——— (1952c) High purity Marble Falls limestone, Burnet County, Texas: Univ. Texas, Bur. Econ. Geol., Rept. Inv. 17, 27 pp.

——— (1954) Phosphorite in eastern Llano uplift of central Texas: Univ. Texas, Bur. Econ. Geol., Rept. Inv. 23, 9 pp.

——— (MS.) Geology of the Sandy P.O. quadrangle, Blanco County, Texas: Univ. Texas, Bur. Econ. Geol., Geol. Quad. Map.

———, and BELL, W. C. (1954) Cambrian rocks of central Texas: San Angelo Geological Society Guidebook, Cambrian field trip—Llano area, March 19–20, pp. 35–69.

———, CLOUD, P. E., JR., and DUNCAN, HELEN (1953) Upper Ordovician of central Texas: Bull. Amer. Assoc. Petr. Geol., vol. 37, pp. 1030–1043.

———, ———, and WARREN, L. E. (1947) Devonian rocks of central Texas: Bull. Geol. Soc. Amer., vol. 58, pp. 125–140.

———, DAWSON, R. F., and PARKINSON, G. A. (1947) Building stones of central Texas: Univ. Texas Pub. 4246, Dec. 8, 1942, 198 pp.

———, SHOCK, D. A., and CUNNINCHAM, W. A. (1950) Utilization of Texas serpentine: Univ. Texas Pub. 5020, 52 pp.

BRIDGE, JOSIAH (1930) Geology of the Eminence and Cardareva quadrangles: Missouri Bur. Geol, and Mines, vol. 24, 2d ser., 228 pp.

———, BARNES, V. E., and CLOUD, P. E., JR. (1947) Stratigraphy of the Upper Cambrian, Llano uplift, Texas: Bull. Geol. Soc. Amer., vol. 58, pp. 109–124.

CLOUD, P. E., JR., and BARNES, V. E. (1948) The Ellenburger group of central Texas: Univ. Texas Pub. 4621, June 1, 1946, 473 pp.

COMSTOCK, T. B. (1890) A preliminary report on the geology of the Central Mineral region of Texas: Texas Geol. Surv., 1st Ann. Rept. 1889, pp. 237–391.

——— (1891) Report on the geology and mineral resources of the Central Mineral region of Texas: Texas Geol. Surv., 2d Ann. Rept. 1890, pp. 553–664.

DAKE, C. L., and BRIDGE, JOSIAH (1928) Initial dips peripheral to resurrected hills: Missouri Bur. Geol, and Mines, 55th Bien. Rept., Appendix 1.

———, ——— (1932) Buried and resurrected hills of central Ozarks: Bull. Amer. Assoc. Petr. Geol., vol. 16, pp. 629–652.

HILL, R. T. (1890) Pilot Knob: a marine Cretaceous volcano: Amer. Geol., vol. 6, pp. 286–292.

HOWELL, B. F., and LOCHMAN, CHRISTINE (1938) The occurrence of galena in Cambrian limestone of central and western United States: Bull. Wagner Free Inst. Sci., vol. 13, no. 1, 4 pp.

LONSDALE, J. T. (1927) Igneous rocks of the Balcones fault region of Texas: Univ. Texas Bull. 2744, 178 pp.

OHLE, E. L. (1951) The influence of permeability on ore distribution in limestone and dolomite: Econ. Geol., vol. 46, pp. 667–706 and 871–908.

——— (1952) Geology of the Hayden Creek lead mine, southeast Missouri: Mining Eng., vol. 4, no. 5, pp. 477–483.

PAIGE, SIDNEY (1911) Mineral resources of the Llano-Burnet region, Texas, with an account of the pre-Cambrian geology: U. S. Geol. Survey Bull. 450, 103 pp.

——— (1912) Description of the Llano and Burnet quadrangles: U. S. Geol. Survey Geol. Atlas, Llano-Burnet folio (No. 183), 16 pp.

PALMER, A. R. (1954) The faunas of the Riley formation in central Texas: Jour. Paleont., vol. 28, pp. 709–786. Reprinted as Univ. Texas, Bur. Econ. Geol., Rept. Inv. 24.

PHILLIPS, W. B. (1904) Lead ore in Burnet County, Texas: Eng. Min. Jour., vol. 77, p. 364.

PLUMMER, F. B. (1950) The Carboniferous rocks of the Llano region of central Texas: Univ. Texas Pub. 4329, Aug. 1, 1943, 170 pp.

SHUMARD, G. C. (1886) A partial report on the geology of western Texas . . . journal of geological observations . . . geology of Grayson County, 145 pp., Austin.

STENZEL, H. B. (1932) Pre-Cambrian of the Llano uplift, Texas: Bull. Geol. Soc. Amer., vol. 43, pp. 143–144.

———(1935) Pre-Cambrian structural conditions in the Llano region, *in* The geology of Texas, Vol. II, Structural and economic geology: Univ. Texas Bull. 3401, Jan. 1, 1934, pp. 74–79.

TARR, W. A. (1933) Disseminated galena, Upper Cambrian of Central Mineral region, Texas: Econ. Geol., vol. 28, p. 607.

WILSON, J. L. (1949) The trilobite fauna of the Elvinia zone in the basal Wilberns limestone of Texas: Jour. Paleont., vol. 23, pp. 25–44.

APPENDIX A. DESCRIPTION OF CAMBRIAN SECTIONS, LLANO UPLIFT

MORGAN CREEK COMPOSITE SECTION, BURNET COUNTY

The Morgan Creek composite section consists of several segments scattered through a distance of about 5 miles. The top of the section is 10 miles airline northwest of Burnet and 400 feet northwest of the North Fork of Morgan Creek at a point 1.6 miles airline northeast of the point where the creek is crossed by the county road. Four important segments of the section, including much of the Wilberns formation, are situated along the North Fork of Morgan Creek. Two other segments, one near Spider Mountain, are situated along the South Fork of Morgan Creek, now occupied in part by Lake Buchanan; much of the Riley formation is described in the segment of the section situated on Potato Hill (Potatotop) and to the south. The bottom of the section is about 5 miles airline northwest of Burnet.

The thicknesses of the various stratigraphic units in the section are as follows:

	Thickness (Feet)
Wilberns formation	.487+
San Saba member	228+
Dolomitic facies	169+
Calcitic facies	59
Point Peak shale member	114
Morgan Creek limestone member	130
Welge sandstone member	15
Riley formation	591
Lion Mountain sandstone member	47
Cap Mountain limestone member	204
Hickory sandstone member	340

The Morgan Creek composite section is described as follows:

Description	Thickness in feet Interval	Cumulative	Feet above base
Wilberns formation: 487 feet measured			
San Saba member: 228 feet measured			
Dolomite facies: 169 feet measured			
1. Dolomite and covered—dolomite fine grained, pinkish gray to yellowish gray, abundantly cherty. Chert mostly in curved, filmy layers following the structure of vertical stromatolites having a diameter of 1 to 3 inches and in part in vertical pipe-like structures exceeding a foot in length; mostly quartz druse in part interlayered with chalcedonic chert. Fossils from about 1,065 to 1,075 feet are *Scaevogyra, Hypseloconus,* trilobites.	55	55	1023 –1078
2. Dolomite—fine grained, mostly pale yellowish brown and pale red, bedding indistinct, elongate pits on weathered surfaces indicate bedding direction, interval except for top few feet is exposed in a cliff. Chert from 963 to 991 feet common as very quartzose, thin, bedding plane streaks; from 971 to 962 feet and to a lesser extent elsewhere, semiporcelaneous, somewhat quartzose, crowded by pellets.	70	125	953 –1023
3. Dolomite—fine grained approaching medium grained; pale red purple, pale yellowish green, bottom bed grayish orange; bedding indicated by poorly defined elongate weathering pits. Girvanella at 932 feet are replaced by granular quartz; some quartzose chert films.	27	152	926 – 953
4. Dolomite—fine grained, pale red purple containing specks of pale reddish brown, stromatolitic, mostly massive. Chert in part massive, poorly dolomoldic, contains some quartz druse; in part in lacy curving films as if conforming to stromatolites, yellowish gray, subchalcedonic to porcelaneous; some irregular branching tubes.	3	155	923 – 926
SHIFT downstream about 200 feet to the opposite bank of the North Fork of Morgan Creek using the base of the stromatolitic zone for making the shift; continue downstream.			
5a. Dolomite—fine grained; pale yellowish brown, flecked by purplish pale brown; beds in creek bottom indistinct, up hill-	14	169	909 – 923

Description	*Thickness in feet* *Interval*	*Cumulative*	*Feet above base*
side 6 to 12 inches thick; stromatolites at 914 feet are spheroidal. At point of ridge downstream basal bed contains unidentified upward-branching silicified fossils which elsewhere are calcite and associated with stromatolites.			
SHIFT southwest about 3,900 feet airline to a point 1,700 feet up Rock Hollow (northwest) from the mouth of Rock Hollow and continue down in section down bluff. The shift was made using recognizable beds in the calcitic facies of the San Saba member. Eleven feet of section is repeated after the shift.			
5b. Dolomite—fine grained, between yellowish gray and light olive gray; bottom bed 6 inches thick, next bed 3.5 feet thick, followed by a 1.5-foot zone of medium beds, and topped by a 5-foot bed. Chert oöids at 913.5 feet.	11	169	909 - 920
Calcitic facies: 59 feet thick (lower boundary arbitrarily placed)			
6. Limestone—fine and coarse grained, yellowish gray, beds as follows in ascending sequence: 5 inches—coarse-grained intraformational conglomerate; 25 inches—1/2 to 2-inch beds plane to wavy; 4 inches—coarse-grained intraformational conglomerate with coarse-grained limestone plastered on top surface displaying ripples 15 inches between crests and projecting 2 inches into next unit; 10 inches—1/2 to 2-inch beds plane to wavy; 16 inches—coarse-grained intraformational conglomerate topped by oolitic limestone.	5	174	904 - 909
7. Limestone, shale and covered—nodular, irregular beds of limestone separated by irregular wavy shale films; lower 2 feet not exposed.	4	178	900 - 904
8. Limestone—very fine grained, light olive gray, beds up to 6 inches thick.	2	180	898 - 900
9. Limestone and shale—limestone fine grained, light olive gray, beds 1/4 to 1/2 inch thick, some very small dark specks may be glauconite; shale very silty, light olive-brown films.	5	185	893 - 898
10. Limestone and minor shale—3-foot stromatolitic reef at top and 2-foot stromatolitic reef at bottom separated by mottled limestone. The lower reef is in part aphanitic, light olive gray, in part mottled pale yellowish-brown stromatolites which project into the overlying beds, and in part granular, yellowish-brown, inter-reef limestone containing silicified brachiopods, probably *Finkelnburgia.* The next foot is shale and thin-bedded, pale yellowish-brown limestone followed by 2 feet of fine-grained, mottled yellowish-gray and grayish-orange, dolomitic limestone which weathers in relief. The upper reef contains considerable inter-reef bedded, pyritiferous, ripple-marked, granular limestone, and some mottled thin-bedded limestone and shale beneath the stromatolites.	8	193	885 - 893
11. Limestone and shale—limestone fine grained, yellowish gray, thinly and irregularly bedded; shale is in films between limestone beds and increases in amount upward.	10	203	875 - 885
SHIFT across fault eastward and continue section down bluff.			
12. Limestone and shale—limestone fine grained, yellowish gray, irregularly bedded, nodular; shale is in films between limestone beds.	2	205	873 - 875
13. Limestone—medium grained, yellowish gray mottled pale orange, oolitic, one massive bed.	3	208	870 - 873
14. Limestone and shale—limestone fine grained, yellowish gray, irregularly bedded, nodular; shale is in films between limestone beds.	3	211	867 - 870
15. Limestone—medium to coarse grained, yellowish gray, oolitic, beds 4 and 8 inches thick, somewhat glauconitic. Fossils are abundant trilobite fragments and alate *Billingsella.*	1	212	866 - 867
16. Limestone and shale—poorly exposed, thin, irregularly bedded limestone, separated by shale films.	3	215	863 - 866

	Description	*Thickness in feet* *Inter-val*	*Cumu-lative*	*Feet above base*
17.	Limestone—very fine grained, light greenish-gray stromatolites separated by medium- to coarse-grained inter-reef limestone the top portion of which is oolitic. Trilobite fragments are abundant in the coarser grained limestone.	4	219	859 - 863
18.	Limestone—very fine grained, yellowish gray, distinctly bedded, beds 1 to 6 inches thick. Chert, light colored, subchalcedonic in top 2 inches in plates along bedding; chert also at 850.5, 851, and 858 feet. Abundant hexactinellid and lithistid(?) spicules in chert at 851 feet.	9	228	850 - 859
	Point Peak shale member: 114 feet thick (upper boundary arbitrarily placed)			
19.	Limestone and shale—the limestone is fine grained, light olive green to light olive gray, mostly as thin beds separated by dusky yellow-green to grayish-green shale; both contain very fine-grained glauconite. The beds in ascending order are as follows: 6 inches—intraformational conglomerate; 22 inches—1/4 to 2-inch limestone beds separated by shale films; 4 inches—intraformational conglomerate; 28 inches—1/8 to 1-inch limestone beds containing hexactinellid spicules and separated by thicker shale beds; 18 inches—stromatolites in granular limestone containing *Plectotrophia* and trilobites; 42 inches—1/4 to 2-inch limestone beds separated by shale films; 4 inches—intraformational conglomerate with yellowish-gray pebbles and greenish-gray matrix; 56 inches—1/4 to 2-inch limestone beds, separated by shale films.	15	243	835 - 850
	SHIFT 2,200 feet southwestward to point of ridge about 900 feet northwest of Morgan Creek and continue down in section along cattle trail. The correlation of the two sections is made using a combination of beds containing oolites and silicified brachiopods. Exposures in the line of section are very poor but better than elsewhere in the Morgan Creek area. A portion of the section is repeated including 23 feet of the calcitic facies of the San Saba member.			
20.	Limestone and covered—much of the covered portion is probably shale containing very thin limestone beds. The exposed portions are limestone described as follows: 806 to 808 feet—stromatolites surrounded by intraformational conglomerate; 812 to 813 feet—stromatolites containing silicified *Plectotrophia*, unidentified upward-branching calcite fossils, and interspersed intraformational conglomerate; 815 to 816 feet—intraformational conglomerate containing fragments of silicified brachiopods, perhaps *Plectotrophia;* 818 to 819 feet—intraformational conglomerate containing scattered stromatolites at top; 820 feet—stromatolites which may not be in place; 828 to 829 feet—intraformational conglomerate mostly edgewise, some dark yellowish-orange matrix; 829 to 831 feet—stromatolites and intraformational conglomerate containing silicified *Plectotrophia;* 849 to 850 feet—intraformational conglomerate containing silicified alate *Billingsella;* 854 to 860 feet—several 3- to 6-inch intraformational conglomerates; 861 feet—a block, perhaps float, contains hexactinellid spicules, and laterally stromatolites are present which contain unidentified upward-branching calcite fossils; 864 to 866 feet—oolitic, stylolitic, flecked by dark yellowish orange, contains lenses of trilobite fragments, and silicified fossils including some alate *Billingsella;* 870 to 873 feet—light olive gray, stylolitic, and oolitic.	67	272	806 873
21.	Covered and limestone—much of the covered portion is probably shale containing very thin, fine-grained, light olive-gray to yellowish-gray limestone beds. The bottom 8 inches is a flat pebble intraformational conglomerate; 777 to 782 feet—a few 1/2 to 2-inch limestone beds and two intraformational conglomerates, both edgewise and horizontal; 790 to 791 feet—stromatolites surrounded by intraformational conglomerate; 803 to 804 feet—intraformational conglomerate with dark yellowish-orange	30	302	776 - 806

Description	Thickness in feet Inter-val	Cumu-lative	Feet above base
matrix except where changed by brush fires to moderate reddish brown.			
22. Covered and siltstone—most of the interval is covered, but float indicates that the rock is fine-grained, thin-bedded, very calcareous siltstone; above 765 feet somewhat thinner bedded and poorly exposed; at 738 feet a 4-inch pale olive-gray, very fine-grained, stromatolitic limestone. In Rock Hollow about 15 feet of this interval is excellently exposed revealing 1/4 to 1-inch beds of light olive-gray siltstone which weathers yellowish gray, separated by thin films of shale. The bedding surfaces are smooth with little evidence of burrowing organisms.	40	342	736 - 776
SHIFT northeastward about 4,100 feet to a point about 100 feet east of the North Fork of Morgan Creek and continue down in section down hillside and bluff to creek bank and thence downstream. The shift was made on the highest red bed exposed at the top of the Morgan Creek limestone and is probably correct within 2 or 3 feet.			
Morgan Creek limestone member: 130 feet thick			
23. Limestone and covered—less than half exposed. Limestone medium to coarse grained; lowest bed white mottled by moderate orange-pink dolomite(?), upward beds are very pale orange, moderate orange pink, and at top grayish orange pink to light brown; beds mostly 6 to 8 inches thick, some thin nodular beds; trilobite fragments common, identifiable fossils very scarce.	16	358	720 - 736
24. Limestone—medium to fine grained, greenish gray, glauconitic, mostly thickly bedded, some thinly bedded shaly zones, mica present but not abundant, stylolites common. From 693 to 694 feet—one bed; 694 to 695 feet—thin bedded, shaly; 695 to 699 feet—3 beds, lower foot contains dark yellowish-orange dolomite patches; 699 to 700 feet—one bed indistinctly nodular at base; 700 to 701 feet—thin bedded, shaly; 701 to 706 feet—massive 2 beds in upper half; 706 to 707 feet—recessive, probably shaly; 707 to 708 feet—one bed, shale partings; 708 to 710 feet—one bed except for some thin beds at top; 710 to 712 feet—one bed; 712 to 715 feet—covered; 715 to 716 feet—recessive, thin-bedded limestone and shale; 716 to 720 feet—coarse grained, beds 6 to 18 inches thick, trilobitic.	27	385	693 - 720
25. Limestone and shale—limestone mostly fine grained and nodular, some beds and lenses are medium to coarse grained, greenish gray; shale pale olive, micaceous, silty, in films between limestone beds and around nodules. The more resistant beds 4 to 6 inches thick are at 676.5, 678, 680, 682, 686, 688, and 691 feet, and the one at 686 feet contains small, orange dolomite patches. Four inches of recessive very shaly limestone is 6 inches above the base, upward for a few feet progressively less shaly, then shale remains constant to 683 feet, followed by 2 feet of recessive, more shaly beds, then progressively less shaly beds to the top of the interval.	22	407	671 - 693
26. Limestone—coarse to fine grained, light olive gray to dark greenish gray, irregularly bedded to fairly evenly bedded, glauconitic, bottom few inches contains abundant *Eoorthis* and very fine-grained, yellowish-gray, irregular pebble- or mudball-like objects which may be algal in origin. The fine-grained limestone is silty and micaceous. Beds in ascending order are as follows: 29 inches—nodular; 12 inches—fairly regularly bedded, contains shale films; 15 inches—fine to medium grained, somewhat thicker bedded; 6 inches—coarse grained, *Billingsella* abundant; 24 inches—fine to medium grained, *Billingsella* present; 8 inches—coarse grained, contains *Billingsella;* 18 inches—fine grained, thin bedded; 12 inches—coarse grained, some fine grained, contains *Billingsella.*	10	417	661 - 671
27. Shale and limestone—limestone granular, greenish gray, glauconitic, silty, micaceous; beds thin, mostly less than half an inch thick, smooth surfaced; shale pale olive or a little darker, silty, micaceous, all the mica being crinkled.	1	418	660 - 661

Description	Thickness in feet Inter-val	Cumu-lative	Feet above base
Irvingella stands in relief on a limestone bed 2 inches above the base and is also present in a limestone lens 3 inches beneath the top of the interval.			
28. Limestone—coarse grained, two shades of yellowish brown to yellowish gray, slightly glauconitic, irregular-surfaced beds average about 4 inches in thickness, some shaly beds near top of interval, bottom foot is oolitic, the bed at 659 feet is a light-colored *Irvingella* coquinite, and some *Irvingella* range to the top of the interval. Beneath the *Irvingella* coquinite other trilobites are common including *Pterocephalia* at 657 feet.	5	423	655 - 660
29. Limestone—coarse grained, various shades of gray, interval as a whole recessive, bedding irregular and wavy, glauconitic. Beds in ascending order are as follows: 6 inches—recessive shale and limestone; 24 inches—nodular to irregularly lenticular, yellowish gray to light olive gray, containing variable amounts of glauconite; 9 inches—one bed, yellowish gray, resistant; 21 inches—wavy bedded, nodular, glauconitic, stylolitic, contains a few oolites, light olive gray streaked by grayish olive green, contains some trilobites; 18 inches—similar to above but contains more glauconite layers and larger trilobites; 7 inches—recessive, thinly nodular limestone and shale; 59 inches—mostly nodular, irregularly bedded, yellowish-gray to light olive-gray limestone beds separated by pale olive shale films, more abundant in lower part. Between 653 and 654 feet abundant irregular dolomite patches up to a foot or two in length weather to a pale yellowish orange and on fresh surfaces are slightly lighter in color.	12	435	643 - 655
30. Limestone—coarse grained; grayish orange pink, light brownish gray, yellowish gray; glauconitic; wavy bedded; from 640.5 to 641 feet, shaly; small corneous brachiopods abundant.	6	441	637 - 643
SHIFT along bedding downstream to better exposure.			
31. Limestone—mostly coarse grained, some medium and fine grained; various shades of red, green and gray; beds from mostly less than a foot in thickness to very thin and recessive, mostly wavy to irregular from stylolites and original depositional features; some zones very shaly; others very glauconitic; sand common; glauconite common to abundant; some silt. Beds in ascending order are as follows: 6 inches—recessive, covered; 12 inches—one bed, pale red; 16 inches—pale red to grayish olive green, nodular from cross-bedding, stylolitic, contains irregular thin glauconite and shale streaks; 6 inches—nodular, recessive, composed of pale olive to brownish-gray shale and glauconitic limestone; 14 inches—nodular, light brownish gray, where glauconitic greenish gray, an inch thick thinly bedded grayish-red shale, grayish olive-green glauconite zones show original depositional irregularities, irregular, dark yellowish orange, inch-sized mudball-like object, corneous brachiopods; 18 inches—light brownish gray to light olive gray, stylolitic; 69 inches—alternating beds of nodular, pale red to light brownish gray limestone averaging 1 to 2 inches in thickness, none over inches thick, and recessive zones of brownish-gray shale and grayish olive-green glauconite, mostly evenly bedded and only slightly disturbed by organisms, irregular, dark yellowish-orange inch-sized mudball-like objects are common at 630 feet, yellowish-gray mudball-like objects common in some beds above 630 feet, trilobites common in some beds; 5 inches—pale olive to grayish-olive, sparsely glauconitic, recessive shale; 22 inches—stylolitic limestone, the lower 6 inches of which is recessive, contains glauconite in thin wavy layers and cross-beds, mudball-like objects have yellowish-gray interiors and light brown to dark yellowish-orange exteriors; 9 inches—one bed, light brownish gray, contains dark yellowish-orange inch-size mudball-like objects; 11 inches—nodular limestone and yellowish-gray to light olive-gray shale containing irregularly distributed dark grayish-green glauconite; 4 inches—one bed, light brownish	16	457	621 - 637

Description	Thickness in feet: Interval	Cumulative	Feet above base
gray. From 633.5 to 643 feet resistant forming a rapids in the North Fork of Morgan Creek.			
32. Limestone—coarse grained fossil debris, grayish red to pale red, glauconite common, ranges from calcareous sandstone in basal bed to slightly sandy limestone at top of interval, beds mostly 1 to 3 feet thick, a few as little as 6 inches thick, bedding wavy, in part from stylolites, in part from original bedding features. Sand well rounded but poorly sorted. The rock of this interval boldly crops out within the Morgan Creek map area.	15	472	606 - 621
SHIFT almost due south 2,900 feet airline to top of the Welge sandstone north of road where road traverses bluff on north side of the South Fork of Morgan Creek at a point about 1,600 feet airline west-northwest of the ford across South Fork of Morgan Creek.			
Welge sandstone member: 15 feet thick			
33. Sandstone—medium grained, glauconitic, consisting of alternating resistant and recessive zones. From 591 to 593 feet—recessive greensand; 593 to 600 feet—recessive, very glauconitic; 600 to 605 feet—light olive gray, mostly recessive. Trilobites belonging to the *Elvinia* fauna are common in bottom bed.	15	487	591 - 606
The very glauconitic Welge sandstone in this section is not characteristic of the Welge occurring westward in the Llano uplift. In mapping, the Welge is recognized as more resistant to weathering than the underlying Lion Mountain sandstone, but on final analysis the two members in this section are separated on the basis of their fossils.			
Riley formation: 591 feet thick			
Lion Mountain sandstone member: 47 feet thick			
34. Greensand, shale, sandstone, limestone and covered—from 563 to 566 feet—dusky green greensand, composed about equally of glauconite and quartz, abundant corneous brachiopods and lenses of yellowish-gray, cross-bedded, trilobite coquinite; 566 to 569 feet—dusky green greensand; 569 to 574 feet—mostly covered; 574 to 575 feet—very coarse-grained glauconitic sandstone; 575 to 577 feet—greensand, some brown shale; 577 to 582 feet—greensand; 582 to 583 feet—greensand, some brown shale; 583 to 587 feet—covered; 587 to 590 feet—somewhat argillaceous greensand; 590 to 591 feet—coarse-grained, glauconitic sandstone.	28	515	563 - 591
SHIFT 85 feet eastward and continue section down to road level at 560 feet, then across road and to base of vertical bluff.			
35. Greensand and limestone—the dusky green greensand is about equally glauconite and quartz sand, abundant corneous brachiopods; limestone lenses yellowish gray, cross-bedded, trilobite coquinite.	3	518	560 - 563
36. Covered.	12	530	548 - 560
37. Limestone—coarse grained, glauconitic, trilobitic.	1	531	547 - 548
38. Covered	3	534	544 - 547
Cap Mountain limestone member: 204 feet thick			
39. Limestone—coarse grained, greenish to olive gray, very sandy, glauconitic, massive, cross-bedded on small scale, some yellowish-gray trilobite coquinite from 530 to 540 feet, forms vertical cliff in line of section.	14	548	530 - 544
40. Greensand and limestone—greensand, greenish black, about equally glauconite and quartz sand, friable, recessive, contains hematite concretions and lenticular cross-beds of trilobite coquinite.	2	550	528 - 530
SHIFT south-southwestward 3,400 feet to shallow drain on western side of Spider Mountain (Baldy Mountain) and continue down in section down drain.			
41. Limestone—in part fine grained, greenish gray to light olive gray, silty; in part coarse grained, mostly light olive gray speckled by yellowish gray, some yellowish gray, trilobitic, glauconitic. From 505 to 506 feet—fine grained; 506 to 515 feet	23	573	505 - 528

Description	*Thickness in feet* *Inter-val*	*Cumu-lative*	*Feet above base*
—coarse grained, some dark yellowish-brown dolomite patches from 507 to 508 feet; 515 to 521 feet—fine grained, mottled, mostly recessive; 521 to 522 feet—coarse grained; 522 to 528 feet—fine grained, recessive except for resistant 6-inch bed at top, in part poorly exposed.			
SHIFT along bedding about 450 feet west-southwest to edge of bluff and continue down in section along top of bluff. The base of bluff is in Lake Buchanan.			
42. Limestone—coarse to very coarse grained, mostly very glauconitic, glauconite coarse, some beds oolitic, some are cross-bedded trilobite coquinite, weathers into lenticular plates.	6	579	499 – 505
43. Limestone—medium grained to coarse grained, a few beds fine grained; mostly moderate yellowish brown mottled and speckled by dark yellowish orange, some light olive gray mottled by white, and some dark yellowish brown; somewhat sandy; glauconitic; oolitic; contains irregular-shaped objects; bedding surfaces irregular, bedding wavy; vertical joints widened by solution up to 3 feet. Fossils are trilobites and corneous brachiopods.	26	605	473 – 499
44. Limestone—mostly fine grained, finely glauconitic, mottled, distinctly bedded, silty; some medium to coarse grained, greenish gray to light olive gray, yellowish gray, and similar shades; in part sandy, coarsely glauconitic, trilobitic. The bottom foot contains pronged and spinelike objects and, except for color, resembles the "bronze" beds elsewhere in the eastern part of the Llano uplift. Trilobites and an occasional corneous brachiopod in coarse-grained beds.	28	633	445 – 473
45. Limestone—mostly fine grained, light olive gray of several shades to dusky yellow and pale olive, mottled; slightly glauconitic, very silty; thinly bedded, bedding wavy, in bluff forms massive smooth surface, on slopes poorly exposed. A few medium- to coarse-grained beds are trilobitic and glauconitic.	21	654	424 – 445
46. Limestone—similar to above; not exposed when lake is full.	5	659	419 – 424
SHIFT 3 miles in a direction east-southeast to a point on the west face of Potato Hill 14 feet beneath its summit and continue section down west face of hill. The upper 14 feet of beds on Potato Hill are not well exposed, the float is all fine-grained, very silty limestone. The shift was made using the lithologic sequence, placing special emphasis on the fossils from 418 to 419 feet.			
47. Limestone—medium to coarse grained, mostly greenish gray with top 2 inches moderate yellowish orange, very glauconitic, stylolitic with wavy bedding possibly being stylolites, very resistant to weathering forming lip of bluff. Some trilobites in lower part, upper part very trilobitic.	1	660	418 – 419
48. Limestone—fine grained, mostly yellowish gray weathering to pale to dark yellowish orange and very pale orange mottled and streaked by pale brown, silty, distinctly bedded, beds 2 to 6 inches thick with much closer spaced plane to wavy bedding.	42	702	376 – 418
49. Limestone—pale brown to reddish brown, sandy, somewhat oolitic, forms a smooth surface, some wavy bedding.	6	708	370 – 376
50. Limestone—medium grained, moderate yellowish brown to moderate brown mottled by some dark yellowish orange, very sandy beds 10 inches and less in thickness.	11	719	359 – 370
51. Sandstone—mostly coarse to very coarse grained, some medium grained; grayish brown, dark yellowish brown, and moderate yellowish brown to moderate brownish yellow; some mottles; very calcareous in part approaching a very sandy limestone; a few quarter-inch quartz grains, fifth-inch grains common. From 340 to 353 feet massive; 353 to 354.5 feet recessive, some argillaceous thin beds in lower part; 354.5 to 355 feet one coarse-grained bed; 355 to 356 feet argillaceous and recessive; 356 to 359 feet one bed, coarse grained to very coarse grained. Abundant corneous brachiopods.	19	738	340 – 359

Description	Thickness in feet: Inter-val	Cumu-lative	Feet above base
Hickory sandstone member: 340 feet thick			
52. Sandstone and minor shale—mostly medium-grained sandstone; grayish red, very dusky red, pale to moderate yellowish brown, dark yellowish orange, and intermediate colors; some shaly material in thinner bedded intervals. From 275 to 277 feet thin bedded; 277 to 278 feet grayish red mottled by dark yellowish orange, abundant corneous brachiopods; 278 to 280 feet thin bedded, some corneous brachiopods; 280 to 281 feet grayish red, corneous brachiopods common; 281 to 282 feet thin bedded, light brown; 282 to 283 feet one bed; 283 to 289 feet beds 6 inches and less in thickness, many corneous brachiopods; 289 to 296 feet medium grained to coarse grained, very dusky red, beds 1 to 2 feet thick; 296 to 299 feet thin bedded, poorly exposed; 299 to 340 feet medium grained to coarse grained, very dusky red to grayish red, some minor cross-bedding.	65	803	275 - 340
SHIFT northward along bedding about 100 feet and continue section down west face of Potato Hill.			
53. Sandstone and shale—sandstone mostly medium grained, moderate brown to moderate yellowish brown and pale to dark yellowish orange, alternating thickly and thinly bedded intervals. From 261 to 262 feet one bed; 262 to 264 feet thin-bedded sandstone and shale; 264 to 266.5 feet beds from 4 to 12 inches thick; 266.5 to 271.5 feet thin-bedded sandstone and shale; 271.5 to 275 feet thickly bedded, somewhat cross-bedded, very dusky red mottled by dark yellowish orange, beds up to 2 feet thick. Fossils are numerous corneous brachiopods.	14	817	261 - 275
54. Sandstone, shale and covered—very poorly exposed, mostly sandstone, medium grained, yellowish gray with dark yellowish mottles and streaks, glauconitic, an inch exposed every foot or so, rare intervals of sandy shale. A 3-inch bed at 245 feet, dark yellowish brown mottled moderate yellowish brown, is beneath a 6-inch coarse-grained sandstone bed. Two other 4-inch mottled beds somewhat lighter in color are at 253 and 256 feet. Corneous brachiopods common throughout.	30	847	231 - 261
55. Covered	5	852	226 - 231
56. Sandstone—medium grained, grayish red to moderate brown, lower beds a foot and more in thickness, upper ones mostly 4 inches and less in thickness. Corneous brachiopods common throughout.	7	859	219 - 226
57. Shale and sandstone—thin bedded, dusky yellow mottled by dark yellowish brown, glauconitic, poorly exposed in lower portion. Corneous brachiopod fragments common.	2	861	217 - 219
58. Covered.	2	863	215 - 217
59. Sandstone—medium grained, grayish red with some dark yellowish-orange specks.	1	864	214 - 215
60. Covered.	4	868	210 - 214
61. Sandstone—medium grained, grayish red with some dark yellowish-orange specks.	1	869	209 - 210
62. Covered.	7	876	202 - 209
63. Sandstone—coarse grained, bottom bed grayish red, 2.5 feet thick with irregularly silicified top surface; rest of interval beds 4 to 6 inches thick, moderate brown to moderate yellowish brown. A few corneous brachiopod fragments.	6	882	196 - 202
64. Sandstone and shale—from 190 to 193 feet sandstone medium to coarse grained, moderate brown, beds about 8 inches thick, some mudball-like objects along strike. From 193 to 196 feet sandstone and shale, glauconitic, recessive, thin bedded. Corneous brachiopods scattered throughout interval.	6	888	190 - 196
SHIFT along beds south-southeast 1,700 feet and continue down in section across flat for a distance of about 1,000 feet. The rock is poorly exposed upon this flat, and the thickness of section ob-			

Description	Thickness in feet Inter-val	Cumu-lative	Feet above base
tained could be seriously in error. An attempt was made, with indifferent success, to trace beds from near the southern edge of the flat into the vicinity of Potato Hill. The thickness used for this portion of the interval was obtained by measuring between the bed traced and the base of the Potato Hill portion of the section.			
65. Covered.	2	890	188 - 190
66. Sandstone—essentially in place, dark yellowish to moderate yellowish brown and dusky yellowish brown.	2	892	186 - 188
67. Covered.	8	900	178 - 186
68. Sandstone—essentially in place; bedding not apparent; dark yellowish brown to moderate yellowish brown, moderate reddish brown, and dark yellowish orange with black specks.	2	902	176 - 178
69. Covered.	5	907	171 - 176
70. Sandstone—blocks essentially in place, with markings suggestive of both ice crystal molds and burrows. In lower part moderate yellowish brown and grayish red; in middle part a large variety of colors and mottlings in dark yellowish orange, dark yellowish brown, dusky yellowish brown, dark grayish brown, grayish brown, dusky brown, light brown, moderate brown, and moderate yellowish brown; in upper part dark yellowish brown, moderate yellowish brown, dusky yellowish brown, pale reddish brown with some black specks. Fragments of corneous brachiopods.	27	934	144 - 171
71. Sandstone—medium grained; grayish orange to dark yellowish orange in part very pale orange mottled, some moderate yellowish brown; indistinctly cross-bedded, beds up to 18 inches thick; some indication of burrows; elongated pits on top surface may be ice crystal molds; grains rounded but rough, poorly sorted.	10	944	134 - 144
72. Sandstone—mostly slumped, some may be in place; a wide variety of colors and mottles such as moderate yellowish brown, grayish red, dark yellowish orange, very pale orange, grayish brown, dark yellowish brown, dusky red, moderate brown, dark yellowish orange and dark reddish brown; a dusky red oolite bed near top of interval furnished much float and contains numerous corneous brachiopods and some markings resembling trilobite fragments. Corneous brachipod fragments are common in float.	28	972	106 - 134
73. Sandstone—fine to coarse grained; mostly dark yellowish orange, light brown, moderate brown, grayish orange, and moderate yellowish brown; poorly sorted but better sorted than lower in section; grains mostly rounded, very rough, mostly quartz; cross-bedded; beds vary in hardness; mostly between 4 and 12 inches, probably thinner in covered intervals. From 70 to 72 feet poorly exposed; 72 to 74 feet one bed; 74 to 76 feet poorly exposed; 76 to 77 feet thin bedded; 77 to 79 feet one bed; 79 to 85 feet thin bedded, poorly exposed; from 85 to 86 feet one bed with *Arthrophycus* (?) on bottom surface and ice crystal molds on top surface; 86 to 92 feet beds 4 to 8 inches thick; 92 to 93 feet poorly exposed; 93 to 96 feet beds 4 to 8 inches thick; 96 to 102 feet poorly exposed; 102 to 106 feet beds 4 to 6 inches thick, some indication of burrows.	36	1008	70 - 106
74. Sandstone—fine to coarse grained; dark yellowish orange, light brown, moderate brown, grayish brown, pale reddish brown, moderate reddish brown, and yellowish brown in part mottled; massive; beds poorly defined, about 1.5 to 2 feet thick; some grains angular, others rounded, all rough; some argillaceous matrix.	25	1033	45 - 70
75. Covered.	20	1053	25 - 45
The next 5-foot interval is exposed upstream to the east and rests on Precambrian Valley Spring gneiss. Farther east a sharp ridge of Valley Spring gneiss stood even higher when the Hickory sandstone was deposited.			
76. Sandstone and conglomerate—angular quartz cobbles up to 6 inches in size are in the basal bed and the sandstone throughout contains pebbles, is very coarse grained, poorly sorted, dark yellowish orange, pale brown grayish orange, cross-bedded, beds	5	1058	20 - 25

Description	*Thickness in feet* *Inter-val*	*Cumu-lative*	*Feet above base*
mostly 6 to 12 inches thick. A foot bed of angular quartz conglomerate near middle contains pebbles mostly an inch to 3 inches in size in a matrix of coarse sand.			
77. Sandstone—fine to coarse grained, argillaceous, poorly sorted, pale reddish brown, grayish orange, and dark yellowish orange, mottled, cross-bedded, mostly quartz, microcline common, one bed contains quartz pebbles up to one-half inch in size, beds mostly 4 to 18 inches, some argillaceous ones thinner, 3-inch shale lens at 15 feet, vertical structure common in many beds may be caused by burrows or borings.	9	1067	11 – 20
78. Covered.	5	1072	6 – 11
79. Sandstone—poorly sorted, some grains up to one-quarter inch, mostly quartz, some microcline, all grains very rough, some partly rounded, ice crystals molds in upper surface.	1	1073	5 – 6
SHIFT downstream about 200 feet along bedding and continue down in section to base of sandstone outcrop.			
80. Sandstone—poorly sorted ranging from fine grained and argillaceous in some beds to very coarse grained in others; mostly pale red to grayish orange mottled by moderate orange pink with the argillaceous material more brightly colored; mostly quartz and microcline, quartz grains angular to partly rounded, all surfaces rough; beds mostly 6 to 18 inches thick, one near middle of interval with vertical structure suggestive of burrows or borings.	5	1078	0 – 5

The base of the section is at the lowest exposure of sandstone along the north bank of a drain. A 4- to 5-foot covered interval below the base of the section could conceal sandstone.

The base of the section is along one of the headwater branches of Clear Creek 3,200 feet south of the top of Potato Hill and about 6,200 feet east-northeast of the point where Clear Creek crosses the road to the Southwestern Graphite Company property.

The amount of insoluble residue from each 5-foot interval of the Morgan Cree composite section, after dilute hydrochloric acid treatment sufficient to remove th carbonate minerals is as follows:

Feet above base	*Percent residue*	*Feet above base*	*Percent residue*	*Feet above base*	*Percent residue*
1013–1018	2.3	870– 875	8.9	630– 635	19.1
1008–1013	0.6	865– 870	13.6	625– 630	11.5
1003–1008	0.7	860– 865	7.8	620– 625	15.9
998–1003	0.7	855– 860	20.0	615– 620	14.0
993– 998	4.6	850– 855	21.3	610– 615	21.2
988– 993	0.4	845– 850	33.9	605– 610	40.8
983– 988	20.9	840– 845	23.4	600– 605	56.2
978– 983	3.2	835– 840	42.8	595– 600	85.6
973– 978	5.2	730– 735	4.7	588– 595	80.2
968– 973	6.1	725– 730	4.7	583– 588	92.2
963– 968	10.1	720– 725	2.4	578– 583	97.3
958– 963	7.1	715– 720	5.5	573– 578	80.2
953– 958	7.5	710– 715	3.1	568– 573	41.9
948– 953	6.9	705– 710	2.6	563– 568	56.2
943– 948	20.3	700– 705	21.4	558– 563	66.6
938– 943	10.5	695– 700	12.2	543– 548	20.4
933– 938	8.9	690– 695	19.1	538– 543	4.2
928– 933	11.5	685– 690	24.7	533– 538	8.5
923– 928	7.7	680– 685	16.0	528– 533	47.0
918– 923	3.1	675– 680	13.1	525– 528	34.0
910– 918	3.9	670– 675	33.4	520– 525	43.6
905– 910	7.5	665– 670	17.2	515– 520	53.2
900– 905	10.1	660– 665	27.1	510– 515	10.4
895– 900	11.4	655– 660	14.9	505– 510	22.2
890– 895	15.3	650– 655	13.1	500– 505	13.4
885– 890	8.5	645– 650	6.2	495– 500	11.8
880– 885	10.5	640– 645	6.2	490– 495	22.8
875– 880	13.4	635– 640	4.5	485– 490	18.8

Feet above base	*Percent residue*	*Feet above base*	*Percent residue*	*Feet above base*	*Percent residue*
480– 485	12.2	325– 330	90.2	160– 165	92.1
475– 480	11.7	320– 325	86.5	155– 160	95.5
470– 475	24.9	315– 320	84.7	150– 155	96.8
465– 470	54.1	310– 315	94.4	145– 150	96.6
460– 465	33.5	305– 310	84.5	140– 145	96.7
455– 460	54.6	300– 305	79.0	135– 140	97.0
450– 455	27.4	295– 300	85.6	130– 135	99.1
445– 450	9.8	290– 295	86.0	125– 130	94.5
440– 445	65.9	285– 290	94.4	120– 125	96.1
435– 440	68.6	280– 285	89.0	115– 120	95.1
430– 435	35.4	275– 280	87.2	110– 115	91.7
425– 430	47.1	270– 275	96.6	105– 110	100.0
415– 419	27.1	265– 270	98.8	100– 105	100.0
410– 415	54.7	260– 265	93.1	95– 100	98.6
405– 410	58.7	255– 260	75.9	90– 95	97.7
400– 405	57.1	250– 255	78.5	85– 90	99.8
395– 400	71.0	245– 250	72.7	80– 85	97.8
390– 395	69.7	240– 245	68.2	75– 80	100.0
385– 390	69.2	235– 240	70.3	70– 75	99.6
380– 385	52.5	230– 235	63.1	65– 70	99.0
375– 380	68.7	225– 230	83.4	60– 65	98.9
370– 375	18.6	220– 225	94.8	55– 60	100.0
365– 370	35.2	215– 220	96.3	50– 55	100.0
360– 365	70.0	200– 205	95.6	45– 50	100.0
355– 360	82.8	195– 200	95.4	20– 25	98.1
350– 355	83.0	190– 195	95.6	15– 20	97.3
345– 350	80.7	185– 190	95.3	10– 15	99.7
340– 345	73.4	175– 180	97.8	5– 10	100.0
335– 340	90.2	170– 175	96.6	0– 5	98.2
330– 335	95.7	165– 170	96.4		

KLETT-WALKER SECTION, BLANCO COUNTY

The top of the Klett-Walker section is about 30 feet south of a wire gap on the Walker ranch and about 650 feet in a direction N. 60° W. from the ranch house. The section is marked in 5-foot intervals below 405 feet by yellow paint spots. An additional 8 feet of section, which is rather poorly exposed, is present to the edge of the flat. The rest of the dolomitic facies of the San Saba member crops out on the flat but is poorly exposed.

The thicknesses of the various stratigraphic units in the section are as follows:

	Thickness (Feet)
Wilberns formation	284+
San Saba member	121+
Dolomitic facies	121+
Point Peak shale member	25
Morgan Creek limestone member	126
Welge sandstone member	12
Riley formation	129
Lion Mountain sandstone member	31
Cap Mountain limestone member	98

The Klett-Walker section is described as follows:

Description	*Thickness in feet Inter-val*	*Cumu-lative*	*Feet above base*
Wilberns formation: 284 feet measured			
San Saba member: 121 feet measured			
Dolomitic facies: 121 feet measured			
1. Dolomite—coarse grained; light yellowish gray; massive except lower 7 feet which is faintly bedded; weathers into rounded, pitted boulders.	34	34	379 – 413
2. Dolomite—fine grained, yellowish gray, poorly exposed in line of section, better exposed in creek bank to south.	9	43	370 – 379
3. Dolomite—fine grained, yellowish gray, beds 6 to 12 inches thick, weathered and only partly exposed.	23	66	347 – 370
4. Dolomite—fine grained, yellowish gray, oolitic, weathered and poorly exposed.	8	74	339 – 347
5. Dolomite—fine grained, yellowish gray, beds about 1 foot thick.	9	83	330 – 339

Description	Thickness in feet Inter-val	Cumu-lative	Feet above base
6. Dolomite—fine grained, yellowish gray, oolitic, beds about 1 foot thick.	4	87	326 – 330
7. Dolomite—fine grained, yellowish gray, below 315 feet beds 8 inches and less, in rest of interval a foot or more thick. A steeply dipping stylolite at 320 feet has light brown limonitic clay along it and trends N. 50° E.	34	121	292 – 326
Point Peak shale member: 25 feet thick			
8. Dolomite—fine grained, pale yellowish brown, beds mostly ¼ to 1 inch, except for composition similar to beds below. A 4-inch cherty oolite bed at 291 feet.	2	123	290 – 292
9. Limestone—very fine grained; mostly greenish gray, in upper part some yellowish gray; micro-oolitic; contains very fine glauconite, biotite and silt; beds average ⅜ inch, thickest 1.5 inches; minutely cross-bedded; some thin beds of intraformational conglomerate.	10	133	280 – 290
10. Limestone—mostly aphanitic, between greenish gray and light olive gray, yellowish-gray reef masses 6 to 12 inches in diameter separated by thin, medium-grained septae containing small, moderate yellowish-brown, irregular, dolomitized objects. Some porous chert in inter-reef limestone.	2	135	278 – 280
11. Limestone and covered—in part coarse grained, greenish gray, glauconitic, 2-inch beds; in part fine grained, greenish gray, silty, very thinly bedded.	6	141	272 – 278
12. Limestone—mostly aphanitic, between greenish gray and light olive-gray reef masses 6 to 12 inches in diameter separated by thin yellowish-gray, medium-grained septae containing small, moderate yellowish-brown dolomitized objects.	2	143	270 – 272
13. Limestone and covered—coarse-grained, 3-inch trilobitic beds separated by covered intervals.	3	146	267 – 270
Morgan Creek limestone: 126 feet thick			
SHIFT downstream along bedding about 75 feet and continue down in section.			
14. Limestone—several types, mostly in beds 6 to 18 inches thick, mica common. From 239 to 240.5 feet—fine to medium grained, moderate yellowish orange, very dolomitic; oöids, irregular objects and streaks of dolomite are pale yellowish orange; 240.5 to 242 feet—microgranular reef masses in medium-grained, yellowish-gray limestone; 242 to 247 feet—medium to coarse grained, between light olive gray and greenish gray, glauconitic, slightly dolomitic toward top, contains trilobites and some pelmatozoan debris; 247 to 248 feet—aphanitic, pinkish-gray reef masses in a coarse-grained, light brownish-gray, trilobitic bed; 248 to 251.5 feet—alternating coarse grained, trilobitic with fine-grained, silty, nodular, thin-bedded, glauconitic; 251.5 to 254.5 feet—yellowish gray, with dark yellowish-orange and moderate yellowish-brown dolomite replacing variously shaped objects; 254.5 to 256 feet—mostly aphanitic, pinkish gray reef masses cut by horizontal stylolites with half-inch amplitude; some coarse grained, light brownish gray, trilobitic; 256 to 257 feet—similar to that from 251.5 to 254.5 feet; 257 to 267 feet—medium grained, yellowish gray, slightly dolomitic, glauconite in middle, films of silicification in lower part, silicified *Billingsella* in upper part.	28	174	239 – 267
15. Covered.	3	177	236 – 239
SHIFT downstream along bedding about 150 feet and continue down in section.			
16. Limestone—several types, beds mostly 6 to 18 inches thick, some thinner, mica common. From 210 to 211.5 feet—medium grained, yellowish gray; 211.5 to 212.5 feet—very fine grained, light olive gray; 212.5 to 213.5 feet—medium grained, light olive gray; 213.5 to 214 feet—fine grained, light olive gray; 214 to 214.5 feet—coarse grained, very pale orange, brachiopod coquinite; 214.5 to 215 feet—fine grained, light olive gray; 215 to 215.5 feet—coarse grained, many brachiopods; 215.5 to 216 feet—medium grained, greenish gray; 216 to 218 feet—medium grained, yellowish gray with mottles and elongated patches a	26	203	210 – 236

Description	*Thickness in feet* *Inter-val*	*Cumu-lative*	*Feet above base*
foot or more in length of dark yellowish-orange dolomite; 218 to 219 feet—very fine grained, mottled as above; 219 to 223 feet—medium grained, yellowish gray to light olive gray, slightly glauconitic; 223 to 226.5 feet—medium grained, pale yellowish brown with dark yellowish-orange mottles and patches of dolomite; 226.5 to 229 feet—mostly coarse grained, light gray to medium light gray, slightly glauconitic, fossiliferous, beds 4 to 8 inches thick, some beds fine grained, nodular, silty; 229 to 230 feet—fine grained, nodular, silty, grayish green, recessive; 230 to 233 feet—coarse grained, very trilobitic, slightly dolomitic, massive, yellowish gray; 233 to 235 feet—coarse grained, yellowish gray, slightly glauconitic, trilobitic, beds mostly 6 inches or less in thickness; 235 to 236 feet—coarse grained, yellowish gray, slightly dolomitic.			
SHIFT along bedding about 150 feet from valley floor and continue down in section.			
17. Limestone—several types as follows: from 199 to 199.5 feet—fine grained, greenish gray, glauconitic, fairly evenly bedded; 199.5 to 201.5 feet—medium to coarse grained, yellowish gray, glauconitic, a *Billingsella* coquinite; from 201.5 to 203.5 feet—medium grained, yellowish gray; 199.5 to 203.5 feet massive, bedding faint; 203.5 to 204 feet—fine grained, greenish gray, silty, glauconitic; 204 to 205 feet—coarse grained, yellowish gray mottled by pale brown; 205 to 208 feet—fine grained, massive, yellowish gray weathering to dark yellowish orange in bottom foot, to medium light gray in upper part; 208 to 210 feet—fine grained, yellowish gray to light olive gray, beds mostly 1 to 6 inches, contains fine glauconite.	11	214	199 - 210
SHIFT along bedding about 150 feet from valley floor and continue down in section.			
18. Limestone—several types as follows: from 185 to 187 feet—fine grained, greenish gray, silty, glauconitic, burrowed; 187 to 189 feet—medium grained, yellowish gray mottled by moderate yellowish brown and dark yellowish orange, mottles may be dolomite, essentially one bed; 189 to 190 feet—fine grained, greenish gray, silty, glauconitic, burrowed; 190 to 191 feet—fine grained, mostly moderate yellowish brown, several beds; 191 to 193 feet—medium grained, yellowish gray, oolitic; 193 to 194 feet—medium to coarse grained, light olive gray, glauconitic, contains many trilobites; 194 to 197 feet—yellowish gray, central part much mottled by moderate yellowish brown; 197 to 199 feet—fine grained, greenish gray, silty, glauconitic, burrowed.	14	228	185 - 199
SHIFT downstream about 400 feet using *Billingsella* bed at 200 feet for making the shift. Continue down hillside and down in section.			
19. Limestone—coarse to fine grained beds as follows: from 176 to 177 feet—fine grained, silty, burrowed, glauconitic; 177 to 177.5 feet—coarse grained, some dark yellowish orange spots, glauconitic; 177.5 to 178 feet—medium grained, pale yellowish brown; 178 to 179 feet—medium grained, pale yellowish brown with greenish cast from glauconite; 179 to 182.5 feet—fine grained, silty, glauconitic, burrowed except for bed from 179.5 to 180.5 feet; 182.5 to 185 feet—medium grained, pale yellowish brown, oolitic, fine grained, silty bed near middle.	9	237	176 - 185
20. Covered—recessive, the top part can be seen beneath a ledge, is weathered and mostly glauconite and calcite.	2	239	174 - 176
SHIFT along bedding about 400 feet from valley floor and continue down in section.			
21. Limestone—coarse grained, light brownish gray with numerous dark yellowish-orange objects, glauconitic, two beds.	1	240	173 - 174
22. Limestone—fine grained, medium gray to greenish gray, silty.	2	242	171 - 173
23. Limestone—coarse grained, between light olive gray and greenish gray, glauconitic, oolites and other objects are mostly dolomitized, dark yellowish-orange patches up to several inches in length are at 165 feet, trilobites common.	8	250	163 - 171
24. Limestone—fine grained, medium gray to greenish gray, silty.	1	251	162 - 163

Description	*Thickness in feet*		*Feet above base*
	Interval	*Cumulative*	
25. Limestone—coarse grained, pale yellowish brown, oolitic, one bed, slightly glauconitic.	1	252	161 - 162
26. Limestone—fine grained, silty, medium gray to greenish gray, poorly exposed, appears to be burrowed, some thin, coarse-grained beds.	2	254	159 - 161
27. Limestone—coarse grained fossil debris; mostly pale yellowish brown and grayish orange pink and some pale red and light olive gray; glauconitic; stylolitic; bottom 3 or 4 feet may be calcareous sandstone, sand less abundant upward, almost absent above 155 feet; beds mostly wavy, 6 to 12 inches thick ranging up to 3 feet in lower part; from 151 to 152 and 154 to 155 feet oolitic, oolites in part dolomitized; dark yellowish-orange mud-balls(?) and other irregular objects, perhaps fossil fragments, are in a 6-inch bed at 157 feet.	18	272	141 - 159
Welge sandstone member: 12 feet thick			
28. Sandstone—fine to coarse grained, dark yellowish brown to pale yellowish brown, cross-bedded, well cemented, some quartzite, grains reconstituted, some portions glauconitic and shaly. The bottom 6-inch bed is glauconitic, coarse-grained quartzite which thickens to 1 foot northward in next segment and contains a few pebbles up to one-half inch in size; the next 10 inches is sandy, glauconitic shale followed by 6 inches coarse-grained, glauconitic sandstone; 12 inches fine-gained, cross-bedded sandstone slightly glauconitic toward top; 4 inches recessive, glauconitic sandstone; 28 inches cross-bedded, fine- to medium-grained sandstone with cross-beds weathering in relief; 12 inches of recessive glauconitic sandstone and shale; 4-foot bed of cross-bedded, fine-grained sandstone; and at top a 15-inch bed of cross-bedded, fine-grained sandstone.	12	284	129 - 141
SHIFT downstream along Pedernales River, using the base of the Welge sandstone for making the shift, about 1,750 feet to a point about 330 feet north of the fence between the Klett and Walker ranches.			
Riley formation: 129 feet thick			
Lion Mountain sandstone member: 31 feet thick			
29. Shale—moderate olive brown, weathering pale brown to moderate brown, glauconitic, much weathered especially in upper part.	2	286	127 - 129
30. Greensand—medium grained, grayish olive green, composed of glauconite, quartz sand, a minor amount of shaly material and a few thin cross-beds of trilobite coquinite, mostly friable except for a few 2-inch, indurated, less glauconitic beds.	10	296	117 - 127
31. Greensand and limestone—greensand grayish green composed of glauconite, quartz sand, some shaly material; limestone in part poorly exposed, coarse grained, greenish gray, sandy, glauconitic, very trilobitic cross-beds; from 115 to 117 feet moderate yellowish-brown to dark yellowish-brown 6-inch beds, very sandy, boldly outcropping. Corneous brachiopods are common including acrotretids.	7	303	110 - 117
SHIFT about 350 feet southwestward along the bedding and continue down in section along drain, thence along edge of flood plain to granite outcrop.			
32. Limestone and greensand—limestone coarse grained; light olive gray to greenish gray and dark greenish gray depending on the glauconite content; somewhat sandy; mostly cross-bedded; lower 5 feet weathers to medium gray, irregular, thin slabs; top 3 feet weathers to moderate yellowish brown, beds mostly 6 to 12 inches thick; some white beds are trilobite coquinite; greensand poorly exposed in line of section especially from 105 to 107 feet, well exposed upstream; light olive gray, shaly portions burrowed, composed of glauconite, quartz sand and calcite. Fossils are abundant trilobites throughout the limestone and some corneous brachiopods including acrotretids.	10	313	100 - 110

Description	Thickness in feet Interval	Cumulative	Feet above base
33. Sandstone—very fine grained, light olive gray weathering to dark yellowish brown, glauconitic, one bed.	2	315	98 – 100
Cap Mountain limestone member: 98 feet thick			
34. Limestone—coarse grained, some medium grained, yellowish gray to greenish gray, weathers mostly to medium gray with patches of moderate yellowish brown; glauconitic; beds wavy, mostly 4 to 8 inches thick. Trilobites common throughout; from 92 to 95 feet corneous brachiopods form a coquinite.	17	332	81 – 98
35. Limestone—fine to medium grained, yellowish gray to greenish gray weathering medium gray to mostly moderate yellowish brown, silty; bottom few inches coarse grained, glauconitic, trilobitic.	4	336	77 – 81
36. Siltstone—fine grained, dark yellowish brown on both fresh and weathered surfaces, dolomitic, glauconitic, top 2 feet one bed, lower foot thin bedded.	3	339	74 – 77
37. Limestone—from 70 to 71 feet coarse grained, yellowish gray to greenish gray, very glauconitic, thin bedded, abundantly trilobitic; top 3 feet fine grained, medium gray with a network of moderate yellowish brown dolomite, sparsely glauconitic, beds 6 to 12 inches thick.	4	343	70 – 74
38. Dolomite and limestone—dolomite fine to medium grained, pale yellowish brown and light olive gray weathering to moderate yellowish brown and medium gray, glauconite sparse to absent except in some thin beds. From 53 to 55 feet—alternating thin beds of dolomite and limestone; 55 to 56 feet—moderate yellowish-brown limestone, one bed; 56 to 57 feet—alternating beds of dolomite and limestone; 57 to 60 feet—moderate yellowish-brown limestone, two beds, upper one 2 feet thick; 60 to 70 feet—very massive dolomitic limestone, beds up to 4 or 5 feet thick, dolomite weathers in relief as bedding plane streaks and as a network, oolitic, oöids in lower part dolomitic, in upper part calcitic, in weathered exposures beds about 1 foot thick. Trilobites common.	17	360	53 – 70
39. Dolomite—fine grained, light gray to yellowish gray weathering light to moderate brown, beds mostly 3 to 4 feet thick; splotches of galena in lower 6 inches and at 50 feet, and away from line of section in pits from 45 to 46 feet. From about 35 to 40 feet the section crosses a solution crevasse, probably formed during the present cycle of erosion, filled by dark yellowish-orange, limonitic material containing quartz derived from the weathering of granite.	18	378	35 – 53
SHIFT from bottom of pit northward a few feet up dip slope.			
40. Dolomite—fine grained, greenish gray to yellowish gray weathering light to moderate brown, slightly glauconitic, beds 1 to 3 feet thick, pyrite specks at 28 feet.	10	388	25 – 35
41. Dolomite—fine grained, very massive, greenish gray to yellowish gray depending upon glauconite content, ranging toward dark yellowish orange, mottled light and moderate brown in workings, less mottled on more highly weathered surfaces; galena common from 10 to 13 feet, an occasional speck up to 20 feet.	15	403	10 – 25
42. Dolomite—fine grained, yellowish gray, mottled moderate brown on weathered surfaces; glauconite very scarce; no galena or pyrite seen; elongate pits parallel to bedding on weathered surfaces.	5	408	5 – 10
43. Dolomite—fine grained, greenish gray weathering to moderate yellowish brown; glauconitic; one massive bed; contains scattered grains of galena and an occasional speck of pyrite.	5	413	0 – 5

The bottom of the section is at the bottom of a pit on the east bank of Pedernales River and may be along a fault having not more than 20 to 30 feet displacement, with Cap Mountain limestone against a coarse-grained highly silicic granite, described by Barnes, Dawson, and Parkinson (1947, pp. 51–52).

The amount of insoluble residue from each 5-foot interval of the Klett-Walker section, after dilute hydrochloric acid treatment sufficient to remove the carbonate minerals, is as follows:

Feet above base	*Percent residue*	*Feet above base*	*Percent residue*	*Feet above base*	*Percent residue*
400–405	1.1	265–270	10.4	129–135	74.3
395–400	1.2	260–265	4.1	125–129	85.1
390–395	1.4	255–260	4.5	120–125	79.6
385–390	5.5	250–255	3.9	115–120	74.1
380–385	5.1	245–250	4.8	110–115	31.8
375–380	6.8	240–245	5.9	105–110	9.0
370–375	4.0	235–240	8.3	100–105	6.4
365–370	3.6	230–235	5.6	95–100	15.9
360–365	5.1	225–230	2,8	90– 95	5.6
355–360	2.7	220–225	4.5	85– 90	15.0
350–355	4.8	215–220	4.1	80– 85	9.5
345–350	2.6	210–215	8.9	75– 80	55.8
340–345	3.3	205–210	2.1	70– 75	26.4
335–340	2.4	200–205	6.1	65– 70	4.4
330–335	3.1	195–200	18.6	60– 65	4.9
325–330	3.8	190–195	6.7	55– 60	3.7
320–325	3.1	185–190	14.4	50– 55	4.3
315–320	2.6	180–185	13.1	45– 50	1.8
310–315	2.8	175–180	25.9	40– 45	7.1
305–310	2.4	170–175	29.0	35– 40	3.1
300–305	2.5	165–170	6.4	30– 35	4.1
292–300	1.6	160–165	18.1	25–30	4.6
285–290	22.0	155–160	9.0	20– 25	4.4
280–285	38.4	150–155	9.3	15– 20	6.0
275–280	17.4	145–150	19.3	10– 15	10.8
270–275	16.8	140–145	34.2	5– 10	1.8
		135–140	91.8	0– 5	6.9

APPENDIX B. LOGS OF EAGLE-PICHER COMPANY CHURN DRILL HOLES, BURNET COUNTY, TEXAS

Holes Drilled on Pavitte Lease (Silver Creek Prospect)

Drill owner: T. C. Curry
Drill operators: Don Peterson and Elmer Edwards

Hole Drilled May 11 to 13, 1925

Depths (Feet) From	*To*	*Description*
0	8	Red, calcareous limestone and sandstone.
8	37	Round quartz sand grains, lime cemented.
37	43	Round quartz sand grains, green brown glauconite, and little limestone.
43	55	Muddy green glauconite sandstone, little limestone.
55	65	Rounded clear quartz sand grains with glauconite limestone.
65	80	Gray limestone with green glauconite, some sandstone.
80	105	Gray limestone with sandy glauconite layers; *from 80 to 85 feet lead in one rock and traces of lead; and from 90 to 95 feet very thin lead traces.*
105	135	Gray limestone, pink calcite, some glauconite sandstone.
135	150	Gray limestone, pink calcite, some glauconite sandstone, and a few grains of glauconite.
150	163	Brown sandy limestone.
163	168	Gray limestone, glauconite; *traces of lead.*
168	188	Gray limestone, glauconite, few grains of pink feldspar.
188	193	Glauconite sandstone and some pink feldspar.
193	198	Decomposed granite stained with glauconite.
198	204	Pink granite.

Interpretation:	*Feet*
Morgan Creek limestone	0– 8
Welge sandstone	8– 37
Lion Mountain sandstone	37– 80
Cap Mountain limestone	80–193
Town Mountain granite	193–204

Hole Drilled May 19 to 22, 1925

Depths (Feet) From	*To*	*Description*
0	40	Gray limestone and red sandstone; *lead traces.*
40	80	Gray limestone, little stone, and green glauconite.
80	95	Gray limestone, and some glauconite; *lead traces.*
95	145	Gray lime sandstone and glauconite.
145	160	Gray limestone, little sandstone; *lead traces.*
160	170	Gray limestone and sandstone; *fair lead traces.*
170	200	Gray limestone, sand, and glauconite; *good lead.*
200	215	Gray limestone, sand, and glauconite; *good lead.*
215	218	Granite.

Interpretation:	*Feet*
Morgan Creek limestone	0– 40
Welge sandstone and Lion Mountain sandstone	40– 95
Cap Mountain limestone	95–215
Town Mountain granite	215–218

Hole Drilled May 23 to 26, 1925

Water level: 100 feet

Depths (Feet) From	*To*	*Description*
0	20	Gray limestone.
20	50	Gray limestone and red sandstone.
50	60	Gray limestone and red sandstone; *trace of lead.*
60	70	Gray limestone and gray sandstone; *trace of lead.*
70	140	Gray limestone and sand with glauconite.
140	165	Gray limestone and sand with glauconite; *trace of lead.*
165	195	Gray limestone and sand with glauconite.
195	225	Gray limestone, sand, glauconite spalls; *good lead traces.*
225	229	Granite.

Interpretation:	*Feet*
Morgan Creek limestone	0– 60
Welge sandstone and Lion Mountain sandstone	60–110
Cap Mountain limestone	110–225
Town Mountain granite	225–229

Lead assays for part of hole:

Depth (feet)	*Lead (percent)*
190–195	0.10
195–200	0.24
200–205	0.28
205–210	0.31
210–215	0.12
215–220	0.30
220–225	0.24
225–229	0.31

Hole Drilled May 27 to 30, 1925

Water level: 75 feet

Depths (Feet) From	*To*	*Description*
0	5	Gray limestone and red sandstone.
5	70	Gray limestone and red sandstone, little glauconite; *from 15 to 20 feet, trace of lead; from 20 to 60 feet, good lead; from 60 to 70 feet, trace of lead.*

70	115	Gray lime sandstone, glauconite.
115	145	Gray lime sandstone, glauconite; *fair lead traces.*
145	215	Gray limestone, red gray sand, little glauconite; *from 145 to 155 feet, trace of lead; 190 to 215 feet, trace of lead.*
215	230	Gray limestone, red gray sand, little glauconite, trace of feldspar; *trace of lead.*
230	235	Gray limestone and gray sandstone; *trace of lead.*
235	270	Gray limestone, red and gray sand, little glauconite, feldspar; *trace of lead.*
270	275	Gray limestone, gray sand, little glauconite.
275	278	Granite.

Interpretation:	*Feet*
Morgan Creek limestone	0– 70
Welge sandstone and Lion Mountain sandstone	70–120
Cap Mountain limestone	120–275
Town Mountain granite	275–278

Hole Drilled June 1 to 6, 1925

Water level: 100 feet

Depths (Feet) From	*To*	*Description*
0	10	Red sandstone.
10	20	Red sandstone and green glauconite.
20	90	Gray limestone and sandstone with glauconite.
90	225	Gray limestone and sandstone with glauconite; *from 90 to 105 feet, lead traces; from 160 to 170 feet, good lead shines; from 170 to 180 feet, lead traces.*
225	235	Red sand.
235	250	Gray limestone, sand with glauconite, and specks of feldspar.
250	256	Granite.

Interpretation:	*Feet*
Morgan Creek limestone	0– 15
Welge sandstone and Lion Mountain sandstone	15– 65
Cap Mountain limestone	65–250
Town Mountain granite	250–256

Hole Drilled June 4 to July 31, 1925

Water level: 135 feet

Depths (Feet) From	*To*	*Description*
0	35	Cotton rock and shale.
35	85	Cotton rock, shale, and glauconite.
85	165	Gray limestone, shale and sandstone.
165	215	Gray limestone and sandstone.
215	255	Gray limestone and some glauconite.
255	290	Gray limestone and white sand.
290	325	Gray limestone, sand, shale and feldspar.
325	332	Granite.

Interpretation: Impossible to make except that the hole is in Town Mountain granite from 325 to 332 feet and the overlying gray limestone belongs to the Cap Mountain limestone. Lion Mountain sandstone may be within the interval 35 to 85 feet.

Hole Drilled June 8 to 15, 1925

Water level: 30 feet

Depths (Feet) From	*To*	*Description*
0	55	Gray limestone and red sandstone.
55	95	Gray limestone, red sandstone, and glauconite.
95	315	Gray limestone and sand with glauconite.
315	350	Gray limestone, sand, some shale.
350	380	Gray limestone, sand, some shale, some feldspar.
380	383	Granite.

Interpretation:	*Feet*
Morgan Creek limestone	0 – 55±
Welge sandstone and Lion Mountain sandstone	55±–105±
Cap Mountain limestone	105±–380
Town Mountain granite	380 –383

Hole Drilled June 15 to 19, 1925

Water level: 40 feet

Depths (Feet) From	*To*	*Description*
0	70	Gray limestone and sand with glauconite.
70	95	Gray limestone and sand with glauconite; *fair lead traces.*
95	130	Gray limestone and sand with glauconite; *lead traces.*
130	165	Gray limestone and sand.
165	171	Granite.

Interpretation: Cannot be made from information given.

Hole Drilled June 20 to 26, 1925

Water level: 105 feet

Depths (Feet) From	*To*	*Description*
0	20	Gray limestone and sandstone.
20	60	Gray limestone and red sandstone.
60	90	Gray lime sandstone and green glauconite.
90	235	Gray limestone and sandstone; *from 165 to 180 feet and from 220 to 235 feet, lead traces.*
235	320	Gray limestone and mostly all sand.
320	355	Gray limestone, sand, and shale.
355	362	Granite.

Interpretation:	*Feet*
Morgan Creek limestone	0– 60
Welge sandstone and Lion Mountain sandstone	60–110
Cap Mountain limestone	110–355
Town Mountain granite	355–362

Some of the lower part of sedimentary section may be Hickory sandstone.

Hole Drilled June 27 to July 3, 1925

Water level: 90 feet

Depths (Feet) From	To	Description
0	65	Gray limestone and red sandstone.
65	95	Gray limestone, sandstone, and green glauconite.
95	335	Gray limestone and sandstone.
335	365	Gray limestone, sandstone, and shale.
365	378	Gray limestone, sandstone, shale, feldspar, and granite.

Interpretation:	*Feet*
Morgan Creek limestone	0 – 65
Welge sandstone and Lion Mountain sandstone	65 –115
Cap Mountain limestone with perhaps lower part Hickory sandstone	115 –375(?)
Town Mountain granite	375(?)–378

Hole Drilled July 5 to 13, 1925

Water level: 60 feet

Depths (Feet) From	To	Description
0	60	Gray limestone and red sandstone.
60	125	Gray limestone, red sandstone, sandstone, and iron glauconite.
125	180	Gray limestone and sandstone: *lead traces from 135 to 180 feet.*
180	285	Gray limestone, sandstone, and shale; *lead traces from 220 to 235 feet.*
285	345	Gray limestone, sandstone, shale, and feldspar.
345	359	Sand and granite.

Interpretation:	*Feet*
Morgan Creek limestone	0 – 75
Welge sandstone and Lion Mountain sandstone	75 –125
Cap Mountain limestone with perhaps lower part Hickory sandstone	125 –355(?)
Town Mountain granite	355(?)–359

Hole Drilled July 14 to 19, 1925

Water level: 65 feet

Depths (Feet) From	To	Description
0	55	Gray limestone and sandstone.
55	80	Gray limestone and red sandstone.
80	140	Gray lime sandstone and glauconite.
140	170	Gray lime sandstone, glauconite, shale; *lead traces.*
170	230	Gray lime sandstone, glauconite, red sandstone; *lead traces.*
230	240	Gray limestone, sandstone, feldspar; *good lead traces.*
240	250	Gray limestone, sandstone, feldspar; *lead traces.*
250	255	Granite.

Interpretation:	*Feet*
Morgan Creek limestone	0– 80
Welge sandstone and Lion Mountain sandstone	80–130
Cap Mountain limestone	130–250
Town Mountain granite	250–255

Hole Drilled May 14 to 29, 1925

Drill owner and operator: Ed Norred

Water level: 80 feet

Depths (Feet) From	To	Description
0	15	Yellow sandy limestone.
15	20	Gray limestone and sand; *trace of lead.*
20	25	Brown sandy limestone.
25	35	Brown sandstone, quartz crystals.
35	50	Brown sandstone, limestone and glauconite.
50	55	Brown sandy limestone.
55	60	Gray limestone.
60	65	Gray limestone and pink calcite; *trace of lead.*
65	75	Pinkish limestone; *lead traces.*
75	90	Gray sandy limestone; *lead traces.*
90	105	Gray limestone, very sandy.
105	110	Brown sandy limestone.
110	115	Gray limestone, some quartz.
115	125	Brown limestone, some quartz.
125	145	Brown lime sandstone.
145	165	Brown limestone and sand.
165	185	Brown sandy limestone.
185	190	Brown sandy limestone, some glauconite.
190	195	Gray lime sand and glauconite.
195	235	Hard blue limestone with feldspar buttons.
235	240	Granite.

Interpretation: Cannot be made except that Town Mountain granite is from 235 to 240 feet. This hole encountered rock similar to that in the hole drilled on the Edwards property (p. 62).

Hole Drilled on Matthews Property, Beaver Creek Area

Hole Drilled August 2 to 17, 1925

Drill owner: T. C. Curry

Drill operators: Don Peterson and Elmer Edwards

Struck water: 125 feet

Water stands: 10 feet

Depths (Feet) From	To	Description
0	75	Gray limestone.
75	105	Gray and pink limestone.
105	130	Gray limestone and red sand.
130	140	White sand and little limestone.
140	170	Gray limestone, white sand, and glauconite.
170	200	Gray limestone, white sand, and shale.
200	225	Gray limestone, red sand, and shale.
225	235	Gray limestone, white sand, and shale.
235	240	Gray limestone, red sand, and shale.
240	405	Gray limestone and white sand.
405	430	Gray limestone and red sand.
430	600	Gray limestone, white sand, and shale.
600	710	White sand.
710	735	White and red sand and spar.
735	740	Granite.

Interpretation:	*Feet*
Morgan Creek limestone	0–130
Welge sandstone and Lion Mountain sandstone	130–180
Cap Mountain limestone	180–400
Hickory sandstone	400–735
Town Mountain granite	735–740

Hole Drilled on O'Donnell Property, Fairland Area

Hole Drilled August 22 to September 20, 1925

Drill owner: T. C. Curry

Drill operators: Don Peterson and Elmer Edwards

Depths (Feet) From	*To*	*Description*
0	55	Pink marble.
55	65	Blue limestone and pink marble.
65	70	Pink marble, blue limestone, some green glauconite.
70	75	Blue limestone, pink marble.
75	80	Pink marble, pink limestone.
80	100	Gray limestone and pink marble.
100	150	Gray limestone.
150	210	Gray limestone and shale.
210	220	Gray limestone, pink limestone, and shale.
220	245	Gray limestone.
245	255	Gray limestone, pink limestone, some shale.
255	305	Gray limestone, some shale.
305	330	Gray limestone, pink limestone, some shale.
330	350	Gray limestone, red sand and some shale.
350	365	Red and white sand, little gray limestone, shale, some green glauconite.
365	400	Black, pink quartz, sand, gray limestone, some shale, green glauconite.
400	445	Gray limestone, some black sand, some green glauconite.
445	475	Gray limestone and shale.
475	575	Gray limestone, brown sand, some shale.
575	630	Gray limestone, brown sand, quartz, sand, shale.
630	660	Gray limestone, red and brown sand, and some shale.
660	705	Gray limestone, red sand, and some shale.
705	725	Gray limestone, most all red sand, and some shale.
725	730	Little limestone, some all red sand, and some shale.
730	860	Sand, some limestone and shale.

Interpretation:	*Feet*
San Saba member (dolomitic facies and calcitic facies)	0–150
Point Peak shale	150–220
Morgan Creek limestone	220–350
Welge sandstone and Lion Mountain sandstone	350–400
Cap Mountain limestone	400–705
Hickory sandstone	705–860

The well starts in the dolomitic facies of the San Saba member; its location is shown on figure 13.

Holes Drilled on Edwards Property, Fairland Area

Drill owner and operator: Ed Norred

Hole Drilled May 5 to June 15, 1925

Water level: 60 feet

Depths (Feet) From	*To*	*Description*
0	10	Clay opening with limestone and sandstone boulders.
10	12	Yellow sand.
12	17	Brown sand and limestone.
17	22	Yellow sand and limestone.
22	29	Brown sandy limestone, opening at 29 feet.
29	33	Black limestone.
33	60	Sandstone boulders and clay; water at 60 feet.
60	70	Sandy clay. Hole caved; abandoned until casing arrived; moved on No. 2. Cased hole June 1.
70	75	Gray limestone.
75	90	Gray limestone and brown sand; *traces of lead.*
90	95	Brown sandy limestone.
95	100	Gray limestone.
100	125	Gray sandy limestone.
125	140	Brown sandy limestone.
140	150	Gray sandy limestone; *few lead shines.*
150	190	Brown sandy limestone; *few shines lead between 150 and 160 feet.*
190	200	Light brown sandy limestone.
200	205	Gray limestone.
205	240	Hard blue limestone with feldspar buttons.
240	242	Granite.

Interpretation:	*Feet*
Cap Mountain limestone	0–240
Town Mountain granite	240–242

EXPLANATION OF FIG. 13. The Upper Cambrian is represented by two formations, comprised of seven members, shown by the following symbols: Wilberns formation: €ws(mg), dolomitic facies, and €ws(ca), calcitic facies of the San Saba member; €wpp, Point Peak shale member; €wm, Morgan Creek limestone member; €ww, Welge sandstone member. Riley formation: €rl, Lion Mountain sandstone member; €rc, Cap Mountain limestone member; €hr, Hickory sandstone member. The Precambrian is represented by Town Mountain granite, tm. Base from U. S. Department of Agriculture, Soil Conservation Service, aerial photographs flown by Park Aerial Surveys, Inc., 1939-1940. Geology by Virgil E. Barnes and Lincoln E. Warren, 1945.

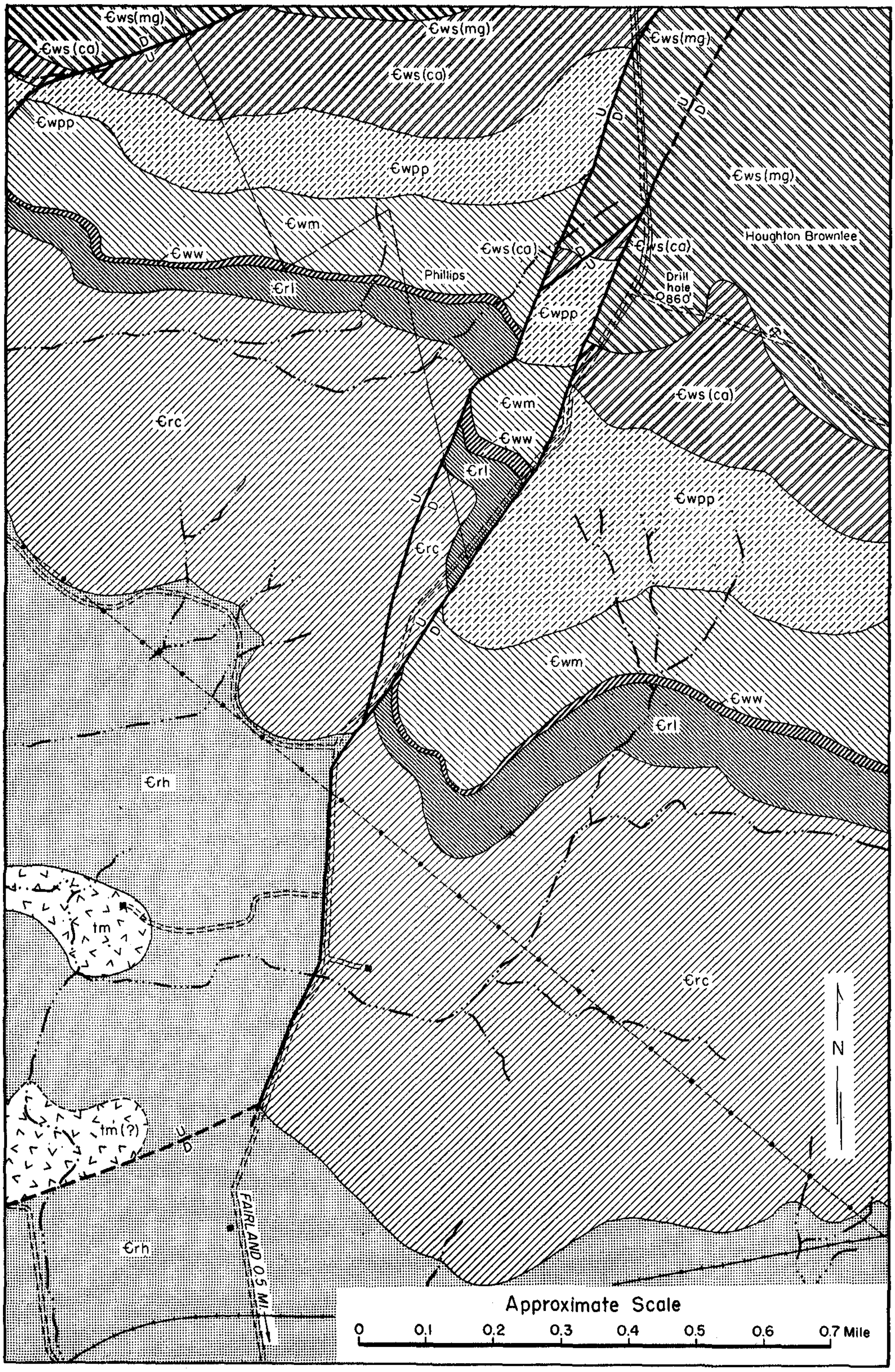

Fig. 13. Geologic map of an area north of Fairland, Burnet County, Texas.

Hole Drilled June 18 to July 3, 1925

Depths (Feet) From	*To*	*Description*
0	10	Brown and white limestone and clay.
10	15	Brown and white limestone, sand, and clay.
15	20	Sandy limestone.
20	25	Sandy limestone, little glauconite.
25	40	Gray limestone; *few lead traces from 35 to 40 feet.*
40	45	Brown sand, limestone and clay; *few traces of lead.*
45	55	Gray sandy limestone and clay; *few traces of lead.*
55	65	Gray and pink sandy limestone; *few traces of lead.*
65	70	Gray limestone, traces of glauconite; *few traces of lead.*
70	80	Brown and pink limestone, some sand; *few traces of lead.*
80	90	Pink sandy limestone; *few traces of lead from 80 to 85 feet.*
90	95	Lime sandstone.
95	100	Gray limestone and sand.
100	110	Gray limestone, very sandy; *traces of lead.*
110	115	Gray sandy limestone; *traces of lead.*
115	120	Brown sand and limestone.
120	135	Brown sandy limestone.
135	140	Brown sand, gray and green limestone.
140	145	Gray sandy limestone; *few traces of lead.*
145	175	Brown sand and limestone; *few traces of lead from 170 to 175 feet.*
175	180	Gray and green limestone, sand; *few traces of lead.*
180	185	Brown sandy limestone; *few traces of lead.*
185	190	Brown sandy limestone and shale.
190	195	Gray limestone and shale, some sand.
195	245	Fine-grained blue limestone and shale with feldspar.
245	255	Granite with limestone and shale buttons.
255	260	Granite.

Interpretation:	*Feet*
Cap Mountain limestone	0 –135(?)
Hickory sandstone	135(?)–255
Town Mountain granite	255 –260

Hole Drilled July 6 to 16, 1925

Water level: 60 feet

Depths (Feet) From	*To*	*Description*
0	3	Clay.
3	55	Gray and brown limestone, some sand.
55	75	Blue limestone.
75	80	Blue and gray limestone.
80	90	Gray limestone.
90	100	Yellow limestone and sand.
100	105	Blue limestone.
105	110	Blue and gray limestone and glauconite.
110	135	Blue sandy limestone.
135	150	Gray sandy limestone.
150	155	Brown sandy limestone.
155	160	Gray sandy limestone.
160	165	Brown sandy limestone.
165	170	Gray limestone and brown sandstone.
170	185	Red sandstone.
185	200	Red sandstone with gray limestone.
200	270	Red sandstone.
270	295	Dark gray limestone and sand.
295	300	Blue limestone.
300	305	Blue limestone and shale.
305	310	Gray sandy limestone.
310	325	Blue limestone and shale.
325	340	Blue limestone, shale, and feldspar.
340	345	Granite with limestone and shale buttons.
345	352	Granite.

Interpretation:	*Feet*
Cap Mountain limestone	0–170
Hickory sandstone	170–345
Town Mountain granite	345–352

Index