DESCRIPTION OF THE LLANO AND BURNET QUADRANGLES.

By Sidney Yale.

GEOGRAPHY.

LOCATION, AREA, AND CULTURE.

The Llano and Burnet quadrangles, in Texas, are bounded by parallels 30° 30' and 31° north and meridians 98° and 99° west. Each quadrangle covers one-fourth of a square degree, or an area of about 1025 square miles. They include nearly all of Llano and Burnet counties and parts of Mason, San Saba, Travis, and Williamson counties. (See fig. 1.) The greater portion of each quadrangle lies within the county of the same name.

The more important towns are Llano, in the Llano quadrangle, and Burnet, Marble Falls, and Bertram, in the Burnet quadrangle.

Llano County is distinctly a stock-raising country, but much farming is carried on there. Burner County is more characterized by farming but also raises cattle.

The region is accessible by the eastern division of the Houston & Texas Central Railroad, which traverses the central part of Burnet County and terminates at Llano, the county seat of Llano County. A spur from Burnet to Lampasas, 35 miles north, connects this railroad with the Gulf, Colorado & Santa Fe Railway and a short spur runs to Marble Falls.

CENTRAL GEOGRAPHY AND GEOLOGY OF THE REGION.

The broad physical and geologic features of the State of Texas have been well described by Hill and Vaughan. Hill recognized six great provinces in the State—the trans-Pecos, the Great Plains, the central, the coast, the western, and the southern—each of which he subdivided into smaller physiographic units.

As may be seen by reference to the general geologic map of Texas (fig. 2) more than half the State is covered by marine Cretaceous limestones—known as the Edwards limestone. It differentiates the central province from the plains largely because of its deeper covering over the Eden Plateau. There have been, however, many cross-cutting faults, causing the plains to be somewhat irregular in structure. The region is not hilly, being steepest below the level of the Edwards Plateau, and its form is due to a combination of structural and erosional conditions, which will be discussed later.

The location of the Llano and Burnet quadrangles is shown by the darker ruling (No. 183). The second mountain type is characterized by maturely dissected upper surface.

Isolated mountainous masses in the pre-Cretaceous basin.—The irregularities within this plain-like area are two types: (a) such mountain-like elevations as Riley, Puckett, Lampasas, Stonewall, and Smoothing Iron; and (b) such heights as the groups of hills west of Oxford and northeast of Bexar County and the many isolated hills north and south of Llano. These elevations are all of less or less modified parts of a pre-Cretaceous erosion surface, partly reduced remnants of the erosion which formed the pre-Cretaceous basin.

The first type is characterized by a general table-like outline formed by a cupping of nearly horizental beds, with steep marginal escarpments. Smoothing Iron Mountain, in the northwest end of the Llano quadrangle, and Riley Mountain in the southern part, are examples. The main mass of Smoothing Iron Mountain extends in a north-south direction about 10 miles and has a maximum width of about three-fourths of a mile. The mountain rise steeply 400 feet from the relatively featureless plateau just described and forms a more or less maturely dissected unitary surface, partly reduced remnants of the erosion which formed the pre-Cretaceous basin.

The second mountain type is characterized by maturely dissected mountain groups and by isolated symmetric peaking hills which rise steeply from the surrounding plains. Such areas are Hobson Mountain, the irregularly dissected group of hills in the south-central part of the Llano quadrangle, and the mountain group in the vicinity of Bexar County.

The plains are broad and featureless, but the Llano and Burnet quadrangles show three types of rolling hills which are of importance. The first is characterized by a general table-like outline. These hills may be seen on the general geologic map of Texas (fig. 2) more than half the State is covered by marine Cretaceous Tertiary and Tertiary beds. In a broad sense the Greater Texas region consists of a vast and featureless plateau country to the south, yet the relief of the region is hardly so great as really to warrant such a characterization.

Isolated mountainous masses in the pre-Cretaceous basin.
The rolling plains of Llano County slope, periphery, several varieties of thorny bushes, and cacti of various types. The limestone series at Morman Mill, Tex. for convenience in pointing out the number of ridges in a northwest-southeast direction from the edge of the region by measuring a number of sections and making important collections of fossils. A notable exception is the Nowosky sandstone, which is an especially favorable horizon for their formation. The limestone is mapped in this folio as the Ellenburger lime- stones are regarded as a limestones in Cedarburg shales. Again, though Shumard seemed to recognize that his best sandstones were “based on granite,” he appears to have regarded at least a part of the granite as intrusive into Paleozoic beds, for he speaks of these beds as being “slightly metamorphosed near the granite.” No evidence of post-Cambrian intrusion was noted by the author of this folio, and the lowest Paleozoic beds were considered by him to be part of the granite as intrusive into Paleozoic beds, for he considered by him to be part of the granite as intrusive into Paleozoic beds, for he
2. Though he seemed to recognize the presence of faulting, he did not use this knowledge to explain the presence of contemporaneous beds in apparently illegal positions.

3. He connected granite intrusion (of pre-Cambrian age) with minor superimposed faulting of post-Paleozoic age. Though he recognized "cracks" and unconformities in pre-Cambrian beds beyond the limits of pre-Cambrian beds, he did not delineate any such divisions.

4. Failing to see any reason for the "consequent" beds in apparently illogical positions.

5. In directing attention to prospecting for iron ores he lays stress upon the presence of "consequent" beds in apparently illogical positions.

6. In comparing the Llano-Burnet region with the neighboring region the writer has observed, he notes that the series is divided into two formations, the Valley Spring gneiss and the Pack saddle schist.

**COMPARE WITH OTHER REGIONS.**

As the rocks exposed in this region represent a geologic time interval extending from possibly the earliest recorded sedimentation to a relatively late date (Ordovician in the Crowe Creek region), it may be well briefly to compare the nature of the pre-Cambrian complex and the broad characteristics of the Paleozoic section with those of the comparable series in neighboring regions. Such areas are found in the Ozark, Arbuckle, and Ouachita mountainous regions to the northeast, in the El Paso and Van Horn quadrangles, and in several localities in Arizona and New Mexico.

By comparing the central Texas region with the areas to the northeast marked differences, both in the pre-Cambrian and Paleozoic rocks, are at once noted. In central Texas the pre-Cambrian complex is made up largely of schist and gneiss, much of which is of undoubted sedimentary origin. In the Ozark region and in the Arbuckle and Ouachita mountains the pre-Cambrian rocks are wholly igneous, granite, granite porphyry, and some gneissic rocks forming the floor on which the bedded Paleozoic series are superimposed. Examination of the Paleozoic column reveals also wide differences in the sedimentary record, that of central Texas showing great gaps that represent intervals of time during which deposition was not taking place, or areas where erosion unconformities have been produced. In the Arbuckle Mountains the Upper Cambrian, Ordovician, Silurian, Devonian, and Carboniferous (Mississippian, Pennsylvanian, and Permian) are represented. In the central Texas region the later Cambrian and early Ordovician rocks are distinctly thinner than to the northeast, and part of the Ordovician, the Silurian, and Devonian systems, and the Mississippian and Pennsylvanian rocks, are absent. In the Wichita Mountains of Oklahoma much the same sequence as in the Arbuckle region is believed to exist, but the overlying Permian red beds are absent. In the Ordovician, the Silurian, the Devonian, and a part of the Carboniferous series are present.

The sections in southeastern Texas also show striking differences from those of central Texas. The pre-Cambrian rocks of the El Paso quadrangle have been divided into a lower formation consisting of schists and a granite porphyry flow 1500 feet thick resting on the quartzite. On this rhythm flow were deposited the basal beds of the Cambrian system, and the quartzite is post-Cambrian.

On page 295 it is said:

**Valley Spring Gneiss.**

On the top of Sandy Mountain * * * * this Hillier layer has been exposed where for some distance it is covered by a flat bed of sandstone. This probably forms a gradual transition from above downward, between the nearest massive sand rock and a rock which in some places is intersected by a granite. Similar conditions exist on Sharp Horn, Horse Mountain, Packsaddle Mountain, and elsewhere, but not on Pack saddle Mountain. * * * * It seems clear that the probable age of these rocks is Mesozoic, and that the magma assumed several broad folds in the Hillier strata, leaving certainly two great synclinal basins to be afterward partly filled by igneous intrusions. Their varying altitude is due partly to faulting and partly to erosion.

He could not therefore have observed accurately the nature of these beds, as is also shown by the following statement on page 250:

Most of the exposures of granite rocks in direct contact with the Potomac suite and lower series are of different character from those on the Baton Rouge gneisses * * * * and their relations to the overlying beds have been determined. The reason for this is that the intrusion is later than the deposition of the overlying material.

The writer found no instance of contact metasomatism in any post-Cambrian beds, nor was any intrusive into these beds noted. Moreover, the basal Cambrian beds in many places contain fragments of the underlying igneous rocks.

He states that Sandy Mountain is 50 miles east-southeast of the El Paso, and that valley rock flows have been mapped in the Valley Spring gneiss. The writer notes that the Llano series has been divided into two formations, the Valley Spring gneiss and the Pack saddle schist.

**Alokanía (7) Rocks.**

Four principal subdivisions of the pre-Cambrian rocks have been recognized in mapping this area—(1) the Valley Spring gneiss, which includes acid intrusive gneiss, quartzite and its derivatives, light-colored meta-schist, and beds of wallotrites, with some bands of dark basic schist; (2) a series of dark-colored, predominantly basic rocks called the Pack saddle schist, consisting of amphibolite, gneissic, and meta-schist, limestone, marble, and basic intrusive (some intrusive granite is mapped with each of these formations); (3) a very coarse-grained granite which is probably a remnant of an overlying sialic series; and (4) all the remaining granite rocks, including a number of varieties. The Van Horn area is different, however, from the central Texas region in containing a thick series of rocks which carries a fauna not found elsewhere in central Texas and presumably is of Algonkian age. The Valley Spring gneiss and the Pack saddle schist together compose the Llano series. In addition to these major distinctions, bands of conglomerate and wallotrites have been seen mapped somewhat possible. The outcrops of a quartz porphyry of porphyry type, locally termed granitic, and the Pack saddle series have been seen mapped somewhat possible. The outcrops of a quartz porphyry of porphyry type, locally termed granitic, and the Pack saddle schist have been mapped extensively near the Schuylkill River in Pennsylvania, near the mouth of the Schuylkill River in Pennsylvania, near the mouth of the Schuylkill River in Pennsylvania, near the mouth of the Schuylkill River in Pennsylvania, near the mouth of the Schuylkill River in Pennsylvania, near the mouth of the Schuylkill River in Pennsylvania, near the mouth of the Schuylkill River in Pennsylvania, near the mouth of the Schuylkill River in Pennsylvania, near the mouth of the Schuylkill River in Pennsylvania.
The broadest and perhaps most marked distinction of the rocks of this formation from those of the overlying one is their more numerous occurrences. This difference is most marked when the formations are compared as wholes, rather than in individual small areas. A study of areas occupied by this formation leaves the impression that a thick series of sedimentary rocks of rather uniform composition has been subjected locally to intense regional metamorphism and metasomatism, in a zone where rock-folding and minor folding have been dominant. The dark Puckaddle schist as a whole does not present the massive appearance characteristic of the Valley Spring gneisses.

Petrography.—Below are given the results of the microscopic examination of a number of specimens of the Valley Spring gneisses.

<table>
<thead>
<tr>
<th>Quartz-feldspar schist</th>
<th>Graphitic slate schist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pink, fine-grained rock</td>
<td>Dark-green to black glittering schist</td>
</tr>
<tr>
<td>Abundant fibrous black mica</td>
<td>Even-toned pink fine-grained rocks</td>
</tr>
<tr>
<td>Bands straight and narrow, made by pink and white constituents</td>
<td>Black rock showing on weathered surface evidence of schistosity</td>
</tr>
<tr>
<td>Distribution</td>
<td>Microscopic character</td>
</tr>
</tbody>
</table>
| As the Packsaddle schist overlies the Valley Spring gneisses, and as the major axes of folding determine its is developed to varying degrees. There are numerous lime-sheets lying upon the surrounding Valley Spring locally, it is believed, enough to be of commercial value. A original bedding of the sediments of which they are the meta-morphosed equivalents. | Abundant fine flakes of black mica. Rock is identified, through low thin bands. Sake of bands.
| Packsaddle schist whose structural relations are those of a southeast of Rough Mountain, there is an isolated area of the gneisses formed almost certainly by the metamorphism of a sedimentary series. It is believed that the presence of iron one also points to the same conclusion, a more summary fully considered in a previous bulletin by the author. The amphibolite, as has been stated, because of their basic character probably represent in part old basic intrusive or flows, or perhaps sedimentary in origin. As a whole the schists are characterized by an excellent chasm, which in the main coincides with the original bedding of the sediments which are the metamorphic equivalents. |...

Petrography.—The results of a microscopic examination of a number of specimens of these rocks are as follows:

- **Microscopic character.**—Absurdly small, a little coarse, with a very dark gray to black groundmass, and an opaline quartz porphyry. The rocks are sharply defined, with a medium to fine grained granite including some coarse-grained varieties, and an opaline quartz porphyry. Microscopic examination has shown that the differences between these two types are largely textual, the mineral constituents in the three types being essentially the same.

Diorite.—Medium-grained dark-gray to gray rock.

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red-stained conglomerate contains subangular quartz fragments as large as half an inch in some and coarse feldspar fragments up to an inch in length, associated with fine-grained quartz containing particles of iron oxide.

In another coarse sandstone facies of basalt 1 to 2 inches thick, making up the lower bed, the iron is probably derived from the underlying eolith in the form of augite and later altered to basalt. In still another locality where pegmatite dikes are abundant the overlying basalt bed contains many large angular masses of quartz. Again, where the lower beds are on a coarse-grained granite surface they are formed largely of arkose.

The conglomerate is overlain by sandstone, commonly cross-bedded. In place this is colored deep red or brown by iron oxide. Toward the upper portion of the formation the beds become decidedly calcareous and grade into the limestone of the overlying formation.

Distribution.—The Hickory sandstone, where not displaced by faulting, occupies the base of the Pecosian scarps which surround the pre-Cambrian basin and forms the capping of a number of isolated hills, such as House, Stuntinton, Rough, and Putnam mountains. In some areas, such as those northeast of Fort Worth, northeast of Possum Kingdom, and south of Stronghorn Mountain, the formation is but a thin skin or apron extending out from the escarp.

Section. The following sections are representative of the formation. The Pawnee section illustrates the transition to limestone at the top of the formation.

Section of Hickory Sandstone at north-eastern end of Pawnee Mountains, showing transition bed at top.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hickory Sandstone</td>
<td>Limestone and shale, with intraformational conglomerate of Illinoian age.</td>
</tr>
</tbody>
</table>

The Cap Mountain formation is named from a hill of that name, about 4 miles west of the town of Comanche Peak. The formation includes about 90 feet of beds, largely sandstone alternating with thin beds of limestone, with occasional glauconitic beds. The upper portion is largely shale, with more limestone at the top.

Where observed in the limestone, the glauconite grains exist essentially as such, but in the sandstone the material is more apt to form the matrix in which the well-rounded quartz grains are embedded. Partial analysis of a specimen from a bed carrying parish as high a content of glauconite as any other in the field gave the following result:

Partial analysis of a specimen from north fork of Comanche Creek:

<table>
<thead>
<tr>
<th>Element</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>52.61</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>1.44</td>
</tr>
<tr>
<td>CaO</td>
<td>39.61</td>
</tr>
<tr>
<td>Na₂O</td>
<td>0.98</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.19</td>
</tr>
</tbody>
</table>

The composition and origin of glauconite and its sedimentary significance have received considerable attention from a number of investigators, but there is not space in this folio to discuss in detail this interesting question. It may be said that the glauconite beds of the Llano-Blackland region are found locally resting upon a granite floor; that the origin of the glauconite in this region is apparently not connected with the presence of Foraminifera; and that its position, at least locally, is in a horizon of the Lower Cretaceous, probably of the Santonian age.

Distribution.—As the Cap Mountain formation line immediately above the Hickory sandstone, its distribution is much the same. As a rule, however, its area of occurrence is considerably narrower than that of the sandstone, which in a number of places spreads as a thin veneer over considerable territory. The outcrop of the Cap Mountain formation is more ribbon-like and, except where cut out by faulting, as along the north end of Phillips Rock and in the north escarp of Backbone Ridge, is invariably present in the rocklike Palonosic exposures. It is found also on the flanks of a number of the mountain masses, such as Cap, Riley, Cedar, and Long mountains.

WILBERNS FORMATION.

Definition.—The Wilberns formation, named from Wilberns Creek, on Little Llano River, in the Llano quadrangle, is of irregular thickness, in places spanning 220 feet. It is composed of limestone and shale, with intercalated conglomerate. The base of this formation is well defined by the top of the glauconitic sandstone which forms the upper member of the Cap Mountain formation. Its upper limit is at the base of the overlying massive chert-bearing beds. This horizon is not difficult to locate and the contact there is not difficult to follow. The exact stratigraphic relation, however, is not always so clear. In Riley Mountain, at the locality where the cherty limestones is mapped as bounded by an unnamed fault, there is some indication of an unconformity. Yet, although some chert beds do lie unconformably on both the Cap Mountain and Wilberns formations and although the locality was studied in some detail, a definite conclusion could not be reached. As in most places where the contact between the rather flabby limestones of the Wilberns formation and the overlying heavy chert-bearing beds was observed there was apparently perfect conformity between the two, and as there are many faults in this vicinity, it is possible that the apparent unconformity at this point is due to faulting. Hence an assumed fault has been shown on the map. The evidence from the fault points to the conclusion that at least a part of the chert-bearing beds are considerably later than the Wilberns formation, and that there is an unconformity at a horizon not far above the base of the overlying formation.

Character.—The Wilberns formation may be divided on lithologic criteria into a lower and an upper portion. The lower portion, comprising about two-thirds of the whole, is rather thin-bedded flabby limestones generally marked by sandy impurity and containing locally a small amount of glauconite. The upper portion is largely shale, with more limestone at the top. In the upper portion there are several conglomerate horizons. (See P. VIII.) These are not persistent along the strike, nor is their number everywhere the same. They are of two kinds—one composed of perfectly flat channeled flutes, fragments, such as could be formed only in place or from material transported a very short distance, the other composed of rounded or almost subangular cherty clasts in a matrix of decidedly calcareous texture containing locally considerable glauconite. In one place what appeared to be a sun-cracked shale fragment was found.
This section was measured in inclined beds and the total thickness is believed to be rather too small. It is of value, however, in indicating the succession.

**Section of Wilberns formation near the head of Little Llano River.**

Thicker-bedded gray crystalline limestone, called middle section of Wilberns formation on the Colorado River, about one-third mile above old tanyard crossing. In a number of places, as may be seen on the map, the formation is faulted out.

### Distribution.
The Wilberns formation lies immediately above the Cup Mountain formation and in general is found in the same areas. It is present in the Paleozoic rocks and in many of the higher mountains of the interior plains.

### Black-fingered limestone complexes.

In a number of places, as may be seen on the map, the formation is faulted out.

### Section of Wilberns formation near the head of Little Llano River.

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### Zoic strata in the Llano and Burnet quadrangles.

Large areas are exposed in the rolling uplands of the northern portion of the Llano and Colorado quadrangles and a considerabie portion of the Llano Mountain escarpment is formed by it. The formation is widespread throughout the northern part of the Llano quadrangle. Southward of this formation, it forms the steep slope mass tapering to a point at the southwestern extremity of Backbonse Ridge. A considerable strip also occurs north and south of the Missouri River. It is probable that 1000 feet of beds would include all the strata deposited in this region.

### The base of the section is probably about 30 feet thick above the top of the Cup Mountain formation.

This data which follows were brought together with the collaboration of E. O. Ulrich.

### Other formations of the same age.

The data which follows were brought together with the collaboration of E. O. Ulrich.

### Distribution.
The fauna of the Upper Cambrian beds consists chiefly of brachiopods and crinoids, with a few other types of invertebrates. The collections were obtained largely from the upper part of the section, where, however, the brachiopods have been sufficiently studied to warrant the presentation of a chart. The following brachiopods are ascribed to Cambrian beds of Texas by Charles D. Walcott.

*Laretia depressa*

*Ringia ovalis*

*Sidneroidea lata*

*Sidneroidea microsiphon*

*Sidneroidea waltzii*

*Sidneroidea angulata*

*Sidneroidea tenuinana*

*Sidneroidea robusta*

*Sidneroidea destructor*

*Sidneroidea robusta*

*Sidneroidea destructor*

*Sidneroidea robusta*

*Sidneroidea destructor*

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common fossils are Cretaceous bivalves (curved variety) and the Helcionota (usually associated with it and with Bathysoma, and ammonites. Two species of Helcionota and two species of Cretaceous bivalves are abundant in Texas. The lower part of the Ellenburger limestone may be correlated with the basal division of the Arkle formation in Oklahoma.

In the Austin fair division of limestones of Lower Ordovician age in the Franklin Mountains of western Texas. The greater part of the collections from that area, like the fauna in the upper part of the Ellenburger limestone, indicates the Cretaceous zone.

CARBONIFEROUS SYSTEM.

Pennsylvania Series.

The Carboniferous system is represented in this region by the Marble Falls limestone; the Smithwick shale, a member of Lower Pennsylvanian age; and the middle division of the typical Bend of the Texas Survey.

Sections. The Smithwick shale, named from the old town of Smithwick, in Burnet County, consists of soft, very dark or nearly black carbonaceous shale in which are included a number of fossils; and the Middle Ordovician and Silurian strata near El Paso, western Texas. The shale includes some sandstone lentils. The depositional and stratigraphic orientation of the larger section is as follows:

- **Helicotomaf** 8
- **Trinity formation**
- **Comanche Peak limestone**
- **Ellenburger limestone**
- **Marble Falls limestone**
- **Georgia limestone**
- **Walnut clay**
- **Taylor marl**
- **Georgetown limestone**
- **Comanche Peak formation**
- **Trinity formation**
- **Comanche Peak limestone**
- **Taylor marl**
- **Georgetown limestone**
- **Comanche Peak formation**
- **Trinity formation**
- **Comanche Peak limestone**

**Trinity formation**.—The Trinity formation in the Llano-Burnet region includes the equivalents of the Travis Peak and Glen Rose formations. The name is a group name and was originally applied by Hill to describe the beds at the head of Trinity River. Of the two formations, Hill says:

- **Trinity formation** is especially marked by strata of flinty white pack sands, which do not occur in the other divisions and which in places resemble the flinty pack beds of the Cretaceous. The sandstones in these beds are composed of minute shells or fragmental pieces of shells and sands having a lithologic and paleontologic individuality by which they can be easily distinguished. All the calcareous strata are white or yellowish and occur in numerous persistent alternation of hard and soft strata of various thicknesses. In general, these beds are the rocks of the Trinity division were laid down upon a subsiding bottom of a former land surface. The varying composition and size character of the Trinity division are due to the fact that they were laid down against the nearly steep slope of the subaerial land from which the material was derived.

The distinctive characteristic of the Trinity formation in the Llano-Burnet quadrangle is the wide range of the thickness and nature of the bed composing it. This condition is the natural result of deposition upon a gradually subsiding land surface on which, owing to a not too rapid rise of the land surface, variations of rocks were exposed to erosion. The composition of the basal beds is closely related to that of the rocks of the adjacent land that was undergoing erosion, and the mixture of the beds depends largely on the relief of the land edge of the subaerial shore line. For example, a Little out of the land near the fork of Morgan Creek the formation is lacking in small areas.
and the Walnut clay rests directly on the uneven eroded surface of the Palaeozoic limestones, but on Colorado River near the southerly border of the Trinity region conglomerate and about 450 feet of Cretaceous limestone and marl occur beneath the Walnut clay. (See PL VI.) The conglomerate contains pebbles of granite, and Palaeozoic rocks derived from the denuded area to the west. The beds to the north, however, being in conglomerates, begin by their character moderate topographic relief along the encroaching shoreline, but the beds to the south, on Colorado River, suggest quite the opposite.

Above the conglomeratic basal member, which is about 30 feet thick in the southernmost part of the Burnet quadrangle, are beds of shaly, sandy oolite- and shale breccia, sand, conglomerate, and calcareous sandstones. Higher in the section occur alternating series of buff, white, and yellow sandy and calcareous limestones with thin beds of clay and sandy clay.

**Figure 4.—Ideal section illustrating the lateral change in sedimentation of the Trinity formation in the Burnet quadrangle and east to conglomerates adjacent to the ancient sea floor.**

The base of the Trinity formation lies gradually from an elevation of 750 feet on Colorado River to about 1200 feet in the northerly part of the Burnet quadrangle. Figure 4 illustrates an ideal section the condition which is believed to have existed, namely, that the conglomeratic basal beds were in place up to about 50 feet above the present elevation of the Colorado River. Further, the middle Tertiary deposits are represented by a continuous series of sands that have been progressively less coarse, thinner, and more calcareous as the elevation of the sea floor has decreased. The lower Tertiary deposits have been represented to a great extent by the Conglomerate basal member, which contains pebbles of schist, granite, and Paleozoic marl occur beneath the Walnut clay. (See PL VI.) The moderate topographic relief along the encroaching shoreline, and the elevation of 750 feet on Colorado River to about 1200 feet in the northerly part of the Burnet quadrangle, have been represented to a great extent by the Conglomerate basal member, which contains pebbles of schist, granite, and Paleozoic marl.
The first blocks are not displayed in the Burnet region, possibly because only the lower part of the formation is exposed. In many places, it is a serious problem to place the upper limit of such a formation as the Cretaceous almost to the surface in the central Texas region. This would mean that the Cretaceous strata would be described under "Structure of the pre-Cambrian rocks." ...Quite different are the forces which have been at work in the central Texas region. Subsidence in the floor of the Gulf of Mexico would initiate subsidence at that point under the influence of which the central Texas region would be compressed between the two land masses. West of the Llano, does not seem to have suffered such extensive faulting. The great granite masses at least the one in the southwestern part of the Llano quadrangle and that in the southern part of the latter plunges southeastward and ends in the southwestern part of the Gulf of Mexico. The structure is therefore complex. Faults of considerable throw or displacement have been active in this region. At this point a number of sections throw light on the stresses which have been active. The series of breaks which follow the eastern scarp have the greatest throw. In the valley of the valley, the series of breaks which follow the western scarp have the greatest throw. The structure of the pre-Cambrian schists is highly complex and can be indicated only in general terms. The rocks, especially those of the Lower Ordovician, have been deeply buried and in consequence subjected to deep-seated metamorphism. They have as a mass been thrown into broad folds, on which in turn minor folds have been formed. The process was carried on for so long that the rocks are completely foliated, and individual beds are no longer visible, especially, perhaps, many times. Dips are in most places though not everywhere, steep, and the dominant trend of the folds is north and northeast.
The slightness of deformation since they were laid down. The period of such rocks would assume to be a result of simple uplift from beneath sea level to their present position. This uplift was accompanied by a gentle tilting which the slight thickness of relief of these beds perhaps indicates. These intrusives indicate igneous activity. After their formation the processes of sedimentation and conditions of life at the time active igneous intrusion. The character of the individual beds to be later affected by sufficient pressure to create incipient accompanied by faults. Basic intrusives broke the beds, themselves and minor folds were developed and were undoubtedly accom­panied by the bedded limestone at the top of the formation. This intrusives intrude their quartz to the sea again covered the land and Paleozoic deposition began during Paleozoic and later periods. Igneous activities, too, evidence of them.

Cambrian schist, gneiss, and granite indicates in a striking manner in general stratigraphic and paleogeographic considerations. It is evident from paleontologic data that great gaps occur in the record of Carboniferous deposition. The beds are introduced during an interval of Mesozoic time. The relation of the basal conglomerates and sandstones of the Llano-Burnet 11 of this plain. The lower areas were filled, while here and there sands. The subsidence, however, was not regular and uninter­ruptedly. These conditions of sea during the Williams Epoch, the great in the Cambrian-Ordovician sequence, the absence of Silurian, Devonian, Mississippian, and Triassic sediments points to the same conclusion—that during much of Paleozoic and Mesozoic time a broad subaerial erosion. This erosion is indicated by the parallel and more continuous uplifted and long-continued denudation. Later the sea again covered the land and Paleozoic deposition began upon a nearly level surface.

PALEOZOIC ERA.

To present more clearly the history of the sedimentary succession in the central Texas region during Paleozoic time it would perhaps be well to outline, in a broad way, the relation of the region to sea level throughout that era. It is evident from paleontologic data that great gaps occur in the sedimentary record, and it is very probable that these gaps represent periods of elevation above the sea. The evidence for this belief lies in the phenomena of overlap, in comparison with the land, and other regions to the northeast, and in general stratigraphic and paleogeographic considerations. Some of these will be set forth below. All point to the important conclusion that the central Texas region was one of relative elevation during several long periods.

The history of the Paleozoic sediments in this region see of Upper Cambrian age, it is clear that prior to their deposition (that is, in Lower and Middle Cambrian time) the region was at sea level above sea level. The indications of shallow seas during the Williems Epoch, the gaps in the Cambrian-Ordovician sequence, the absence of Silurian, Devonian, Mississippian, and Triassic sediments points to the same conclusion—that during much of Paleozoic and Mesozoic time a broad subaerial erosion. This erosion is indicated by the parallel and more continuous uplifted and long-continued denudation. Later the sea again covered the land and Paleozoic deposition began upon a nearly level surface.

PALEOZOIC ERA.

Folding and faulting were marked accomplishments of the uplift which closed the Paleozoic era and marked the initiation of Mesozoic time. During the Jurassic and Triassic periods the area probably remained a land mass and erosion was the important process at work. This fact is clearly proved by the bevelled beds which appear beneath the upper Triassic formation of the Edwards, forming a surface cutting across hard and soft strata and across such features as faults and folds. That this surface was not horizontal but bevelled is strongly suggested by the fact that in place basal Cambrian beds now stand at a higher elevation than basal Cretaceous beds, and, though Cretaceous beds overlie Pennsylvanian pro-Cretaceous rocks do not occur in the area, there is almost no doubt that such relations existed and were caused by post-Cretaceous erosion. It is evident from the evidence that there had probably been a relatively slight change in the topography of the ancient pre-Cretaceous plain prior to the post-Cretaceous erosion which now brought these rocks to light.

After this pre-Cretaceous planation and presumable partial exposure of the massive crystalline rocks, the region subsided and was covered by Cretaceous sediments. In its significance this upheaval quite probably the great transgression of the sea in early Cretaceous time.

PHYSIOGRAPHIC DEVELOPMENT.

The remaining history of the region may perhaps be best described in a discussion of the physiographic development, for it is deduced from present topographic form. There is only a fragmentary record in the Llano-Burnet region of the geologic events which took place after the close of Cretaceous time. Upper Cretaceous rocks have been removed by erosion and there is no record of Tertiary time. An examination of the geologic history recorded in the Austin quadrangle and in the Gulf Coastal Plain, however, will throw some light on these later periods, and it may be true to say how low and the major physiographic features of the region developed. In brief, Cretaceous deposition in this area was closed by a widespread uplift of the region during the early portion of the Cenozoic era. Subsequent erosion. This erosion interval was terminated by subaerial erosion. The Cretaceous sediments were laid down upon Upper Cretaceous strata in the Austin quadrangle. The data at present available are insufficient to permit statements as to the exact time of this erosion as stated in the Austin folio the line of this sea probably bordered the Basin.

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the highlands. In the past these blocks were the low areas and were preserved from erosion because the granite, schist, and sandstone of the high areas were more easily eroded away. In large part the spots which surround the basin may be thus seen today. Also, the fossiliferous tablelands mentioned as Riley Mountain, Long Mountain, and Backbone Ridge.

Certain peculiarities of the drainage developed on the Paleozoic and Pro-Cambrian rocks deserve the consideration here. Colorado River markedly and Llano River to a lesser degree are meandering streams. Scenic Creek cuts completely across the Llano Mountain mass in a peculiar fashion and Honey Creek, near the north end of Riley Mountain, also traverses a gorge-like valley within which the streams flow out upon a broad plain which then reaches Pro-Cambrian rocks. All these streams are adjusted to the major structural feature—that is, they have established normal gradients. The members of Colorado and Llano Rivers are evidently inherited from some earlier period when possibly these streams flowed at an elevation much nearer sea level, when their gradients were not so steep as at present, and when they flowed more slowly and were less actively cutting. It is not possible at present to place this period exactly, but certainly it followed after and perhaps was initiated by the uplift of the Coloradoan arc. So the drainage basins of the Colorado and Llano Rivers can be considered as having been established when Cretaceous rocks covered all of this territory. As erosion progressed and the Pro-Cambrian areas were cut down these streams were able to keep pace with the general lowering and incline their courses in the Paleozoic rocks. Incidentally each of these streams affords additional evidence to support the idea that Cretaceous strata once covered the area. The depth to which erosion can take place within these rocks has been limited by the resistance of rocks of the Llano and Colorado Rivers. Both of these rivers are cutting rapidly. It is probable, therefore, that the topography of the basin will become less steep in the future, for both of these master streams cut faster than the tributary drainages and will therefore allow tributary streams to deepen their channels.

At present, however, the physiography of this central denuded region may be summed up in the statement that a shallow basin has been etched beneath the level of a pre-Cambrian basin almost or quite free of the older rocks at least, an early stage in a new erosion cycle.

MINERAL RESOURCES.

The mineral resources of the Llano-Burnet region comprise, in the order of their present importance, building stone, rare-earth minerals, iron ore, gold, gypsum, serpentine, talc, phalate, lead ore, pyrite, copper ore, manganese ore, and oil, beside water resources. Of these only the first two are of commercial importance at present, the copper and manganese ores are rare and the oil probably varied, and the value of the resources is in uncertainty. It is impossible to ascertain specifically the value of these natural resources vitally affects the growth of the granite industry. The abundance of granite in the region could have but a small growth. It may be said at once, however, that an enormous quantity of clean granite is once, however, that an enormous quantity of clean granite is present in the region. A number of quarries have been opened in areas more or less broad areas underlain by coarse-grained granites, (2) the medium to fine grained granites, (3) the very coarse grained granites, (4) the coarse to very coarse grained granite, and (5) the very coarse grained granite. All these types of granite are at hand.

Only a few attempts have been made to utilize the marne-

llini mineral resources. The mineral resources of the Llano-Burnet region consist of various types of building stone, rare-earth minerals, iron ore, gold, gypsum, serpentine, talc, phalate, lead ore, pyrite, copper ore, manganese ore, and oil, beside water resources. Of these only the building stone is of commercial importance at present. The other minerals are of little consequence.

BULM STONE.

Building stone is

granite. Granite forms a considerable proportion of the Pro-Cambrian rocks in the Llano and Burnet quadrangles, but unfortunately much of it is of such a character as to be of little or no value as building stone, as it contains abundant schist fragments. Were it not that many extensive areas are underlain by clean stone the granite industry in this region would have been successful. It may be said at once, however, that an enormous quantity of clean granite is available and can be utilized when transportation and market are at hand.

There are two very different types of the granite—the coarse to very coarse grained granite, (2) the medium to fine grained granites, among which a number of varieties may be distinguished. The former is in most areas free from such imperfections as would prevent its use; the latter, in some places, is marred or spoiled by the presence of included schist fragments or of pyrite. Granite forms a considerable proportion of the Pro-Cambrian rocks in the Llano and Burnet quadrangles, but unfortunately much of it is of such a character as to be of little or no value as building stone, as it contains abundant schist fragments. Were it not that many extensive areas are underlain by clean stone the granite industry in this region would have been successful. It may be said at once, however, that an enormous quantity of clean granite is available and can be utilized when transportation and market are at hand.

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crystallized granular schists or gneisses, which have undergone the same degree of metamorphism as the associated rocks. The ore proper consists of ore and lens-like zones of magnesite, with quartz, feldspar, and a little biotite. The deposits are typically bedded or stratiform before being deformed with the foliation of the enclosing schistose rocks. So far as could be observed they form an integral part of the metamorphic zone and have much the same structure as the limestones and graphitic schists. They can be traced along the strike where not concealed or interrupted by intrusive bodies, and they follow the curvatures of the enclosing beds. Their thickness is irregular, and the amount of ore varies from place to place, as shown, for example, by the amount of carbon in the graphitic schist. In places the ore merge into the enclosing rocks through a gradual decrease in the amount of magnesite. Nowhere were outcrop beds observed to cut across neighboring beds, as might be expected of intrusive sheets, nor do lens beds essentially change in character along the strike, at least not more rapidly than a sedimentary one would normally.

Therefore, there is a possibility that the iron ores owe their origin to processes combined with igneous intrusion, the conclusion has been reached after carefully weighing the available evidence, that they are contemporaneous deposits in a sedimentary series, which have been altered to their present form during regional metamorphism.

**Gloss mine**—The Olive iron-ore property is located on Little Llano River about 6 miles east-northeast of Llano, a mile south of Lone Grove post office, and a mile north of the Llano & Texas Central Railroads.

The property has been more extensively developed than any other in the district. It was opened by a shaft in 1892 and the Houston & Texas Central Railroads. The exploration proves that the main mass is cut off below some distance to the southwest. The proximity of the ledge, been carried to its present position. Float ore, which is derived from the overlying Cambrian sandstone and some of which is a fragment of magnetite beyond the west line of the Otto tract. That the ore may continue in this direction is thought to be possible but improbable. The ore, if improved, is a valuable addition to the supply that might be made toward forming the ore range, farther to the north.

The following analyses are given through the courtesy of Messrs. Johnston, Eliot & Co., of Dallas, Tex. Both northwest and southeast of the ore body the surface is largely covered with soil and there are only scattered outcrops of the ore. The writer took carefully a number of average samples, which were assayed with the following results:

<table>
<thead>
<tr>
<th>Location</th>
<th>Analysis</th>
<th>Sample Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface pit (about 60 feet)</td>
<td>5.52</td>
<td>0.015</td>
</tr>
<tr>
<td>Incline, west wall, 80 feet from upper end (core sample)</td>
<td>5.93</td>
<td>0.019</td>
</tr>
<tr>
<td>Incline, east wall, 80 feet from upper end (core sample)</td>
<td>5.90</td>
<td>0.015</td>
</tr>
<tr>
<td>Incline, east wall, 50 feet from upper end (by float)</td>
<td>5.95</td>
<td>0.017</td>
</tr>
<tr>
<td>Incline, east wall, 50 feet from upper end (by float)</td>
<td>5.93</td>
<td>0.019</td>
</tr>
<tr>
<td>Mineral soil (in mixed ore)</td>
<td>5.56</td>
<td>0.010</td>
</tr>
<tr>
<td>Surface pit (five points) near the river</td>
<td>5.60</td>
<td>0.015</td>
</tr>
<tr>
<td>Surface pit (five points) near the river</td>
<td>5.55</td>
<td>0.015</td>
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</tbody>
</table>

The company has had many assays made of material both from the surface and from the cuts and incline. Separate assays of quartz from veins have also been made. In all these samples values higher than those found in the samples collected by the writer were reported. Some of the analyses of quartz are reported to carry exceptionally high values. The sample from the ore taken by the writer at a depth of 9 feet contained 5.62 percent of iron ore.

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<tr>
<td>Incline, east wall, 50 feet from upper end (by float)</td>
<td>5.95</td>
<td>0.017</td>
</tr>
<tr>
<td>Incline, east wall, 50 feet from upper end (by float)</td>
<td>5.93</td>
<td>0.019</td>
</tr>
<tr>
<td>Mineral soil (in mixed ore)</td>
<td>5.56</td>
<td>0.010</td>
</tr>
<tr>
<td>Surface pit (five points) near the river</td>
<td>5.60</td>
<td>0.015</td>
</tr>
<tr>
<td>Surface pit (five points) near the river</td>
<td>5.55</td>
<td>0.015</td>
</tr>
</tbody>
</table>

A cover of red and brown residual soil effectually conceals the underlying deformed schist and schists. This residual soil varies greatly in color, uniformity, and extent. In some areas removal of solutional and eroded parts of the underlying bedrock has exposed the top surface. The principal factor in determining the area which is covered by the residual soil appears to be the rate of runoff. The writer believes that the area which is covered by the residual soil is largely associated with the quartz stringers.
The graphite is seen in schists of the Packardville formation, which in this vicinity contains con-

omenes. Omanite and pegmatite intrusions have locally disrupted the beds.

The deposit is seen as a vein with well-defined boundaries. Its horizontal extent is not well defined.

The deposit was prospected by a shaft with under-

ground workings and a number of crosscuts. About 5,000 tons of 12 per cent graphite ore has been revealed.

At least 30 feet in thickness might be gained that the pegmatite had introduced the graphite. A careful examination of the graphite bunched in the pegmatite shows, however, that they are broken fragments of aplitic gneiss. A specimen was polished and etched with hydrochloric acid, which, by dissolving out the chlorite between the flakes, fragments showed clearly the aplitic nature of the graphite.

As much of the territory included in this property has not been adequately tested by surface core, it is possible that a successful graphite deposit may be established at this point. It may be said in general that it would not be advisable to spend money on prospecting or test drilling until additional information of this text above, prospect, though graphite schists, as stated, occur at many localities throughout the region. It must be born in mind, when making an estimate of the graphite content of a band of schist, that a little graphite makes a striking showing, and appearance is therefore likely to be deceptive.

SERPENTINE.

The Collins property, located 9 miles south of Llano and a little west of the Oxford road, contains about 250 acres lying in a northwest-southeast line, about 11 miles long. On a hillside near the north and of the property is a pit, perhaps 20 feet in diameter and 10 feet deep, dug in serpentinite and exposing on its west side a deposit of serpentine. Serpentine is exposed for perhaps 100 feet east and northeast, and for at least 500 feet southwest and south of this pit. At the foot of the hill a second pit about 30 feet in diameter and 10 or 12 feet deep exposes serpentine rock. Here a diamond-drill boring 275 feet deep did not pass out of the serpentinite. Over the next 25 feet to the south entrance the pit is exposed for 100 feet or more down the slope and a third pit about 10 feet wide, 20 feet long, and 10 feet deep has been opened. Despite the presence of two faults the pit exposure only serpentine.

The dimensions given above indicate a considerable deposit of serpentinite and talc at this locality. Specimens were seen which took a fine polish. The commercial value of such a deposit will depend directly on the demand that can be created for its use.

The deposit is seen as a vein with well-defined boundaries. Its horizontal extent is not well defined.

The talc deposit east of Cedar Mountain is associated with the Packardville schist. This locality, however, is exceptional in that considerable bodies of dioritic rock are intertaced into the schist. The talc in this area is probably in large masses derived from biotite by the hydration of magnesite.

Sulphur occurs at two localities west of Burnet, in the drainage basin of Spring Creek. A fluorite-bearing reef has been opened on the Bailey platz, about 4 miles from Burnet and a mile from the Bluffton road. In this vicinity the rocks are pre-Cambrian in age and consist of quartzschists, gneiss, and quartzite, with interbedded masses of granite and pegmatite. The structural trends are east and west, the rocks, though poorly exposed, evidently being com-

FLUORITE AND SPHALERITE.

Deposits of fluorite carrying irregular amounts of metallic sulphides occur at two localities west of Burnet, in the drainage basin of Spring Creek. A fluorite-bearing reef has been opened on the Bailey platz, about 4 miles from Burnet and a mile from the Bluffton road. In this vicinity the rocks are pre-Cambrian in age and consist of quartzschists, gneiss, and quartzite, with interbedded masses of granite and pegmatite. The structural trends are east and west, the rocks, though poorly exposed, evidently being com-

TAG.

Talc is found at a number of localities in addition to that associated with the serpentinite deposit described above. In the area immediately east of Cedar Mountain numerous small outcrops were seen, though no deposit was mapped separately.
Fluorite accompanied by sphalerite is found at several points on and near the Frank Thomas place, in the upper valley of the north fork of Spring Creek about 7 miles west of Burnet. There are several showings along the north-south trend of the inclining dark hornblende schist. About half a mile north of the dwelling house a shaft has been opened to a depth of 25 feet. Here the last 10 to 15 feet is almost 35 feet thick at the outcrop. The material thrown out of the shaft is a mixture of fluorite, sulphides, and a little quartz. Sphalerite is the most abundant sulphide, but galena, pyrite, and molybdenite also occur. The assay of a carefully taken 3 feet thick at the outcrop. The material thrown out of the shaft is a mixture of fluorite, sulphides, and a little quartz. Sphalerite is the most abundant sulphide, but galena, pyrite, and molybdenite also occur. The assay of a carefully taken specimen shows that the sulphide shows no valuable amounts of gold or silver.

COPPER.

No encouragement can be given that any copper prospect visited during the mapping of those quadrangles will ever be of commercial value.

On both sides of the road about half a mile northwest of William G. Tisdale’s place a shaft 35 feet deep has been opened. Flux of machebelite was noted associated with epidote-green schist. About three-fourths of a mile west of the eastern edge of the Llano quadrangle, 400 feet south of the Mason road, prospecting has been carried on in a hill which is left to the Brewer prospect. At this point schist stricking east and west lie near the edge of a large area of fine-grained granite. An inclined of unknown depth dips 50° S. Carbonates were noted over about 150 feet of prospected ground. No sulphides were seen on the dump. A little grütz was observed. Two centers of ore are reported to have been shipped.

In May’s pasture, 2 miles south of Balchymid, a short dike of the Llano granite, a fine-grained pink granite contains machebelite and some arfvedsonite. About 2 tons of 3 per cent copper is exposed at the surface, and a small trend has been made. There has been some prospecting for copper on Adolf Schneider’s place, 1½ miles north of Llano River, 5 miles east of the Mason County line, on a stream joining the Llano above Bauer’s ford. Three holes to 1½ to 20 feet deep have been sunk in schist, which strikes about north and south and dips 35° E. A little chlorapatite associated with black garnet, epidote, quartz, and a little calcite may be seen in a layer of schist. Carbonates are common, and a few feet deep a little greenish pyrite is seen. The occurrence is in the west side of a tongue of basic rock, which is cut off by a large 30 feet deep. The dip to the east is 25°, and the schist is a little chalcanthite occur in the intrusive granite as well as in the schist, and a microscopic examination shows clearly the secondary nature of the one—that is, it is full of cracks in the feldspars. The solutions which brought in the copper therefore penetrated the rocks after the introduction of the granite and took advantage of fractures existing at this locality. An assay of some specimens collected from a collection in Mr. Schneider’s blacksmith shop gave the following result: Gold, 0.04 per ton; silver, trace; copper, 0.94 per cent.

Other prospect pits were seen on several localities, but none showed any possibilities for the development of an ore body.

MANGANESE.

On the southeast flank of Horse Mountain, 5 miles north of Llano River, prospecting has been done on what is known as the Goff manganese deposit. The schists and gneisses at this point strike N. 11° W. and dip 24° SW.

Two pits were opened here, the southern one 15 feet long on the strike and 12 feet wide on the dip. About 2 feet of manganese oxide is exposed in this pit. Ore must be hauled by horse to begin the primary crushing. Two 50-foot north on the strike a second pit reveals much leaner material.

Both north and south from these pits, at intervals, small showings of gneiss are cropping out. An examination of the pits shows clearly that the oxide present is a decomposition product formed from the alluvium which are seen in place. Both spar apatite (a manganese garnet) and pleonaste (a manganese epidote) occur in considerable abundance. They are associated with iron oxide, forming layers, and probably represent metamorphic equivalents of the original elements in the sediments. Microscopic examination of a specimen shows apatite intergrown with pleonaste accompanied by much muscovite and quartz and some magnetite. Decomposition in this vicinity has extended to very shallow depths and it seems almost certain that the deposits below the oxidized zone, because of their high antimony content, extremity, and hardness, are without commercial value.

An analysis of the Home Mountain ore by R. A. Penrose, Jr., follows:

Analysis of manganese ore from Horse Mountain, Llano County, Texas

<table>
<thead>
<tr>
<th>Material</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetite</td>
<td>24.00</td>
</tr>
<tr>
<td>Dolomite</td>
<td>3.00</td>
</tr>
<tr>
<td>Silica</td>
<td>38.00</td>
</tr>
<tr>
<td>Pyrophyllite</td>
<td>5.00</td>
</tr>
<tr>
<td>Lepidolite</td>
<td>4.00</td>
</tr>
</tbody>
</table>

In Mason County manganese occurs in somewhat the same manner as at Horse Mountain. It has been described in the report just cited.

OIL.

A small oil seepage in a spring near the town of Burnet has been deposited at this point in the cracks and interstices of the neighboring limestone. In Post Mountain, also, a little oil resides is found about 20 feet above the base of the Cretaceous. The beds in which this oil resides is found are very near the base of the Cretaceous system, and consequently only a few feet above the underlying Paleozoic rocks. (See geologic map, PI. I.)

The underlying rocks of the Cretaceous system, on the other hand, have a decided petrolierous character. Though the Trinity formation below has been deposited on Eliannahuman limestones, it is quite possible that a short distance to the east Cretaceous beds, mixed with shale, are susceptible of the Trinity formation and spread laterally for as far west as Burnet. As has been pointed out by Toft and Boyd, the sands of the Trinity formation are of such character as almost to preclude the idea that oil originated in them.

The lack of other indications of oil in other portions of the Trinity in this region, the structurally broken and eroded condition of the underlying Paleozoic, and the petrolierous odor of the Cretaceous beds point to the conclusion that though a small quantity of oil may have passed upward from below, it is extremely improbable that oil in commercial quantities is present in the Burnet and Llano quadrangles.

CEMENT MATERIALS.

A number of specimens of limestone were examined for their magnesia content, with reference to their usefulness in the manufacture of cement. The results were as follows:

<table>
<thead>
<tr>
<th>Percentage of magnesia in limestone from Llano-Burnet and vicinity</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliannahuman limestone on Balchymid Creek near road main</td>
<td>0.50</td>
</tr>
<tr>
<td>Carbonate limestone near Mobile Falls</td>
<td>0.45</td>
</tr>
<tr>
<td>Carbonate limestone near Chalk Knob on road from east</td>
<td>0.40</td>
</tr>
<tr>
<td>Carbonate limestone near Burnet</td>
<td>0.40</td>
</tr>
<tr>
<td>Carbonate limestone in railroad cut north of Llano</td>
<td>0.40</td>
</tr>
</tbody>
</table>

It is evident that magnesia in these rocks would not be a disturbing factor in the manufacture of cement.

WATER RESOURCES.

RAINFALL.

The central Texas region has a climate bordering on the semiarid. Cotton seems to thrive there, but the region has had a distressing record of other crops either injured or completely destroyed by droughts. The annual precipitation averages about 20 inches. Unfortunately, however, this supply is not distributed equally over the season, being concentrated more or less in the spring and fall, with occasional summer rainfalls. The failure or partial failure of this supply at any one of these periods results in loss to either the farmers or the stockmen. The range depleted by cattle during the winter are dependent on the spring rains; the crops are directly dependent on occasional showers throughout the summer; and the stockmen are forced to appear in response to the pressure or absence of autumnal precipitation. A portion of the annual precipitation is lost by evaporation immediately or soon after falling; a portion sticks in the soil and crevices in the rocks; and a portion runs off in the streams. The recoverable portion will be briefly discussed.

STREAMS.

There are two types of streams in the region,—(1) the through-flowing rivers, the Llano and Colorado, and (2) sub-sidary drainages, tributaries of the Llano and the Colorado and of other streams. The flow of Colorado River is extremely variable and is subject to rapid rise with occasional floods. At Austin the stream, when low, discharges from 900 to 400 second-feet; when "up" it discharges 8000 second-feet or more. Llano River discharges at low water about 75 second-feet and, like Colorado River, increases its discharge enormously when precipitation is heavy within its drainage basin. Along both of these streams irrigation has been practiced on a small scale, and on both also there are dams suitable for the development of water power. At Llano a concrete dam furnishes power for electric light and other purposes, and at Marble Falls a concrete dam of considerable dimensions is being built on Colorado River. As the stream of these streams passes through a perennial flow, ranches along their courses have an ample supply of water and can be irrigated by pumping with gasoline or other engines to be driven from the stream itself. (See geologic map, PI. II.)

The lack of other indications of oil in other portions of the Trinity in this region, the structurally broken and eroded condition of the underlying Paleozoic, and the petrolierous odor of the Cretaceous beds point to the conclusion that though a small quantity of oil may have passed upward from below, it is extremely improbable that oil in commercial quantities is present in the Burnet and Llano quadrangles.
Of a very different character, however, are most of the streams in the pre-Cambrian basin. The beds of these are filled with an increasing load of sand. During most of the year they are to all appearances dry, and it is only by digging in their beds that water can be found. Uninviting as they appear, however, they furnish with a little labor sufficient water for the ranges through which they flow. Among the factors which bring about this overloaded condition of the pre-Cambrian streams are the occasional torrential rains, the stripping of vegetation from the granite areas by overstocking of ranches, and the rapid disintegration of the bare rocks, a result of alternating hot days and cool nights.

**SPRINGS.**

The springs of the area have been described under the heading "Drainage." They are important in that they give rise to a number of perennial streams and afford water for cattle in many areas that would otherwise be quite worthless for grazing.

**WELLS, TANKS, AND CISTERNS.**

Where springs or streams are not available wells furnish the necessary water supply, if the season is favorable. Wells are very generally distributed throughout the region. In the pre-Cambrian area they are dug either in soil, granite, or schist, and to only moderate depths. The water which they furnish is derived entirely from the supply held in the porous surficial material or in fissures or joints in the upper portion of the bedrock. As these joints and fissures are distributed with extreme irregularity, the successful location of wells becomes more or less a matter of chance. Inasmuch, however, as the rocks are generally much fractured, usually but little difficulty is encountered in obtaining a moderate supply of water. This supply, however, is dependent on rainfall, and in times of protracted droughts many wells go dry and water must be hauled.

In some areas underlain by limestones wells must be sunk to greater depths, for in these rocks water channels are likely to be more localized and unless a channel is struck a well may be sunk many feet without success.

In the Cretaceous areas wells usually encounter water at some horizon in the Trinity formation. Farther east, where deeply buried beneath overlying rocks, this formation is an extremely important factor in underground water supply.

In many places cisterns are constructed and the drinking supply for a season caught during the cold winter rains. Locally, too, cisterns are filled during winter with river water. This device insures a supply of cool water during the summer.

On the cattle ranges where other supplies are not at hand artificial ponds, locally termed tanks, are constructed by building earthen dams across small streams and are filled during heavy rains. Some of these tanks are of considerable size and water many head of stock. To guard against drought many of them are equipped with wells and windmills.

**SUMMARY.**

In conclusion it may be said that no abundant supply of underground water is to be expected in the area underlain by pre-Cambrian rocks; that in the Paleozoic areas the structure is not such as to promise more than a moderate supply for local use; that in the Cretaceous areas of the region the Trinity formation is not buried deep enough to give more than a moderate supply for purposes of stock raising, etc.; that irrigation on a moderate scale can be practiced along both Colorado and Llano rivers by utilizing the rather steep gradient of the rivers either for power or small ditches; and that much of the country must continue to depend on rainfall for its water supply.

January, 1912.