Geology and Ore Deposits

of the

Little Dragoon Mountains

by

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INTRODUCTION

Field Work

This report is based upon field work done in the summer of 1937 and on week ends during the school year of 1937-38, and upon laboratory investigations at the University of Arizona during the school year of 1937-38.

As no adequate topographic map of the region was available, the first step was to make one. A base line was set up on the eastern slope of the Little Dragoon Mountains, a transit and steel tape being used to measure it. The azimuth of this base line was established by solar observations. By means of a transit a triangulation system was extended from the base line into the area. The altitude of a station on Lime Peak was established by an observation from a United States Geological Survey bench mark stamped 156H 1907 which is situated on the right of way of the Southern Pacific Railway one-quarter mile southwest of the station at Dragoon, Arizona. The vertical angle was measured by use of the Stebinger drum on an alidade and the horizontal distance was scaled off upon a photograph of the region taken by Fairchild Aerial Surveys. A map on the scale of 1 inch equals 1,000 feet was made by plane table and alidade.

Acknowledgments

The writer wishes to acknowledge the work done by the entire faculty of the Department of Geology of the University of Arizona in criticizing and correcting his manuscript, and the help of Professor A. A. Stoyanow of this department in the identification of fossils and the solution of stratigraphic problems. Acknowledgments are also due to F. Stearns Cook and Arthur Peck Jr. for aid in mapping the area covered in this report.

The writer extends his thanks to the owners and the manager of the Seven Dash ranch for their hospitality. He wishes especially to thank Mr. Brian Whalen, manager of this ranch.

Previous investigations

Prior to 1925, the only literature available on the area was in the form of short reports concerning the mining district around Johnson, the best one of which was written by L. O. Kellogg and published in Vol. 1 of Economic Geology in 1906. In 1925, N. H. Darton of the United States Geological Survey made a reconnaissance survey of the area which was covered in one short paragraph in his bulletin No. 119, "A Resumé of Arizona Geology" published by the University of Arizona. In 1927, Robert E. S. Heineman wrote a master's thesis on

"The Geology and Ore Deposits of the Johnson Mining District, Arizona", which offers the best information available on the mining district of the area. In 1938, F. Stearns Cook wrote a master's thesis, "The Geology of the Seven Dash Ranch Area, Cochise County, Arizona", based upon information he had collected during 1937 while engaged with the writer in examining the area. The geological map prepared by Cook and much of the information gathered by him is, with his consent, incorporated into this report.

GEOGRAPHY

Location

The area under consideration covers the eastern half of the Little Dragoon Mountains which are about seven miles northwest of the town of Dragoon, Cochise County, Arizona, in T. 15 S., R. 22 E., measured from the Gila and Salt River principal meridian and base line. The area covers approximately seven square miles. The Seven Dash ranch, which is in the heart of the area and which served the writer as a base of operations, can be reached by a thirteen mile dirt road from Willcox. Both Willcox and Dragoon are on the Southern Pacific Railway and Arizona State Highway No. 86.

Climate

The region is typically semi-arid, the rainfall averaging only sixteen and one-half inches. The precipitation comes in two rainy seasons, one during the winter months and one during July and August. Much of the rain comes as sudden violent downpours which wash loose debris down the hill slopes and fill the usually dry stream beds with rushing torrents. Most of the degradation of this area is carried on by these "cloud bursts." With the exception of one spring, located on the southeastern flank of the range, all water supplies are obtained from wells.

The region experiences a considerable range of temperature. During the summer the temperature may rise as high as 100 degrees Fahrenheit, but owing to the elevation, which is 5,200 feet at the ranch, the nights are cool. The daily temperature range under these conditions may amount to as much as fifty degrees. This is an important factor in the erosional processes of the region and the hillsides are mantled with more talus than the short but violent rainstorms can carry away. Although the abundant sunshine keeps the days comfortable, freezing nights are common during the winter months, and a few light snows are to be expected.

Flora and fauna

The rocky slopes of the region support a scanty vegetation, and the floors of the canyons have a much heavier mantle. On the slopes cactus is abundant, especially the rainbow, barrel, and prickly pear. Other plants and shrubs are agave, yucca, catclaw, manzanita, and mesquite. On the northern slopes piñon, juniper, and mountain ash grow. In the canyons live oak, walnut, and here and there a cottonwood, are found as well as heavier growth of the plants found on the slopes. Grass grows everywhere but on the very steepest slopes and supports the cattle from the Seven Dash ranch.

Game is abundant, especially Gambels quail, rabbits, and deer. Bobcats and coyotes seem to thrive on the game. Rattlesnakes are scarce, but king snakes are more abundant.

PHYSIOGRAPHY

The Little Dragoon Mountains lie in what Fenneman[1] terms the Mexican Highlands, which is a subdivision of Gilbert's[2] Basin and Range province. Like the Great Basin, the Mexican Highland is half mountain and half plain and differs from the Sonoran Desert in that the latter has a larger proportion of desert plains and is, in general, lower. The mountains in the Little Dragoon area rise from the San Pedro Valley on the west and the Sulphur Springs Valley on the east to an elevation of 6,700 feet. They are about ten miles long and eight miles wide and trend in a general north-south direction. In the Texas Canyon region at the south end of the range erosion is guided by faulting and jointing in a homogeneous igneous rock, and features such as "hoodoos", balanced rocks, and rounded boulders typical of weathering of this type of rock in a semi-arid climate are the result. In the main range of the mountains the controlling features are faults and the variable resistance of the tilted sedimentary and metamorphic rocks.

The prominent ridge capped by cliff-forming Escabrosa limestone is the main topographic feature. It is

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[1] Fenneman, Nevin M., - Physiography of the Western United States: McGraw-Hill Book Co., p. 379-393, 1931.

[2] Gilbert, G. K., - Report upon the U. S. Geol. Surveys west of the 100th meridian, vol. 3, p. 21-42, 1875.

broken into isolated peaks in places by several fault-guided depressions. The division of Lime Peak from Little Lime Peak in the eastern part of the range is an excellent example. Encircling these main peaks on the north, south, and west, are secondary ridges formed by the resistant Cambrian and pre-Cambrian quartzites. The soft Cambrian sandstone above the Pioneer shale, and the Pinal schist below the quartzite form gentler slopes. At the extreme northeast where the sediments dip under the valley floor, subdued hills with rows of prominent ridges are formed by alternating hard and soft limestone beds of the Naco formation. Other prominent features are the dike-like walls formed by vertical layers of purple quartzite, and by outcrops of dazzling white vein quartz in the soft Pinal schist. Many of the deep narrow canyons of the region are guided by faults.

STRATIGRAPHY

Sedimentary rocks

Apache Group. Lying with angular unconformity upon the Pinal schist is the Apache Group of Ransome.[3] Originally placed in the Cambrian, but more recently considered Proterozoic it has been placed in the latter division by the writer.

Exclusive of the Troy quartzite which has been shown to be Cambrian in age, the standard section of the Apache group in the Mescal Mountains, according to Ransome,[4] is as follows:

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        Troy Quartzite
        .
        . Vesicular basalt flow. 25-75 feet
        . Mescal limestone.        225 feet
        .   Thin, varicolored, more or less dolomitic beds
        .   with conspicuous cherty layers.
        . Dripping Spring quartzite 450 feet
        .   Fine-grained, varicolored, arkosic quartzite,
Apache. .   much of it with dark red and gray banding.
Group   .   Partings between beds not distinct. Ripple marks.
        . Barnes conglomerate.   10-55 feet
        .   Well-rounded pebbles of hard white or pink
        .   quartzite, with some white vein quartz imbedded
        .   in matrix of arkosic grit.
        . Pioneer shale.           150 feet
        .   Maroon shale, arkosic and quartzitic near the base.
        . Scanlan conglomerate.   0-15 feet
        .   Imperfectly rounded pebbles of white vein quartz
        .   and schist in a matrix of local derivation.
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        Pinal Schist
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[3] Ransome, F. L., - Geology of the Globe copper district, Arizona: U.S. Geol. Survey Prof. Paper 12, p. 28-39, 1903.

[4] Ransome, F. L., - Some Paleozoic sections in Arizona and their correlation: U.S. Geol. Survey Prof. Paper, 98k, 1916.

In Peppersauce Canyon in the Santa Catalina Mountains the section of the Apache group, according to Stoyanow,[5] is as follows:

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        Troy Quartzite
        .
        . Un-named sandstone.        325 feet.
        .   Purple sandstone of angular quartz grains
        .   in a sericitic matrix. Intraformational
        .   conglomerate 30 feet thick at base. The
        .   upper 150 feet are slabby and show mud
        .   cracks near top.
        . Dripping Spring quartzite. 300 feet.
        .   Fine-grained arkosic yellow to brown quartz-
Apache. .   ite as in type section.
Group   . Barnes conglomerate.        37 feet.
        .   As in type section.
        . Equivalent of Pioneer shale. 385 feet.
        .   At the base light gray coarse-grained sand-
        .   stone, with well-rounded pinkish pebbles in
        .   sericitic matrix, 120 feet. Above it is a
        .   mottled, banded, fine-grained, red to gray
        .   quartzite.  The upper member is a hard,
        .   slaty, light gray shale, sandy and micaceous
        .   near the top.
        . Scanlan conglomerate. 3 plus or minus feet.
        .   As in type section.
        .
        Granite (Archean)
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Both the Mescal limestone and the basalt are missing in the Little Dragoon Mountains. Although the rest of the group are present they are much thinner than in their type section which is northwest of this area. A thinning toward the southeast is also noted in the Little Dragoon Mountains themselves, and in the Dragoon Mountains ten miles southeast of the Little

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[5] Stoyanow, A.A., - Correlation of Arizona Paleozoic formations: Bull. of the Geol. Soc. of Amer., vol. 47, p. 477, 1936.

Dragoons, the Apache group is absent.

1. Scanlan conglomerate.

At the base of the group is a conglomerate varying from several inches to a maximum thickness of six feet. This conglomerate is composed of angular or slightly rounded pebbles of white crystalline quartz, a few red jasper pebbles and some fragments of Pinal schist. These are closely packed and cemented by a purplish gritty matrix.

2. Pioneer shale.

The Scanlan conglomerate underlies and grades upward into the Pioneer shale. This member varies in thickness from 300 feet in the northern part of the area to twenty feet in the extreme southeast. At the base is a massive blue to purple, coarse-grained sandstone pebbly in places and containing gray and brown bands. Several lenses of conglomerate similar to the Scanlan conglomerate but extremely thin are found in this basal portion of the Pioneer shale. This lower sandstone grades upward into a cross-bedded, ripple-marked sandy shale containing a few soft sandstone lenses. The shale varies in color from purple to maroon, is banded with purple, gray, and brown bands, and contains many irregular bleached spots. At the top is a hard, cross-bedded sandstone. The member as a whole is soft and well-jointed and weathers to angular, blocky fragments, and subdued slopes.

Near the top a diabase sill varying from five to 74 feet in thickness is found in several places intruding the shale and altering it to some extent.

3. Barnes conglomerate.

Resting conformably upon the Pioneer shale is the Barnes conglomerate. This member is a thin, persistent conglomerate composed of well-rounded pebbles of white vein quartz, brown quartzite, and jasper, some of which is banded with white quartz in a matrix of rather coarse arkosic sandstone which graded into quartzite in places. The matrix varies in color from gray to purple or pink. The pebbles range from one to six inches in diameter, but the majority are approximately two inches in diameter. The conglomerate is very resistant and shows prominent outcrops. Its thickness varies from five to fifteen feet, thinning toward the southeast.

4. Dripping Spring quartzite.

Overlying the Barnes conglomerate is a layer of quartzite and hard sandstone from twenty to 135 feet in thickness, prevailingly pink to purple at the bottom, but grading upward into brown and gray. This material ranges from a medium-grained, hard sandstone at the bottom to a fine-grained, hard quartzite at the top. It ordinarily forms cliffs with the Barnes conglomerate and the overlying Cambrian quartzites.

Cambrian.

1. Troy-Bolsa quartzite.

Resting with seeming conformity on the Dripping Spring quartzite is another quartzite formation. At the base a layer of conglomerate consisting of pink, flat, angular pieces of Dripping Spring quartzite in a purple quartzite matrix may or may not be present. This conglomerate reaches a maximum thickness of seven feet near station XI. It thins both north and south of station XI and eventually disappears, but is found again toward the extreme southwestern portion of the area where it is about six inches thick. Overlying the conglomerate where it is present, or resting with smooth but discernable contact on the Dripping Spring quartzite where the conglomerate is absent, is a reddish to tan quartzite, cross-bedded, fine-grained, and hard. In places it is flesh-colored with distinctive wavy lines in white. This is at maximum thickness toward the northern part of the area, where it reaches thirty feet, and thins toward the southeast, although it is nowhere entirely absent. This red to tan member grades upward without appreciable break into a tan to white, hard, fine-grained, cross-bedded quartzite. At the top of this upper quartzite are found several soft, rusty layers of sandstone containing worm casts. This quartzite also is at a maximum in the northern part of the area but thins only slightly toward the southeast, where it is about fifty feet thick. Both members are hard and cliff-forming.

The upper tan to white quartzite resembles the Bolsa quartzite, originally described by Ransome,[6] outcrops of which the writer has inspected at several places. In the Dragoon Mountains about ten miles southeast of the Little Dragoons undoubted Bolsa quartzite with a basal conglomerate of schist fragments and white vein quartz overlies the Pinal schist. In the Whetstone Mountains 25 miles west of the Little Dragoons, the Bolsa quartzite contains worm casts similar to those found in this quartzite and is very similar in appearance. However, the Bolsa quartzite in the Dragoon and Whetstone Mountains is much thicker than the white quartzite in the Little Dragoons.

Eighty miles northwest of the Little Dragoons in the Santa Catalina Mountains, the Apache group is overlain by the Troy quartzite which, at that point, is tan to yellow to pink, cross-bedded quartzite, 350 feet thick.

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[6] Ransome, F. L., - Geology and ore deposits of Bisbee quadrangle of Arizona: U.S. Geol. Survey Prof. Paper 21, p. 28-30, 1904.

In its type locality in the Mescal Mountains, Ransome[7] describes it as 400 feet of generally pebbly, cross-bedded, quartzite with lenses of conglomerate and containing rusty beds with worm casts near the top.

In view of these facts and considering the difference in color and lithologic character of the two members of the quartzite overlying the Dripping Spring quartzite in the Little Dragoons, it seems reasonable to suppose that here is the meeting and overlap of the basal members of the Cambrian in southern Arizona; the bottom member of the quartzite being the Troy which is thinning toward the south, and the top being the Bolsa thinning toward the north. This fits well with Stoyanow's division of the Cambrian of southern Arizona into two depositional sub-areas, the Tucson-Globe sub-area and the Bisbee-Tucson sub-area. The writer realizes that the Troy quartzite also has rusty sandy beds with worm casts at the top, and that the whole Cambrian quartzite might well be Troy, but he thinks the evidence points to the first explanation.

The vertical gradational contact between the two members would seem to indicate that they were of essentially the same age, thus justifying Stoyanow's correl-

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[7] Ransome, F. L., - Some Paleozoic sections in Arizona and their correlation: U.S. Geol. Survey Prof. Paper 98k, p. 139, 151, 1916.

ation of the Troy and Bolsa.[8] With the exception of worm casts in the upper member no fossils were found in this formation, but as the Troy has been proved to be of Middle Cambrian age, this quartzite is also placed in the Middle Cambrian.

2. Santa Catalina formation.

Conformably overlying the Troy-Bolsa quartzite is a formation about 45 feet thick composed of thin-bedded sandstone and quartzite, and sandy shale of reddish brown color containing some layers of greenish, impure limestone and shale near the base,and hard, gray, pure limestone near the top. Weathered outcrops of this formation show a characteristic laminated appearance. This formation is similar to the formation described by Stoyanow as overlying the Troy quartzite in the Santa Catalina Mountains which he named the Santa Catalina formation,[9] although it is much thinner in the Little Dragoon Mountains and contains more limestone. In both the Santa Catalina and the Little Dragoon Mountains the formation is characterized by the same undescribed

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[8] Stoyanow, A.A., - Correlation of Arizona Paleozoic formations: Bull. of the Geol. Soc. of America, vol. 47, p. 480, 482, 1936.

[9] Idem., p. 476.

trilobite of which only the cranidia are well preserved. Although this trilobite is also found in the basal variegated shales of the Cochise formation, the lithologic character and the absence of the Pima sandstone indicate to the writer that this is not part of the Cochise formation. The Santa Catalina formation, like the underlying Troy-Bolsa quartzite is of Middle Cambrian age.

3. Cochise formation.

The Santa Catalina formation is overlain by two feet of pisolitic gray limestone and eleven feet of grayish-green, limy sandstone, followed by eighteen feet of black shale and capped by eighteen feet of gray limestone and sandstone beds. This formation contains *Alokistocare* sp. and *Obolus* (*Westonia*) *euglyphus* (Walcott) and is Middle Cambrian in age. The presence of the pisolitic limestone, of *Alokistocare*, and the brachiopods led the writer to believe that this formation is equivalent to the upper part of Stoyanow's Cochise formation whose type locality is in the Whetstone Mountains. If this be true, another overlap of sediments from the Bisbee-Tucson sub-area over sediments of the Tucson-Globe sub-area is indicated, as this is the first place these two formations have been reported together. The age relations of the two formations correspond to Stoyanow's correlation of the upper part of the Santa

Catalina formation with the lower part of the Cochise formation.[10]

4. Abrigo formation.

Ransome described the Abrigo in its type locality at Bisbee as being "thin-bedded, impure, in part shaly, in part arenaceous, very cherty, dolomitic limestone" and stated that it contained Middle Cambrian fossils.[11] Walcott, who determined the age of the formation from material gathered by Ransome, later mentioned Obolus tetonensis Walcott, Obolus zetus Walcott,[12] and Crepicephalus texanus (Shumard) [13] as being found in the Abrigo. Obviously the beds containing Crepicephalus texanus are younger than the rest and are not Middle Cambrian but Upper Cambrian. Stoyanow subdivided the original Abrigo and defined the base of the Abrigo by the appearance of Crepicephalus texanus (Shumard), Hesperaspis butleri Stoyanow, and Hesperaspis ransomei

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[10] Op. cit., - p. 482

[11] Ransome, F. L., - Geology and ore deposits of Bisbee quadrangle of Arizona: U.S. Geol. Survey Prof. Paper 21, p. 30-33, 1904.

[12] Walcott, C.D., - Cambrian brachiopoda: U.S. Geol. Survey Mon. 51, p. 417, 422, 1912.

[13] Walcott, C.D., - Cambrian geology and paleontology: Cambrian trilobites: Smithson. Misc. Col., vol. 64, No. 3, p. 213, 1916.

Stoyanow.[14] Crepicephalus texanus persists through the entire formation, whereas Herperaspis fauna is characteristic of the base.

The Abrigo in the Little Dragoons consists of 135 feet of gray limestone with sandy laminations and a few brown shale lenses. The base of the formation contains the Hesperaspis fauna. This is followed by 21 feet of massive, cross-bedded, reddish brown, sandstone with interbedded thin quartzites, and capped by 42 feet of sandstone interbedded with gray dolomite. The top 42 feet becomes brown and laminated on weathering.

In several places a thin diabase sill intrudes the formation about 100 feet from the base.

5. Peppersauce Canyon sandstone.

Overlying the Abrigo formation are ten to fifteen feet of alternating thin-bedded white quartzite and coarse, porous, brown sandstone. Although no fossils were found in this formation it is lithologically identical with the Peppersauce Canyon sandstone as exposed in the type locality of Peppersauce Canyon which the writer has carefully examined. This sandstone was originally described by Stoyanow.[15]

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[14] Op. cit., - p. 466-472, 482.

[15] Op. cit., - p. 476-478.

Devonian.

Martin limestone.

The Martin limestone of Upper Devonian age was named and described by Ransome from the Bisbee area.[16] In its type locality it comprises beds of dark gray, hard, compact, limestone, generally fossiliferous, associated with which are here and there beds of lighter hue and in some places calcareous shales of a pink tint.

In the Little Dragoons the Devonian is represented only by the Martin limestone. It lies with apparent conformity on the Peppersauce Canyon sandstone and is composed of 112 feet of gray dolomite capped by 10-20 feet of pink to yellow friable shale. The basal 58 feet of dolomite is interbedded in places with hard, brown, sandstone, and in places is very impure, weathering to brown sandy material. The upper 54 feet of dolomite is massive and stylolitic and contains *Atrypa reticularis* (Linné), reefs of *Cladopora* sp. and *Nortonechinus welleri* Thomas. *Nortonechinus welleri* is reported here for the first time in Arizona, but its discovery is not surprising. Williams as early as 1904 pointed out the

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[16] Ransome, F. L., - Geology and ore deposits of Bisbee quadrangle of Arizona: U.S. Geol. Survey Prof. Paper 21, p. 33-35, 1904.

similarity between the fauna of the Martin limestone and that of the Hackberry shale of Iowa.[17]

Mississippian.

Escabrosa limestone.

At Bisbee Ransome described the Escabrosa limestone of Lower Mississippian age as being composed of rather thick-bedded, white to dark gray, granular limestone, made up largely of crinoid stems, as a whole non-magnesian, containing no sandy strata, and very little chert.[18]

The Escabrosa limestone of the Little Dragoon Mountains, although similar to the foregoing in many respects, differs in others. As elsewhere it lies conformably on the Martin limestone and is about 750 feet thick. At the base is fifty feet of massive black dolomite containing Mississippian corals. Above this is massive, dense to granular, gray to white, limestone with several gray to black dolomite layers. In places the massive limestone is made up almost entirely of crinoid stems and in places it contains considerable chert. The Escabrosa limestone is, in general, cliff-

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[17] Op. cit., p. 38.

[18] Op. cit., p. 42-44.

forming and resistant and forms the capping for the Little Dragoon Mountains.

In addition to the crinoid stems, large reefs of Syringopora sp., Productus (Echinoconchus) punctatus Martin, Productus alternatus Norwood and Pratten, Spirifer centronatus Winchell, and fragments of cup corals have been found in the Escabrosa limestone of the Little Dragoons.

In several places at or near the contact with the Pennsylvanian limestone is a four foot sill of diabase.

Pennsylvanian.

Naco limestone.

Ransome described the Naco limestone of Pennsylvanian age at Bisbee as being made up chiefly of light colored beds consisting of $CaCO_3$ essentially.[19] It differs from the Escabrosa limestone in being compact and nearly aphanitic, while the Escabrosa is more granular and crystalline.

The Naco limestone in the examined area of the Little Dragoons appears at the extreme southeast corner

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[19] Op. cit., p. 44-46.

and dips under the valley fill to the east. It is composed of dark gray to black, dense, rather thin-bedded limestone. Alternating beds two to three feet in thickness dipping at a steep angle to the northeast stand up in the form of ridges. Lenses and bands of cherty material are common. Although the Upper Mississippian is missing, the contact between the Pennsylvanian and the Lower Mississippian seems to be gradational and conformable and could not be located accurately within about fifty feet. Pennsylvanian fossils were found approximately fifty feet above the chosen contact and typical crinoidal Escabrosa limestone just below it. At the contact chosen, massive, granular, white limestone changes rather abruptly to thin-bedded dense black limestone.

Fossils identified in the Pennsylvanian were: *Spirifer rockymontanus* Marcou, *Chaetetes milleporaceous* Edwards and Haime, *Productus cora* D'Orbigny, and *Spiriferina kentuckyensis* Shumard.

Quaternary.

Quaternary deposits of alluvium are mainly in the bottoms of canyons at the foot of steep slopes on the north, east, and south sides of the area. The coarse débris comes mostly from the cliff-forming Escabrosa limestone, but some is from the Martin limestone and locally fragments of Cambrian limestone, sandstone, and quartzite are found. The débris is washed from the steep sides of the mountains and is deposited in the canyon floors where the gradient becomes more gentle. In many places this material has been cemented by a limy cement forming a coarse conglomerate composed of angular fragments of limestone, with a subordinate amount of sandstone and quartzite fragments. Due to changes in the stream bed or renewed activity of the stream this material is in places dissected, forming narrow, vertical walled, canyons in the stream valley. These canyons may be as deep as fifteen feet. In other places the débris collects merely as coarse, loose, alluvium. The finding of limestone boulders and gravel in the alluvium is very interesting as, due to the high solubility of $CaCO_3$, these are seldom, if ever, found in a more moist climate or even in arid regions more remote from the source of limestone than the region under discussion.

Only the thicker deposits of alluvium were mapped. Where the underlying rocks could be determined the alluvium was ignored.

Igneous rocks.

Texas Canyon granite.

Although the Texas Canyon granite does not crop out in the area studied by the writer, the ore deposits of the area are presumably emanations from this stock and much of the structure is probably due to it, so a brief description of the granite seems desirable.

There are at least 25 square miles of the granite exposed in the region of Texas Canyon and in the foothills on the south side of the Little Dragoons. The following discription is from Heineman's thesis on the Johnson mining area.[20]

"The rock has a porphyritic texture and is remarkable for the large size of the orthoclase phenocrysts, which may reach a length of two inches or more and a width of over an inch. They stand out very prominently on weathered surfaces. These large crystals are untwinned, as far as was observed.

"At the margin of the granite is a border phase. The orthoclase crystals become smaller in size, and at the contact the texture may be aplitic and hard to distinguish in hand specimens from the aplite of the dikes occurring in the district.

"Fairly large grains of quartz are seen in hand specimens of the granite, as well as large and small crystals of feldspar and small flakes of brown biotite.

"Under the microscope the granite was found to consist of the following minerals: about equal parts of

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20 Heineman, R.E.S., - Geology and ore deposits of the Johnson mining district, Arizona: Univ. of Ariz. Master's Thesis, 1927.

plagioclase and orthoclase. The plagioclase is acid oligoclase. ---------- The granite is sodic as shown by the presence of microperthite and microcline. The feldspars are somewhat altered to sericite and paragonite. Some muscovite is also present, but biotite is the predominant mica. Some of the biotite is altered to chlorite. Quartz is present in the large scattered grains noticed in the hand specimens. There is a little apatite in typical rod-shaped crystals. A few small grains of a mineral with a higher index than sericite were seen. These may be garnet showing optical anamolies. A little magnetite occurs in small disseminated grains."

Heineman found the granite cutting Carboniferous limestone, thus dating it as of post-Carboniferous age.

Diabase.

Four diabase sills intrude the sedimentary rocks of the area. Although no connection has been observed between the various sills, the very fact that the area has been intruded by four diabase sills and no other igneous rocks, and a general similarity in composition as well as texture suggest that they might come from a common source. All show an ophitic texture and are composed of a plagioclase feldspar close to the oligoclase-andesine boundary and an intensely altered ferromagnesian mineral, probably originally hornblende, and usually abundant magnetite.

I. The thickest sill intrudes the Pioneer shale a few feet below the Barnes conglomerate. It varies from five to 74 feet in thickness. As would be expected, the thickest portions are much coarser grained than the thinner parts of this sill and the other thinner sills. It is a dark green, dense rock weathering to a soft brown mass and showing small feldspar laths in the thicker portions of the sill.

In thin section the rock is seen to be composed of 47 percent oligoclase in well formed laths, some as much as two millimeters long, intensely altered to sericite or paragonite. About 38 percent of the rock is epidote and chlorite in small grains and intergrown as large irregular masses iron-stained in places. Epidote and chlorite are present as alteration products of an original ferromagnesian mineral. Upon examining a specimen of this same sill in the Seven Dash Ranch area, Cook states that the original ferromagnesian minerals were hornblende and biotite.[21] Fifteen percent of the rock is magnetite, the grains reaching one millimeter in diameter.

II. Near the top of the Abrigo formation a sill from one to three feet thick is found. It is a dense, dark green rock, showing no phenocrysts and weathering readily to a soft olive green to brown material. Plagioclase feldspar close to the oligoclase-andesine border in well formed laths up to 0.5 millimeters long form 65

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[21] Cook, F. Stearns, - The geology of the Seven Dash Ranch area, Cochise County, Arizona: Univ. of Ariz. Master's Thesis, 1938.

percent of the rock. The feldspar is partially altered to sericite or paragonite and kaolin, a ferromagnesian mineral, now almost entirely altered to chlorite, and a little magnetite make up the balance of the rock.

III. In the Martin limestone is a third diabase sill about one foot thick. It is usually completely altered and little could be determined concerning its original composition. It is a soft, dense, brown rock. In thin section well-defined laths composed of white mica and iron-stained kaolin were observed, evidently the alteration product of a feldspar. This formed about forty percent of the rock, 55 percent was chlorite, and about five percent magnetite. Despite the alteration the ophitic texture was well shown.

IV. Near the observed contact of the Mississippian and Pennsylvanian limestones another thin, much altered sill is found. The rock is dense, brown, and soft, and made up of sericitized feldspar, epidote, chlorite, magnetite, and hematite. The grains and crystals were very tiny, but again good ophitic texture was observed.

<u>Vein quartz</u>.

In the Pinal schist are several veins of dazzling white quartz. That these are pre-Cambrian can be determined from the fact that they are bevelled off by the overlying Scanlan conglomerate. This conglomerate contains much angular vein quartz seemingly identical with that found in the veins in the schist. The quartz veins are much harder than the soft schist in which they occur and form prominent outcrops.

Metamorphic rocks.

Pinal schist.

The basement rock of the Little Dragoon area is the Archean Pinal schist. The Pinal schist was originally described by Ransome from the Pinal Mountains from whence it derived its name.[22] It was described as follows:

> "With the exception of occasional bands of greenish amphibolite, the Pinal schists are generally rather light gray in color with frequently a silvery satiny luster. In texture they range from cryptocrystalline slaty sericite schists, through fine granular fissle rocks of somewhat sugary texture to imperfectly cleavable, highly crystalline, muscovite schists."

Microscopically they were described as aggregates of quartz and muscovite, a little microcline and plagioclase, iron ore, zircon, tourmaline, hornblende, biotite, and chlorite. The amphibolite schist is a green rock with fibrous texture containing mostly green hornblende, quartz, and epidote, with smaller amounts of biotite, chlorite, and magnetite. Andalusite and sillimanite are in places abundant.

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[22] Ransome, F.L., - Geology of the Globe copper district, Arizona: U.S. Geol. Survey Prof. Paper 12, p. 23-28, 1903.

In respect to their origin Ransome states:

> "The preponderance of quartz and muscovite together and the general absence of calcic minerals are strongly indicative of the derivation of the Pinal schists from quartzose sediments."

Partly metamorphosed beds of grit found in the schists and banding are additional data that support this theory.

In the Little Dragoon Mountains the predominant type of schist is a fine-grained sericitic variety. It varies in color from light silvery gray to greenish brown, depending upon the amount of chlorite and other dark constituents it contains, and most specimens show a very perfect schistose cleavage. Microscopic examination shows it consists ordinarily of more than sixty percent sericite, from five to 35 percent chlorite, and from five to 25 percent quartz as fine grains and veinlets. Garnet is commonly present as an accessory mineral occurring in small rounded grains or larger euhedral crystals.

A second type of schist is a medium-grained, gritty rock of silvery gray color exhibiting very imperfect schistosity. An examination of thin sections of this type of schist reveals a composition of seventy percent quartz in grains varying from very small to 1.8 millimeters in diameter. Sericite and chlorite, forming about thirty percent of the material, is intimately mixed with the small quartz grains forming a ground mass in which the larger quartz grains are imbedded, making typical "augen" structure. Accessory minerals are small grains of andesine and microperthite and irregular fragments of garnet.

A green amphibolite, and lenses of hard, reddish purple quartzite appear in the schist at several places. Good outcrops of both can be found in the hills a short distance south of the Seven Dash Ranch.

The amphibolite is bright green in color, soft, and exhibits poor schistosity. It is composed of seventy percent green hornblende, chloritized in part. The hornblende particles are three millimeters or less in diameter. Laths of plagioclase feldspar partially altered to white mica and kaolin make up twenty percent of the rock. Grains of magnetite, quartz, and epidote, and a few garnets make up the remaining ten percent of the rock.

The purple quartzite appears in lenses in the schist striking and dipping parallel with the strike and dip of the schistosity. It is composed of tiny interlocking grains of quartz, usually from 0.01 to 0.08 millimeter in diameter, traversed by veinlets made up of slightly larger grains of quartz. Garnets occur sparingly in the quartzite.

In general the schistosity has a north-south strike, but varies locally. The dip varies from sixty to ninety degrees with an average of about 75 degrees in a general easterly direction. In most places the schist is soft and weathers to gentle slopes, whereas the resistant purple quartzite and the white vein quartz intruding the schist weather out as prominent ridges or walls.

The writer agrees with Ransome and Cook that the schists, with the exception of the amphibolite, were originally sediments. The lenses of quartzite are probably portions of an original sandstone that has been faulted and tilted as well as metamorphosed. Most of the schists seem to have been formed from quartzose sediments. The amphibolite was probably formed from a basic igneous rock.

Altered Pioneer shale.

The Pioneer shale has been altered for a few feet on each side of its contact with the thick diabase sill intruding it. A description of one unaltered and two altered specimens of the shale may illustrate what has happened to the rock.

1. The unaltered Pioneer shale at the point of intrusion is not strictly speaking a shale, but a hard sandstone with many "bleached spots" from one to five millimeters in diameter on the even maroon surface. A study of a thin section of this rock shows that the "bleached spots" are in reality just that, merely spots where the iron oxide causing the maroon color of the rock has been removed. The rock is composed of equal parts of angular to well rounded, but usually slightly rounded, quartz grains 0.8 millimeter or less in diameter, and feldspar grains, now mostly altered to sericite and iron-stained kaolin, about the size and shape of the quartz grains. These make up about eighty percent of the rock, the rest being composed of sericite and kaolin cement (five percent) and hematite (fifteen percent). Judging from this description, the original rock must have been a medium-grained arkose.

2. In the altered zone farthest from the contact the rock is soft, greenish, and fine-grained, containing numerous concretions composed of a green center surrounded by a thin pink ring. These concretions average about three millimeters in diameter. Under the microscope it can be seen that the concretions are composed of a core of serpentine, chlorite, and magnetite surrounded by a ring of orthoclase crystals. Whether or not the chlorite and serpentine represent the alteration products

of some other ferromagnesian mineral it is impossible to determine. The groundmass is made up of grains and fibers of serpentine (35 percent), magnetite (35 percent), quartz (five percent), and sericitized feldspar (two percent). The texture is granular.

3. Within a few inches of the contact the rock is hard, dark green and fine-grained and contains tiny pink concretions. A study of a thin section of this material would lead one to believe it is a diabase. The concretions are from 0.5 to two millimeters in diameter and composed mainly of serpentine, but contain a little chlorite and considerable feldspar, magnetite, and hematite. The ring of feldspar, as found around the concretions of specimen number two, is missing. The groundmass has an ophitic texture and is formed of laths of plagioclase feldspar within the oligoclase-andesine range (fifty percent), magnetite (thirty percent), serpentine (fifteen percent), chlorite (three percent), and hematite (two percent). As in specimen number two, it is impossible to determine whether the serpentine and chlorite are alteration products of an earlier ferromagnesian mineral.

The alteration seems to have been mainly a substitution of magnetite and ferromagnesian minerals for quartz, and alteration of the sericite and kaolin to feldspar. The hematite in the unaltered rock has given place to magnetite. In the alteration, therefore, iron, magnesium, and potassium have been added, and silica has been removed.

STRUCTURAL GEOLOGY

Pre-Cambrian structure.

The Pinal schist shows evidence of pre-Cambrian orogeny by its schistosity and by pre-Cambrian faults. Over large areas the strike and dip of the schistosity is fairly uniform and is parallel to the purple quartzite layers in the schist. This would suggest that it is parallel with the original bedding. Ransome working in the Ray-Miami area,[23] and Galbraith in the Silver King area,[24] also drew this conclusion; Ransome on the basis of banding, and Galbraith from a conglomerate found in his area. From these facts it seems that the schist was formed by regional forces. It may have been at this time, or shortly thereafter, that the vein quartz appeared. The vertical beds of purple quartzite have been offset by faults that cannot be traced into the younger rocks and which the writer takes for evidences of pre-Cambrian faulting. The faults seem to dip steeply, but due to the yielding nature of the schist, no other details could be determined.

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[23] Ransome, F.L., - The copper deposits of Ray and Miami, Arizona: U.S. Geol. Survey Prof. Paper 115, p. 34, 1919.

[24] Galbraith, F.W. 3rd., - Geology of the Silver King area, Superior, Arizona: Univ. of Ariz. Doctor's Thesis, 1935.

Post-Carboniferous structure.

Following the Carboniferous at some undetermined time came the intrusion of the Texas Canyon granite. This bowed up the sediments giving them a general east and northeast dip in the area mapped.

A system of normal faults striking in general north-south and one striking east-west are well developed in the area. The east-west faults are usually downthrown toward the south, making a series of steps running counter to the general northeast dip. These are cut by three large north-south faults downthrown toward the west. Near station XII is a system of normal faults striking northeast-southwest and cut off by a north-south fault with a 312-foot throw. This system shows a very good horse-tail pattern.

One overthrust is found in the southwest section of the area. The overthrust is practically flat with only a slight dip toward the southwest. Escabrosa limestone of Mississippian age has been thrust over Cambrian and pre-Cambrian rocks, thus dating the thrust as post-Mississippian. As the Escabrosa limestone has been pushed over tilted Cambrian and pre-Cambrian rocks, the thrust seems to have come after the doming in the area. The overthrust is cut by one east-west normal fault.

The normal and overthrust faults show that both tensional and compressional forces were at work. The normal faults were probably formed during and after the doming and were due to the tension developed during the doming or to slumping after the doming, or both. The thrusting came some time after the doming, but what generated the compression is unknown.

HISTORICAL GEOLOGY

The Archean rocks show a period of sedimentation, a period of diastrophism, and a period of erosion. The rocks seem to have been originally arkoses and sandstone deposited in a shallow-water basin. These sediments were elevated, metamorphosed, faulted, and intruded by vein quartz. A period of erosion long enough to reduce the surface of the schist to a peneplane followed the diastrophism.

The basal member of the Apache group, the Scanlan conglomerate, was formed as a basal conglomerate as a sea advanced over the peneplaned surface of the schist. As the sea continued its advance, the Apache group was deposited in the shallow water. The members of the Apache group following the Scanlan conglomerate were considered by Ransome to be formed in fluviatile, or shallow, near-shore, marine conditions, and suggested a delta. Ripple marks, mud cracks, and cross-bedding in the Little Dragoons indicate shallow-water conditions, and the writer follows Ransome in believing that the Apache group is most satisfactorily explained as a delta deposit. The Barnes conglomerate, according to Ransome, was probably derived from the quartzites of the Sierra Ancha and Mazatzal ranges.

Between the deposition of the Dripping Spring quartzite and the Troy-Bolsa quartzite erosion must have taken place, but how much is not known. Darton, in speaking of the relation of the Apache group to the overlying Troy quartzite in several sections found in the Gila River Valley about 25 miles from Globe, states:[25]

"The overlap relations in this region also show that the Troy lies unconformably on the Dripping Spring quartzite and Mescal limestone, as well as on the great sills of diabase which invade these two formations. Moreover, to the eastward near the east end of the Mescal Mountains, its upper part overlaps the edge of the Dripping Spring quartzite and becomes the basal formation of the sedimentary series corresponding to the Bolsa quartzite of the region not far southeast of that locality. The relations in this region and elsewhere to the north indicate that there was a long interval between Troy and Mescal deposition, for chert from the latter and apparently also boulders of the Dripping Spring quartzite contributed to the basal conglomerate of the Troy."

In the Little Dragoon Mountains the Troy-Bolsa quartzite is separated from the Dripping Spring quartzite by only a thin conglomerate lying upon a hardly noticeable unconformity. Evidently if the Mescal limestone was deposited in this area it was eroded away during the long interval between Proterozoic and Middle Cambrian times.

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[25] Darton, N.H., - A resumé of Arizona geology: Univ. of Ariz. Bull. No. 119, p. 36-37, 1925.

The cross-bedded Troy-Bolsa was probably deposited near the edge of two areas of deposition, probably under delta conditions. Further subsidence was accompanied by deposition of the sandstone, shale, and limestone, of the Santa Catalina, Cochise, Abrigo, and Peppersauce Canyon formations.

A large gap now appears in the geologic record, as the next sedimentary rocks found are Upper Devonian in age. Although a tremendous time gap is indicated here, the Upper Devonian lies with apparent conformity on the Upper Cambrian. If the missing periods were represented by sediments, they were evidently completely removed before Upper Devonian. The Devonian limestone, dolomite, and shale were deposited in shallow, clear water where life was abundant.

The Escabrosa limestone lies conformably upon the Upper Devonian. The Escabrosa limestone is of Lower Mississippian age, Kinderhook and Osage, according to Girty.[26] The absence of clastics and the presence of abundant crinoid remains and corals in the Mississippian strata indicates clear, warm water conditions during Lower Mississippian time.

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[26] Ransome, F. L., - Geology and ore deposits of the Bisbee quadrangle of Arizona: U.S. Geol. Survey Prof. Paper 21, p. 46, 1904.

Despite the absence of the Upper Mississippian, the contact between the Lower Mississippian and the Naco limestone of Lower Pennsylvanian age appears conformable. Perhaps a great interruption of deposition would best explain this blank page in the geologic history of the area. The deposition of Lower Pennsylvanian limestone shows a continuation of the clear warm water conditions present in the Lower Mississippian.

Some time after the Carboniferous the area was raised and intruded by the Texas Canyon granite. Faulting and tilting probably accompanied and followed this intrusion.

The geologic record is lost from the time of the intrusion of the granite to the recent. During recent time the area has been extensively eroded and both consolidated and unconsolidated débris has been collecting in the valleys and at the foot of the mountains.

ECONOMIC GEOLOGY

Early history.

In 1883, activity in the Johnson mining area was first reported in the literature,[27] but according to Tenney, the district was producing in the seventies.[28] He states that the ore was shipped out by ox team and sent to Swansea, Wales, for smelting. During the World War, the camp was very active. The Republic mine, the best producer of the district, was shipping 5000 tons of ore a month to the smelter at Douglas. After the war, most of the mines closed down with the fall of the copper prices. Only a few shipments of ore have been made since. As the camp is a marginal one, that is, production pays only when the price of copper is high, there is very little activity at present.

The production of the district prior to 1907 is not obtainable, but from 1907 through 1920, 293,506 tons

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[27] Williams, Albert Jr., - Mineral resources of the United States: U.S. Geol. Survey, p. 224, 1883.

[28] Heineman, R.E.S., - Geology and ore deposits of the Johnson mining district, Arizona: Univ. of Ariz. Master's Thesis, 1927.

of ore valued at $5,765,976 were produced.[29] This is an average value of $21.12 per ton. Copper, silver, lead, zinc, and gold were produced, but the camp was primarily a copper producer.

Mines in the area.

The Johnson mining area lies at the foot of the Little Dragoon Mountains on the eastern slope and only a few of the smaller mines lie far enough up the slope to be included in this report. Although miners in the district assert that ore has been shipped from the few small mines included in this report, nothing is seen in the drifts at present but empty chambers. Evidently the limits of the ore bodies were very sharp and clear cut. Most of the data concerning the mines has been obtained from the oxidized zone close to the entrance and from fragments of ore obtained from the dumps.

The mines are located on a small, almost vertical, normal fault in the southeast portion of the area. This fault is underlain and probably connected with a larger fault dipping 22 degrees south toward the Texas Canyon granite. The writer believes that

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[29] Op cit.

emanations from the granite coming up the larger fault made off into the small fault and formed the ore bodies. The ore bodies were in the base of the Santa Catalina formation, where it consists of greenish impure limestone and shale.

Mineralization.

The mineralization is of two types: (1) small pyrite and quartz veins and (2) pyrite and chalcopyrite disseminated throughout the rock.

The small pyrite and quartz veins usually follow the bedding in the limestone, but here and there they follow small fissures that cross the bedding. They are never more than a few inches wide. Examination of many specimens of these veins failed to show any sulphides but pyrite. These veins weather to masses of quartz containing both hydrous and anhydrous iron oxides in the position formerly occupied by the pyrite. A second generation of quartz is found in places coating both first generation quartz and iron oxide. This layer of second generation quartz is chalcedonic near the base but finely crystalline on the outside. A brown mica is found coating primary quartz and iron oxide or intimately mixed with the iron oxide. This mica is optically negative, has a very small optic axial angle, and the index for both β and γ was determined as 1.605. The mica appeared too light to be biotite, and since it was found in a metamorphosed limestone and phlogopite is essentially a mineral of the crystalline limestones, the writer has called it phlogopite.

A polished specimen of the quartz pyrite veins shows goethite replacing pyrite. The mineral determined as goethite is a hydrous iron mineral, anisotropic and hard, giving a yellowish brown powder, and negative to all reagents used by Short in his determinative table. Islands of pyrite surrounded by rhythmic bands of goethite are very common. The gangue is mostly quartz with some iron-stained calcite. The rhythmic banding of the goethite and the chalcodonic second generation quartz seem to indicate colloidal replacement.

The distribution of the disseminated pyrite and chalcopyrite is also controlled by the bedding, the greatest concentration of sulphides appearing in the limestone lenses of the green shale. They are also concentrated in tiny fissures cutting across the bedding. This material weathers to brown and green earthy masses of clay, chrysocolla, malachite, and both hydrous and anhydrous iron oxide.

Polished specimens of this ore show pyrite as well developed cubic crystals or as grains with smooth borders, which contain veinlets and small grains of goethite, evidently showing alteration by supergene solutions. The chalcopyrite is present in irregular masses or as small grains in the pyrite. The larger masses of pyrite and chalcopyrite are seldom in contact, but where they are the pyrite usually shows its characteristic cubic form and is bordered by irregular masses of chalcopyrite. Probably the pyrite appeared before the chalcopyrite. The chalcopyrite contains grains of a gray mineral too small to identify. The pyrite and chalcopyrite seem to be hypogene minerals appearing in that order; the goethite, hematite, malachite, and chrysocolla are alteration products of the two hypogene minerals formed by descending oxidizing solutions.

Thin sections of the disseminated material show the gangue as irregular masses of calcite with subordinate quartz grains, the average of which are 0.2 millimeter in diameter. Small quantities of quartz and epidote as irregular masses replace calcite. The sulphide masses range in size from tiny blebs to 1.1 millimeter.

Prospects.

The mines studied, never very productive, have no developed ore. One prospect only is being worked at present. The large fault dipping south from the central part of the range and which underlies the small mining area at the southeast end of the range has several small faults making out from it into Devonian and Carboniferous limestone in the east central part of the range. Several pits have been sunk on these faults without any ore being discovered. At present Pete Dworayk is driving a long drift into the broken country just above the main fault. As yet he has reported nothing but low silver assays and a little molybdenite, but is continuing his work.

SUMMARY

This report deals with some seven square miles in the eastern part of the Little Dragoon Mountains. The sedimentary rocks consist of the pre-Cambrian Apache group, with the exception of the Mescal limestone; the Cambrian Troy-Bolsa, Santa Catalina, Cochise, and Abrigo formations, and the Peppersauce Canyon sandstone; the Devonian Martin limestone; the Mississippian Escabrosa limestone; and the Pennsylvanian Naco limestone. Metamorphic rocks are represented by the pre-Cambrian Pinal schist, and igneous rocks by pre-Cambrian vein quartz and four diabase sills of undeterminable age. The Apache group appears to be thinning toward the southeast and becomes very thin at the extreme southeast corner of the area. The basal Cambrian quartzite seems to have been formed in an area of overlap between the Tucson-Globe, and the Bisbee-Tucson depositional sub-areas, and thus both the Troy and the Bolsa quartzites are present with Troy at the base.

The sediments dip in general northeast away from a granitic stock located a short distance to the southwest. Two systems of high angle faults are present, one striking generally north-south and the other striking approximately east-west. A thrust fault in the south-

west section of the area brings Mississippian limestone over Cambrian and pre-Cambrian sediments.

On the southeast side of the range some small mines have produced a little copper ore. Chalcopyrite is the chief ore mineral.

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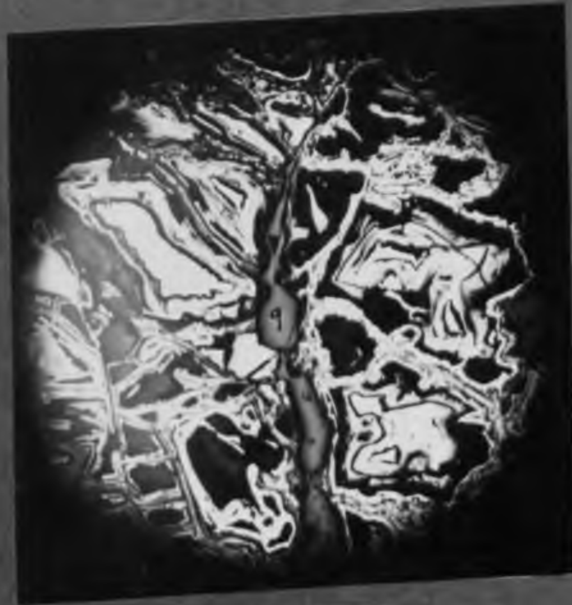

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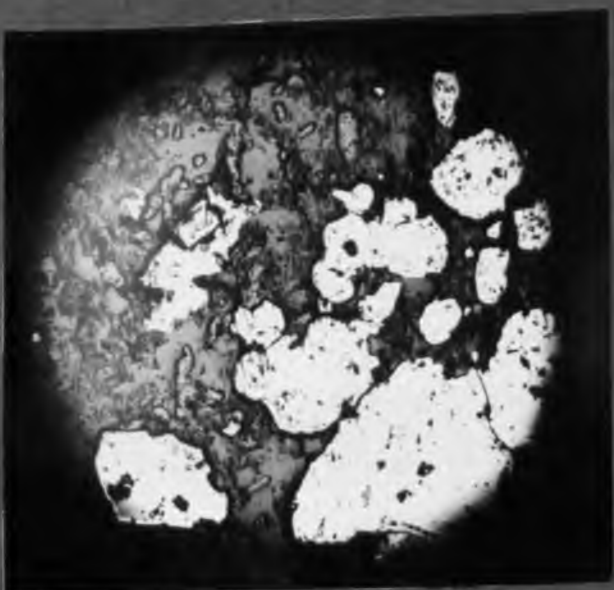

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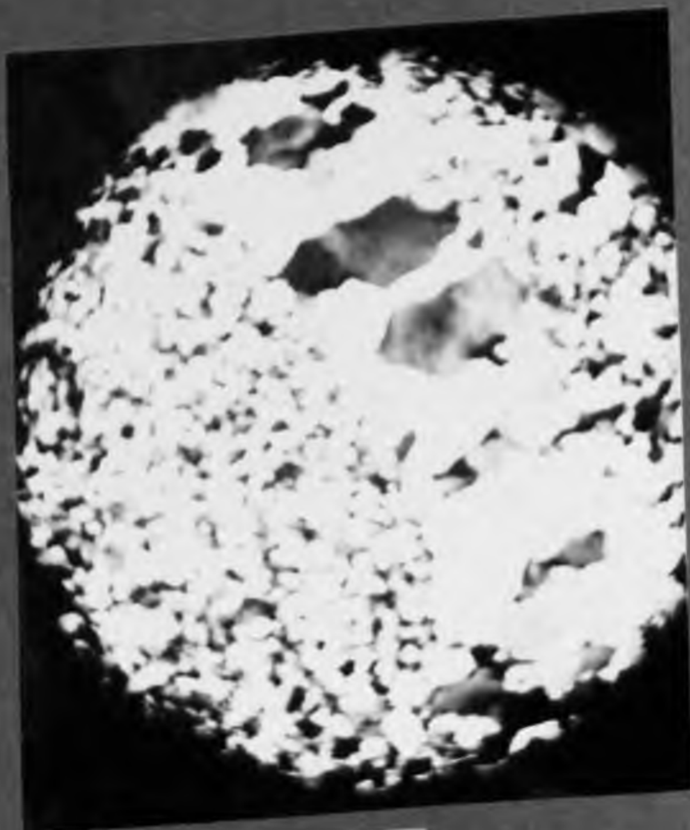

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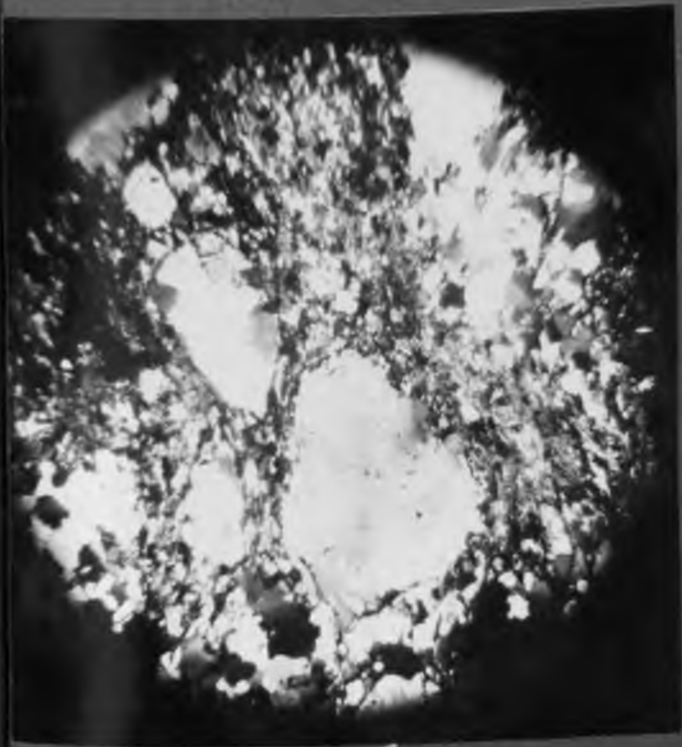

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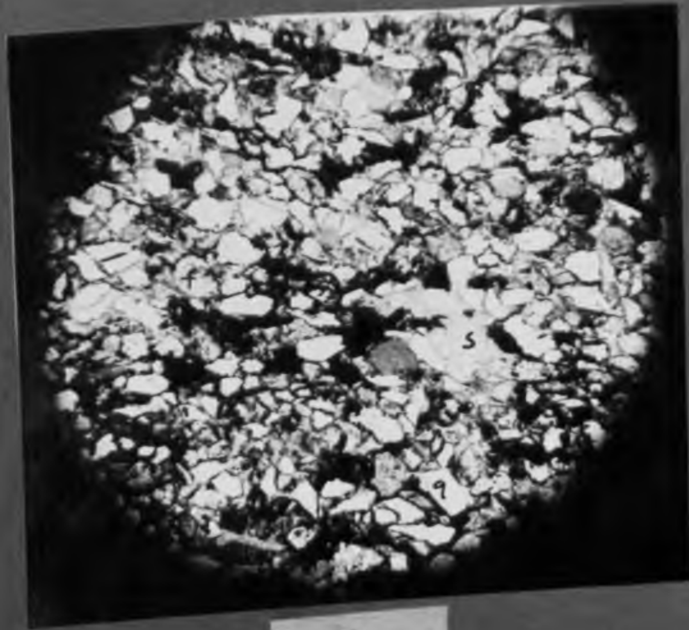

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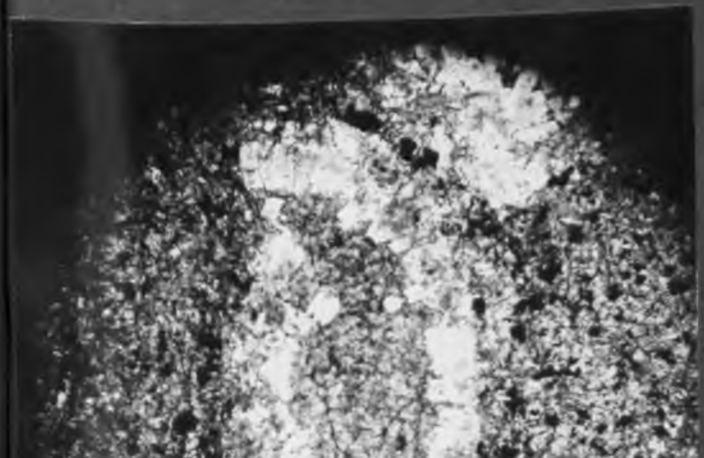

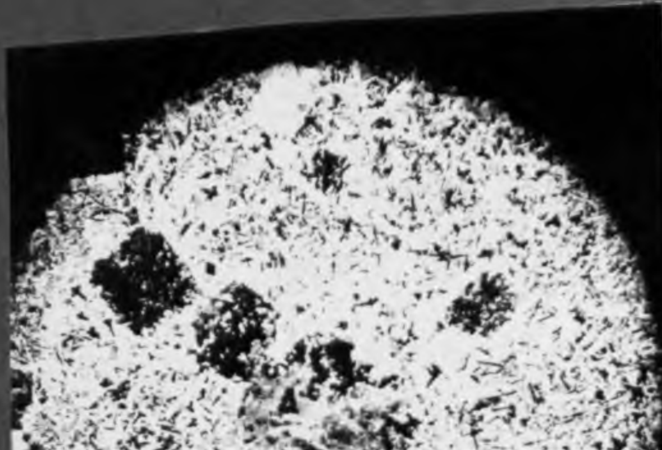

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In POCKET:
2 plates

PLATE NO. I

LEGEND

SEDIMENTARY ROCKS

- Qr RECENT
- Cp PENNSYLVANIAN
- Cm MISSISSIPPIAN
- D DEVONIAN
- Є CAMBRIAN
- PЄ PRE-CAMBRIAN

METAMORPHIC ROCKS

- PЄ PRE-CAMBRIAN

- STRIKE & DIP
- A ABANDONED MINE
- TRIANGULATION STATION
- PROSPECT
- FAULTS SOLID LINE KNOWN, DASHED LINE UNKNOWN
- CONTACTS

TOPOGRAPHY
F. STEARNS COOK
ARTHUR PECK JR.
HAROLD E. ENLOWS

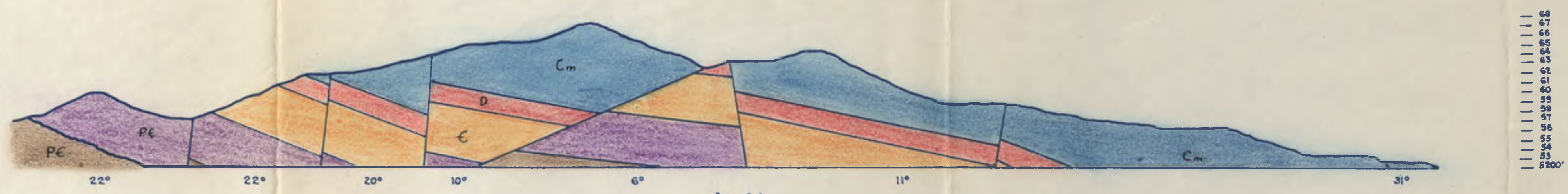
GEOLOGY
F. STEARNS COOK
HAROLD E. ENLOWS

AREAL GEOLOGY
OF
THE LITTLE DRAGOON AREA
COCHISE CO., ARIZONA

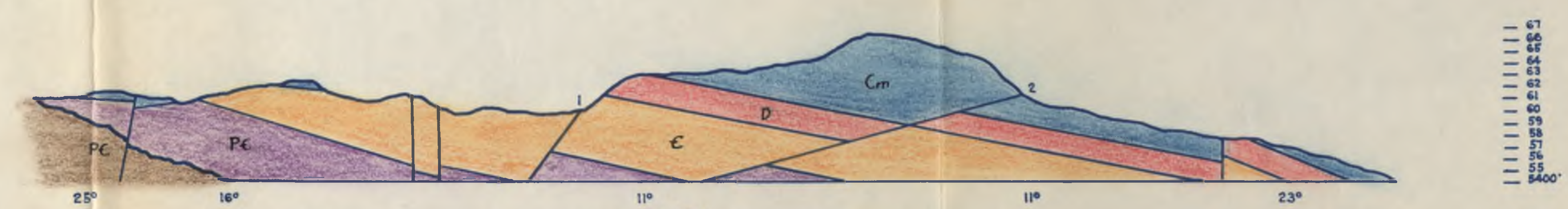
SCALE: 1 IN = 1000 FT. CONTOUR INTERVAL 100 FT.

DATUM MEAN SEA LEVEL

PLATE NO. 2

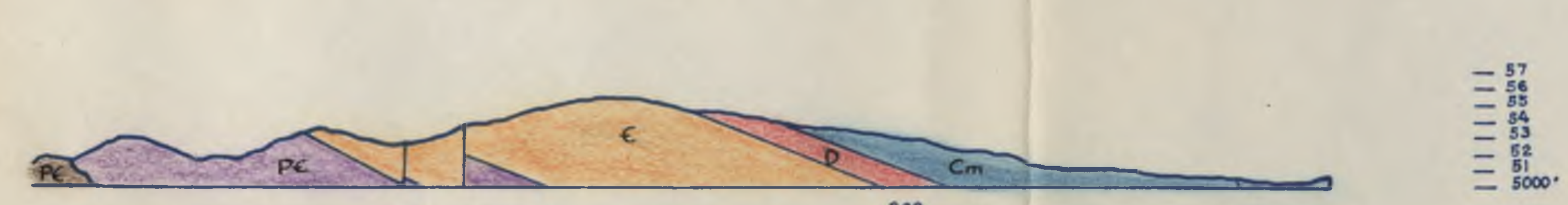


A–A'



B–B'

C–C'



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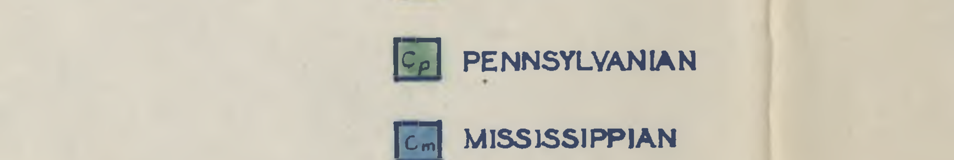

E–E'

LEGEND

SEDIMENTARY ROCKS

- Qr RECENT
- Cp PENNSYLVANIAN
- Cm MISSISSIPPIAN
- D DEVONIAN
- € CAMBRIAN
- P€ PRE-CAMBRIAN

METAMORPHIC ROCKS

- P€ PRE-CAMBRIAN

CROSS SECTIONS
OF
THE LITTLE DRAGOON AREA

COCHISE CO., ARIZONA

VERTICAL SCALE: 1 IN = 1000 FT. HORIZONTAL SCALE: 1 IN = 1000 FT.

DATUM MEAN SEA LEVEL