

SOME NOTES ON THE APACHE GROUP OF THE
SANTA CATALINA MOUNTAINS AND OTHER SECTIONS
IN SOUTHEASTERN ARIZONA,

by

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Introduction

In studying the geology of the Apache group in the Santa Catalina Mountains as exposed in Peppersauce canyon, the entire column was found to be similar to the standard Apache sections of Ransome, ⁽¹⁾ with one marked exception: the Mescal limestone is missing. In its place there is a bed of purple, slabby sandstone which has been intruded by a diabase sill. This two hundred and fifty to three hundred foot sandstone member is separated from the underlying Dripping Spring quartzite by a twenty-five to thirty foot gradational horizon. A few feet above the true Dripping Spring quartzite, there was found a three foot band of what was thought to be a typical intraformational conglomerate. On further examination the flat angular fragments proved to be very different from the purple sandy matrix in which they were embedded. Although some of the fragments were quartzite similar in character to the matrix, by far the largest part of them were found to be white, cherty fragments with occasional bits of greenish serpentized

1. Ransome, F. L. Geology of Globe Copper District
U.S.G.S. Prof. Paper 12 (1903).
Also U.S.G.S. Prof. Paper 98K (1916).

material. This conglomerate suggested a possible shore line for the sea of Mescal time.

In hope of finding some explanation for the absence of the Mescal limestone and the presence of the angular cherty conglomerate mentioned above, other Apache sections neighboring that of Peppersauce canyon were studied.

Sections in the Cañada del Oro were very incomplete, and so badly faulted that only the Barnes conglomerate could be identified, and it was very poorly exposed.

Southeast of Peppersauce canyon the Apache group is well exposed, but igneous intrusions, metamorphism, and intense faulting have entirely obscured the finer points of relationship between the various members of the group.

At the "Stone Cabin" southeast of Stratton canyon, on the Interocean ranch, ⁽²⁾ the horizon which should be occupied by Mescal formations shows only a metamorphic schist of igneous origin. On some of the higher ridges leading up to Apache peak, the Barnes conglomerate was found with thick, igneous intrusives both above and below it, the members ordinarily adjoining it having either been absorbed or forced away.

Though the relationship between the members of the group is obscure, the appearance and character of the fault blocks are such as to indicate without doubt the

2. See map, plate I.

presence at one time of Apache formations at least as far southeast as a point on the south slope of the San Pedro valley somewhere west of Reddington.

It seemed highly improbable that a sedimentary mass as thick as the Apache group is found to be at Peppersauce canyon could end abruptly, or disappear completely, in a distance so short as twenty or twenty-five miles. For this reason Apache sections were searched for in the Little Dragoon mountains. The only sections to be found with any apparent relationship to the Catalina Apache were sediments which have been mapped as Bolsa quartzite. ⁽³⁾ They are so similar in appearance and lithologic character to the Catalina Apache as to suggest a possible relationship between the Apache and the Bolsa.

By many the age of the Apache group and the Bolsa quartzite has been considered the same, although no good fossils have ever been found in either. F. L. Ransome ⁽⁴⁾ considers them as contemporaneous and probably of Cambrian age.

A.A. Stoyanow ⁽⁵⁾ found good specimens of Crepicephalus Texanus in Abrigo sandstone beds resting with apparent conformity upon both the Troy of Peppersauce can-
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3. Geologic Map of the State of Arizona
By Arizona Bureau of Mines (1924).
4. Ransome, F. L. U.S.G.S. Prof. Paper 98K.
5. Stoyanow, A. A. American Journal of Science, Vol XII,
October, 1926, p. 319.
Also personal communication.

yon and the Bolsa quartzite of eastern Arizona. These discoveries and the conformable relationships mentioned seem to indicate a deposition of at least the upper portions of both the Troy and Bolsa quartzites in the same seaway.

The writer has found small, rather obscure traces which resemble middle Cambrian sponge spicules, in certain pink, quartzitic pebbles of the Barnes conglomerate in Peppersauce canyon. Apparently similar traces were found in a single pebble of a thinner, but like conglomerate in the Bolsa quartzite of the Little Dragoon mountains. Because of the indeterminate character and small number of these traces collected, they can hardly be used as good evidence of age or relationship. They do suggest the possibility that other organic remains may be found in the future.

To the northwest of the Catalina mountains, a complete Apache section occurs in the Black hills. It is best exposed in Camp Grant wash, about one mile west of the present location of Feldman post-office.

The Mescal limestone, overlain by a purple, slabby sandstone, is present here. Here it is much thinner than the Mescal of the type sections farther north.

Darton⁽⁶⁾ has studied this section, but he fails to give a thickness for the Mescal limestone.

At the north end of the Tucson mountains there is a small hill, the western one of the group known as

6. Darton, N.H. , Resume of Arizona Geology, p. 274. 

the Calera hills, which is composed, in large part, of a quartzite which Jenkins and Wilson⁽⁷⁾ consider as probably Bolsa. This quartzite was examined in hope of finding some information which would shed light upon the irregularities of the Catalina Mescal.

Darton⁽⁸⁾ has called attention to a quartzite which he suggests may be Dripping Spring, at Shaw's ranch, three miles east of Vail.

Columns for each of the above sections will be given in full followed by a discussion leading to certain conclusions. Few of them will be stated as rigidly proven facts, chiefly because of the lack of organic remains in both the Apache and Bolsa formations. However, the general appearance, sequence and lithology of the beds observed in these sections seem to point to some very logical relationships.

Columnar Sections.

THE SANTA CATALINA APACHE SECTION. ⁽⁹⁾

Top.

8. Abrigo Beds - Cambrian 750 feet
thick. ⁽¹⁰⁾

Apparent conformity.

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7. Jenkins, O.P. and Wilson, E.D. University of Arizona Bulletin 106, p. 11.

8. Darton, N. H. Resume of Arizona Geology, p. 282. ✓

9. An unpublished description of this section by the writer is in the hands of Dr. A. A. Stoyanow.

10. According to A. A. Stoyanow. See American Journal Science, Vol XII Oct 1926, p. 319. ✓

next page

- 4. Dripping Spring Quartzite. 250 to 300 feet thick.
 - a. Maroon to light brown thick bedded quartzite. Fine even grain. No pebbles or grit. 50 feet.
 - b. Yellow to brown quartzite. Lighter tints on fresh fractures. Beds four to eight feet thick. Crossbedded. No pebbles. About 100 feet.
 - c. Yellow to light brown quartzite. Thin beds up to one foot thick. Rain prints. Ripple marks. Crossbedded. 100 to 150 feet.

- 3. Barnes Conglomerate. 35 feet thick.
 - a. Flat scattered lenses of red iron-stained arkose. Contains varying quantities of small scattered quartz and quartzite pebbles of pinkish to yellow hue. Grades up into the overlying Dripping Spring quartzite with apparent conformity. 0 to 3 feet.
 - b. Unassorted deposit of pink, reddish and grey well rounded flattened quartz and quartzite pebbles varying in size from sand grains to individual pebbles six inches in diameter. Yellow, pink or grey arkosic matrix. Red jasper pebbles sparsely scattered through the entire horizon. 35 feet.

- 2. Pioneer Formation With Diabases. 950 feet(?)
 - a. Hard slaty light gray aluminous shale. Barnes conglomerate rests upon its smooth upper surface conformably as to strike and dip. 25 feet.
 - b. Varying brown slabby shale altered and baked near bottom by contact with diabase. Contains pegmatite dikes, sills and veinlets. 75 feet.
 - c. Diabase sill. Same material as the one in Mescal sandstone, 450 feet.
 - d. Mottled and banded fine grained red to grey quartzite. Altered and baked at top and bottom by diabases. 85 feet.

back

7. Troy Quartzite. 350 feet thick.
- a. Upper beds thick arkosic and cross-bedded. Magnetite sand and pebbly streaks. Light to white and glassy on fresh fractures. Weathers pink to dull red. Surfaces show rain prints, ripple marks and worm trails. 150 feet.
 - b. Grades down into thick bedded finer grained quartzite with little unaltered feldspar. Crossbedded. Streaks of magnetite sand. 150 feet.
 - c. Thin crossbedded siliceous quartzite. Many quartz veinlets. Light colors on fracture, Weathers to a rusty brown. 50 feet.
Conformity.
6. Mescal Sandstone. 325 feet thick.
- a. Slabby purple sandstone with a marked cleavage plane oblique to the bedding plane. Grains are very fine almost silty angular quartz in a sericitic matrix. Has a generally shaly appearance. Many thin veinlets and botryoidal druses of black manganese mineral. 150 feet.
 - b. Diabase sill with marked ophitic texture. Green to olive tints. Feldspars kaolinized. Part of pyroxene altered to actinolite, requiring heat and pressure, hence probably intruded while sediments were deeply buried. Has baked sandstone above and below. 85 feet.
 - c. Thick bedded purple shaly sandstone. Individual grains very fine and silty. 90 feet.
5. Gradational Beds.
- a. Alternating beds a foot or more thick of Mescal sandstone and light yellow to brown quartzite of the underlying Dripping Spring. 22-27 feet.
 - b. Slabby mud cake conglomerate. Apparently intraformational. White sharp cornered and angular fragments of cherty and serpentized material. Matrix is purple sandstone. 3 feet.

A

e. Diabase sill. Same diabase as e above and the one in the Mescal sandstone. 120 feet.

f. Intercalated beds of reddish to brown mottled quartzite, silvery schist and coarse arkose. 120 feet.

g. Coarse light grey arkose with pink quartzite and orthoclase pebbles up to three inches in length, very sparsely scattered through it. 80 feet.

1. Scanlan Conglomerate. 0 to 3 feet thick.

Angular fragments of white quartzite and vein quartz in a dark ferruginous cement. Marked unconformity.

0. Oracle Granite.

Pre-Cambrian coarse grained acid granite with large feldspar crystals. White to grey on fresh fracture. Weathers yellow to grey.

The average dip for this section was about 35 to 45 degrees to the northeast.

THE BLACK HILLS APACHE SECTION.

Top

8. Devonian Limestone.

Thickness not definitely known, probably well under 100 feet. Showed shaly, sandy phases.

Unconformity(?) (11)

7. Troy Quartzite. 370 feet thick.

a. Light colored poorly consolidated sandstone. Coarse grained. Weathers grey to black. 100 feet.

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11. A very thin layer of Abrigo may be present.

- b. Hard light colored, on fracture pink to dull red weathering quartzite. Thick crossbedded. Has streaks of black magnetite sand. Rain prints and ripple marks on exposed surfaces. (12) 150 feet.
 - c. Coarse pebbly arkosic quartzite. Weathers grey to yellowish grey. Medium thick bedding. 80 feet.
 - d. Coarse pebbly horizon. Beds up to one foot thick. Some of them pure conglomerates with well rounded silica pebbles. Weather pink to yellow. 40 feet.
6. Mescal Formation. 140 feet thick.
- a. Angular fragmental conglomerate, quartzite pebbles. 1 foot.
 - b. Purple slabby to brownish red compact quartzite. Thin crossbedding. 8 feet.
 - c. Alternating bands of hard, light gray weathering quartzite, and coarse, round grained, loosely cemented arkosic sandstone or grit. Has general appearance of a wind blown sand. 60 feet.
 - d. Grading down from c and conformably beneath it a good, well indurated conglomerate. Individual pebbles up to two or three inches, well rounded and oblate. Arkosic matrix. 4 feet.
 - e. Slabby purple quartzite with thin calcareous lenses near the base. 6 feet.
 - f. Angular fragmental, intraformational conglomerate. Flat slabs or "mud cakes" of white silicified limestone, up to four inches long and one-half inch thick. Some serpentine fragments. Has purple silty matrix. 1 to 3 feet.

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12. An area of good columnar structure similar to that often found in Basalts was seen here. Time to search for an explanation was lacking. Such a structure in a quartzite is rather rare. The one observed may quite possibly be due to a complicated system of fractures.

- g. Typical brown to grey Mescal limestone. Extremely cherty. Thin bedded. Fresh fracture shows it to be crystalline dolomite. 21 feet.
- h. Hard light colored siliceous quartzite free of feldspar. Weathers grey. 6 feet.
- i. Mescal Limestone. Same as g above 12 feet.
- j. Diabase sill along bedding plane of limestone. Dark green. Similar in appearance to diabase found in the Catalinas. 12 feet.
- k. Hard white chert or jasperoid. Is completely silicified limestone. Full of asbestos and green serpentine veinlets up to one-half an inch thick. 8 feet.

Diabase Sill Estimated to be 200 feet thick(?)
 Same diabase as j above, but somewhat coarser grained near its middle.

5. Mescal or Dripping Spring? (13)

Reddish purple slabby quartzite of rather fine grain. 50 feet.

Diabase Sill

10 feet.

Typical Apache diabase but contains masses of green waxy serpentine.

4. Dripping Spring Quartzite.

250 feet.

Yellow to light brown fine grained quartzite. Similar in appearance and sequence (14) of bedding to the Catalina. Dripping Spring.

3. Barnes Conglomerate.

10 feet thick.

Typical Barnes conglomerate. Arkosic matrix. Pebbles average two and one-half to three inches. Red jasper pebbles.

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 13. Darton has definitely placed this with the Dripping Spring. See page 274, Resume of Arizona Geology.

14. See Page 7.

2. Pioneer Shale. 25 feet thick.
- a. Maroon to reddish quartzite with mottled areas due to local reduction of iron. 5 feet.
 - b. Hard brown slabby shale. Splits almost like slate. 15 feet.
 - c. Shale grading down into material containing large pink orthoclase fragments. 5 feet.
1. Scanlan Conglomerate. 0 to 1.5 feet thick.
- Hard white angular vein quartz fragments, often of large size, in arkose. Is really a bottom gradational phase of the Pioneer.
- Unconformity.
0. Pre-Cambrian Granite.
- Coarse pink orthoclase granite. Very compact and weathers slowly.

The beds of this section dip 45 to 50 degrees to the northeast as far up as the two hundred foot diabase, beneath the Mescal. From there to the top of the dip is flatter, from 30 to 35 degrees.

THE CALERA HILLS QUARTZITE

Top.

2. Abrigo Formation.
- Limestone and sandy phases.
Apparent conformity.
1. Bolsa Quartzite (?) 200 feet thick.
- a. Thick crossbedded quartzite. Bands of black magnetite sand. Hard, white and glassy on fresh fractures. Weathers pink to dull red. Rain prints and ripple marks. Identical in appearance, color and manner of weathering to the Catalina Troy. 90 feet.
 - b. Pebbly band with angular quartzite fragments up to a quarter inch in diameter. 1.5 feet.

- c. Maroon to purple quartzite with individual quartz grains rather coarse. Pebbly streaks become numerous as the bottom is approached. Pebbles up to one inch. 10 feet.
 - d. Hard brown to grey quartzite with a few thin pebbly bands. Crossbedded. 85 feet.
 - e. Very pebbly quartzite. Dark maroon. Very tiny fragments of red jasper in some of the pebbly bands. 15 feet.
 - f. Lower part of e buried under recent detrital material.
0. Pinal Schist. (15) Pre-Cambrian.

Much wrinkled and folded greenish brown fissil schist.

This quartzite dips about 35 degrees to the east.

No diabase intrusions were found in the section.

THE QUARTZITE AT SHAW'S RANCH

Top.

- 7. Abrigo Limestone. Apparent conformity.
- 6. Troy Quartzite. Approximately 100 feet thick.
Hard light colored silicified quartzite. Very similar in appearance and manner of weathering to Catalina Troy.
- 5. Purple Slabby Member. Mescal (?) 10 feet.
Sand grains coarser than purple slabby sandstone of Peppersauce Canyon.
- 4. Hard Yellow to Pink Quartzite. Dripping Spring (?)
Lower portion covered by detritus. Probably about 25 to 30 feet.
Fifty feet of recent detrital covering.

3. Pebbly Arkosic Grit. Upper part looks remarkably like quartzite lenses of Catalina Barnes. 8 to 10 feet

Detrital covering. Hard reddish shale and diabase exposed in a prospect hole.

2. Lower shaly quartzite filled with coarse angular fragments. Probably Scanlan Conglomerate.

Unconformity (?)

1. Pre-Cambrian (16) Granite.

This section is rather poorly exposed. Sections must be constructed from data observed at various exposed outcrops.

THE BOLSA QUARTZITE OF THE LITTLE DRAGOON MOUNTAINS

Section at North End of Range.

Abrigo Limestone.

Sandy phases less marked than that in the Catalina Abrigo
Apparent conformity.

Bolsa Quartzite. Estimated at 400 feet

a. Upper Member. Hard, light colored on fracture. Pink to dull red weathering quartzite. Upper beds show worm trails, rain prints and ripple marks. Thick crossbedded with pebbly bands. This member is without doubt the same as the Catalina Troy.

250 to 300 feet

b. Purple slabby horizon. Varies from 10 to 100 feet in thickness within a distance of three quarters of a mile. Has fine pebbly phase at both top and bottom.

100 feet

c. Light yellow to brown quartzite. Thin bedded. Crossbedded.

50 feet

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16. According to Darton. Resume of Arizona Geology, p.282.

- d. Detrital covering. Exposed spots show a brown shale with green diabase. Thickness unknown.

BOLSA QUARTZITE SECTION THREE MILES NORTH
OF THE SEVEN DASH RANCH, DRAGON MOUNTAINS.

Top. Bolsa Quartzite
Erosion Surface.

3. a. Hard compact quartzite. Light to white on fresh fractures. Weathers dull red to pink. Crossbedded. Pebbly. Magnetite sand. Rain prints, ripple marks. Same as top member in section at north end of range. 30 feet still present.
- b. Yellow to brown quartzite grading conformably (apparently) from a above. Fine even grained bedding thin. Crossbedding. No pebbles. 25 feet.
- c. Conglomerate. Identical, both pebbles and matrix, to the Barnes of the Catalina mountains. Arkose lenses sometimes divide it into two conglomerates a few feet apart. Pebbles near the bottom are sometimes rather angular. Red jasper. 10 to 15 feet.
- d. Light colored brown quartzite grading down into brown shale of unknown thickness. Badly altered sills of what may have been diabase are present. About 25 feet exposed.
- e. Recent detrital covering.

At a point about half a mile south of this exposure a brown shale with light grey schist lenses was found. This material is without doubt the bed e above.

2. Scanlan Conglomerate.

Very angular and well cemented small fragments. Matrix pinkish to red with unaltered feldspar fragments.
Unconformity.

1. Pinal Schist.

Beautiful light grey to almost pure white fissile schist. A phyllite in places. Cleavage at a steep angle with horizontal (almost

vertical). The present surface at many points north of the Seven Dash ranch is made up of this schist.

Just south of the Seven Dash ranch house, the entire series of Bolsa beds seem to be four or five hundred feet thick. The thickest individual bed comprising almost the entire Bolsa here is the top one, corresponding to the Catalina Troy.

The purple slabby member, which corresponds to the Mescal sandstone of the Catalinas, has completely disappeared at this point.

In the vicinity of Johnston the Bolsa beds are faulted and metamorphosed to such an extent that it is impossible to draw any accurate conclusions as to thickness and order of deposition. The Texas canyon granite is the probable cause of the metamorphism.⁽¹⁷⁾ In this region the Bolsa beds, resembling the Troy quartzite, Barnes conglomerate, Pioneer shale, Scanlan conglomerate, and possibly the Dripping Spring quartzite, are most certainly present. They rest unconformably upon the Pinal Schist.

Mr. Heineman has found quartzite lenses in the Pinal at Johnson, which seem to indicate a sedimentary origin for this well known formation.

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17. For further information on the Johnson district, see R. E. S. Heineman's paper, now in manuscript form.

General Discussion

All of the Apache and Bolsa outcrops might be termed fragmental within the region embracing the above recorded columns. That is, they are simply large, scattered remnants of a once wide-spread, continuous formation which has since been shattered by uplifts, and in places completely removed by erosion. Many huge blocks of the same formation are without doubt still deeply buried, and may in time be exposed by possible mining operations.

One of the greatest difficulties involved in correlating these disconnected and tilted blocks, aside from their lack of organic remains, is the complete absence of exposed connections. These gaps often reach a distance of thirty to forty miles in the southeastern part of Arizona.

Much may happen as to the change in kind of sediment and in the manner and type of deposition in a distance of even five or ten miles. Were one to walk ten miles in almost any direction in the Santa Cruz valley of today, not knowing or being able to observe the physiographic relations of the surrounding mountains, he would find himself sorely baffled in an effort to see any relationship between the schistose, quartzitic earth derived from one range and the black, basic soils which have come from another, yet both were

deposited at practically the same time and under similar climatic conditions. Areal changes in non-marine formations, however, may be far more pronounced and difficult to correlate than those of marine deposits. Marine formations are more wide-spread, and, except under very unusual conditions, follow a rough, vertical order of zonal arrangement which depends directly upon the depth of the sea depositing them.

The writer, realizing only too well the difficulties of correlating different beds by comparison of sedimentary character, appearance, constituents, color and manner of deposition, is loath to state that all of his conclusions are fixed and unchangeable facts. The sections studied seem to point to certain relationships within the area they represent. New discoveries may shed more light upon the problem and bring us nearer the truth, which is the ultimate aim of all science. It is hoped that the recorded data may be of aid to some future student of the Apache group in his efforts to carry the problem one step farther.

THE TROY QUARTZITE AND THE UPPER MEMBER
OF THE LITTLE DRAGON BOLSA QUARTZITE

To one who has closely observed the Troy quartzite of the Catalina mountains and the upper measures of the Bolsa quartzite as exposed in the Little Dragoon mountains, there can be little doubt that both

are parts of the same once wide-spread sedimentary deposit. Both have been laid down under rather shallow water conditions. They both show worm trails in the higher horizons, are rain and ripple marked, and have thick, crossbedded streaks with frequent, pebbly phases. Their surfaces weather in exactly similar manner. The exposed tops of the beds show a hard, generally flat surface marked with minor irregularities. Tiny specks of black iron and manganese minerals are scattered over these surfaces, generally in the bottoms of tiny fractured pits, or along cracks in the quartzite. Streaks of black magnetite sand are common in both quartzites as well as a high percent of unaltered feldspar fragments. The feldspar is thickest in the bottom beds and grows smaller in quantity higher up. The topmost beds are almost entirely composed of rather well rounded silica sand with arkosic material absent. Both quartzites grade with apparent conformity through a rather shaly phase into the overlying Abrigo beds. Both are well cemented with silica and fracture almost subconchoidally with a hard white or light colored fracture surface. Both weather to pinkish or dull red tints, with reddish brown stains at times present along the tiny surface cracks.

The Troy quartzite of the Black Hills is more sandy and less well consolidated in its upper hun-

dred feet than the Catalina Troy. Lower down the Troy beds are identical in every way to those of the Catalina mountains.

The upper portion (approximately ninety feet) of the quartzite examined in the Calera hills is also so similar to the Troy of the Catalinas that hand specimens of the two cannot be told apart. The thickness, however, is much less, and worm trails seem to be absent. At first glance the thickness might seem to indicate two unrelated areas of deposition. If this thinning out is looked upon as the approach of an ancient shore line or land ridge to the southwest, the thickness would be accounted for. The thinning out and shore phase characteristics of the beds stratigraphically beneath this probable Troy quartzite indicate the former presence of such a land ridge.

The upper portion of the quartzite at Shaw's ranch, which grades conformably into what Darton has determined to be Abrigo limestone, is also quite similar to the probable Troy of the Calera hills. The thickness is approximately the same, and the underlying beds also show a tendency to thin out and show shore line characteristics. It seems quite probable that high ground bordered the seaway of lower Apache and lower Bolsa time along a

line running roughly northwest and southeast. During Troy time the sea overflowed this high ground and deposited sediments much farther south than the waters of Mescal and lower periods. This probable sea margin will be further discussed with relation to the older Apache and Bolsa beds as they are taken up.

Although the Troy quartzite may not be the same as the Bolsa at Bisbee, the writer not having had the opportunity to study that section, it seems almost without doubt to be the same as the upper members of the Little Dra-
gon Bolsa, the Calera hills quartzite and the Shaw's ranch quartzite. In fact these quartzites in their upper portions resemble the Catalina Troy far more than that member itself resembles the real Troy of Roosevelt Dam. Ransome⁽¹⁸⁾ has termed the Roosevelt Troy a sandstone because of its rather poorly consolidated grainy character. The top hundred feet of Black Hills Troy is more nearly of Roosevelt type.

ca. R.

MESCAL FORMATION

The typical Mescal limestone occurs in the Black hills as already noted. The thickness in this locality is far less than two to three hundred feet assigned to it by Ransome. Of true Mescal limestone there is only about thirty five or forty feet, but it is interbedded with sandstones and intruded by diabase. An overlying basalt

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18. Ransome, F. L. U.S.G.S Prof. Paper 98K.

flow is absent. The upper part of the limestone grades by sandy, pebbly phases and calcareous, shaly lenses up to a thin angular conglomerate of unusual character.

This angular conglomerate is composed of flat, mud cake like chunks of silicified and serpentized limestone. These cherty fragments lie in a bed from one to three feet thick. The matrix is a red to purple sandstone, similar in character to the gradational phases beneath.

A similar conglomerate was found in the Peppersauce section. It was made up of white, angular, silicified, lime fragments with some greenish serpentized material and also many fragments of purple fine grained quartzite somewhat like the matrix. The mud cake like structure, and the fact that the bed lay a few feet above and conformable in strike and dip with the true Dripping Spring quartzite led the writer to believe that it was an intraformational conglomerate somewhere close to the base of the supposed Mescal, which in this locality is a purple, slabby sandstone.

A few serpentine fragments found in a pebbly layer beneath a thin, rather coarse purple sandstone in the Shaw's ranch section quite probably mark the same horizon.

The three occurrences seem to indicate the final thinning out of the Mescal limestone and its giving

way to a shallow water silt. They may also mark a huge unconformity for the following reasons:

1. The fragments are all highly metamorphosed lime. The change in chemical character may have taken place after they were deposited and buried as limestone, by either percolating ground water, or pneumatolitic solutions.

2. The mixture of serpentized fragments with cherty ones and the very few tiny bits of the green mineral in the pebbly band at Shaw's ranch would make it seem more likely, in the absence of more general hydrothermal metamorphism, that the fragments had a common origin from an already altered bed. The Mescal limestone at its bottom in the Black hills is composed entirely of such altered chert, filled with veinlets of asbestos and serpentine. ✓

3. Diabases in the Mescal formation show under the microscope, pyroxene altered almost completely to actinolite. Such a change is believed to require pneumatolitic action under extremely high pressures. To account for such pressures a heavy load of sediments would be necessary.

4. The cause of the silicification and serpentization of the Mescal limestone in the Black hills is without a doubt the intrusion of the two diabases, one on either side of the completely altered bottom remnant of that member.

The sequence of events would have been somewhat as follows: the limestone of Mescal time gradually thinned out toward the shore line in the south. In the Black hills district it was grading up into a sandy, silty member, and in the neighborhood of Peppersauce canyon it had disappeared entirely giving way to a fine silt which graded on southward into the sandy beach deposits at Calera Hills. A great mass of sediments were built ✓

up above these Mescal beds. The diabases were then intruded into the deeply buried mass. A cycle of erosion set in, cutting down to a point a few feet above the Mescal limestone in the Black hills. Somewhere farther north the silicified and altered limestone was completely exposed by this period of erosion. In the Catalina mountains only a few feet of Mescal sediment was left above the Dripping Spring quartzite. Sinkage now set in and an advancing sea washed in over this erosion surface bearing with it broken angular pieces of the silicified limestone exposed farther off shore. The four foot pebble conglomerate a few feet above this thin, angular, fragmental horizon in the Black hills would also indicate an advancing sea which really belongs to early Troy time.

Although, the evidence above seems to point to a probable unconformity, as well as the fact that Ransome has found a Basalt flow upon the Mescal limestone farther northwest, the writer hesitates to say positively that such an unconformity really exists without studying the problem more thoroughly.

If such an unconformity exists, the greater portion of the purple, slabby sandstone at Peppersauce canyon, which has been assigned to the Mescal, would have been made a portion of the Troy, into which it grades with apparent conformity. At the northern end of the Little Dragoon mountains the purple, slabby sandstone shows a

marked tendency to vary in thickness over short distances. It was found bounded above and below by pebbly phases, and varying from ten to one hundred feet thick in a distance of less than a mile. Whether this would indicate an old, irregular erosion surface beneath those beds and upon what is apparently Dripping Spring is a question. The evidence of such a surface is not clearly seen, although it may be present.

Near the Seven Dash ranch, the purple, slabby phase is entirely absent.

DRIPPING SPRING QUARTZITE.

In the Black Hills the Dripping Spring quartzite has a thin diabase sill near its upper margin overlain by purple, slabby sandstone beds. These beds are in turn overlain by a very thick diabase which bottoms the Mescal limestone. This slabby sandstone resembles the so-called Mescal sandstone of the Peppersauce section, but whether they are related or whether the beds in the Black hills are only a top member of the Dripping Spring it is difficult to say. Darton⁽¹⁹⁾ has called them Dripping Spring, but he does not mention the thin diabase which separates them from the hard light colored quartzite of undoubted Dripping Spring time.

At Peppersauce canyon the Dripping Spring
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19. Darton, N. H. A Resumé of Arizona Geology, p. 274.

quartzite grades conformably into the Mescal sandstone, beneath the unusual, white, fragmental conglomerate already mentioned.

In the Little Dragoon mountains a quartzite is present which resembles the Catalina Dripping Spring in every way but thickness. At the northern end of the range this quartzite is apparently fifty to seventy feet thick, while one exposure near the Seven Dash ranch showed only about twenty feet.

A considerable thickness of quartzite resembling the Dripping Spring, appears in both the Calera hills and Shaw's ranch sections. Although the lower margins of these beds are in both cases not clearly differentiated, they seem to be well under one hundred feet thick.

The generally thick character and uniform texture of this member seem to indicate a rather widespread area of deposition, which tends to thin out to the southeast and to the south. The sea of Dripping Spring time was second in areal extent in this region only to the one of Troy time.

The Dripping Spring quartzite of the Black hills, Catalina mountains and Little Dragoon Mountains conformably overlies a good conglomerate, which in the first two localities has been called Barnes. ⁽²⁰⁾ In the

20. Ransome, F. L. - Prof. Paper 98K, pp 144-145, and Darton, N. H. - A Resume of Arizona Geology, P. 274.

Peppersauce canyon the Barnes grades up through arkosic pebbly beds into the quartzite with no apparent break.

BARNES CONGLOMERATE

The typical Barnes conglomerate occurs persistently throughout the Catalina mountain area of the Apache group. It averages about thirty-five feet in thickness at Peppersauce canyon, but shows a general tendency to thin out irregularly to the southeast.

In the Bolsa of the Little Dragoon mountains, a good conglomerate is located just beneath the quartzite, which is apparently Dripping Spring, and just above a shaly member which seems quite probably Pioneer. This conglomerate, from ten to fifteen feet thick, resembles the Catalina Barnes to a marked degree. The pebbles are of generally similar material. The matrix is a coarse arkose well cemented and of the same general color and weathering character as the true Barnes. Red jasper pebbles are found throughout the member. One type of pebble is found here, however, which the writer was unable to find in the Catalina Barnes. It is a brown quartzite with a curiously pitted surface.

This conglomerate is, without doubt, a continuation of the Barnes.

At Shaw's ranch and in the Calera hills the Barnes does not seem to be present as a good conglomerate. A thick mass of material grading up from possible Scanlan conglomerate into what is apparently

Dripping Spring quartzite may include the Barnes as an angular, fragmental, marginal phase.

The round, well water-worn and slightly flattened pebbles with the coarse arkosic matrix give the Barnes an appearance generally associated with the gravels of a river deposit. Lenses of arkose with few or no pebbles occur in many places in it.

Mr. Lausen, formerly of the Arizona Bureau of Mines, has called the writer's attention to the fact that at some places north of Globe the Barnes conglomerate rests upon the Pre-Cambrian granite in such a way as to indicate a northeastern margin for the deposit.

If one considers the few apparent lateral limits of the Barnes, the tendency for the individual pebbles to grow smaller to the southeast, and the character of the materials composing it, one might conclude that this conglomerate represents a rather short, steep river of a desert climate.

River deposits may vary greatly in thickness and in general appearance within very short ranges of distance. This is especially true of rivers in desert countries where alluvial fans are carried into the main valley from side canyons and washes. Because of these facts, it is a very difficult, if not impossible proposition, to attempt to say which way such a river flowed. We might surmise from our observations that the Barnes

river lay along an axis roughly northwest and southeast, parallel to the higher land which seems to have existed to the south, but whether the gradual reduction in the average pebble size to the southeast indicates a flow in that direction is very doubtful.

The sea floors of Apache time all seem to have tilted north to northwest. If the Barnes river flowed in the opposite direction, as pebble size might seem to indicate, a marked uplift and change of slope must be accounted for at the close of Barnes time.

PIONEER FORMATION,

The Pioneer in the Black hills at Camp Grant wash is only about twenty-five to thirty feet thick, while in the Catalina mountains at Peppersauce canyon, the Pioneer sediments alone, - disregarding the thick diabases intruding them, - are apparently well over three hundred feet thick. Part of this thickness may be due to overthrust faulting connected with the Catalina uplift.

A brown to red shaly member with some silvery schist lenses occurs beneath the conglomerate, which the writer considers an extension of the Barnes, in the Little Dragoon mountains. This shale is without doubt the Pioneer.

At Shaw's Ranch a hard, reddish shale is found near the base of the quartzites. Angular quartz

fragments in quartzite occur above and below it. This fragmental conglomerate may represent the thinning margin of the Barnes and the underlying Scanlan. In the Calera hills nothing resembling the Pioneer shale could be found. The great thickness of recemented fragmental material here may represent the merging together of the Scanlan, Barnes and lower Dripping Spring horizons along a sloping shore line.

In general, the Pioneer of this region consists of a sandy lower phase grading up from the underlying Scanlan conglomerate and carrying many large fragments of unaltered feldspar. This lower phase gives way to a hard, brown, shaly measure which in turn grades into a silvery schist, which is only conformable to the Barnes conglomerate in strike and dip.

Few conclusions could be drawn regarding the original manner of Pioneer deposition within the region studied. It seems, however, to have had a southern margin along the high land which marked the edge of the members immediately above it.

SCANLAN CONGLOMERATE

The Scanlan is highly variable in thickness and character, and it seems, as Ransome⁽²¹⁾ has suggested, to represent the reworked land surface beneath an advancing sea. In places in both the Catalina and Black

21. Ransome, F. L. U.S.G.S. Prof. Paper, 98K.

hills exposures it is really only a bottom phase of the Pioneer formation. In the Dragoon mountains it is a rather clearly separated individual bed, while at Shaw's ranch and in the Calera hills, it seems to merge into and become part of a number of the overlying beds.

PRE-CAMBRIAN FORMATIONS

In the Catalina mountains the Oracle granite represents the lowest exposed formation. It is separated from the overlying Scanlan conglomerate by a marked erosional unconformity.

A pink orthoclase granite lies unconformably beneath the Scanlan in the Black hills.

The silvery white, Pinal schist is the oldest formation in the Little Dragoon mountains. The same schist of greenish color, badly wrinkled and folded, underlies the quartzites in the Calera hills.

At Shaw's ranch a Pre-Cambrian granite is the basement rock.

Conclusions Summarized

1. The Troy quartzite and the upper portions of the Bolsa Quartzite in the Little Dragoon mountains are the same.
2. The lower members of the Apache group are all represented by thinning overlapping lens margins in the lower portions of the Bolsa quartzite of the Little Dragoon mountains.
3. The Shaw's ranch and Calera hills quartzites represent the Troy quartzite in their respective upper members. Below the Troy, the Apache

members appear as probable marginal facies indicating the proximity of a shore line. The Dripping Spring quartzite in these lower members appears to have been more widespread than the Mescal, Barnes, Pioneer and Scanlan members.

4. The typical Mescal limestone gives way to a shallower water shale somewhere between the black hills and the Peppersauce canyon in the Catalina mountains. This shale becomes more sandy and is of a typical beach sand type in the Calera hills and at Shaw's ranch.
5. A huge unconformity may exist a short distance above the Mescal limestone.
6. The Barnes conglomerate seems to be a deposit of river origin in a desert climate. Its axis was probably along a line running roughly northwest. The direction of flow is not clear.
7. Climatic conditions during Apache time were generally dry as shown by the great quantities of unaltered feldspar in most of the sediments. A gradual change to more moist conditions went on through the upper part of Troy time, finally culminating in the lower Abrigo.



SOUTHEASTERN ARIZONA
 Based on Arizona Bureau of Mines map
 0 10 20 MILES
 Balsa and Apache Sections Studied