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The Geology of the Cleveland Mine Area, Gila County, Arizona

By:

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ABSTRACT

This thesis is based on field work done in the Cleveland area during the fall of 1937.

Three rock types were mapped. The Pinal schist and the Madera diorite which intrudes the schist are pre-Cambrian in age. A diabase dike intrudes both the schist and diorite.

Zones of mixed schistose and igneous material border the outcrops of the diorite and show gradational facies on one side into the schist, and on the other into the diorite. Evidence is presented as to the origin of these migmatites.

The underground workings are confined almost wholly to a shear zone which strikes about north 45° east, with a dip to the northwest of from 50° to 70°. No accurate production figures are available. The mine operators report that several hundred tons of ore containing one to two ounces of gold per ton have been mined by them.

# CLEVELAND MINING AREA

The field work for this report was done during the months of September, October, and November, 1937. During September and October the work was done only during week-ends; in November, three full weeks were spent in the field.

The writer is indebted to Dr. B.S. Butler, Dr. M. N. Short, and Dr. F. W. Galbraith, of the Department of Geology, University of Arizona, for the use of field equipment and for many valuable suggestions during the course of the fild work and the subsequent laboratory and office work. The writer also wishes to thank Mr. A. C. Stoddard of the Inspiration Consolidated Copper Company for permission to use some of that Company's surveying equipment.

Mr. Victor Atanasoff, owner of the property, cooperated in every way possible, as did Mr. Andy Prehavec, who is doing the development work on the property. Mr. W. E. Hollingsworth assisted during part of the field work. Mr. C. B. Scholefield, District Ranger, Pinal District, Crook National Forest, was most kind in loaning maps of the Forest Service, which were of great aid. Mr. B. I. Simmons furnished the financial support necessary to complete the laboratory work and the manuscript. To all of these people the writer is very grateful.

## GEOGRAPHY

The Cleveland mining area is in the Globe mining district, Gila County, Arizona, lying within the Crook National Forest. The area is in Township 1 South, Range 15 East, with reference to the Gila and Salt River Baseline and

Principal Meridian. Its approximate latitude is 33° 18', and its approximate longitude is 110° 48'. It is included in the Globe quadrangle topographic map of the U. S. Geological Survey.

The area is best reached via automobile from Globe, by way of the old Pioneer Pass road, a distance of ten miles. The nearest shipping point is Cutter, a station on a branch line of the Southern Pacific Railroad.

The district lies in the Pinal mountains, a part of the Basin and Range topographic province. It is well drained, the topography being typical of a maturely dissected mountain region. The southwestern edge of the area is a ridge trending northwest and southeast. This ridge is the highest topographic feature in the area. From the top of this ridge the drainage is southeastward to the southeast edge of the area where it turns south. Only a small part part of the area is on the southwest slope of the highest ridge. The relief is approximately 1,5000 feet, the average elevation about 5,200 feet above sea level. The streams drain into Arrasta Canyon, a tributary of the Gila River.

The climate is mild and semi-humid.[1] The mean annual temperature at Globe is 62.9°F. The mean monthly low temperature is 44.6°, reached in December. The mean monthly high temperature is 82.6°F., reached during July. The average growing season at Pinal Ranch, which more closely approximates the conditions of the Cleveland area is 161 days.

The mean annual precipitation at Pinal Ranch is 24.85 inches. This is well distributed throughout the year; April, May, and June being the only months which average less than one inch of precipitation. The mean annual snowfall is 21 inches.

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[1] U. S. Weather Bureau - Climatic Summary of the United States. Section 26 - Southern Arizona. 1931.

As the Cleveland area is higher than either of the observation stations named, the temperature there is probably lower and the precipitation higher than the figures given.

## GENERAL GEOLOGY

Pinal schist: "Highly crystalline muscovite schists." All of these textures are found in the Pinal schists of the Cleveland area.

Under the microscope, the rock was found by the writer to consist mainly of quartz and muscovite in almost equal amounts. The schistosity is readily apparent, being marked by a more or less parallel alignment of fibrous muscovite. Magnetite grains are scattered through the rock and have a crude alignment parallel to the schistosity. Chlorite is present in a very minor amount.

The northeastern half and southwestern border of the area are almost wholly schist. Schist also outcrops in smaller patches in the central, higher, portion of the area.

Age: The Pinal schist is Archean in age.[1] It has been correlated with the Vishnu schist of the Grand Canyon and the Yavapai schist of Yavapai County, Arizona.[2]

Structure: As might be expected in rocks so old and so intricately intruded by batholithic masses, the Pinal schist shows great variations in strike and dip of its plaines of schistosity. The prevailing strike of the planes of schistosity is northeast. The dip is generally to the northwest and varies from 30° to nearly 90°. The strike of the schistose cleavage

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1 Ransome, F. L. - op. cit. p. 27, 1903.

2 Wilmarth, M. Grace- Tentative correlation of named geologic units of Arizona: U. S. Geol. Survey, 1932.

runs nearly at right angles to the dominant trend of the present mountain ranges, a fact which was first reported by Ransome.[1]

<u>Origin:</u> Ransome[2] considered this schist to have been originally quartzose sediments. He based his conclusions on the preponderance of quartz in the schist and on the presence of almost unaltered quartzose sediments within the schist. Galbraith[3] also believed the schist, in part at least, to have been originally a sedimentary rock. He found almost unaltered conglomerate beds within the schist. Evidence to support the belief that the schist was originally quartzose sediments is present in the Cleveland area. On the ridge along the southeast portion of the area, a bed of almost unmetamorphosed rock was found. The rock has almost the appearance of a quartzite, the schist planes being very poorly developed.

<u>Madera Diorite:</u> (Quartz-mica diorite)

The Madera diorite was named by Ransome[4], from Mount Madera of the Pinal Range, which is about two and one-half miles northwest of the Cleveland area. Ransome described the Madera diorite as "granitic in general aspect, usually massive, but it becomes somewhat gneissoidal near the Pinal schist ....... Its usual color is bright gray ....... The rock is not porphyritic, but has a uniform granular texture, the average size of the component mineral grains being somewhat less than five millimeters. The minerals visible to the unaided eye are milky white feldspar, usually showing albite striations, quartz, and abundant black mica ....... Near contacts with the Pinal schist, the diorite contains many inclusions of the schist."

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[1] Ransome, F. L. - op. cit. p. 24.
[2] Ransome, F. L. - op. cit. p. 27.
[3] Galbraith, F. W. - Geology of the Silver King area, Arizona: Doctor's Thesis, University of Arizona, 1935.
[4] Ransome, F. L. - op. cit. p. 58.

The exposures of Madera diorite in the Cleveland area do not differ essentially from this description. Weathered surfaces have a distinctly greenish cast. Where weathering has proceeded so far as to make the rock crumbly, it has a brown color.

Microscopically, the rock consists mainly of quartz in anhedral grains, and plagioclase feldspar ($Ab_{62}An_{38}$). The feldspar has undergone incipient sericitization. Biotite and magnetite follow grain boundaries of both feldspar and quartz, and the contacts of both. A few grains of apatite are scattered throughout the section.

Age: The Madera diorite is pre-Cambrian in age.[1] It intrudes the Archean Pinal schist, but is considered older than Algoman.

Pinal schist - Madera diorite contact:

Sederholm[2] has applied the term "migmatites" to "certain confusing mixtures of supercrustal and granitic material - schists, basic eruptives, and granite."[3] The origin of such rock has long been a matter of discussion.

The writer does not profess to settle the question. The term migmatite does, however, define some of the rock near the schist-quartz diorite contact in the area, and a study of this gives some evidence as to its origin. In places, the gradation is such that it is not possible to locate a definite boundary. The gradation zones are two to ten feet wide. In them, every gradation from unquestionable quartz diorite to unquestionable schist can be observed. This type of contact is very suggestive of replacement.

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[1] Wilmarth, M. Grace - op. cit.

[2] Sederholm, J. J., - On migmatites and associated pre- Cambrian rocks of southwestern Finland: Comm. geol. Finlande Bull. No. LVIII, 1923. p. 14.

[3] Stark, J. T. - Migmatites of the Sawatch Range, Colorado: Jour. Geol. vol. XLIII No. 1, p. 1, 1935.

The first stage of the transition is marked by the presence of quartz and feldspar phenocrysts in the schist. These occur along the schist planes. As the phenocrysts increase in number it becomes increasingly difficult to decide whether the rock is schist or quartz diorite.

The microscope offers some evidence, but it is not at all conclusive. A graphic representation of the results of microscopic study is shown in Fig. 1. In going from schist to quartz diorite it is seen that magnetite, biotite-chlorite, and plagioclase feldspar increase. The feldspar in all specimens is andesine, and showed no trend in change of composition. Biotite and Chlorite are plotted together as the chlorite seems to be an alteration product of the biotite. Quartz decreases in amount, but the quartz curve is very irregular. Feldspar increases rather regularly. Muscovite increases in the migmatite zone and decreases toward the diorite.

It should be noted that the muscovite in the migmatite and the diorite is intimately associated with the feldspar. If the quartz diorite replaced the schist, it is reasonable to believe that the igneous fluids with the addition of some material, converted the sericite into feldspar. It should also be noted that in a specimen of quartz diorite some distance from the schist, the feldspar is almost entirely free from sericitization.

Fig. 2 is a graphical representation of the oxide composition of quartz, feldspar, and muscovite, of the specimens studied, as determined by calculation from the mineral composition. Silica is very irregular, but shows a decrease in going from schist to quartz diorite. Alumina shows a marked increase in passing from schist to migmatite, and a small decrease from migmatite to quartz diorite. Potash likewise shows an increase in the migmatite and then a decrease to almost zero in the freshest diorite. Soda and lime display a steady increase from their first appearance in schist near the contact with mágmatite, to fresh quartz diorite.

The potash, alumina, and silica, seem to be removed in part from the replaced rock and concentrated in front of the wave of replacement; whereas calcium and sodium are added to the zone of replacement. The solutions which, in the early stages of alteration, became richer in calcium and sodium, were able to deposit these in the latter stages. These findings agree, in part, with those of others which have been reported.[1]

Diabase:

A diabase dike which has intruded the Pinal schist and the Madera diorite, outcrops in about the center of the area. It has a strike of north 25° west, and a nearly vertical dip. The dike is about twenty feet wide and has a continuous outcrop of about 400 feet.

The diabase is a tough, heavy, dark gray, holo-crystalline rock of medium grain. The weathered surfaces are distinctly greenish. Megascopically, the rock consists of an amphibole, probably hornblende, plagioclase feldspar, quartz, and magnetite. Under the microscope, a typical section was found to consist of a groundmass of hornblende and feldspar with an ophitic texture. Much, if not all, of the hornblende is a replacement of augite. Fresh feldspar associated with quartz was determined as albite. It is deuteric. The feldspar of the phenocrysts is too much altered to identify, but probably is considerably more calcic than albitic. Magnetite and apatite grains are scattered throughout the section.

Age: The age of this diabase is unknown. It is younger than the Pinal schist and the Madera diorite which it intrudes, but can be dated no closer than that.

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1 Butler, B. S., - Influence of the replaced rock on replacement minerals associated with ore deposits: Econ. Geol. vol. 27, No. 1, Jan. 1932.

# GEOMORPHOLOGY

## General Statement

The area lies within the Basin and Range Province, and the Mexican Highlands sub-Province.[1] The physiographic development has been largely controlled by climate. The relief is about 1500 feet.

## Development of topography in the area:

The area is semi-humid, with no perennial streams. Although the rainfall is well distributed throughout the year, considered on a monthly basis, most of the rains are torrential and erode the surface rapidly for a short period. Most of the washes are deeply and steeply cut, especially those in the lower parts of the area. The ainfall has a high runoff, and as a consequence, the vegetation is more sparse than would be expected from the amount of precipitation. The small amount of vegetation offers but little protection from the torrential rains.

In this area sunset is marked by a sudden change in temperature. More extreme changes result from summer showers on highly heated rocks. These changes have but little effect on the schist, but affect the intrusive rocks considerably, the quartz diorite and diabase being broken down to a fine gravel. Apparently, however, the schist is inherently more susceptible to erosion as there is no marked correspondence between lithology and topography.

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1 Fenneman, N. M., - The physical divisions of the United States: U. S. Geol. Survey map, 1930.

# MINERAL DEPOSITS

## History of the Cleveland Mine Area

Little is known of the early history of the Cleveland mine area. It is improbable that any work was done on the area prior to 1874. In that year the Apaches were temporarily subjected and a party of prospectors crossed the Pinal Mountains from the west and located the Globe claim, now part of what is generally known as the Old Dominion mine.[1] It is probable that, in 1874, or shortly thereafter, the adit now known as Adit No. 1 (Old Cleveland) was started.

Bickel[2] states that the early prospectors worked the claims in the spring and summer, and returned to Tucson in the winter. In 1917, location work had been done on several of the claims, and the Old Cleveland adit had been driven "about 100 feet." Evidently, the legal right to the claims has been allowed to lapse several times, due to insufficient work, both before and after 1917.

In 1930, the present owner began work on the property. Adit No. 2 (New Cleveland), Adit No. 3 (High Grade), Adit No. 4 (Water Tunnel), and Adit No. 14, have been driven since that time. A road which makes the workings more accessible was built in 1932 and 1933. In the summer of 1934 a mill was built, but as recovery was low, it has not been operated since October, 1934. The mine operators report that " a little less than an ounce of gold" was recovered from each ton of ore milled, and recovery was "less than half." Most of the ore milled came from the adits No. 1 and 2.

The present owner has added other claims to his original holding so that the property now consists of 21 contiguous claims. Only one man is working the property now, (February, 1938), and all of his drilling is by hand.

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1 Ransome, F. L., - op. cit. p. 114

2 Bickel, F. E., - Private report, 1917; now in possession of Mr. Victor Atanasoff, Globe, Arizona

No accurate production figures are available. The mine operators report that an average of five or six tons a day were milled during the four months the mill was in operation.

## General Character of Deposits

Most of the mining on the property has been confined to a single lode. This lode has formed in a shear zone which marks a contact of the schist and quartz diorite. The lode seems to be mainly a replacement deposit, though fissure filling may have played some part in its formation.

The mineralogy of the deposit is simple.

Quartz is by far the most common mineral. It is massive, vitreous, and light gray or white in color.

Sericite is abundant throughout the lode. It is found in thin layers in the quartz, but is more abundant in the walls than in the veins.

Pyrite is present in the unoxidized portions of the veins, and is by far the most abundant sulphide. It occurs usually in small stringers through the quartz. These stringers vary from almost microscopic to an inch in width.

Gold No free gold was seen. It is believed that the gold is intimately associated with the pyrite.

Copper minerals are present in small amounts. In only one place, Adit No. 4, was copper stain visible.

Limonite is abundant in the oxidized portion of the lode. It was probably pseumorphic after pyrite, but has lost its original character for the most part. In only two places were good pseudomorphs found.

Calcite is found locally in the lode. It occurs as stringers in the lode and along the walls of the shear zone.

Chlorite occurs with calcite, and in the same manner.

Specularite. Small blades of specularite occur as stringers through the quartz.

The shear zone outcrops at and near the portals of Adits No. 1, 2, and 3. It is from one to two feet wide at its outcrops. Underground it is seen in places to have pinched to six inches wide, and in others to have swelled to four feet. Apparently the shear zone was formed by faulting movements which brought the schist up to its present position at this place.

The level of the ground water table seems to lie at a depth of from twenty to 100 feet beneath the surface. Above the water table pyrite has been changed to limonite; if the gold is associated with pyrite, this would have the effect of making the ore more nearly free-milling. Enrichment has probably been residual and very slight. Assays from the deeper workings are reported to be about the same as the assays from nearer the surface. The operators did not permit samples for assay to be taken by the writer.

Genesis of the ores:

It is possible that the mineralizing solutions and quartz diorite may have originated in the same magma chamber in depth, but an appreciable amount of time must have elapsed after the quartz diorite was intruded and before the ore forming solutions ascended. The basis for this statement is the fact that the quartz diorite is fractured and sheared and must, therefore, have been solidified before the veins were formed. There is no evidence, however, to warrant an assumption that the quartz diortie and the ore-forming solutions are even this closely connected. It is possible that the ore-forming solutions were introduced long after the close of the pre-Cambrian. There is no indication of more than one period of mineralization.

In addition to the veins in the shear zone, there are several quartz veins which outcrop in the area. These veins are from three inches to two feet wide. They are composed almost entirely of massive, white, sugary quartz. They contain a little muscovite. A few feet of drifting has been done on some of these veins. The writer assumes that they contained no valuable minerals.

Economic possibilities:

Little can be said of the economic possibilities of the area as knowledge of the value of the ore is lacking. Before any further work is done, the dumps and the lode should be very carefully sampled. The nature of the gold mineralization should be determined. The specularite may be indicative of a change in the nature of the primary mineralization. If the gold is intimately associated with sulphides, and the specularite marks the top of the oxide zone of primary mineralization, the gold content of the lode may decrease abruptly at a point slightly lower than the present level of mining. The lode may continue to greater depth. Shear zones were probably developed at considerable depth and may be persistent.

## Factors Affecting Development

Transportation:

The Cleveland area is about ten miles from Globe, a station on a branch line of the Southern Pacific railroad. The gravel and dirt road between the mines and Globe is partly improved, and is passable in most weather. Heavy supplies could be hauled in during the summer months. At some time during all except possibly the winter months, light supplies could be trucked to the camp.

Labor:

Labor costs are likely to be high, being determined by the prevailing wage for miners in the nearby copper mines. The base daily pay for miners in these is about $5.00, increasing with a rise in the price of copper. During periods of curtailed production in the copper mines, a plentiful supply of skilled labor should be obtainable at somewhat lower wages.

Timber:

The ground in the mines stands well and requires a minimum of timber, a plentiful supply of which, for development work, is on the claims. If the ore warrants large scale production, it will be necessary to ship in timber.

Water:

Water for domestic purposes is obtained from the adit nearest the camp. As this produces forty gallons per day, it also furnishes enough water for test milling operations. With more drifting from this adit, it is probable that a larger supply of water could be obtained.

Power:

At present, all drilling on the property is by hand. For more rapid development it seems feasible to install a gasoline or Diesel engine. If an ore body of sufficient size is developed to warrant the expense, electric power could be brought in from Globe. The rate would probably be low, as the area is not far from Roosevelt Dam where the power is generated.

Milling:

An eight-ton ball mill, two amalgamating plates $2\frac{1}{2}$ by five feet, and accessory equipment, are on the property. This mill is furnished power by a gasoline motor.

## The Mine

No attempt will be made to give a detailed description of all of the workings. Plans of all of the workings accompany this report. The three longest adits, (Nos. 1, 2, and 3) follow in a general way the strike of the shear zone previously mentioned. The shear zone, in general, strikes north $35^{\circ}$ east, and dips $48^{\circ}$ to the northwest. The adits follow a contact of schist and quartz diorite for the most part, but as the contact is highly irregular, the coincidence of the two is not perfect. In Adit No. 3, a winze has been sunk a distance of 35 feet on a quartz vein. From the bottom of the winze, about 100 feet of drifting and cross cutting has been done. The mine operators report the highest assays from this level.

Adit No. 4 and the workings connected with it were driven primarily to increase the water supply, and the operators planned to stop work here within the near future.

## Bibliography

Eickel, F. E. — Private report, 1917. Now in possession of Mr. Victor Atanasoff, Globe, Arizona

Butler, B. S. — Influence of replaced rock on replacement minerals associated with ore deposits. Econ. Geology. vol. 27, No. 1, January, 1932.

Fenneman, N. M. — The physical divisions of the United States. U. S. Geolog. Survey map. 1930.

Galbraith, F. W. — Geology of the Silver King area, Arizona. Doctor's thesis, University of Arizona. 1935.

Ransome, F. L. — Geology of the Globe copper district, Arizona. U. S. Geolog. Survey. Prof. paper 12. 1903.

The copper deposits of Ray and Miami, Arizona. U. S. Geolog. Survey. Prof. paper 115.1919.

Ray folio, Arizona. U. S. Geolog. Survey. 1923.

Sederholm, J. J. — On migmatites and associated pre-Cambrian rocks of southwestern Finland. Comm. geol. Finlande Bull. No. 58, 1923.

Stark, J. T. — Migmatites of the Sawatch Range, Colorado. Jour. Geol. vol. 43, No. 1, p. 1. 1935.

Wilmarth, M. Grace. — Tentative correltion of named geologic units of Arizona. U. S. Geolog. Survey. 1932.