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GEOLOGY AND ORE DEPOSITS OF THE SUNSHINE AREA, PIMA COUNTY, ARIZONA

by

Charles E. Higdon

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Submitted in partial fulfillment of the
requirements for the degree of

Master of Science

in the College of Mines and Engineering, of the
University of Arizona

1933

Approved: B.S. Butler — Major Adviser

May 18, 1933 — Date

SUMMARY

The rocks of the district are divided into two strongly contrasted groups, an older Cretaceous group to which the ore deposits are restricted, and a younger group consisting of cemented Conglomerate and arkose of recent origin. The Cretaceous series forms a narrow belt of schistose rocks that are parallel to the crest of the range. The younger rocks extend southward f from the schist belt.

The Cretaceous rocks comprise shales, limestone, and rhyolite. They were invaded in post Cretaceous time, by a medium grained soda granite. The intrusion and folding associated with it intensely metamorphosed the nearby rocks. Faulting then ensued, breaking and displacing some of the early formed dikes. The ores are closely associated with the intrusion. Two types of mineralization are evident. The first, accompanied by much tourmalinization, was of high temperature type. The second was of moderate temperature and includes the lead and silver deposits that have been mined.

The main ore deposits are localized along fault fissures, and limestone appears to have favorably influenced the precipitation of ore. The metallization is widespread in the area, but prospecting has disclosed only bodies of comparatively small size.

The richest ore has come from shallow workings in small enriched silver deposits. Near the Sunshine mine enrishment by supergene solutions has not been important.

The fissure zones in the limestone have not been thoroughly prospected and further exploration may encounter sulphide ore bodies similar to those already mined.

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INTRODUCTION

The Sunshine-Sunrise group of claims was mapped during the autumn of 1932 and the spring of 1933. The work was undertaken as a partial requirement for the degree of Master of Science in Geology at the University of Arizona. The writer is grateful to the geological faculty of the University and especially to Professor B.S. Butler and Professor M.N. Short. Acknowledgment is also made to Mr. A. Fisher, A. Gerhardt, and W. Moore for their assistance in the field and to Judge S. W. Purcell for hospitality and much assistance.

LOCATION

The Papago district is about forty miles southwest of Tucson, Arizona. The metallized portion of the district lies in a narrow belt of hills on the west slope of Sierrita Mountain and is about four miles in length. The belt appears to be more prominent along the northern part of the range. The mapping has been confined to the most southerly group of claims in this belt, known as the Sunshine-Sunrise group.

PROPERTY

The group consists of fourteen claims and three fractions which are owned by Judge S.W. Purcell of Tucson. The principal exploratory work has been done on the Sunshine No. 1 claim and includes a shaft 140 feet deep with short drifts and crosscuts. South of the shaft is an open cut about sixty feet wide and nearly as high. A stope extends north from the open cut for about one hundred and fifty feet. West of the open cut is another shaft and drift under the limestone hill. The Schafer Mines Company in 1929 built a sixty ton wet mill which they operated for about three months on ore from the stope north of the open cut.

TOPOGRAPHY

The Sierrita Mountain forms a broad low range of nearly north-south direction. The range has a length of nearly fourteen miles and width of approximately four miles. About six miles west of the crest of the range the slope has descended two thousand feet to a definite belt of foot-hills in which the prospects of the Papago district are situated.

The general surface relief in the area mapped is rather rugged, although west of the property for a distance of a mile is only hilly and the opening out to the alluvium bottom of Altar Valley is broad with gentle slopes.

The limestone has been locally silicified and is generally more resistant to weathering than most of the associated rocks. It crops out conspicuously along the ridge tops of the foothills.

VEGETATION AND RAINFALL

The slopes of the Sierrita Mountain carry little or no timber. The vegetation consists of mesquite, palo verde, and various kinds of cacti.

Rainfall averages about ten inches a year, a large share of which is precipitated during the wet season, from June to August.

Ash Creek flows west from the upper part of the range and is lost in the desert plain a short distance from the mine.

GEOLOGY

Cretaceous sediments, of which there is a considerable thickness, in the area are marine sediments laid down in shallow water. The series forms a narrow irregular belt extending with the crest of the range for a distance of about six miles. At some time subsequent to late Cretaceous the rocks were intensely compressed and folded. At a later date than the folding came the intrusion of a large mass of granite and related rocks.

The sediments are intensely altered for a short distance from the intrusive contact and show over the whole area a greater or less degree of alteration, due to mechanical squeezing and thermal metamorphism.

The closely folded thin bedded sedimentary rocks dip steeply to the west and are cut by many faults. They may be in part faulted against the granite.

The granite mass makes up the crest and gentle slope of the mountain range and is flanked by metamorphosed rocks of sedimentary and volcanic origin.

The sedimentary rocks because of their schistose character appear at first to be rather old. No fossils were found in them, and consequently their age is uncertain, but they are arbitrarily assigned to the Cretaceous. The reason for doing this is their resemblance to other known sediments of this age.

The schistose series is upturned and close folded and seems to be the dominant rock in the vicinity of the intrusive. West of the shaly slates and underlying the upper margin of the plain that slopes gently westward from the foothill belt is a fairly coarse porphyritic granite with phenocrysts of reddish orthoclase. This is regarded as pre-Cambrian. An exposure of what is probably a basal conglomerate was seen at one place between this granite and the shaly slates.

The Cretaceous beds are mainly shales, arkose, and quartzites. In the series are several thin bedded limestones which are conformable with thin beds of sericite schists. Associated with these sedimentary beds and like them now schistose are elongated masses rhyolite. These are presumably flows that were erupted during the deposition of the sediments and have been folded and compressed with the sedimentary rocks. The present attitude and close folding of the beds is attributed to the orogenic revolution at the close of the Cretaceous and during early Tertiary times. In southern Arizona granitic intrusions abound in the smaller mountain ranges and the intrusions are linked with thrust faults.

STRATIGRAPHY

No columnar section was measured since the series varies so greatly. The limestone north of the district, especially near the Aguinaldo mine, appears to be much more prominent and there are clearly five or six parallel belts. Near the Sunshine mine the maximum thickness of the limestone seems to be about seventy feet and only three belts are evident. South of the mine and across Ash Creek there is only one exposure of the limestone.

The section is well exposed for measurement but the lense like character of the limestone and quartzite is the cause of much variance in these formations along the strike. The rather thick silicified limestone that determines the crest of a prominent ridge near the Aguinaldo and Olympia mines does not continue thru to the Sunshine group altho its strike is southeast.

South of the mine, about eight hundred feet, is a considerable thickness of cemented conglomerate that rests against the intrusive and extends to the plain that opens to Altar Valley.

A thickness of at least 6000 feet of rock appears to be represented.

CHARACTER OF THE SEDIMENTARY ROCKS

Forming a considerable part of the sedimentary series, particularly along its eastern margin, near the intrusion, are pale lilac-grey rocks that, although plainly squeezed and schistose, have not been recrystallized as a whole and still show clearly their original elastic texture. They appear to have been deposited as sand and gravel, and are composed largely of rock fragments with quartz and feldspar. The feldspar, mainly plagioclase, in part has altered to sericite. Sediments of this heterogenous character must have been derived from areas in which igneous rocks were undergoing disintegration and erosion so rapid that grains of feldspar, not as a rule a very resistant mineral, were carried away and deposited in some adjacent water body before they could decompose. Because of the coarseness of some of the grains this material may represent a mingling of ordinary rock detritus with volcanic tuff.

The shale is a grey to purple, rarely red argillaceous rock. A considerable thickness of red shale appears to the west of the area mapped. In places the grey shale is so fine that individual mineral grains do not show. Commonly, however, it is distinctly micaceous, and in some places it approaches a quartz schist. The shale is banded and foliated as a result of the parallel arrangement of the secondary mica. Nearer the intrusion it is a fine grained, flint-like rock that breaks with a parallel fracture. In places small spots of black tourmaline about three millimeters in diameter form a considerable part of the rock.

Limestone forms a considerable part of the schistose series. There are many distinct bodies of limestone, some are only a few feet thick; others measure one hundred feet or more. Some continue for a mile or two, others are less than one hundred feet in length. They are apparently folded, upturned, and squeezed lenticular beds that were deposited as members of the sedimentary and volcanic series (within which they lie). Along the course of the limestone there is intense replacement by silica on Sunshine Hill. In general it is difficult to detect the true bedding in the massive fractured limestone. Most of the beds, including all the black fine grained beds, are limestone and effervesce freely with acid, but some of the more crystalline beds are dolomitic. Flint or chert is found in a very few places. In the light grey siliceous laminated beds and thin-bedded dolomites and dolomitic limestone, many of the lamellae are broken, making a flat-pebble "conglomerate", though the fragments are angular and not rounded. Outcrops of the thin bedded limestones suggest that they are interbedded with the schist.

Lying generally west of the limestone ridge in the area of the Sunshine mine is a belt of blue-grey shaly slates with which are interbedded a few thin beds of dark quartzite. This belt is obviously metamorphosed shale and sandstone.

A conglomerate composed of volcanic material extends south and east for a distance of 1000 feet from Iron Mountain. It is made up of red andesite fragments about one inch in diameter. It contains sporadic fragments of granitic rocks and siliceous sediments. Several fragments of a rather coarse porphyritic light-grey granite were seen in this conglomerate. No exposure of such an igneous rock was seen within an area of three miles. The conglomerate appears to be faulted against the limestone and shale. The contact with the intrusive is seen about 1200 feet east of Iron Mountain and this also appears to be a fault contact. Small areas of the conglomerate are altered by the tourmaline mineralization.

IGNEOUS ROCKS

The main intrusive rock in the district is a fine grained brownish rock of sada granite composition. Thin sections show it to be composed mainly of microperthite occurring in grains ranging up to five millimeters in diameter. Plagioclase feldspar is subordinate to microperthite. The plagioclase is somewhat elongated and shows traces of euhedral outlines, the grains being about the same size as microperthite. Quartz occupies interstitial spaces between feldspars and contitutes about fifteen per cent of the rock. Ferromagnesian minerals are conspicuously absent, some small grains consist of aggregates of sericite in parallel orientation in which are formless grains of iron oxide. This sericite is probably pseudo morphic after biotite. Some of the plagioclase feldspars are considerably altered to sericite and carbonate, whereas microperthite is nearly fresh. The rock is stained by limonte that occurs along numerous fractures.

The intrusive nature of the granite is clearly shown by the change to porphyritic texture near the contact and by tongues and dikes of this facies in the adjacent limestone. Near the Aguinaldo workings which are about four miles from the mapped area; limestone has been intruded by a dioritic offshoot from the main mass of granite. This is regarded as a calcic border phase of the granite. The limestone shows contact metamorphism with layers or streaks of tremolite in radial fibrous aggregate associated with galena.

Several areas of lighter color and finer grain occur as apophyses of the main mass. A thin section shows some chlorite and carbonate which is not pseudomorphic after biotite; this is probably from hydrothermal solutions connected with the mineralization.

Aplites and pegmatites do not occur.

A narrow dike of lamprophre cuts the granite near Iron Mountain but does not enter the limestone. It shows trachytic texture in which the feldspar laths show distinct parallelism. Olivene is present and is now much serpentinized. The feldspars are very fresh and in places occur in radiating laths nearly all of which show Carlsbad twinning. The ferromagnesian content is represented by the groundmass. Carbonate has extensively developed and occurs in rounded grains up to one millimeter in diameter.

Interbedded with the sedimentary rocks and like them now schistose are area of squeezed rhyolite. They are presumably flows that were erupted during the deposition of the sediments and are older than the granite intrusion. This material is of variable character. The distribution of quartz in the hand specimens suggests an igneous rock. Thin sections of altered material taken in Ash Creek about two hundred and fifty feet below the lower tunnel show the following: the rock is composed of quartz with considerable sericite. The quartz is in irregular grains about one millimeter in diameter. There has been some growing of the crystals and evidence of slight recrystallization. The quartz grains are cracked and the original material of the groundmass has been squeezed around them. Fresher specimens of the rock from Sunshine Hill shows the presence of some feldspars the laths of which are somewhat angular. The feldspars were determined to be orthoclase and albite. Some of the material may have been rhyolite tuff. The rhyolites dip 15° - 65° W., averaging about 45° W., and they trend nearly parallel to the range. Their attitude is determinable, as thin well-bedded volcanic grits are interstratified with them from place to place.

Latite is the most abundant of the Tertiary volcanic rocks and it is more than one hundred feet in thickness southeast of the Sunshine mine.

It is dark greenish or brown. It contains large phenocrysts of plagioclase feldspar surrounded by a fine ground mass. No quartz can be recognized. Traces of flow structure can be observed. The phenocrysts show partly euhedral outlines and are about five millimeters in length. The rock is extensively carbonized.

Irregular areas of basalt occur in lower Ash Creek. The rock is dark green in color and fine grained. It is in places spotted with amygdules from three to five millimeters in diameter. The spherical amygdules are composed chiefly of calcite but some contain chlorite as well. There are also numerous veinlets filled with calcite. Microscopically it proves to be composed of tiny feldspar laths showing distinct parallelism and between the feldspars is a very fine grained groundmass which is apparently devitrified glass. The index of the feldspars is above that of Canada balsam. The rock is distinctly stained by red iron oxide.

GENERAL STRUCTURE

The westerly dip of the sedimentary series becomes less as the shaly slates and red shales are encountered. Along the six mile contact of the schistose series with the intrusive the beds are upturned. It is apparent that the sediments were altered by pressure and much of this alteration was before the main intrusion of granite. The thin bedded sediments yielded by close folding.

South of the well on the Water Edge claim the contact of the limestone with the granite appears to be due to faulting. The fault is not very clear and there is no brecciation but this explains most simply the unaltered character of the limestone. The shale between the two limestone members shows the same alteration as that farther south on the contact.

As may be seen from the detailed map the main mineralized area is cut by a large number of small normal faults. Small dikes of andesite occupy some of the faults; in the vicinity of the Sunshine mine. These dikes are in turn broken by faults, and along some of the dikes white chert is developed. Two of the faults can be traced eastward nearly to Iron Mountain. The intense normal faulting is confined to Sunshine Hill, the most mineralized part of the area.

A sharp fold in the limestone beds is present about 1500 feet north of the mine, and a large closely compressed fold is developed in the Iron Mountain area. Part of this fold is cut by a fault that tends to lower the west limb.

A portion of intrusive basalt has been faulted against the limestone a little southeast of the Sunshine mine. The basalt, which makes the footwall country rock, is considerably shattered near the contact.

METAMORPHISM

The rim of intense metamorphism surrounding the granite is narrow. The limestone close to the contact is epidotized and abundant sericite is developed in the schists.

In the contact zone of the area is commonly a dense green shale, that is greatly fractured. The shale is slightly calcareous, and in the Iron Mountain area numerous small calcite veins are developed. A strong fault separates this shale and the limestone to the west.

The contact between the granite on the east and the schist on the west, about eight hundred feet east of the Sunshine workings, shows no very conspicuous contact metamorphism. Ashort distance east of the contact

metamorphism

a narrow mass of limestone is included within the granite. This has been changed in part into a hard, tough, greenish-yellow rock consisting largely of garnet with some green amphibole. In places it contains a little pyrite and sphalerite, and on the surface shows copper carbonates.

Close to the contact the limestone is commonly bleached and more coarsely crystalline and may show a considerable development of lime silicate minerals. In immediate contact with the granite there is considerable epidote. In the area of metamorphosed sediments in the Iron Mountain area limestone is altered to a dense white rock consisting essentially of quartz and coarse calcite.

Tourmaline

A conspicuous feature in the soda granite is numerous veinlike masses, as much as five feet wide, and irregular areas of black tourmaline and quartz. The tourmalinization evidently proceeded from joint planes in the granite; where the jointing was closely spaced or the tourmalinization was intense the granite is altered completely and solidly to a quartz tourmaline rock. In places the grain of this quartz tourmaline rock is so dense that the tourmaline is not discernible and the rock resembles a black jasperoid; in other places the grain is coarser and the radial fibrous structure of the tourmaline is readily apparent. Tourmaline attains its maximum development near Iron Mountain in fine grained silicified shale where it forms "eyes" and prisms about three millimeters in diameter. The intervening rock is tourmalinized on a large scale, except the limestone, so that it is manifest that here was a focus of intense pneumatoysis.

As a rule the tourmaline crystals are most numerous and best developed in the finer grained sediments particularly those having an abundant sericitic matrix. The coarse, highly siliceous quartzites and the calcareous rocks are apparently the least favorable to the development of the minerals.

The tourmaline veins do not appear to be of economic value, but they are of interest in showing the diversity of mineralization in the district.

The tourmaline content in areas of the soda granite and its concentration in the Iron Mountain area, which was near the intrusive contact, point to the fact that the mineralization was a differentiate from deep lying portions of the magma.

ORE DEPOSITS

General

A lode system five miles long extends along the lower west slope of the Sierrita Mountain. The main ore deposits of the district are lead-silver deposits characterized by a gangue of calcite or siderite. Some mineralization is associated with a fibrous amphibole, probably tremolite. Galena is the chief mineral; argentite is commonly associated with it, but other primary sulphides are rare.

There are no regular or persistent veins but the mineralization is usually confined to fissuring in the limestone.

Adjacent to the intrusion there are contact deposits that have been developed for copper.

In the main granite mass, near the head of Ash Creek, are several small silver ore bodies in fissures.

The ores in general are not oxidized extensively. Residual sulphides, especially galena, commonly occur in the outcrops. There is no evidence that enrichment by supergene agencies is important. At the slight depth attained the galena is accompanied by cerusite, anglesite, cerargyrite, and other products of oxidation. It is probable that the small quantity of silver ore shipped is the result of secondary enrichment.

SUNSHINE MINE

Geological features. The workings of the Sunshine explore a zone of fissuring that is in a faulted area of limestone and rhyolite. A limestone bed about fifty feet in total thickness is cut off to the south by a fault, the movement along which was mainly horizontal. On Sunshine Hill it lies about eight hundred feet west of the granite, from which it is separated by a belt of grey schists. West of the limestone are alternations of similar schistose and slaty rocks with belts of schistose rhyolite. The limestone gives way to the north of the open cut to a light brown aggregate of quartz, the contact between the two being a fault of small movement, the dip of which varies from 60° to 20° in a very short distance. Some ore occurs as a replacement in the limestone along this fault.

Dikes of andesite porphyry, ranging in width from five to twenty five feet, occupy faults on Sunshine Hill. The dikes are quite schistose with considerable areas of kaolin. A plagioclase of the composition of acid andesine forms parallel laths in the dike. The groundmass of the dikes appears to be glassy and there is a considerable pereentage of small magnetite grains. The contacts of the dike are sheared and reduced to gouge in places; evidently an old fault continued to be a locus of movement. The dikes seem to be prominent in other crushed zones. They are evidence of the break in the formations between the open cut and the limestone mass near the west shaft. In a drift running north from the west shaft no lead ore was found, but two strong fractures in the limestone were mineralized with galena and sphalerite.

What may be an intrusion of rhyolite is seen on the higher part of Sunshine Hill. Areas of silicification occur on the east and west side of the rhyolite. If the rhyolite was intruded before the major period of faulting it differs from the other rhyolite in not being greatly schistose due to the dynamic action.

Ore Deposits. The main ore body is replacement of limestone on both walls of a northerly striking fault-fissure. The fault-fissure is shown on the enlarged map of Sunshine Hill. The limestone adjoining this fault is broken and crushed, and there is some evidence that the shattering facilitated or governed the replacement of the limestone by the mineralizing solutions.

The ore consists mainly of galena, with a little resinous sphalerite, which occupies fractures in the dark fine grained aggregate of limestone. The ore also occurs partly as a replacement of limestone walls, where limestone is faulted against quartzite.

Surface cuts and pits along the limestone show the presence of more or less galena for a length of five hundred to seven hundred feet but the work done does not prove the existence of a continuous ore body along the line of these openings. The strongest mineralization is seen acrosss the face of the open cut at the south end of the ridge. The limestone strikes N 20° W and dips about 24° W. The pitch of the ore shoot is nearly that of the bedding of the limestone. The deposit as a whole appears to be comparatively low grade, and it is difficult to make any close estimate of the quantity and average tenor of ore present in any definite mass of limestone.

The main northerly vein is much crushed and irregular and shows weathering to the bottom of the shaft. The crushed zone is limited by walls that are highly irregular in plan and cross section. Where explorations cut through the walls the country rock is either fresh cream colored dolomite or a greenish shale.

The lower tunnel extends north from Ash Creek and follows the fault contact. In about fifteen feet the crushed quartzite gives way to the limestone. In the tunnel there are several branches from the main fault that are followed for a short distance by drifts.

The walls of the veins are not simple fractures but part of an elaborate branching system and only exploration can determine their persistence. Altho two veins have been the source of the ore so far, minor fractures are locally ore bearing.

Most of the argentite that is associated with the galena in the Sunshine mine is undoubtedly primary and the amount increases with the percentage of galena.

IRON MOUNTAIN

The Iron Mountain mineralization is in an area of silicified limestone with much hematite and epidote. A little oxidized copper ore is seen along the outcrop where areas of hematite are present. Microscopic examination of this material shows very small areas of chalcopyrite in the hematite mass.

Areas of coarse recrystallized limestone appear near the hematite mineralization. The massive silica in the area is evidence of the amount of metamorphism that has been caused by the mineralizing solutions.

It is evidently a type of contact metamorphism closely related to the intrusion.

ORIGIN OF THE ORES

The district contains two distinct types of ore deposits, namely a type characteristic of high temperature represented by the tourmaline mineralization and the contact deposits, and a type of intermediate temperature mineralization represented by the lead silver deposits.

Both types are associated with fissures. The tourmaline type occurs in fissures in the soda granite and are evidently later than the solidification of that rock.

It seems a reasonable assumption that the mineralizing solutions were given off from deeper lying portions of the granite mass that is now exposed by erosion.

BIBLIOGRAPHY

No detailed study of the area has been made. Ransome[1] has written a brief description of some of the prospects in the Papago mining district.

1 Ransome, F. L., Ore Deposits of the Sierrita Mountains, Pima County, Arizona; U.S.G.S. Bull. 725 pp 414-419