
NOTES ON THE ORE-DEPOSIT OF THE TREADWELL MINE, ALASKA.

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By George M. Dawson, D. S., F. G. S.
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The Treadwell mine, situated on Douglas island, Alaska, is a somewhat remarkable ore-deposit, and has of late years become prominent as a producer of gold. I am not aware that any systematic description of the character of this deposit has yet been published, and this circumstance may render the following notes on its mode of occurrence of interest, while the microscopical examination of the gold-producing rock by Mr. F. D. Adams, throws further light on the character of the deposit. My examination of the mine itself was made, by the kind permission of Mr. Treadwell, while I was on my way back from the Yukon District in the autumn of 1887.

Attention was first drawn to this deposit, by the discovery of gold-placers, which were worked for several years previous to the finding of the ore, and in a few cases were found to pay well. The gold of the placers was fine, but rough and unworn in character. The placers occurred on the surface of the ore-mass itself and on the rather steep slopes running down from its outcrop to the shore, and must have been produced by the natural decay of the ore subsequent to the glacial period, as they were found to lie above the boulder-clay, which fills many of the hollows and rests directly on the rock wherever it occurs. It may be noted here in passing, that Mr. Treadwell informed me that barnacles and various marine shells had been found still adhering to the surface of the rock, in places from which the clay had been excavated, up to a hight of 150 feet above the present sea-level.

The ore-mass, which has been extensively exposed by stripping and proved as well by several drifts, has a thickness of about 400 feet. Its length, or at least the length of that part of it which will pay for working, is not accurately ascertained but must be considerable. It runs in a general northwesterly direction, parallel to the shore of the eastern side of Douglas island and is bounded to the northeast and southwest by dark, rather slaty argillites, which, from analogy with similar rocks which

I have examined on the coast of British Columbia, to the southward, may very probably be of Triassic age and referable to the Vancouver series of the reports of the geological survey of Canada.[1] On the northeast side, in the immediate vicinity of the Treadwell mine, the ore-mass is bounded by a zone about seventy feet in thickness of greenish schistose slate, but it is uncertain whether this zone owes its character to peculiar alteration, or to a difference in original composition, as the slaty rocks as a whole, do not show any marked degree of alteration in the vicinity of the ore. A slate 'horse,' more or less completely silicified, is passed through in one place in the main working drift, but its character as a portion of the country rock is still clearly apparent. The argillites or slaty rocks are often found to be flexed and tilted at high angles along this part of the coast, and it is probable that the main period of elevation of the coast ranges has been subsequent to that of their deposition.

The ore itself presents none of the characters of that of an ordinary lode or vein, being without any parallel banding or arrangement of its constituent minerals, and showing no such coarse crystalline structure as a lode of larger dimensions might be expected to exhibit. It is, on the contrary, a nearly homogeneous crystalline mass, of medium grain, and pale grey in color, evidently consisting principally of quartz and white feldspar with a little calcite, and specked throughout with small cubical crystals of iron pyrites. The quartz, however, as well as the calcite and pyrites, may occasionally be found traversing the mass in small irregular veinlets and stringers, and the pyrites in some instances forms little distinct aggregations or bunches.

A clue to the true nature and origin of this deposit, (otherwise of a somewhat enigmatical character)appears to be afforded by the existence in it, in some places, of kernels of a distinctly granitoid appearance. Some of these were observed to be six inches in diameter, and portions of others were found which may have had a diameter of several feet. The material of these kernels—which around their edges blend imperceptibly with the main mass,—is similar in size of grain to that of the ore-mass itself, but includes little or no pyrites. It is harder and less evidently decomposed, often greenish in tint from the

[1]See Annual Report Geo. Sur., Can., 1886. p. 10 B.

development in it of chloritic minerals or reddish, and, microscopically examined, shows two feldspars with some quartz. In general aspect it in fact resembles the varieties of fine grained granite which are frequently met with near the junction of an ordinary granite with other older rocks through which it has broken.

The impression formed from such examination of this remarkable deposit as I was able to make is, in fact, that it represents the upper portion, or "feather edge" of a granitic intrusion, probably contemporaneous and connected with the characteristic granites of the neighboring Coast Ranges, but which, owing to peculiar conditions, has become decomposed and silicified by solfataric or hydrothermal action, to which the concentration of gold in it and the deposition of pyrites, are also due. To what extent the presence of gold may depend on the occurrence of the adjacent slaty argillites (elsewhere known to contain auriferous quartz-veins) it is impossible to say, but it appears not improbable that the deeper portions of these rocks may, under the action of such heated solvent waters, have afforded both the gold and the pyrites. It is conceivable that the hydrothermal action which has affected this part of the original granitic magma may have been due to the water included by the mass itself while in a state of "aqueo-igneous" or "granitic" fusion, the escape of such water through the substance of the upper part of the intrusive mass being rendered possible by the relief from pressure consequent on the approach of the intrusion to the actual surface. It may, however, perhaps with greater probability, be supposed that the water included in the adjacent sedimentary deposits, became vaporized by the heat of the intrusive mass, and found its way to the surface in the form of steam through the substance of that mass. It will be noticed that Mr. Adams finds evidence in the microscopical character of the rock of much crushing and fracture, so that in any case it must have afforded a convenient channel for the passage of heated waters or steam, and this appears to have been one of the more important circumstances leading to its mineralization.

The slaty rocks themselves in the vicinity of the ore-deposit are traversed by numerous small veins of quartz; and at the distance of a few miles (on the mainland opposite Douglas island in "Silver Bow Basin") similar slaty rocks are found

to be cut by quartz-veins of greater width, which hold visible gold. The association of metalliferous quartz-veins with masses of granite or other intrusive rocks traversing sedimentary deposits is a fact of general observation. Had the higher portions of the rocks, which may at one time have completely covered this particular granitoid intrusion, remained, it might be anticipated that it would be found to pass upward into one or more ordinary auriferous quartz-veins, these filling fissures through which the heated waters ultimately reached the then surface. In depth the present ore-mass should be found, on the other hand, to pass gradually into ordinary unaltered granite. Many cases of course occur in which intrusive masses have led to the formation of metalliferous veins without producing extensive low-grade metalliferous deposits of an intermediate character, such as the one here naturally exposed by subsequent processes of denudation appears to be. This deposit therefore affords an interesting example of the manner in which intrusive masses may directly give rise to ordinary metalliferous veins.

The quantity of gold contained in the ore of the Treadwell mine is small. Though not informed as to the actual yield, I believe it to be on the average less than $10 to the ton. The ore is, however, easily and cheaply obtained by work resembling quarrying rather than mining, and can in consequence be profitably worked on a large scale. It is not intended here to enter into particulars as to the mode of working, but it may be stated that at the time of my visit 120 stamps were constantly employed, and that since that date this has been increased to 240, the quantity of ore milled daily being now reported at from 500 to 600 tons. A considerable proportion of the gold is "free" and this is saved on amalgamated plates. The remainder is contained in the iron pyrites, which is separated by Frue Vanners. The pyrites was then formerly roasted in revolving cylinders, but these were being replaced at the time of my visit by continuous automatic furnaces similar to those employed in sulphuric acid works. The gold is dissolved from the roasted product by chlorine gas, and precipitated by sulphate of iron.

As the geological conditions are very similar along the west coast all the way from Lynn canal to the strait of Fuca, it appears highly probable that other deposits of a similar character to that here described remain to be discovered. With the facts developed in connection with this mine in view it would appear to be well worth while to subject to examination and assay all pyritous granitoid rocks in contact with or penetrating the sedimentary formations, and in particular those which may be found to traverse the slaty argillites of the formation above referred to as the Vancouver series.

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The material employed in this examination consisted of several small specimens kindly placed at my disposal by Dr. Geo. M. Dawson who collected them at the Treadwell mine in 1887, together with two collected by Mr. R. G. McConnell, of this survey, who visited the mine when returning from the Yukon country last autumn.

The ore is a more or less altered granite, rather coarse in grain and of a light grey color. As mentioned by Dr. Dawson in the previous paper it encloses "kernels" often greenish in color and distinctly granitoid in appearance, having a diameter of from six inches to several feet. These are of the same grain as the rest of the mass, but are harder and less evidently decomposed, and pass rather sharply but imperceptibly into the ordinary grey granite. As these represent the granite in its least altered form they will be described first.

The Kernels.—One of the hand specimens shows a portion of one of these "*kernels*" which is seen to differ from the ordinary granite in two particulars: 1st, in being light reddish in color instead of grey; 2d, in being free from quartz-veins and holding but little pyrite. When a thin section is held against a dark background it is seen to be made up of numerous rather large translucent crystals or individuals closely packed together, but separated by narrow, transparent, intermediate lines. Under the microscope these translucent crystals are seen to be feldspar a good deal decomposed (which accounts for the opacity) while the intervening spaces are found to be in part grains of quartz or of broken feldspar and in part the edges of feldspar crystals, which are often much freer from decomposition products than their central portions.

Most of the feldspar is untwinned and is referred to orthoclase. A much smaller amount, however, shows polysynthetic twinning, in a few cases two sets crossing at right angles, and is therefore plagioclase. In one of the sections a few large grains showing perthitic intergrowths were seen. Both feldspars often possess a marked zonal structure, caused or accentuated by the accumulation of decomposition products along certain concentric lines. Although many of the feldspar individuals extinguish simultaneously over their whole extent many

sible to determine their exact limits owing to an impregnation of the rock about their edges, with the minerals of the vein. In these veins and masses both minerals occur in large grains. Very irregular-shaped masses of the calcite, also clearly secondary and often associated with pyrite are also found, especially in the crushed and broken portions of the rock. As before it occurs in large grains, frequently enclosing little bunches of a black, rod-like mineral. Little isolated crystals of calcite also occur in a similar manner. The calcite does not occupy cavities into which the other minerals have crystallized but seems to have eaten its way into the feldspar, in some cases showing crystalline boundaries in the substance of the latter. Pyrite is present in considerable amount and is generally found well crystallized in little cubes. It occurs almost invariably in the crushed and broken portions of the rock and is very frequently associated with the calcite. In one slide, reproduced in Figure I, a mass of pyrite was observed enclosing a fragment of orthoclase, evidently a corner broken off from a large individual adjacent to it *and with which its orientation was identical*. In the figure the clear spaces show unbroken fragments of orthoclase separated by broken material, the result of crushing. A number of these small grains near the top of the cut, which are bounded by a somewhat heavier line, show one of the large fragments in the act of falling to pieces, a phenomenon which can be observed in most of the slides, when they are revolved between crossed Nicols. A number of little cubes of pyrite are seen in the broken portion. After the corner of the large orthoclase individual had been broken off, the pyrite was evidently deposited in the crack and around the detached fragment. The other little white spaces in the same pyrite mass represent little inclosures of quartz. These facts together with the occurrence of the pyrite almost exclusively in the crushed portions of the rock clearly prove the secondary character of this mineral.

FIGURE I.
Section of the granite showing cataclastic structure with deposition of secondary pyrite. Magnified 32 diameters.

As it was a point of much interest to ascertain if possible the manner in which the gold occurred in the rock, the sections, twelve in number, representing five hand specimens very carefully examined

by reflected light. In ten of them no trace of gold could be detected, but in the other two both from the same hand specimen, a few little bright yellow spots having exactly the color of gold could be distinctly seen in three of the pyrite grains. These spots were quite different in color from the pyrite and easily distinguished from it. Figures 2 and 3 represent two of these grains of pyrite with their inclusions of gold. In order to make certain of the character of the yellow spots, the cover was removed from one of the sections and a portion of the section containing the grain of pyrite seen in figure 3 was removedto a clean glass slide and treated with hot concentrated nitric acid. The acid was found to dissolve away the pyrite with effervesence leaving the bright yellow spangles of gold behind. The gold therefore occurs in part at least, in a free state and imbedded in the pyrite; no gold could be detected except in the pyrite. The zeolite mentioned as occurring in the rock is present in small amounts and is not seen in every section. It is evidently secondary, occuring in small irregular-shaped masses as a microcrystalline aggregate. The individual grains were too small to allow its optical character to be determined. The cover was however removed from one section containing it and the rock was treated with concentrated hydrochloric acid in the cold for half an hour. On treating with fuchsine the aggregate was found to take up the coloring matter readily, showing that it had been decomposed by the acid and is probably one of the zeolites.

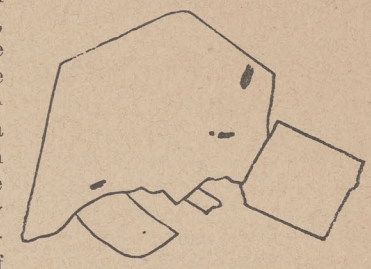

FIGURE 2.
Grain of pyrite holding inclusions of native gold, magnified 43 diameters.

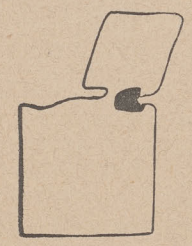

FIGURE 3.
Grain of pyrite with inclusion of native gold.

It is a matter of difficulty to determine whether any cases of secondary enlargement are to be found in the sections. I believe however that in some cases the broken fragments have commenced to grow again by secondary deposition of material around their edges, although on account of the ragged character of the latter due to breaking away of fragments by crushing, it is very difficult in some cases to determine whether an irregular boundary is the result of crushing or of a secondary growth. The outline of some grains is very similar to that of a feldspar crystal showing secondary enlargement which is figured (Fig. 1, b.) in the preliminary notice of a paper on the Archean Geology of Missouri by Erasmus Haworth, (John Hopkins University Circulars, No. 65, April 1888). The feldspar of the rock is generally much clearer and more transparent along the borders of the veins and irregular masses of secondary quartz. In one case an individual of decomposed plagioclase was observed which was very clear and fresh

where it approached a quartz vein. Both fresh and decomposed portions had the same orientation, and it is possible that the clear portion may have been an enlargement of the original grain.

In order to ascertain the character of the rock around the edge of the "*kernels*" where a transition between the two varieties might be looked for, two sections were cut from a small hand specimen one-half of which consisted of a portion of a "*kernel*" and the other of the usual grey granite. The granite near the "*kernel*" was found to resemble the ordinary granite in containing a considerable amount of pyrite, though less than the more altered granite usually holds, as well as in the fact that all the hornblende and epidote and practically all the chlorite has disappeared. A number of oblong forms were also to be seen, being of the same shape as those described in the sections of the "*kernels*" as probably decomposition products of hornblende. This rock however shows these in a still further stage of alteration, being now composed of an aggregate of calcite grains, often with a little pyrite and iron ore. The rock also contains some quartz, a portion of which occupies corners and is more or less broken and probably a primary constituent, while the rest occurs in a few irregular-shaped aggregations associated with calcite and pyrite in crushed portions of the rock and is secondary. The rock near the edge of the "kernels" therefore may be said to be intermediate in character between that of the "*kernels*" and the ordinary granite, but to resemble the latter more closely than that of the former. It is probable that some of the calcite masses found in the ordinary granite may be remains of the hornblende originally present but which have now to a certain extent lost their original shape owing to movements in the rock. It may therefore be stated that the ore of the Treadwell mine is a granite, probably belonging to the class of the hornblende granites, much crushed, altered and impregnated with secondary quartz, calcite and pyrite; that the "*kernels*" are portions of the rock in which alteration is less complete than in the mass of the granite and that at least a considerable portion of the gold present in the ore is contained in the pyrite as free gold.