

In Alaska the White Horse Copper Belt attracted a good deal of attention last autumn and the present spring, on account of the large size of some of the mineral outcrops, and the richness in copper of the specimens taken from a number of claims, of which more than 200 have been located, including, quite a number of the so-called concessions, having an area of 160 acres each. Some account of the general surroundings and geological features may therefore, interest the readers of the "Engineering and Mining Journal."

The writer visited the locality in May, 1900 and again in August and September, and made a more or less careful examination of some 40 or more locations, extending some 10 miles along the belt from north to south, and the views here are expressed are a generalization of the information gathered at that time. It is evident that in many cases it would be unfair to the owners to specify the names of the claims on which certain facts were observed, so that such references will as much as possible be avoided, as there is no intention to boom any particular property, or, on the other hand, to belittle merits.

These locations lie in the Yukon Territory, a few miles to the west of White Horse Rapids, in latitude 60; deg. 40 min. north, longitude 135 deg. west; and are accessible by rail from Skagway to White Horse or Closeleigh, as the name appears on the earlier maps.

There is such widespread misconception of the true conditions surrounding mining in Alaska that it seems desirable to discuss the probabilities of successful mining.

First of all the mind must be disabused of the idea of perpetual snow and glacial cold, which has obtained through the wide distribution of pictures of the Chilkoot Pass, and those taken to show the difficulties of railroad construction in winter. The region is no further north than Stockholm and St. Petersburg in Europe, and the cold is no greater than in many portions of Canada and the Northern United States, or than in Siberia, where mining has been carried on for centuries.

At Skagway (lat. 59 deg. 30 min. north) the snow line in February was 1,000 ft. above sea level. In the region of the White Horse Mines in 1899, while the upper lakes were yet more or less covered with ice, the country was almost entirely free from snow by May 20th. There is, in fact, in this latitude, no more difficulty, so

far as the climate is concerned, in operating a mine at White Horse, than in Northern Michigan, British Columbia; and fully seven months can be counted on as available for the necessary outdoor preparations, with the advantage that for several of these months operations can go forward night as well as day without artificial light.

It is true that much of the gravelly land is frozen to considerable depths, but this is not universally the case, and the laws governing the condition do not seem to be well understood; but this feature is ameliorated by the denudation of the forest and influx of sunshine and would have little weight or influence on rock work. The work on the railroad shows that in the open air and working on a large scale the cost of rock work, including explosives, range from \$1.40 to \$2.40 per cubic yard, or about 87¢ to \$1.40 per ton. These rates are fairly applicable to mining at White Horse, and may serve as a basis for computation. Labor was 50¢ an hour, and \$1 per diem was charged for board. The passenger rate from Skagway to White Horse is \$20, and the rate per ton on merchandise is 4¢ per pound on ton lots of 5 tons or over, and 4 1/5¢ per pound on smaller quantities. To secure return freight, which is now practically nothing, the railroad offers a very liberal schedule on ore shipments. For ore in bulk under \$50 per ton gross value, \$8 per ton; under \$100, \$9; under \$200 per ton, \$11 per ton; with a reduction of \$1 per ton, when sacked. So far as known at present, there is no available coal in the region, and all supplies must be brought from the outside. To the above rates should be added a general average of about \$8 per ton from the ports of Puget Sound to Skagway, and about \$5 for the return voyage. Still further to foster the mining industry the railroad will, for the present, take charge of ore shipments to the outside smelters and collect transportation charges out of the returns, so that the prospector is at no expense, except those incident to mining, sacking and delivery to the nearest railroad station. So far as the writer knows no advantage has yet been taken of this offer.

It is not an easy country to explore. The entire inner country below the timber line may be described as forested, with the exception of a few open grassy slopes, which usually face the south and east and catch the maximum of sunshine. The timber is spruce and birch with cottonwoods on the swamplier ground, or on deep gravel banks, through which the tree roots can easily penetrate in search of water.

Much of the region is swampy and willow clad; and large forest areas are covered with thick moss, not unfrequently resting on frozen ground. Forest fires have devastated large areas, and though they have left the underlying rock surface visible, the resulting windfalls have made traveling very laborious. To make an examination of the rock structure still more difficult, a second growth of small spruce and willow has frequently sprung up in the more ancient windfalls. The rock exposures are comparatively few, and to accurately trace and prove an outcrop of ore is a slow tedious operation.

The topographical features are simple, a wide river and high mountain range running parallel to each other in a northwesterly direction, with a rolling plateau between them, ranging from 2,300 to 2,600 feet above sea level. In this portion of its course, the Yukon river flows between abrupt banks of gravel, sand and silt, which rise from 150 to 250 or even 300 feet with only occasional rock outcrops. The absence of heavy rainfall is shown by the smooth slopes of these bluffs, which stand at an angle of 40 deg. It is only the bedded silts which weather into castellated forms. On the river the rock outcrops consists chiefly of the old, reddish, course-grained basalts of the Miller canyon and White Horse Rapids, and these are overlaid by the gravels. On reaching the crest of the bluffs the plateau, from 3 to 5 miles wide, extends to the base of the mountain, with a rolling surface and low hills, and a gentle gradient to the northward. This plateau is intersected by a number of small streams (connecting numerous shallow, marshy lakes) which have a general northwest trend, parallel to the mountains, and while traversing wide shallow valleys near their sources, enter the main river through deep V shaped gorges. Long, low ridges of gravel, containing erratic boulders of the old basalts and other rocks found only to the southward have a similar general parallelism. All these features suggest an ice-worn surface where the general motion was to the north and west; a cross-section of which reveals a series of swampy valleys cut down to the underlying bedrock, with a morainal deposit along each side; while between each pair of moraines we find a somewhat higher backbone of rock. In general terms it would seem that as the ice cap, which formed the immense gravel banks along the main river, gradually thinned, the higher rock ridges finally divided the cap into a number of parallel glacial streams, each one of which was employed in cutting its own channel deeper, and depositing lateral moraines; while the resultant streams continued the

process, as the interior lakes were drained of their contents. The progress of the latter process is beautifully shown by the numerous terraces which extend from Bennett lake to Selkirk, at altitudes up to 400 or 500 feet.

It is on this plateau that ore has been found in a narrow strip following the base of the mountain range and the western edge of the heavy gravel banks, which cover the rocks along the river. The mountains are essentially limestone, with bold escarpments, resting on a granitic foundation, which forms the floor of the plateau as far south as Mount Goldenhorn, which is principally composed of eruptive rocks and appears to have been the source of the Miles Canyon basalt, as erratic blocks of this rock extend for some miles to the northward, gradually diminishing in size and frequency. The older granites in this floor are cut by many felsitic and porphyritic dikes, but the tangle of vegetation, moss and dead timber makes tracing of them for any distance impossible. It would seem that many of them must be older than the limestones, as but few instances are found in which they cut the latter. The best instances are at the Little Chief Group, where dark blue limestones contrast strongly with a 2-foot seam of felsite, and diabasic rocks are found interbedded in crystalline lime. On the plateau the limestones have been very largely removed, occurring now, as patches varying in size from a few feet across to 600 or 700 feet in length. It will thus be seen that the geology is very simple. While there are obscure traces of faulting in the presence of sheeted lines, such dislocations are difficult to prove on account of the uniformity of rock structure, and the only evidence of recent volcanic or chemical activity observed is a small cold spring on the Miller group, which furnishes an acidulated water, but makes no deposit of lime or gelatinous silica. In general terms, there are presented a wide area of lime granite contact, with nearly all the lime eroded from the plateau, and with but small evidence of the penetration of the limestones by intrusive dikes on a large scale. Probably the largest of such bodies is found on the Miller Group.

The ore occurs either at the line of contact of the two rocks or in seams of varying size, penetrating the underlying granites and it is the extensive erosion of the limestones which has revealed it. Only in a very small number of cases as at the Little Chief, was ore found penetrating the limestones, and then it

accompanied an intrusive granitic tongue, which appeared to be the ore carrier, being largely replaced by magnetite.

Two distinctive classes of ore are present, and their occurrence is quite different. We have large masses of specular or magnetic iron, as at the Pueblo, where it is hematite, or at the Little Chief, where magnetite prevails, both carrying a moderate tenor of copper; or outcrops of much smaller dimensions in which the ore is essentially bornite, with occasional patches of chalcopyrite and green copper carbonates, in the condition of sand, or disintegrated granular limestone stained with copper. Azurite is rare; chalcocite and black oxide occur sparingly, but native copper seems to be absent as well as the red oxide. The typical ore is bornite. These outcrops are scattered all over the plateau, and are probably the remains of much more extensive bodies, which were denuded in the general erosion. They are found resting on the granite with no lime in the vicinity, or associated with the patches of lime which still remain; and their discovery in the dense tangle is largely a matter of accident, even to the careful searcher.

Many of these outcrops proved to be connected with a series of more or less east and west seams, penetrating the granites, some of which may produce considerable ore when explored, but the writer saw no evidence of massive vein structure to support the popular theory of a great north and south lode. This idea has probably arisen from the fact that in some cases the stream has cut a deep gorge in the granite below the line of contact, which now shows, with its accompanying ore, as two slightly divergent lines, on either side of the stream gorge. At one or two points, where there are apparently dioritic intrusive masses, the lime contact stands much steeper than the usual angle, and these form desirable points of exploration.

From what can be seen it is, therefore, probable that at one time there existed a large number of masses of iron ore, occupying by replacement cavities in the limestone; that these ores were leached of a portion of their copper contents; the latter metal being precipitated on the lower granite contact, forming more or less extensive beds of high grade oxidized ore; and that the percolation continued downward into the granites where the same had been sufficiently sheeted to allow of such a process. Traces of such percolation were seen fully 200 feet below the general level of the plateau. All the phenomena presented can be thus explained. That the entire contact was not thus enriched is, however, evidenced by the occurrence of pockets of simple granular magnetite, lying directly on the granite; while in the same

vicinity may be found little bunches and stringers of bornite in the magnetite, and not far away good bornite uncontaminated with the magnetic iron; but all such localities show the action of the chemical agencies, by the modification of the granite surface, and the formation of epidote, lime-garnets and other lime-iron minerals in abundance, as well as the hydration of the micas. The granite seams show crystallized quartz penetrating the ore. A feature which is absent from the large iron masses. For the reasons just set forth, the exploration of the contact beneath the large mass of the Pueblo (the outcrop of which has a visible area of 14,300 square feet in the shape of a huge letter T) will be an interesting study. The writer started a shaft in the lowest depression of the outcrop in the hope of proving this problem enrichment with depth, but unfortunately there proved at this point to be a narrow gully filled with surface wash, although ore cropped within 10 feet on either side, and as this was all frozen ground, the work was stopped at a depth of about 10 feet. Yet more interesting will be the discovery of some point where the contact can be followed by a tunnel into the mountains on the west, where the ore bodies have been protected from destruction, as, from the presence of extensive iron staining of the surface; at one or two points, which there was no time to examine, the presence of other iron masses is possible. In the portion of the belt known to the writer, the best locality for such exploration is on the Anaconda Claim, where the floor of the valley is granitic and massive limestones occur on the east, owing to the gradual depression of the granite floor of the plateau from south to north, and quite likely to the presence of faulting, as the ore at this point stands nearly vertical, an exception to the general rule.

While gold seems to be constantly present, and high assay are said to have been obtained, it was not the writer's good luck to obtain more than quite moderate amounts. A comparison of the bornite assays (from 100-lb. samples quartered down to 10 lbs.) seems to indicate the presence of silver to the extent of about  $\frac{1}{4}$  oz. to unit of copper, Zinc, arsenic, lead and antimony are notably absent, the only other mineral present being occasional flakes of molybdenite, which is also a common accompaniment of granitic contact in the State of Washington. The iron ores show about 45 per cent metallic iron in a gangue of lime and silica, and such ores should produce an excellent grade of copper.

The district is well watered. There is excellent mining timber in abundance, but fuel for reduction purposes must be brought from the outside or consist of

domestic charcoal made from spruce timber. Labor for awhile will probably be high, owing to the difficulty of keeping good men, but the actual cost of living, with freight rates less than 5¢ per lb., should not be more than 25¢ per diem over Seattle prices. Good men on steady underground work will probably command from \$4 to \$5 per diem, and outside help from \$3 to \$3.50, as the rates paid on the railroad 30¢ an hour for common labors, ranging upward to 55¢ for higher grades of service.

For some time at least but little mining machinery will be required, as much ore can be collected from the surface outcrops and the larger iron bodies are practically quarries, until the output has reached 100,000 tons. It is probable that these latter will require treatment on the ground; the cleaner bornite ores can be hand-sorted up to 30 per cent. to counterbalance the high cost of suitable fuel. The season of 1900 will probably decide most of the points at issue.