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CONCENTRATION OF GOLD IN THE KLONDIKE.

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The study of the origin of ore deposits is one of the most fascinating subjects of investigation which the mining engineer or geologist can undertake. The results of his investigations are, in most cases, sufficiently indefinite to escape final conclusions, but at the same time they constantly bring together new groups of facts and ideas which tend towards definiteness and raise hopes of conclusive results.

The uncertainty which hangs over our knowledge of the origin and mode of deposition of ores is especially marked in connection with the consideration of veins or lodes, but the mode of formation of many placer deposits is also not clearly understood, and the source and method of concentration of the gold or other valuable mineral has not been definitely determined.

In the midst of this uncertainty it is interesting to consider briefly the conditions that prevail in the Klondike District, Yukon Territory, Canada, a country of exceedingly rich gold-bearing placers, where the origin and processes of deposition and concentration of the gold into its present position are quite easily recognized and interpreted.

The Klondike gold-bearing District lies in the basin of the Yukon River just south of north latitude 64° , and about fifty miles east of the 141st meridian which forms the boundary line between Canada and Alaska. It is more or less rectangular in

shape, with a greatest diameter in a general east and west direction. Its total area as considered in this paper is about eight hundred square miles.

FIG. 34. Map of the Klondike District, Yukon Territory.

It is a well-defined physiographic unit, consisting of a mountain mass separated from all the surrounding mountains of the Territory, except at its extreme southeastern angle, by deep and wide valleys, from which the land rises in easy slopes to a highest point near the centre of the area. The greatest relief is 3,050 feet, this being the difference in height between the bank of the Yukon River at Dawson, with an approximate elevation of 1,200 feet above the sea, and the summit of "The Dome" with an approximate elevation of 4,250 feet above the sea.

The district is bounded on the west by the valley of the Yukon River which is one of the largest streams on this continent; on the north by the equally wide valley of the Klondike River; on the east by a great valley much wider than those just mentioned, that extends along the southwestern base of the Ogilvie Range of the Rocky Mountains and constitutes one of the principal topographic features of the Yukon Territory. On the south the valley of Indian River, a tributary of the Yukon, forms the boundary for the greater part of the distance, the exception being

a narrow ridge at the southeast corner of the area, connecting these mountains with those to the south.

These mountains are not rugged pinnacles and ridges like the Rocky or Coast mountains to the north and south, but their summits are well rounded and their sides descend in gentle slopes into the valleys that radiate in all directions from the highest points. The bottoms of the valleys too, both small and large, have very regular grades, and the streams that flow in them are not interrupted by either lakes or waterfalls. Some of the north-flowing streams have rather steeper and more gorge-like channels cut to depths of two or three hundred feet into and below the bottoms of the old flatter valleys, but even in these the grades are regular and continuous.

The country is largely underlain by schistose rocks which take their distinguishing characters from the presence of sericite, chlorite, graphite or quartz. They are all very old, geologically speaking, dating probably from Precambrian or Cambrian times, and have been very much folded, crumpled and twisted, and consequently they have been greatly altered from the eruptives or sediments as at first formed or deposited.

These schists are cut by many narrow veins, stringers and lenses of gold-bearing quartz, and while these veins, etc., are more numerous and probably more highly mineralized in some places than in others, they would seem to be present everywhere in these schists although in no place have they been found sufficiently closely aggregated, large or rich to pay for mining in themselves. However they are very interesting and important, as the gold collected in the placers in the bottoms of the valleys was derived from them.

In a few places around the margin of the Klondike district outliers of sedimentary rocks of Eocene age occur. During this period the land would seem to have been lowered so that the present four thousand feet contour line was at or near the level of the sea, for at this elevation the remains of a vast peneplain can be traced on the hills, not only of the Klondike district itself, but over great expanses of the Yukon Plateau which stretches

away to the south and west, the rounded tops of the mountains, as seen from any of the higher summits, extending away to the horizon like billows on the ocean. The summit of the Klondike mountain mass evidently formed part of this old peneplain, though some of the largest depressions around and near it were undoubtedly marked out at that time. Assuming that this portion of the peneplain sloped down into the surrounding valleys, which were then submerged, the general elevation of the Klondike mountain mass, taking present sea level as a datum, was about 3,500 feet.

At or shortly after the close of the Eocene period the land was raised above the sea, and it has not since been submerged, so that ever since then it has been continuously subject to decomposition by meteoric agencies, and to subaerial and stream erosion, the streams having assumed and retained normal courses outwards from the centre of the mountain-mass.

The district lies in the unglaciated area between the glaciated Ogilvie Range of mountains to the northeast, and the much more severely glaciated Chilcat or Coast Range of mountains to the southwest, and while there is a possibility that during the glacial period it may have had some local glaciers of its own in the higher portions of its valleys, none of the glaciers from the north or south reached it, and there was no transportation of material to it from any outside source. Its problems of erosion, transportation and concentration are therefore entirely confined to itself.

After the land was raised well above the level of the sea atmospheric agencies began the decomposition of the rocks, and the breaking apart and liberation of the rock particles one from another, while the rain and the smaller and larger streams cut out the valleys, dissolved parts of the rock, and washed the undissolved particles from the higher to lower levels. The very heavy particles, such as the grains and nuggets of gold, would settle close to the places from which they were derived, while the lighter particles would be carried farther away.

The processes of decomposition and erosion, with transporta-

tion and separation of the eroded material, went on continuously from year to year and from age to age until the land had been reduced almost to its present level, and the bottoms of the wide and relatively shallow valleys had been filled with coarse pebbles and cobbles of the harder and more resistant kinds of rock, though chiefly vein quartz, that had been slowly washed down from the adjoining hills. Mixed with these larger masses of rock were the smaller but heavier nuggets and grains of gold, which had been washed out of the same hills, but on account of their weight had not been carried away with the rock particles of the same size. The beds of quartzose gravel thus formed are locally known as the "White Gravel" or "White Quartz Wash."

After these gravel beds were formed the northward-flowing streams were accelerated and given greater cutting power in some

FIG. 35. Bank of "White Gravel."

way, probably by a tilting of the land from the south northward, consequent on the continued rising of the mountains near the Pacific Coast. These streams therefore cut narrower valleys, with steeper sides, through the "white gravel" and into the

underlying rock, leaving terraces of the "white gravel" on one or both sides of the valleys, and reconcentrated into their beds the gold from the gravel which they had cut through and washed away, as well as any gold that may have been in the rock cut through below the older gravel.

These two sets of gravel deposits have together produced to date about six million fine ounces of gold, and it is not improbable that there are still four million ounces remaining in the placers, making a probable total gold content for these Klondike placers of ten million fine ounces of gold.

As has been shown above this gold was concentrated by the rills and streams from the whole of the rocky material washed down from the Klondike mountain-mass, and it probably represents a considerable proportion of the gold originally contained or included in the rock.

In reference to the quantity of rock that was so washed down by eroding and transporting agents acting continuously through a long period of time only approximate data are obtainable, but the following statement is believed to represent with a reasonable degree of accuracy the conditions as they existed during the erosion period.

As stated above the mean elevation of the land when active denudation began at the close of the Eocene period was 3,500 feet, taking the present sea level as a datum. The mean elevation of the district at present is about 2,600 feet above the same datum, from which it would appear that the thickness of rock removed from the surface between the end of the Eocene Age and the present time is equal to a thickness of 900 feet over the whole area. Adopting the ordinary time scale of 4,000 years for the removal of one foot of surface, 3,600,000 years would be the time required for the removal of this 900 feet of surface, and such, according to this computation, would be the length of time since the close of the Eocene period. A thickness of 900 feet over an area of 800 square miles would equal a mass of 136 cubic miles or 1,600,000,000,000 tons of rock. This is therefore the quantity of rock that was removed by denudation, and from

which 10,000,000 ounces of gold was washed and concentrated into the Klondike placers, and it represents an average gold content of 0.003 grains or 0.013 cents to the ton of the original rock in place.

It is thus seen that the Klondike district owes its phenomenally rich placers not to the wearing down of highly mineralized gold-bearing veins or lodes, but rather to the favorable conditions of long continued and uninterrupted concentration from a great mass of rock that contained only very minute quantities of gold.