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ECONOMIC GEOLOGY AND HISTORY OF THE COPPER RIVER DISTRICT, ALASKA

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The part of Alaska which this paper describes was at one time a thriving mining community. Through its early years it was heralded as one of the great copper districts of the world. Many men travelled its well-beaten trails. Mining camps and prospectors' cabins were scattered over a wide region. Men fought and even died to hold exclusive rights to railroad routes through the great coastal range of mountains, which formed an almost impassable barrier against entry. It was a district of great activity and promise.

Now the prospectors, miners and railroaders are gone. The old trails would be hard to find and tough to follow, and the railroad, over which the richest copper ore ever mined moved out by the trainload, has been torn up and removed. To use a mining term, the district is worked out.

The reason for this is that the geologic factors necessary to make orebodies were not present there except in one relatively small area, in spite of the great original promise of the district as a whole. Paradoxically, at this one point conditions were so uniquely favorable that there were deposited great orebodies of the highest grade copper ore ever found anywhere. The scope of this paper covers those geologic factors, not in a highly technical way but simply as they related to mining possibilities and problems. It also covers a little of the history of the mining discoveries and the men who made them. Because the Kennecott and adjoining Mother Lode orebodies were the only workable copper deposits ever found in the district description and discussion herein will be confined in most part to those mined and their immediate surroundings.

It is almost fifty years since the Copper River country came to my attention. I was working at an iron mine in Minnesota. I had read a magazine article telling about the building of a railroad from the coast into the interior of Alaska. It told of wide spread copper discoveries in the valley of a river called the Copper, along which the railroad was being built, and of fabulously rich copper ore in the Bonanza Mine at a place called Kennecott. I decided to go there.

Four years later I found myself engaged in making the first detailed geologic study of the ore occurrences at Kennecott and was holding down the job of field exploration engineer for the Morgan-Guggenheim interests who owned the mine and the railroad. The subject matter of this paper is based on that original study and on continued studies as development of the mine progressed during the years, and on examinations of prospects and workings throughout all the surrounding region, including the headwaters of the Tanana and White Rivers.

Economic geology means geology applied to mining. It is the study of the various geologic factors in and surrounding a mineral deposit so as to use these as a guide to the evaluation, development and working of the mine in general. A correct knowledge and interpretation of these factors has a vital effect on the fortunes of the prospector and mining investor. However, in a new country with no past mining experience to serve as a guide a sure knowledge on which to base such interpretations can be gained only by the expenditure of time and money in development work. This was true in the Copper River country and it was only after some years of widespread development that it was generally accepted as true

that only the type of copper deposit found at Kennecott could be worked profitably, and that they were so productive there only because of a certain combination of geologic factors.

These factors were unusual, but in my opinion then and still they were quite simple and apparent. That the geologic combination found there was unusual is shown by the fact that similar orebodies of copper ore have not been found anywhere else in the world, so far as I know, with the possible exception of one place in Africa. Unfortunately this necessary geologic combination was not found elsewhere in the Copper River country either, and when Kennecott was worked out in 1938 the district was through as a copper producer.

That the ore itself was unusual, aside from its being the richest copper ore ever found in equal tonnages, is proved by the fact that a thorough microscopic study of Kennecott chalcocite, which was the main ore mineral at Kennecott, by one of the highest scientific authorities of the time led to wrong conclusions, which probably cost the company many millions of dollars. However, what was Kennecott's loss proved to be a gain for the stockholders of the adjoining Mother Lode Mine, so there were smiles on that side of the mountain at least.

At the time a scientific investigation was being conducted into the secondary enrichment of copper ores, that mineralogical phenomenon which was proving to be so important a factor in the copper mines of the southwest, especially the porphyry coppers. Microscopic study seemed to show that the copper glance at Kennecott was secondary after bornite. This was

a most important conclusion at that stage of the mine's development. Mining was being done only on the Bonanza fissure, the original discovery. Development had only been started at the Jumbo, a parallel fissure, and apparently there was nothing there on the surface to indicate the enormous orebodies which were later developed in that mine. Back at the Bonanza the wonderful cliff outcrop orebody of glance, which had excited the mining world, had pinched as we followed it down the incline, and at 300 feet, which was as deep as the mine had progressed at that time the lime was tight and the fissure relatively small. In other words there was not much ore in sight. My own concept of the genesis of the ore had just been formed but not yet accepted, so the importance of certain surface and underground indications which we had in the mine was also not accepted. The copper discoveries farther down along the railroad were known by this time to be of doubtful value, And, finally, the total investment, including railroad construction, was a great many millions of dollars in the red.

To be faced at this juncture with a scientifically authenticated statement that this remarkable high grade, which was being shipped in full trainloads averaging 72% copper, and out of which even jewlery and other ornaments was being made, and polished chunks of which could be found as paperweights on the desks of mining offices in every mining city from San Francisco to Montreal, was only secondary ore, and might lead to a disastrous fall in grade as depth was attained forced the company into a conservative attitude toward the future and they missed buying the Mother Lode, which lay behind and adjoined the Bonanza on the east and could have been had at a reasonably low figure. I had recommended its purchase,

because my belief was that from all practical angles the glance was primary and would persist in high grade to the very bottom of the mine. Some years later the Mother Lode Coalition Mines was formed, owned half by Kennecott and half by Mother Lode Mines, and the Mother Lode ore was mined and milled through Kennecott facilities.

The only part of the Copper River drainage in which we are interested for the purposes of this paper is that part comprising the south slopes of the Wrangell Mountains, in other words, the north side of the Chitina valley and all of the valley of the Kotsina. The Chitina is the Copper's largest tributary and enters the main river from the east at a point about one hundred miles from the coast, thus draining the north slopes of the Wrangells. Calling the main river the Copper is a misnomer in fact, because no copper discoveries of importance were ever made along it or its other tributaries. The Chitina is the true Copper River, if one wishes to name by copper occurrence, and that was its name in the native language, Chiti meaning copper and na meaning river. They called it the Chi-tee'-nah. With surrounding rivers being called Klutina, Tazlina, Tonsina, Kotsina, Nizina, etc., how somebody happened to settle on Chi'-ti-naw for the 'Chiteena' will always be a mystery. Anyway, the Chitina is the true Copper River, both in native tradition and copper occurrence, and only the north side of it engages our attention, comprising an area roughly eighty miles long east and west by twenty miles wide, north and south. Kennecott is about three-quarters of the distance east in this area, starting from the main Copper River.

The topography of the district is extremely rugged, with glacier-filled valleys and high steep mountains and hills, and the rough rocky slopes which are natural to the rapid erosion of a highly glaciated countryside. At the Kennecott main lower camp there was barely room on the side of the hill next to the glacier for the railroad and the camp buildings. Aerial trams were the only practical method of transportation to the mines, 3500 feet in elevation and about three miles in distance above the mill. The immediate area was subject to snow-slides, and these were the cause of several fatalities.

There are only two rock formations of interest to the copper miner, a greenstone and a limestone. Both rocks are up to thousands of feet thick, with the limestone lying conformably on the greenstone. They are exposed over large portions of the district. The greenstone is a vesicular and amygdaloidal diabasic lava, submarine in deposition. It weathers to a dark greenish brown and its strong contract with the light bluish gray of the overlying limestone furnishes a notably striking feature to the ruggedly beautiful scenery of the country. A detailed mineralogical or petrographical discussion of the greenstone is outside of the scope of this paper. However, it is essential to mention one of its magmatic constituents, namely, copper. Copper is estimated to be present in the rock to the extent of about one-tenth of one percent, or two pounds of copper per ton of rock. The greenstone, therefore, is considered to be the virgin source of all the copper of the district, and so the rock of paramount importance. In spite of this fact no mines have ever been developed in it. Copper prospects are found in it everywhere but no orebodies, although a great amount of development has been done,

at widely separated points.

The beds of some of the creeks which drain the surface of the greenstone are more nearly orebodies than the fissures, because of their placer copper content. The gravel of some of them runs at least as much as one pound of native copper per yard of gravel. The copper occurs as scales and grains and in nuggets up to many pounds in weight. I believe the largest ever found there weighed about 3500 pounds. It was this placer copper, used by the natives for ornaments, weapons, etc., which first attracted attention to the region as a possible source of copper.

Apparently the greenstone releases its copper readily enough to circulating waters passing through it along shear zones or fissuring, but it seems to possess no reprecipitating capability whatever that would tend to redeposit the copper along the walls of a fissure or in the cracks of a shear zone or breccia zone within the unaltered greenstone itself, nor is there any strong tendency toward replacement. At the surface foreign factors favorable to ore deposition are usually present, with the result that many of the shearzone outcrops are relatively high in copper content. Not in any known working in the greenstone, however, has this greater copper content persisted in depth, and at surprisingly short distances below the surface the zones become fatally barren of copper. The typical greenstone showing, then, consists of a shearzone having encouraging or even notable copper content in the form of secondary native copper, impure chalcocite, bornite, chalcopyrite, malachite, and azurite in various proportions at the surface, with a rapid falling off in copper content at depth.

If erosion were less rapid in the district and climatic conditions such that rock alteration and all surface factors favorable to ore deposition

could persist to much greater depths in the shear zones perhaps the story would be different and we would find numerous relatively shallow mines persisting to the bottom of favorable deep surface conditions, but that, unfortunately, is not the case and the favorable surface zones, together with any copper that does deposit, are whittled off by erosion about as fast as they form.

It is my opinion that vast amounts of copper have been wasted by natural causes in the district by having been leached from the greenstone by circulating waters and lost, either by direct discharge into the surface drainage while still in solution or, if first deposited as copper minerals in the surface zones, have soon been removed by erosion and carried away in solid form. What was needed to prevent this waste was something to deposit the copper from solutions and hold it there, protected from erosion. Owing to topographic and climatic conditions a deep surface zone of favorable conditions is not present, as noted above. What was needed was a cap rock of such chemical and physical properties that it would be highly favorable to rapid deposition of the copper from solution and into which the solution channels would penetrate far enough to conduct the solutions to the point of deposition, where, deeply buried in solid rock, they would remain until mined. Simple and ideal as that may sound it is what happened at Kennecott. Nature there set up just such a combination of geologic factors, produced the richest copper mine ever found and, so far as I know, never repeated the experiment anywhere. Even there erosion had finally reached the fissures and probably had removed more copper than was left to mine, but even the remnants made a big mine.

The geology at Kennecott is simple and apparent. The mines are situated high up in a mountain ridge which is a rugged spur about twenty miles long extending straight south from the main mass of the Wrangell mountains. This spur lies between the Kennecott Glacier on the west and McCarthy Creek on the east. Its base is about four miles through and it is nearly one mile high above that base, the ragged crest being about six thousand feet above sea level. The south four miles of this spur is called Porphyry Mountain. It is an igneous intrusion of light colored porphyry. It is factor number one in the geologic combination, because it is undoubtedly the dynamic cause of the formation of the ore-bearing fissures and the circulation of solutions in them. The balance of the spur to the north is greenstone capped with limestone. The porphyry starts about one-half mile to the south of the Bonanza Mine. The limestone strikes about 60 degrees northwest and dips to the northeast at an angle of 25 to 35 degrees. It is made up of two members, of which the lower one is about ninety feet thick. All of the balance of the overlying rock in the immediate vicinity of the mines is composed of the upper limestone, a fact to remember, because this was the host rock of the orebodies, or the 'favorable limestone' as it was originally called at the mine.

The ore at Kennecott was deposited out of rising copper-bearing solutions which followed comparatively thin fracture zones up out of the greenstone, through the lower limestone and up into the upper limestone. These fracture zones were called fissures at the mine and they occured in a parallel system, striking in a northeasterly direction, over the ridge and toward the Mother Lode mine. Individually they were designated by name, for example, Bonanza Fissure, Jumbo Fissure, etc. Ore was formed along the fissures by deposition of copper minerals out of solution by re-

placement of the upper limestone at or near its base. No copper was deposited in the lower limestone but as soon as the base of the upper lime was reached copper ore began to deposit and continued to replace the limestone up along the fissure to variable heights. For the most part, therefore, the greatest concentration of ore occured at the very base of the upper lime. Deposition was aided at that point by the presence of a think parting between the two beds of limestone. In this parting the lime was sheared and softened to a small extent, thereby giving the copper-bearing solutions a chance to spread out at this horizon. This parting was known at the mine as the Bedding Plane. It was continuous throughout the mine and was always found at the base of the ore or close to it.

It was evident that as the copper content of the rising solutions decreased due to deposition in the limestone they became progressively and rapidly impoverished until no more copper was left in them and, therefore, beyond a relatively short distance above the bedding plane, or base of the favorable limestone there is no copper ore along the fissures and in its place is an intergrowth of coarse calcite crystals, which condition exists to a relatively short distance above the ore, gradually fading out until the fissures themselves more or less disappear. It follows that a vertical cross-section of the ore at right angles to the fissures is roughly pear-shaped, with the large part resting on and including the Bedding Plane, with the stem end pointed up and topped with a tall zone of calcite crystals. A vertical section taken longitudinally along the fissure shows a continuous orebody, greatly elongated, with its top irregular and having the calcite zone as a sort of cockscomb along the top of it, the bottom following the Bedding Plane in a relatively straight line at a dip of about twenty-two degrees, parallel to the greenstone and

about ninety feet above it. The distance from the Bedding Plane to the top of the ore, normal to the plane, was from 100 feet up to 250 feet over most of the mine but extended up to several hundred feet in the Azurite Claim and in the adjoining Marvelous Claim of the Mother Lode mine along the Bonanza-Mother Lode fissure.

Development and mining of the ore was accomplished through inclined shafts which followed close to the bottom of the ore, that is, more or less close to the Bedding Plane. Drifts and crosscuts were driven from these at convenient levels for stoping and exploratory purposes. Before the mine was abandoned there were many miles of these workings as well as miles of exploratory diamond drill holes, practically all of the latter being driven from stations underground. Many of the orebodies were very irregular in outline with offshoots into the walls which had to be followed carefully to insure full extraction of the ore. Pulling all the ore from the stopes eventually left large caverns, and it is likely that many of these will remain open for years, because the lime showed little tendency to spall or slough.

There were three main fissures in the mines, all roughly parallel and striking in a north easterly direction. The workings on these fissures were all eventually interconnected by means of long crosscuts, some of them more than two miles long. The Bonanza-Mother Lode fissure is the south one of the series. It is the one on which the original discovery was made. It is the one nearest to Porphyry Mountain, which, I wish to repeat, was undoubtedly the dynamic cause of the ore deposits. Looking toward the north the next fissure is the Jumbo. These two fissures produced by far the major part of the ore. The northernmost, and farthest from Porphyry Mountain, is the Erie, the least productive of the three.

In between the major fissures a few parallel minor ones were found, from which there was a relatively small production of ore. The total width of the system is close to three miles.

In the original staking of the claims a continuous group was staked end to end along the Greenstone-limestone contact to cover the possibility that either the contact or the parallel bedding plane, a short distance above it, might be a controlling factor in the genesis of the ore, and, therefore, might assure and control extra-lateral mining rights. The rest of the claims were staked more or less at right angles to the contact and, therefore, along the strike of the fissures, although these fissures were not strongly apparent for any great lengths along the surface, a fact which caused some confusion as to the proper direction in which to stake. This latter staking was the correct one. My first assignment at Kennecott was to determine if the contact or the bedding plane controlled in any way the genesis of the ore, and, therefore, if any matter of extra-lateral rights was involved. It was apprent from the very start that the vertical fissures were the true lodes, and we went on from there.

Up until that time the two limestones had been distinguished from each other by calling the lower bed the unfavorable limestone, because it had no ore in it, and the upper bed the favorable limestone. The visual difference between the two was so slight that it had not been noted. Both lime were slightly crystalline and of about the same colors. I made an analysis of samples of each and found that the so-called favorable lime was dolomitic, analyzing about 35% magnesium carbonate and 65% calcium carbonate.

The unfavorable lime contained about 2.5% magnesium carbonate and the balance was calcium carbonate. Each lime contains only about one-half of one percent insoluble matter. The dolomite is a little more sugary in texture than the straight limestone and tends to a brownish tinge of color, which helps to identify it in a hand specimen..

The dolomite was extremely favorable to complete replacement by the rising copper solutions and ore-deposition started immediately after entry into this bed, causing the orebodies to occur in their greatest width near its base, and in this horizon solid chalcocite up to as much as 80 feet wide was found in some instances. In respect to ore deposition the underlying pure limestone was remarkable. This ninety-foot bed is barren of any metallic mineralization, and in it the fissure itself often exists as wide open cracks up to several inches across, and of great extent, with only occasional green scales of malachite on their sides to hint at the enormous quantities of copper which had passed through them to be deposited in the dolomite above. The full combination there at Kennecott is a classical example of the influence of wall rocks on the deposition of metallic minerals. To repeat this and make it clear: The first dynamic step in the formation of the ore was the intrusion of the porphyry, causing the fissures to form and solutions to circulate up along them. The greenstone contains copper as a magmatic constituent and gave freely of this copper to the solutions, but it has no reprecipitating quality and, therefore, no orebodies occur in it. While passing through it the solutions were collectors, not depositors. On leaving the greenstone the solutions, now copper-bearing, entered first into the pure limestone comprising the lower bed. This bed was neither copper bearing nor copper precipitating

and the only apparent effect on it by the solutions was to dissolve and scour it leaving open cracks through which the solutions flowed on easily through its ninety-foot thickness up to the dolomite, and there easily and rapidly replace the dolomite, leaving therein solid bodies of pure chalcocite and stockworks containing stringers of chalcocite and the copper carbonates, malachite and azurite. Perhaps the microscope told the truth after all, because the deposits might be called upside down deposits, to borrow Lewis Lovensalor's description of the mine. Perhaps the copper first formed bornite just as the microphotographs seem to show, but if this was the case it was, in my opinion, some purely momentary reaction which might have existed under the conditions of nascent mineral deposition. This would not be out of line with secondary enrichment due to surface conditions, where chalcocite forms on and replaces existing pyrite, chalcopyrite and bornite, but if it happened in the case of the Kennecott glance it must have been a continuing molecular interchange of some kind lasting just long enough to leave a record for the microscope. Suffice to say that in all practical consideration the chalcocite at Kennecott was primary and persisted as such to the very bottom of the mine.

Another geologic factor, mechanical in its effect, had a major influence on ore deposition. This consisted of parallel zones of brecciation which crossed the fissures at a large angle. I believe they were due to folding, because there is no evidence of extensive movement along them. The important thing is that they occurred before the deposition of ore, and they had shattered the dolomite, leaving it accessible and permeable to the copper solutions, thus aiding impressively in the replacement

reactions. Wherever one of these zones of prior brecciation crossed a fissure there was usually an enlargement of the orebody. The big bonanzas were always found at such an intersection. We could often prophesy an orebody by projecting the strike of a breccia zone from where it crossed an operating area over into an undeveloped area of a parallel fissure. Furthermore, from the outcrops of these zones by projecting them downwards we were able to prophesy probable orebodies far ahead of development. This reasoning was the basis of my recommendation for the purchase of the Mother Lode, which was situated to the east of the Bonanza on the McCarthy Creek side of the ridge along the strike of the Bonanza fissure, and, of course, in the direction we were advancing the mining operations.

The discovery that the dolomite was the country rock necessary to contain ore immediately led to the need to know how far to the eastward the dolomitization extended. It was in the winter and the ridge behind the mine was entirely too rugged and dangerous for any surface examination at that time of the year. The Mother Lode Mine on the other side of the mountain offered the only point of access at the time, and if the country rock there were dolomite that fact would be of great importance. The owners of the two mines were at loggerheads but the operating personnel was not, and I was able to get permission to take some rock samples from the Mother Lode workings. I found that the rock there was dolomite. However, I had not yet noted the importance of brecciation at Kennecott and so I failed to look for it in the Mother Lode workings. After returning to Kennecott and noting the brecciation and its effect, I returned to the Mother Lode for a second look, but permission to do so this time was not forthcoming. I remember that I was not even invited to have something to eat or to stay overnight. Being too irritated to complain I mushed back

down the road in the dark, at 25 below zero, eventually reaching the little town of McCarthy on the railroad, four miles below Kennecott. McCarthy, now a ghost town, was wide open in those days, and it was not trouble to get a meal at any hour of the day or night. I shall always remember that one, because I had traveled about thirty-five miles with nothing to eat since breakfast at Kennecott that morning.

By projecting the dip and strike of the bedding plane or base of the dolomite as it existed at Kennecott I had estimated that the mining then being conducted at the Mother Lode was about eleven hundred feet above the bedding plane, or most favorable locus for ore. The workings, as I had noted on my one visit there, contained some small bodies of glance, which the management was mining and shipping but no profit was being made from the operations because the showings were too scattered and small. However, these ore occurrences at that height in the dolomite were of great importance, as I saw it, judging by experience over in the Bonanza, where ore, so far, had not persisted in height above the bedding plane beyond a couple of hundred feet. The presence of ore so high up in the dolomite at the Mother Lode, could, therefore, lead to one of three conclusions. First, it had either been moved up there in place by faulting, which was indeed a serious consideration for the future of the Bonanza, or else, as a second unfavorable possible factor of the virgin ground which lay ahead of us at Kennecott, the dolomite was not brecciated ahead but tight and impermeable, thus stifling to a dangerous degree the favorable tendency to replace and deposit. If this were the case, of course, it followed that the orebodies below would be correspondingly small and erratic. However, as a third and most favorable consideration, if the dolomite were extensively and intensely brecciated it followed that the solutions in the Mother Lode area had to have been exceptionally rich and in a long continuing

flow as they entered the dolomite in order that, after normal deposition at the low horizons, there would still be enough copper left in solution to form even small orebodies at an horizon as high up as the Mother Lode workings. If this were the correct answer then there must be very large orebodies close to the bedding plane. Being denied the possibility of determining this by a further examination of the Mother Lode workings was a disappointment, but all I could do about it was to wait until spring, when a surface examination would be possible. Early in the spring of 1913 I made this surface examination and found a very wide zone of brecciation, which included about half of our Azurite claim and most of the adjoining Marvelous Claim of the Mother Lode. There was no evidence of faulting. I was much impressed by the geologic evidence there and again tried to get Mr. Birch to take favorable action on the purchase of the Mother Lode, but was unsuccessful.

The sequel for me came in 1924. I had returned to Kennecott after nine years of absence. The Mother Lode Coalitation Mines owned half by Kennecott, had been formed. The Bonanza-Mother Lode incline had been sunk to a point below the Mother Lode workings and mining operations were being carried on in the Azurite-Marvelous area, and an orebody about one thousand feet long and up to 80 feet wide of almost solid glance had been exposed there. It extended to hundreds of feet above the base of the dolomite and, I believe, was the largest single body of such high grade copper ore ever discovered anywhere.

To return to earlier years for a moment, development had been started and carried on in the Jumbo fissure, which was the next major fissure toward the north from the Bonanza. The surface showing where this fissure and bedding plane intersected was so small that in the earliest staking of claims this showing was not even staked, and there was very little showing

of copper along the outcrop of the fissure itself. When development finally got started it was extended by means of an inclined shaft, sunk parallel to the fissure and a short distance from it and inclined, to keep it parallel with the bedding plane. Short crosscuts were driven from this incline to the fissure and drifts run along the fissure in both directions. In driving back toward the bedding plane on the 300 Level drift we had about one foot of glance for a short distance. Then, in one round, this increased to three feet and in the next round was solid glance the full face, and the place looked like a coal mine. We continued in solid ore for a distance of 120 feet to the base of the ore. Then we drew back and drove a crosscut each way, encountering limestone at about forty feet on each side. This gave a horizontal section of solid glance, shaped like a pear, 120 feet long and 80 feet wide at its greatest width. This ore-body, as I recall it, produced about thirty million dollars worth of copper in ore running about 70% metal, and was one of the big bonanzas found in the mines. There was nothing on the surface to indicate its presence except intense brecciation crossing the fissure. I have described it roughly so that you can have an idea of what these bonanzas were like. This discovery happened at an opportune time. The Kennecott Copper Corpor- was organized and put on the market that winter, and the news of this ore-body and the very profitable production coming from it helped to get the corporation off to a good start.

It was also opportune because, at the Bonanza, things were not looking too bright. Development had reached the 500 level and had encountered what was called the 500 Fault. The line took on a soft earthy texture, the fissure faded out in it, and the ore ended. I was away from the mine

on other examinations at the time this was encountered and when I returned the ground was timbered and there was little evidence to work on. However, it did not look like a fault to me but more like an inclusion of foreign matter in the limestone. In any event it was ominous, and as much or more so was the fact that in the stope immediately preceeding the discovery of this 'fault' the ore had changed in major part from chalcocite to covellite, a lower grade sulphide of copper. Perhaps this was the beginning of the change that the microscope had prophesied. In any event, Mr. Birch had issued orders suspending further development at the Bonanza for the time being.

At the Bonanza as general foreman was a man named Melvin Heckey, whom I had had with me on some other exploration work for the company in 1912, after which he had gone to Kennecott. Heckey was a very capable mining man, with a nose for ore, as the saying goes. We had often discussed the geology of the mine and were in accord on it. We were agreed that the 500 fault was not a fault. That winter of 1914 I was again away from the mine on other work. So I was not at Kennecott when Heckey decided to drive through the 500 Fault. He got permission from W. H. Seagrave, the manager, to use thirty machine shifts in an effort to find ore on the other side of whatever the fault proved to be. After one week his work ran head on into the fissure on the other side, with a three-foot width of glance in it, and from then on the issue at the Bonanza was never again in doubt until the final end came, as it must to all mines.

A little of the early history in discovery of the mine is of interest.

At the same time that the great gold rush was on at Skagway and the head of Lynn Canal a much smaller stampede, far up the coast to the northwest was headed for the interior and the upper waters of the Copper River.

There was no feasible route directly up the Copper itself through the coast range because of impassable conditions in the lower canyons of the river. The only feasible route was from the head of Valdez Bay, an arm of Prince William Sound. Many hundred of men landed there in 1898 on their way into the interior. The only possible route that first year was up and over Valdez Glacier, then down the Klutina Glacier on the north side of the range and down Klutina Lake and River to the present site of Copper Center on the Copper. There are men buried at Copper center who died of scurvy there those early days. In subsequent years the route to the interior followed a trail cut by Capt. Abercrombie and his scouts up Keystone Canyon, across Thompson's Pass and Ernestine Pass and down the Tonsina, the route of the present Richardson Highway. As a part of that original glacier stampede there was a group of eight men, of whom four are pertinent to this historical sketch, namely, R.H. McClellan, D. F. Millard, Clarence Warner and Jack Smith. R. H. McClellan was a timber cruiser from Minnesota, and by nature and in fact the leader of the group. A wonderful man to be out with in the hills. Millard was a promoter; Smith was from Montana, and by experience the only miner in the group. Warner was Smith's partner. In prospecting the group had agreed to pool their interests so as to share in any discovery made by any member. They proceeded over the Glacier and down the Copper to the Chitina and up that valley, and that of its tributary, the Nizina. At the mouth of Dan Creek, about 20 miles southeast of Kennecott was the camp of Chief Nikolai, who sent some of his men with them to a copper outcrop which the natives knew about, because it was situated near some of their favorite hunting grounds for goats and sheep. It was on Nikolai Creek, a small tributary which enters McCarthy Creek from the east a few miles above McCarthy Creek's confluence with the

Kennecott River at the foot of Kennecott Glacier. As far as is known the natives had never seen the Bonanza Mine outcrop, only a few miles away. The Nikolai outcrop was in the greenstone and was one of the best ones ever found in it. The outcrop was spectacular because it contained a considerable amount of bornite or peacock copper ore, and had attracted the attention of the natives. I believe the staking of the Nikolai, in July 1899, was the first to take place in the copper country. Millard, who was a natural mining promoter, made arrangements to buy out the other partners with stock and cash, brought out samples of the ore and promoted a company in the States to develop the mine. He freighted an outfit in during the following winter with which to do the work. McClellan had been asked by Millard's backers to take charge of the development work on the Nikolai but had refused to do so because he wished to be free to carry on with prospecting. All the group helped in the freighting of the Nikolai outfit and McClellan stayed on with Millard at the Nikolai to give him a hand in getting started, but without pay. Millard, in the meantime, in order to devote all his time to development of the Nikolai, had withdrawn from the prospecting partnership. The rest of the group had paired off and were prospecting the district, with McClellan temporarily at the Nikolai. These facts are important because of a suit brought later by Millard claiming an interest in the Bonanza discovery. Jack Smith and Clarence Warner were prospecting together and discovered the Bonanza Mine in July, 1900. McClellan told me, as I recall it, that it was Clarence Warner who came down to the Nikolai to tell him to come and see what they had found. The main outcrop of the Bonanza was in a cliff face of the limestone at the head of a small glacial cirque. The green malachite with which the ore was filled, made a spectacular showing against the light colored lime. Smith and Warner had seen this from far below and had climbed up to in-

vestigate. It happened that one of the members of a U. S. Geological party which was on reconnaisance that year, had also spotted it through binoculars from across Kennecott Glacier and had worked his way across and up to the showing, arriving there only a few hours later than Smith and Warner.

At the Bonanza outcrop erosion had removed a part of what had been one of the large bonanzas of that fissure originally. A large amount of high grade float was imbedded in the ice of the small glacier which occupied the cirque. In later years this ore was mined by standard underground methods. The country rock of the Glacier Mine thus consisting of solid blue ice filled with talus fragments of limestone and glance from the outcrop, - probably another "nothing like it elsewhere" to chalk up for Kennecott.

One of the men on the Valdez beach that first year waiting to get across the glacier, was a young man, named Stephen Birch. He was a member of Captain Abercrombie's scouts, but his real object in coming to Alaska was to scout for mining properties, having the backing of three rich men, one of them his uncle, in the vicinity of New York City. He acted promptly to option the Bonanza discovery and made a deal under which all the partners sold out to himself and his backers. Considering what the mine finally produced, the price paid was not large but it was a high price under the conditions that existed at the time. In fact, the gold prospectors of the Copper River rush laughed at those who had staked on copper showings, pointing out that there was little chance of a railroad ever being constructed two hundred miles through that rugged country. They were nearly right, at that. It took three starts at different points before the Copper River and Northwestern Railroad was finally pushed up the Copper and the Chitina from Cordova on the coast to the mine, finally arriving there in

1911. It took three crossings of the Copper to get there and the bridge across the gorge of the Kuskulana, a branch of the Chitina, rivals in height and size the well known Hurricane Gulch bridge on the Alaska Railroad. The Mile 52 bridge was a famous piece of construction and figured prominently in Rex Beach's novel 'The Iron Trail'. It was estimated that a permanent bridge at the Chitina crossing, Mile 131, would be so expensive that the interest alone on the investment would exceed the cost of driving a new piling bridge each year after the ice had taken the old one out. The problem was handled in that way and each year the mine was isolated for a short period during the breakup. Passengers crossed the rive on an aerial tram during this annual shutdown.

Mr. Birch guided the financial, organizational and to a large extent the operational policy of the mine and the Kennecott Copper Corporation until his death about thirteen years ago. The Corporation eventually purchased the large porphyry-copper mines, Utah Copper, Nevada Consolidated, Chino and Ray in the States and Braden in South America and other mining interests. The Kennecott orebodies, therefore, might be called the seeds that started the growth of what is now the largest copper mining company in the world.

The fact that McClellan was staying at the Nikolai mine when the Bonanza was discovered and went along with Warner to help stake it, led to a famous trial over the ownership of the Bonanza. Kennecott thus, in common with all big mines, had its trial to settle title. Millard and the Nikolai people claimed that McClellan was working for them at the time and that this gave them grubstake rights in the Bonanza discovery. The case was tried in Valdez some years later. Judge Jas. Wickersham, later and for many years Delegate to Congress from Alaska, was district judge at

Valdez at the time and presided at the Kennecott trial. The evidence showed that McClellan was not working for the Mikolai and Millard lost the case.

It was the custom, before the railroad days to leave a watchman each fall at the Bonanza. During some of those years Jack Smith was left there, and he would prospect the surrounding country in the summer. He and Warner found the Mother Lode outcrop in 1906 and staked it, and in with them was a man named Oscar Sale. Sometime after that Oscar Sale in travelling on the ice of the Chitina River broke through. He rolled along under the ice but luckily happened to come up through a hole farther downstream, and got out. The ordeal seemed to affect his mind, and he was not the same after that, finally disappearing on a trip to the States, without leaving a trace. When Jim Godfrey promoted the Mother Lode Mines, he had to deal with Oscar Sales' estate, but that put an element of uncertainty into the value of the company for several years, during which Oscar was not officially dead and could have returned and nullified the Mother Lode deal under which Godfrey had organized his company. Probably that cloud on Godfrey's title had an adverse effect on the sale of his stock, aside from the fact that the mine was not making money and the outlook for even the Kennecott for a considerable period was not too bright. In any event during several of those early years of the life of the Mother Lode Mines shares in the mine which later sold on an equivalent basis as high as $18.00 per share could be purchased in Valdez for 10¢ to 15¢ per share.

Much of the glance from Kennecott was mined directly as high grade and shipped after being sacked without any milling operation on it. The glance derived from the mixed and lower grade portions of the orebodies was milled to a high grade concentrate, also sacked, and shipped. This glance portion

of the milling ore was easy to recover. It was a simple milling operation. However, there was a considerable percentage of the copper in the form of carbonates and this was much more difficult to treat and the tailing from the mill was high in the early days, because no method of recovery other than a simple gravity method was available.

A young man named E. T. Stannard was sent up from operations in South America to try to improve the recovery of the carbonates. He was a brilliant metallurgist and was very successful in improving the milling practice at Kennecott, finally working out the leaching of the carbonates by means of ammonia. The final overall recovery at Kennecott was very high. Stannard was also a brilliant executive and finally worked up to the presidency of the Kennecott Copper Corporation.

Concerning the possibility of another Kennecott mine being found in the Copper River Country it is my opinion that this will not happen. There are a few occurrences in the line, similar in type to those at Kennecott, but they are small and discontinuous. I know of no other place where the geologic factors found at Kennecott occur in full measure. Considering these factors and the great amount of unsuccessful prospecting which has been done it seems highly unlikely that another Kennecott will be found. The greenstone has been proved to contain no orebodies. Therefore the district would seem to have no future as a copper producer. But times change. If I were young again I would prospect the headwaters of the Chitina and the Bremner rivers for Uranium.

OLD MINING RECORDS ARE SAVED KENNECOTT MINE IS HISTORIC AREA

The day-to-day details of the life of the Kennecott Mines lay in drifts of paper in the red-and-white remains of the giant copper mine.

Records of ore weight, purchases from the company store, hospital operations, how many crackers each worker consumed — even the smallest details recorded for someone. And until this summer, they lay in heaps dampened by snow and rain, tossed about by wind and careless tourists.

But this summer, a team of volunteers rescued some 100 cubic feet of documents, to be placed in the University of Alaska-Fairbanks archives.

The Kennecott mines, which opened in 1916, were some of the greatest copper producers in the world until economic conditions forced its closure in 1938. Workers simply turned the machines off and left, leaving the buildings and belongings to the wilderness.

The mine complex, in the Wrangell-St. Elias National Park, is still a staggering array of buildings, all painted red with white trim, climbing up the steep, bare mountainsides.

Today, "It's virtually impossible to climb up and see some of the upper mines," says architect John Baker. "They're some important buildings, but so high up it's probably impossible to get materials to them."

Those may never be preserved, he says, and many of the larger buildings in the main complex may share the same fate.

Baker is a member of the Anchorage Historical Landmark Preservation Commission, a member of the Alaska Historical Society, and the National Trust for Historic Preservation. He and his neighbor, Dr. Ken Richardson, were two of the instigators of the Kennecott records retrieval project.

The Great Kennecott Land Company purchased the property several years ago, trying to take out some of the copper that remains on the surface.

Owner Jim Harrower and his partner tried to preserve some of the buildings and sold others, trying to encourage the new owners to preserve them.

Working through the Alaska Historical Commission, Baker applied for a $50,000 grant from the National Endowment for the Arts architectural division. It was awarded in January 1979, and work began soon after.

The project was finished in 1981, with the publication of "Kennecott, Alaska; A Historical Preservation Plan." But one of the recommendations in the publication was to save the records that were rapidly deteriorating due to weather and vandalism. Michael Sullivan, a Western Washington University professor, wrote a grant application through the Alaska Historical Commission, and received a $3,000 grant to retrieve as many documents as possible and move them to the UAF archives.

Moving them was a major problem, however. The only access to Kennecott is by air and/or foot. Travelers from Anchorage take the Richardson Highway south to the long unpaved Edgarton Highway.

In winter, the two unbridged branches of the Kennicott River can be crossed on ice by car. (The River is spelled with an i, while the town and mining company are with an e.) In summer, travelers must hand-propel themselves across the rushing water on a tiny swinging tram, and walk five miles to the town. Local residents have protested state plans to brige the river, fearing that will bring too many tourists in and disturb their lifestyle; however, it's difficult to bring in restoration materials without better access. A footbridge is being considered, Baker said, along with a car bridge for local residents only.

After the material was gathered, the Bear Creek Mining Company, the exploration arm of The Great Kennecott Land Company, donated a day's use of their C-123 "flying boxcar" to the project. The plane brought in tons of materials for restoring several of the mine buildings, and left with 45 boxes of documents.

The papers, dampened by rain during their transport, are slowly drying in the UAF archives. Sorting should begin this winter within two years, an inventory and access to the papers will be available to the public.

Baker and Harrower are hoping that work on Kennecott will continue. They have spoken with state and national park officials who say they'd like to help preserve the area, but don't have the money.

In the meantime, Great Kennecott Land Company plans to reserve four of the buildings — the leaching plant, office and administration building, power plant and main mill — in case state or federal parks eventually can preserve it.

"It's such a big project that everybody runs when they look at it," Harrower said. However, tax credits are available if the buildings are restored for commercial use, and he's also pushing a plan that would lease the buildings out as summer school or camps for the University of Alaska or other groups.

MINER BEWARE!

Investors considering the purchase of mining claims in Alaska are cautioned by the Bureau of Land Management to check the status, or ownership, of any claims before buying them.

BLM District Manager Wayne Boden, says the principle of "let the buyer beware," is a good one for people to remember when considering the purchase of claims because of Alaska's complicated land status.

"There are hundreds of land orders that affect the status of federal lands and a person's right to claim land or mine. A seller may not always have clear title to the claims he is offering for sale," says Boden. The mere existence of a document which states a claim has been recorded is not enough.

Anyone interested in purchasing mining claims can check the status of those claims by examining the public land records in the BLM's Technical Information Branch. For federal lands located in the Fairbanks District in the northern half of the state, the records are available in the Fairbanks District Office on Fort Wainwright. For lands located within the agency's Anchorage District the records are in the Federal Building, Seventh Avenue and A Street.

ARCO ANNOUNCES SCHOLARSHIP DEADLINES

-- Alaskan high school seniors have until February 15 to apply for Atlantic Richfield Company's 1983 scholarship program.

ARCO will award ten $1,500 scholarships to Alaska high school seniors who will graduate this academic year. In addition, two honorable mention award winners each will receive $500 cash awards.

Every high school in the state has received application blanks to be filled out by the applicants and mailed to the ARCO Public Relations Department in Anchorage, along with letters of recommendation and a high school transcript.

The scholarship program is designed to encourage young Alaskans who show promise of making a future contribution to the state of Alaska, according to Paul Norgaard, President of ARCO Alaska, Inc.

The panel of judges from outside the company will select the winners, taking into consideration scholastic achievement, leadership ability, financial need, character and educational goals.