PE-043-02

TERRITORY OF ALASKA

DEPARTMENT OF MINES

PE 43-2

GEOPHYSICAL EXPLORATION AT THE LOST RIVER TIN DEPOSIT, ALASKA

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by

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March 1953

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INTRODUCTION

The Territorial Department of Mines maintains a staff of mining engineers who are available to prospectors and mine operators for consultation, examinations, and other types of assistance with a view toward helping create new mining production in Alaska. In line with this program, the Department did some geophysical exploration work for the U. S. Tin Corporation at the request of Mr. Paul Sorenson, mine manager, in an attempt to locate areas favorable to tin mineralization. The location of the work was adjacent to the Lost River Mine on Cassiterite Creek, Seward Peninsula. The work was done during August 6 to 14, 1952 by James A. Williams, Robert H. Saunders, and Daniel A. Jones, all of the Department of Mines. Geophysical methods used were magnetic and earth-resistivity measurements. Saunders drafted the accompanying maps and profiles, and Williams is the writer of the report.

Since this report is concerned primarily with the geophysical work, other parts of the report are not so detailed as they would be if it was written on an examination of the mine. Further details on most of the subjects treated here with the exception of the geophysical work can be obtained from various U. S. Geological Survey bulletins and reports, and from R. I. 3902 written by H. E. Heide of the Bureau of Mines as a result of their exploration program there in 1942 to 1944.

SUMMARY

In the course of an exploration project during 1942 to 1944 at the Lost River tin property, the U. S. Bureau of Mines proved by core drilling the existence of a suspected subsurface tin-bearing granite boss or dome. The country rock is limestone. By request of the mine management, the Territorial Department of Mines did some geophysical exploration there in August 1952 in an effort to locate more subsurface granite which would probably also be mineralized with tin. Two methods were employed: magnetic and earth-resistivity.

The plan was to measure the anomalies over the known structure first, then use that data as criteria for interpretation of anomalies obtained in traversing unknown areas. The first stage of the program failed because of the fact that the granite structure was under part of the mining camp, and the various equipment and facilities caused false anomalies. The survey was shifted away from camp to a location considered most likely to overlay more granite, but both types of geophysical exploration failed to reveal indications of subsurface bodies there.

Other items believed contributing to the lack of success were a deficiency of magnetite in the granite, thus reducing the magnetic characteristic of the granite; and permafrost, which would help to mask the higher resistivity of the granite. It is

concluded that the geophysical methods used are quite probably not suited for exploration for subsurface mineralization in the area under consideration.

ACKNOWLEDGMENTS

Acknowledgment and appreciation are due Mr. Sorenson and the mine staff for their hospitality and cooperation in assisting the project. The writer acknowledges the valuable information and advice of Mr. Pemberton Killeen, U.S.G.S., on the geological structures of the area. Special appreciation and thanks are due Drs. Elvey and Keller of the Geophysical Institute at the University of Alaska for their considerable time and effort spent in figuring out the system of the geoscope and instructing Saunders and the writer in its use as well as on other geophysical problems. The writer further wishes to thank Dr. Henry R. Joesting, Chief of Geophysical Branch, U.S.G.S., for the help and advice he has given by correspondence.

LOCATION

The Lost River Mine is located on Cassiterite Creek, tributary to Lost River in the Port Clarence Mining District, Cape Nome Recording Precinct, Second Judicial Division. It is 8 miles north of the Bering Sea beach by way of a road following Lost River, and about 90 airline miles NW of Nome. The geographical coordinates are 167°08' W Long and 65°29' N Lat. The location is shown on the accompanying vicinity map, Plate 1.

HISTORY AND OWNERSHIP

The discovery of cassiterite was made in this area in 1903, and a small amount of placer tin was produced from then until 1912. Lode mining was attempted from 1912 until 1915 and a small tonnage of tin concentrate was produced from a pilot mill during those years. Further development was carried out in two later periods, but no more production came from the property until after World War II. Under the impetus of the DMEA loan program, the U. S. Tin Corporation of Juneau and Lost River was formed, acquired the ground, and started the development work which should shortly result in steady lode tin and tungsten production. Mr. Kenneth J. Kadow of Juneau is president of the corporation.

PHYSICAL FEATURES

The terrain surrounding the Lost River Mine is composed of hills rising more than 1000 feet with slopes varying from 20° to 40°. Toward the Bering Sea, the relief is lower with a wide river bottom. The ground surface is covered everywhere with broken and weathered limestone which is quite sharp and cuts footgear rapidly.

Equipment and supplies must be lightered ashore from freighters at the mouth of Lost River since there is no harbor there. A small flight strip allows small planes to land within two miles of the camp, but a larger one to accommodate DC-3's is scheduled for early completion.

Timber and vegetation are non-existent.


168°
166°
164°
162°
160°
158°
156°
Kotzebue
Kotzebue Sound
Kobuk River
ARCTIC CIRCLE
Selawik River
66°
SEWARD PENINSULA
Cape Prince of Wales
York
LOST RIVER MINE
Teller
Koyukuk River
Norton Bay
Nome
YUKON RIVER
64°
NORTON SOUND
St. Michael
TERRITORY OF ALASKA
DEPARTMENT OF MINES
SEWARD PENINSULA VICINITY MAP
Scale: 1" = 40 mi.
R.H. Saunders
Terr. Dept. of Mines
April 1953

Plate I.

CLIMATE

The weather at Lost River is characterized by sudden changes and strong winds. Fog and rain come and go rapidly in the summer, but the total rainfall is probably not great. Snowfall reaches considerable depths in the winter, and there is much violent weather and temperatures down to minus forty degrees. The snow is not usually completely melted before June or July. The Bering Sea is frozen from November to June.

BUILDINGS AND EQUIPMENT

The mine and mill, though not in continuous production yet, are completely equipped. Details of equipment and operation are uncalled for in this report, but can be found on pages 5 and 6 of the writer's Itinerary Report covering the trip to Lost River and dated November 20, 1952. Numerous residence buildings in addition to the mine bunkhouse and messhall have been erected at the camp. Most of these are Army surplus Quonset huts and prefabricated buildings, some of which can be seen in the accompanying photographs. The remainder are located further downstream toward and at the confluence of Cassiterite and Camp Creeks.

GEOLOGY

The area is one of limestone with subsurface granite intrusions and later acidic dikes. The limestone beds are dislocated by faults striking east-west and dipping steeply to the south, and by another series that strike roughly N 20° W and dip W.1/ Some of

1/ Edward Steidtmann and S. H. Cathcart, Geology of the York Tin Deposits, Alaska: U. S. Geological Survey Bull. 733, 1922, p. 51

Figure 1. Lost River Mine surface plant.

Figure 2. Lost River Mine surface plant.

these faults were intruded by tin-bearing acidic material, thereby forming the dikes which are the known ore bodies under development or investigation. The other granite intrusives are apparently in the form of stocks, bosses, or domes which ascended into the limestone but failed to reach the surface. The Bureau of Mines diamond drilling proved the existence of one of these granite domes and also proved it to be mineralized with cassiterite. Its contours as deducted from the drilling results are shown on Plate 2. This dome and others should become sources of tin ore as well as the dikes.

The contact between the granite and the limestone is a soft kaolin-like material which is altered granite. A similar material is found in Cassiterite Dike. The tin mineralization in the dome is not only at the contact, but extends into the granite a considerable distance with the highest grade in a slightly dipping tabular zone running through the dome about forty feet below the highest point of the structure. It is reasonably safe to assume that other similar structures exist in the vicinity.

A number of other minerals are associated with the tin at Lost River, the most important of which are wolframite and fluorite. Tungsten will form a commercially important part of the mill product.

The Bureau drilling program also disclosed that the presence of permafrost is general, usually extending to 100 or 150 feet where they drilled.

GEOPHYSICAL METHODS

The two geophysical methods employed were vertical magnetic intensity measurements with a magnetometer and earth-resistivity measurements with a geoscope. The magnetometer used was a vertical Wilson-Hull Schmidt-type field balance, Model A. No. 1, and the geoscope was an Oldach and Prow manufactured in Philadelphia for the Department of Mines about 1940 under the direction of Dr. Henry R. Joesting who was then an Associate Mining Engineer for the Department.

In the operation of the magnetic survey, a base sufficiently distant from possible artificial magnetic interference was selected and given an arbitrary intensity value of 500 gammas. This base was used as a check point where readings were taken at the start and finish of each portion of magnetic work each day and every hour during the survey to detect diurnal and instrument changes. When changes were found to have occurred, the readings obtained in the meantime were adjusted accordingly. When the distance from the base was too great to check back to it every hour, checks were made at subbases whose intensities were established by frequent checks between them and the primary base. The instrument was properly calibrated for both sensitivity and temperature coefficient while at Lost River, and these items were included in the calculations of the magnetic intensities from the readings obtained. Readings and results of calculations are recorded in Field Book No. W-1.

Sensitivity of the magnetometer was set at about 28 gammas per scale division. (The exact figure is unavailable at the moment).

In the earth-resistivity measurements, the Wenner electrode configuration was used in which the two current electrodes are placed outside the two potential electrodes, all electrodes being in a straight line and distances between them kept equal. Thus if a potential electrode spread of 25 feet was desired, the current electrodes were placed 25 feet beyond the potential electrodes, and the total length of the line of electrodes was 75 feet. Direct current was used, and the current electrodes were iron rods driven into the ground. The potential electrodes were porous pots containing copper sulfate solution to prevent polarization. The current was reversed at each setting, and the two readings obtained were averaged to eliminate faulty values being obtained as a result of ground currents that often exist. Heavily insulated No. 18 stranded wire was used for connecting the electrodes to the geoscope.

The procedure was to send a measured current between the current electrodes, and then measure the potential between the potential electrodes. The apparent resistivity of the ground in units of ohms-centimeters is then found by the formula $2\pi aV/I$ where "a" is the potential electrode separation in centimeters, "V" is the potential in volts and "I" is the current in amperes. Theoretically, in homogeneous ground the resistivity is obtained to a depth roughly equal to the electrode separation.2/ Thus, as the electrodes are spread further and further apart, one is obtaining readings representing greater depths. This results in depth profiles. Traverse profiles are obtained by traversing along a line with electrodes always set at the same separation. The profile obtained in this manner would represent the varying resistivity of the ground at a theoretical constant depth along the traverse.

PROCEDURE

The problem was to locate other subsurface granite structures, similar to the one outlined by the Bureau of Mines drilling, where further tin mineralization is likely to occur. It was considered that either or both of the two geophysical methods used should reveal anomalies that could be interpreted to indicate the presence of granite bodies in limestone for the following reasons: (1) granite is ordinarily more magnetic than limestone because of the magnetite and other basic minerals it contains, and (2) it usually has a higher electrical resistance than limestone because of limestone's higher water content and more orderly grain orientation.3/ It was decided that the most logical method of attack on the problem was to run traverses with the geophysical equipment over the known granite structure, and use the anomalies

2/ J. J. Jakosky, Exploration Geophysics, (First Edition: Los Angeles: Times-Mirror Press, 1940), p. 317.

3/ C. A. Heiland, Geophysical Exploration, (New York: Prentice-Hall, Inc., 1940), pp. 634, 660-663.

obtained there as a basis for interpretation of anomalies obtained when traversing unknown areas in search of the other bodies.

Accordingly, five magnetometer traverses with 50-foot stations where possible were laid out on the surface over the structure as shown in Figure 3 and in Plates 2 and 6. They were surveyed so as to be parallel to and coincide with the existing grid created by the Bureau of Mines. It was reasoned that in running perpendicular to the ridge-like granite structure, the magnetic anomalies, if any, would vary more quickly and thereby be more easily interpreted.

Results of magnetic observations on Lines 4900 to 5300 were of no value, (all results will be discussed in the next section of the report) so a traverse of 100-foot stations was laid out along the bed of Camp Creek for further magnetic observations. This location for a traverse was chosen because it extends across an area toward which the granite structure appears to trend, and it is also at a lower elevation than the other terrain in that direction, hence should be nearer the granite. The first part of the above statement can perhaps be more easily understood when Plate 2 is superimposed on Plate 6 and properly located by means of the appropriate grid lines. Line A was run parallel to the lower part of the first Camp Creek traverse as a double check, and Line B was a third parallel traverse run in an area that temporarily looked promising as a result of anomalies found in Lines O and A.

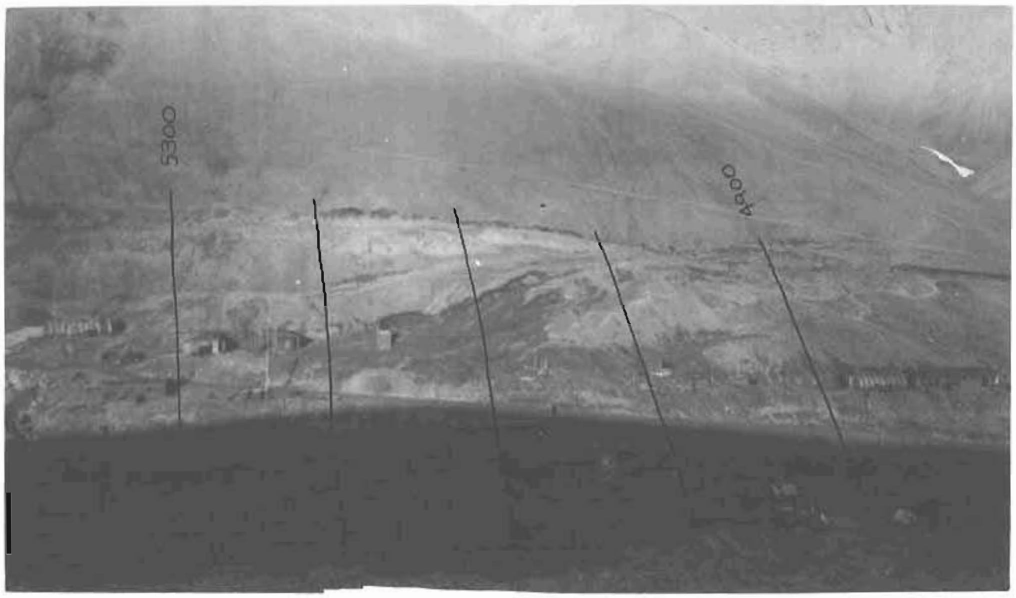

Figure 3. View of area underlain by known granite structure. Inked lines show approximate locations of Magnetic Traverse Lines 4900 to 5300. Snow patch in upper right is at upper end of Camp Creek Traverse Line 0.

Figure 4. Another view of area shown in Figure 3.

Locations of all magnetic traverses and centers of resistivity work can be seen on Plate 6.

A depth-resistivity survey was run centered on and perpendicular to Line 5000 at Station 106½. This location and direction were chosen because they are above and in line with the ridge which is the highest part of the granite structure. It was reasoned that if a relatively marked increase in resistance could be detected at somewhere in the vicinity of the theoretical depth of the contact, that would be the hoped-for indication, and horizontal traverses with large electrode separations could then be run in the search for favorable anomalies indicating other granite structures. When an electrode separation of only 125 feet was reached, (actual depth of granite at this point is about 270 feet) it was seen that various interferences were making the work useless, and the resistivity measurements were halted at this location.

Another depth-resistivity survey was run at Station 124+28 and in line with that portion of Line A. This location was also picked because the granite appears to trend toward that vicinity and because the best magnetic anomalies on Camp Creek were in that area. The location can be seen in Figure 5. This second resistivity survey was carried out to an electrode separation of 600 feet, which was as great a spread as the total footage of wire allowed.

Expected anomalies had not appeared, so the geophysical work was stopped at this time.

Figure 5. Upstream view of Camp Creek. X marks approximate location of center of second resistivity survey.

Figure 6. A third view of the Lost River Mine. The original portal is located back of the left-hand end of the two-story bunkhouse. Two more portals can be seen toward the upper right corner which outline the outcropping of Cassiterite Dike.

A plane-table survey was made of the traverses in order to precisely locate and map them as well as obtain the elevations and contours. This work resulted in the features shown on Plate 6. As already mentioned, the grid used was originated by the Bureau of Mines.

RESULTS

The magnetic traverses over the known granite structure resulted in the profiles shown on Plate 4. The portion of each traverse where the ground surface and the granite contact approached each other nearest was in every case near pipes, power lines, or buildings which caused, or would have caused, false anomalies. These artificial influences continued to the west end of each traverse line except apparently on Line 5100. Inspection of the photographs will show that to have run more traverses to the north or south would have been useless because of more buildings that would have been encountered.

Approaching west from the undisturbed east ends of the traverses, three of the magnetic profiles either stay relatively level or drop slightly as the granite depth decreases; the profile of Line 5200 shows a very slight rise with the anomaly at Station 107 questionable; and the profile of Line 4900 remains level until Stations 106 and 105 are reached, which may have been influenced by a pile of iron roofing.

It appears improbable, therefore, that the granite would have caused magnetic anomalies sufficiently outstanding to be used in future interpretations, had the disturbing factors not been there, but the writer is not positive on this point. A probable reason for this apparent failure of the granite to cause the expected anomalies was given by Mr. Killeen of the U.S.G.S. after the survey when he informed the members of the Department that this particular granite was deficient in magnetite content. This fact was not known when the survey was being planned.

The magnetic traversing of Camp Creek, though free of artificial influences, showed up no anomalies over a sufficiently wide area to indicate the existence of a subsurface body as broad as the structure in question. (See Plates 2 and 5, which are drawn to the same scale). Three small local anomalies in the same area can be seen in Lines O, A, and B, but they do not coincide very well. Their cause is unknown.

In the resistivity work, interference from power and pipe lines again gave false anomalies over the known structure. The erratic results can be seen in the left-hand profile of Plate 3. After reaching an apparent resistivity of about 750,000 ohm-centimeters at electrode separations of 25 and 50 feet, it then drops back to about 250,000 at spreads of 75 and 100 feet, only to jump back to 900,000 ohm-centimeters at 125 feet. Apparently a pipeline or power line was helping to conduct the current at the 75 and 100-foot spreads. Further, currents in the ground became so large in the longer spreads that it was very difficult to overcome them with the current from the geoscope. After the 125-foot spacing, it was impossible to operate further. The existing ground currents were no doubt caused by the mine power lines and various electrical equipment in the vicinity.

The depth-resistivity survey at Station 12A+28 on Camp Creek gave a natural depth profile, but not the type that was hoped for. As can be seen in Plate 3, the resistivity increased (roughly) until a separation of 325 to 375 feet was reached. Then it decreased steadily until the maximum possible spread of 600 feet was reached. If the current entered granite after a certain depth was reached, and nothing else was interfering, the profile should tend to flatten out, theoretically, showing a greater rate of increase of resistivity; or at least the profile would show a continued increase at not less than the existing rate. But here the profile actually reverses to show a decreasing resistivity after some sort of discontinuity is reached.

As mentioned earlier, permafrost is general in the area. Frozen material has a higher resistivity than when it is thawed,4/ and the profile resembles those of Joesting's in his work on permafrost.5/ Under these circumstances, it appears that the break in the profile under discussion was caused by the lower limit of the permafrost, and if granite is there, its effect is overshadowed by the higher resistivity of the frozen limestone. It is also possible that other unknown factors may be changing the results.

4/ Henry R. Joesting: Magnetometer and Direct-current Resistivity Studies in Alaska. A.I.M.E. Tech. Pub. 1284. (1941), p. 11-13.

5/ Ibid., p. 13-17.

CONCLUSIONS

Conclusions were included under RESULTS, but they will be briefly summarized here.

Attempts to obtain magnetic and resistivity anomalies over the known granite structure to use as criteria for unknown areas failed because of the proximity of the mining camp with its facilities, and partly, it is believed, because of a deficiency of magnetite in the granite. The magnetic profiles of the Camp Creek area failed to reveal significant anomalies, and the depth-resistivity survey there indicated only a probable lower limit of permafrost at a theoretical depth of 300 to 400 feet. It appears evident from the results obtained that the methods used are not suited for further geophysical exploration for granite in the area concerned. Unfortunately, this conclusion could not be positively proven because of the interference over the known area.

Other possible geophysical methods are airborne magnetometer surveying and seismic work. The airborne magnetometer could quite possible outline general granite areas in the vicinity in spite of the magnetite deficiency. An authority on aerial work should be consulted on the problem. Seismic exploration might run into difficulties because of the soft material at the contact and the permafrost. Again, an expert in that particular field should be consulted.

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