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GEOCHEMICAL EXPLORATION FOR ANTIMONY IN SOUTHEASTERN ALASKA

By

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GEOCHEMICAL EXPLORATION FOR ANTIMONY IN SOUTHEASTERN ALASKA

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ABSTRACT

Preliminary geochemical prospecting by the Geological Survey was carried out in 1952 in muskeg-covered ground at Caamano Point, Cleveland Peninsula, Alaska, in an effort to delimit areas of stibnite concentrations. It was conducted to aid, if possible, a prospecting project of the Defense Minerals Exploration. Samples were collected from soil and decomposed limestone-and-schist bedrock at depths ranging from 18 inches to 60 inches, by means of a pipe with an interior plunger.

Initial sampling was followed by detailed sampling of the areas where the antimony content of the soils consistently averaged more than 300 ppm. These areas of major soil concentrations were prospected by surface trenching and percussion drilling to depths of 20 feet which proved the existence of stibnite ore. Next a shaft and drifts made in the most favorable area proved disseminated stibnite ore to depths of 60 feet.

This geochemical work of soil sampling to indicate hidden ore bodies in a typical Alaskan muskeg area is believed to be the first application in Alaska of such techniques in active ore exploration. The results show the economic feasibility of such exploration as a first step in extending the known boundaries of mineralized areas, and in directing initial exploration toward the most favorable areas of near-surface ore bodies.

Data are presented to help establish values of soil content of antimony that may be considered as normal in this type of geologic terrain.

INTRODUCTION

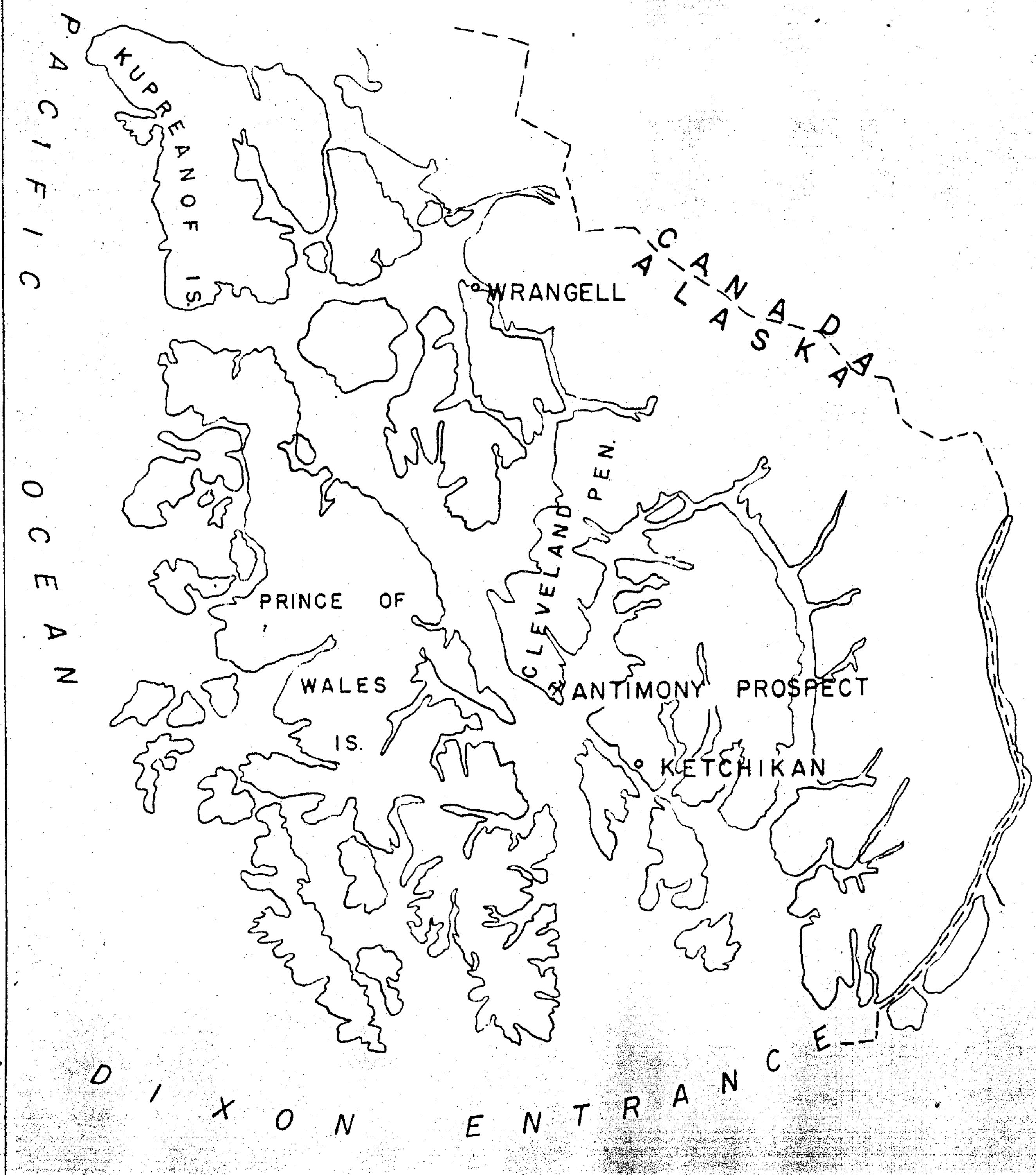
Geochemical prospecting by the Geological Survey was conducted in 1952 at an antimony prospect at Caamano Point on the southwestern tip of Cleveland Peninsula, about 14 airline miles northeast of Ketchikan, which is the nearest town (see Figure 1).

The prospect has been known locally as the Val Klemm antimony mine. Development work at the prospect prior to 1952 consisted of two shallow shafts at the site of the original discovery and of several trenches and shallow rock cuts, none of which disclosed additional stibnite ore. In 1950 the property was acquired by the Tillicum Mining Company of Ketchikan, a partnership with George B. Roberts of Ketchikan as the managing director. In 1952, an exploration contract was negotiated between the Tillicum Mining Company and the Defense Minerals Exploration Administration for additional trenching and subsurface exploration.

Although the prospect at Caamano Point had been mapped geologically (Robinson, 1943), the structural controls of ore deposition were imperfectly known. In addition, the thick vegetal cover obscured bedrock relations, and made surface exploration slow, difficult and costly. Morever, such surface prospecting at best was haphazard, because the location of trenches was influenced more by the proximity of bedrock and thin surficial deposits than by the geologic probability of finding ore. With the development of a field method for the determination of trace amounts of antimony in soils and plants by the Geological Survey, it was decided to apply geochemical techniques at Caamano Point in advance of the Company's surface exploration with a two-fold purpose:

FIGURE 1

INDEX MAP SHOWING LOCATION OF ANTIMONY PROSPECT, CAAMANO POINT, SOUTHEASTERN ALASKA



(1) To develop factual criterial regarding the geochemical behavior of antimony in a typical Alaskan area of high rainfall and thick vegetal cover.

(2) To delimit, if possibe by geochemical methods, those areas most likely to contain bedrock concentrations of antimony, thus facilitating the location of trenches in favorable areas with a resultant saving of Government funds provided to the company by the Defense Minerals Exploration Administration program.

Accordingly, the writer in September 1952, visited the prospect and collected 76 soil samples, spaced as shown in Plate 1. The results of the preliminary sampling were so encouraging that additional samples were collected in March 1953. As a result, two areas with abnormally high antimony concentration in the soil were outlined in detail. Subsequent trenching and drilling under the Defense Minerals Exploration Administration contract proved the existence of antimony ore in both areas. During the summer of 1953, the Tillicum Mining Company, at the author's request, collected additional samples and another area of high antimony concentration was found (Ore zone 4 on plate 1). Surface drilling of this body also showed that stibnite ore underlies the soil.

This paper is written primarily to discuss the results of the geochemical exploration. The writer wishes to acknowledge the courtesies extended to him by Mr. George B. Roberts, Manager, Tillicum Mining Company, as well as the assistance of William Hibberd, Tillicum Mining Company and R. C. Rowe, assayer for the Territorial Department of Mines. All of the samples were analyzed in the laboratory of the U. S. Geological Survey, Denver, Colorado.

GENERAL GEOLOGY

The areal geology of the southern part of Cleveland Peninsula is discussed by G. D. Robinson (1943), and the geology shown on Plate 2 is taken from Robinson's report, with minor additions by the writer.

The Caamano Point prospects occur in limestone interbedded with limy slate and subordinate phyllite of Mesozoic age. The rocks, isoclinally folded and overturned to the west, in general strike northwesterly and dip northeasterly, but local variations are common, particularly in the limestone near the prospects. Locally, the limestone has been intensely brecciated, silicified, dolmitized and re-cemented by calcite and secondary silica. It is significant that three structural conditions are common to each area of stibnite deposition: (1) intense brecciation of limestone (2) partial dolmitization of limestone and deposition of appreciable silica in fractures and by replacement of limestone breccia (3) minor steep faults striking northwesterly to northerly. The stibnite was deposited by replacement of limestone, and as discrete veinlets in fractures in the limestone. Stibnite is the only ore mineral. It is exceptionally pure and contains only traces of arsenic, as shown by the following spectrographic analysis of typical ores.

TABLE I

Spectrographic Analyses of Antimony Ores, Caamano Point

Samples No.	Greater than 5%	Less than 5%	Not detected
53-ASn-220	Sb	Ca, Mg, Pb (< .5%)	
53-ASn-221	Sb	Ca, Mg	Pb, Sn, Cu
53-ASn-222	Sb, Mg, Ca	Mn, Pb (< .5%)	

Sample 53-ASn-220 from Shaft No. 1, Sample 53-ASn-221 from ore at Shaft No. 3, Sample 53-ASn-222 from Shaft No. 2. Analyst, J. J. Matzko, U. S. Geological Survey

GEOCHEMICAL EXPLORATION

Physical Characteristics of Soil

The soil in the vicinity of the prospect is derived in part from reworked marine (?) glacial tills, and in part from weathered material of the underlying bedrock, all of which are overlain by decaying vegetation and humus of variable thickness. The proportion of the two varies from place to place. In areas of limestone bedrock, however, the major part of the soil consists of insoluble material derived from the limestone, overlain by organic matter derived from decaying vegetation. Boulders of glacial origin almost invariably are found only in stream channels or in holes in limestone. Most of the boulders and pebbles in the present stream beds are flattened and have been derived from dynamically metamorphosed conglomerate that occurs in the metasedimentary rocks. A few pebbles or boulders of quartz-diorite, and local areas of blue clay give evidence of reworked glacial material. Without exception, however, the soil profile where observable immediately above limestone bedrock consists of a layer of decayed organic matter grading downward into a yellowish-to-reddish clay containing quartz fragments derived from the underlying rock, and thence downward into limestone. At other places a till zone occurs between the humus and the yellow clay zone overlying bedrock. No glacial deposits are exposed in the banks of the small streams in the general area of the prospects, and such deposits, where they are suspected, are very restricted in areal extent, nowhere exceeding a few tens of yards. Muskeg and peat bogs several feet deep have developed on larger flat areas, and are especially abundant in those areas of suspected reworked glacial material, where drainage is poor. Samples collected from such areas usually came from the yellow clay zone above bedrock, although at a few places bedrock was below the reach of the sampling tube which was 6 feet long. A good guide to the absence of glacial material normally was afforded by the abundance of quartz fragments in the soil. These fragments, usually somewhat porous and completely unabraded, were a certain indication that no glacial debris occurred in the soil profile. The muskeg layer ranges in depth from an inch or less to eight feet, and the yellow-to-reddish zone normally ranges in thickness from a few inches to several inches. This slight reddish color probably represents an initial concentration of iron, or the primary stage of the development of a lateritic soil. Bedrock often crops on knolls and humps, and creek bottoms expose continuous bedrock.

If silicification were confined to the areas near orebodies only, the presence of abundant quartz fragments in the residual soil might be used as a valuable guide to further prospecting. However, fine quartz-calcite-dolomite veinlets are common in joints in the slaty limestone wherever they crop out, and quartz fragments may be obtained from residual soil away from the known orebodies. The limestone near all orebodies, as pointed out by Robinson, appears to be "massive breccia", and this remains a good guide to further prospecting (Robinson, page 4), even though it now appears that this breccia is the result of fracturing of silicified and dolomitized limestone, rather than of the fracturing and brecciation of massive limestone "eyes" in the enclosing slaty limestone.

Method of Collection of Samples

Samples were collected by using a three-quarter inch pipe into which was inserted a wooden rod, or plunger, of proper diameter. The pipe, with the plunger extended slightly, was pushed by hand down to the yellow clay zone. The plunger was then released and the pipe pushed by hand into decomposed bedrock, or residual material derived from bedrock. The pipe was raised and the plunger used to punch out the sample. Three or four samples were collected in different holes at each station. By this method each sample was taken from the lowest soil horizon, and it was not contaminated by the overlying soil, as no material could fall into the hole. Each station was marked by a red flag upon which was written the station number. It was not necessary to transit survey stations, because subsequent testing of promising areas by physical exploration followed immediately after the soil sampling. A transit survey of the sample lines would have served no immediate purpose, and such a survey would have required a great amount of additional time and expense. Each promising area was found by reference to the station numbers marked upon the red flags that identified stations.

After each sample was collected, the pipe was cleaned merely by scraping it out with a flattened stick. To check the degree of possible "salting" if a lean sample followed a rich sample, a sample was collected in soil of low antimony concentration and the pipe cleaned in the manner described. A sample was then collected in a soil of very high antimony content. The pipe was again cleaned in the usual manner and a third sample taken where the first test sample was collected. The results showed negligible contaminations.

Methods of chemical analysis

The methods of analysis used in this work were developed by the Geological Survey. They are described in Geological Survey Circular No. 161, and an open file report entitled "Additional Field Methods Used in Geochemical Prospecting by the U. S. Geological Survey". These methods are simple to perform, require reagents and apparatus that are cheap and readily available, and a minimum of technical training to obtain satisfactory results. They possess a precision of plus or minus 30 percent. Therefore, small differences in values obtained by their use should not be regarded as significant.

Lateral Distribution of Antimony in Residuum

Preliminary orientation traverses: The initial step was to establish a preliminary range of values to indicate normal and anomalous concentrations of antimony in the soil. Accordingly, 72 soil samples were taken as shown on Plate 1, in lines radiating from the main prospect, and along the strike of the limestone (see Table II). These lines also were meant to be true "prospect" lines to indicate possible extensions of the ore zone. Four samples of hemlock inner bark were collected also in general interest to see if this tree showed greater antimony content near the ore. In the analyses of the initial samples, no determinations greater than 2000 ppm. of antimony were made, as it was felt that this concentration would be sufficiently diagnostic to indicate ore.

The initial results proved the feasibility of finding ore by geochemical means by showing a great concentration of antimony in the soil near orebodies compared to the lower, or background, values obtained elsewhere. Two areas of apparently high content of antimony in soils that could not be related to known orebodies were discovered also by the preliminary studies.

The hemlock bark samples also showed an increase in antimony content near the orebody, and the writer is confident that geobotanical sampling also could have been applied successfully in this area. However, it was decided to concentrate on soil samples because of the much greater contrast in total antimony content.

TABLE II

Antimony content of preliminary soil samples, taken at Caamano Point, Alaska, 1952
(See Plate 1)

Line No. Hole No.	ppm Sb	Line No. Hole No.	ppm Sb	Line No. Hole No.	ppm Sb
1-1	120	4-3	20	8-3	300
1-2	180	4-4	70	8-4	900
1-3	50	4-5	30	8-5	>2000
1-4	50	4-6	10	8-6	80
1-5	20	4-7	20	8-7	140
1-6	10	4-8	20	8-8	60
1-7	30	5-1	80	8-9	50
1-8	20	5-2	60	8-10	100
1-9	20	5-3	600	8-11	40
1-10	10	5-4	60	A	1200
1-11	10	5-5	50	B	>2000
1-12	20	5-6	250	C	1800
1-13	100	5-7	60	D	450
1-14	20	6-1	40		
1-15	10	6-2	90		Plant Samples
2-1	40	6-3	30		(Inner bark
2-2	20	6-4	1000		of Hemlock)
2-3	80	6-5	60		
2-4	50	6-6	80		
2-5	80	6-7	60	E	4.5
2-6	40	7-1	40	E	3.5
2-7	10	7-2	30	F	2.3
2-8	5	7-3	20	F	2.5
3-1	40	7-4	70	G	0.6
3-2	40	7-5	120	G	0.4
3-3	20	7-6	40	H	1.5
3-4	40	7-7	60	H	.8
3-5	60	7-8	40		
3-6	20	7-9	80		
4-1	500	8-1	>2000		
4-2	60	8-2	>2000		

Note: Sb by Field Methods

Analysts: E. E. Crowe, soil, Fred Ward, plant. - Geochemical Exploration Section, U. S. Geological Survey, Denver, Colorado

Reconnaissance traverses: In 1953 additional reconnaissance traverses were made to test the regional distribution of antimony in soils overlying diverse rock types (see Plate 2 and Table III).

A significant variation in antimony content of soil in relation to the lithology of the underlying rock is apparent. The soil over the general area covered by lines A, B, and C contains a relatively low concentration of antimony. Samples 1 and 2, line A, were collected over limestone bedrock, and the remaining samples in the line came from soil overlying metamorphosed clastic sediments. The decrease of antimony content to 10 ppm corresponds roughly with the lithologic change in the bedrock. All the samples in line B were collected from soil above schist, conglomerates or metabasalt, and again it is noted that these samples are low in antimony content. Line C begins in limestones or limy slates, and then traverses alternating thin bands of schist and limy slate into metamorphosed clastic sediments. The soil concentration of antimony again appears to fall off rapidly with the lithologic change from limestone to schist. Similar conditions were noted in line D.

Limestone is the predominant bedrock beneath the soil covered by lines E and F, and the antimony content of the soil in these lines is materially greater than the other lines. The median value of 31 samples taken over limestone bedrock in these lines is about 60 ppm, and the average antimony content, excluding as anomalous those values more than twice as large as the median, is about 37 ppm.

TABLE III

Antimony content of soil samples collected by the Geological Survey in 1953 at Caamano Point, Alaska
(See Plate 2)

	Sample No.	ppm Sb
Line A	1	60
Line A	2	30
Line A	3	15
Line A	4	10
Line A	5	10
Line A	6	10
Line A	7	10
Line A	8	10
	9 (Sediment)	10
Line B	11	10
Line B	12	10
Line B	13	10
Line B	14	<10
Line B	15	<10
Line B	16	<10
Line B	17	<10
Line B	18	<10
Line B	19	10
Line B	20	10
Line B	21	15
Line B	22	15
	23 (Sediment)	15
Line C	24	150
Line C	25	30
Line C	26	<10
Line C	27	30
Line C	28	<10
Line C	30A	<10
Line C	30B	<10
Line C	31	10
Line C	32	<10
	33	<10
	34	<10
	35 (Sediment)	10
Line D	36	20
Line D	37	10
Line D	38	<10
Line D	39	<10
Line D	40	<10
Line D	41	<10
Line D	42	<10
Line E	51	3000
Line E	52	3000
Line E	53	300
Line E	54	180
Line E	55	120
Line E	56	60
Line E	57	10
Line E	58	120
Line E	59	10
Line E	60	15
Line E	61	30
Line E	63	60
Line E	64	15
Line E	65	45
Line E	66	30
Line E	67	15
Line E	68	<10
Line E	69	45
Line E	70	75
Line F	71	300
Line F	72	60
Line F	73	300
Line F cont.	74	900
Line F cont.	75	500
Line F cont.	76	150
Line F cont.	77	180
Line F cont.	78	30
Line F cont.	79	60
Line F cont.	80	150
Line F cont.	81	75
Line F cont.	82	45
Sediments	83	120
Sediments	84	90
Sediments	85	75
Sediments	86	10
Sediments	87	15
Over "Hotspot" near sample 52	88	3000+
Over "Hotspot" near sample 52	89	3000
Over "Hotspot" near sample 52	90	3000
Over "Hotspot" near sample 52	91	3000
Over "Hotspot" near sample 52	92	10000+
Over "Hotspot" near sample 52	93	1500
Over "Hotspot" near sample 52	94	1500

Analysts: H. E. Crowe, J. H. McCarthy, A. Marranzino, Geochemical Exploration Section, U. S. Geological Survey, Denver, Colorado

The average of 30 samples taken in lines A, B, and C, excluding one anomalous value of 150 ppm of antimony obtained over limestone near the prospect, is about 11 ppm of antimony.

Detailed studies: At the request of the writer, the Tillicum Mining Company collected an additional 65 samples in a grid on approximately 15' centers over the most promising area indicated by the samples on line 8 of the preliminary orientation studies. Almost all these samples contained more than the average of 37 ppm of antimony obtained for limestone in general. Values in excess of 10,000 ppm of antimony were obtained from many of these samples. The relation of these samples to subsequent physical exploration by trenching, drilling or sinking of shafts is discussed later.

Vertical Distribution of Antimony in Soil

Twelve groups of samples were taken to determine the vertical distribution of antimony in the soil profile. The results indicate to the writer a tendency for the occurrence of two zones of antimony concentration - one immediately over bedrock and one at the base of the humus layer - separated by a leaner zone. In the writer's opinion this reflects an enrichment at the base of the humus from the decay of considerable vegetal matter containing antimony, and an enrichment immediately above bedrock caused by the solution of limestone and a resulting concentration of the less-soluble antimony. The leaner portion of the profile represents an area of leaching by capillary water and roots. Very small fragments and needles of stibnite could be panned from bulk samples of decomposed material above bedrock in areas containing 10,000 ppm of antimony, which indicates a relative inertness of stibnite. The occurrence of small fragments of stibnite in the soil is another good indication that the soil immediately above bedrock is composed of the insoluble residues left from the solution of limestone or slaty limestone. The high content of antimony in soils throughout the limestone areas can be explained by assuming that the insoluble material (especially stibnite, kernesite or stibiconite) has been concentrated in the clay and decomposed material over bedrock during the solution of a considerable thickness of limestone containing as little as 2 ppm of antimony. The solution of limestone probably was accelerated by the distinctly acid surface water normally derived from muskeg areas in Alaska.

Distribution of Antimony in Fluvial Sediments

Eight samples of stream sediments were taken as shown on Plate 2 from streams draining the general area of the prospect. The results show conclusively that the sediments from streams that drain the immediate area of the prospect and the limestone band in the metasedimentary rocks contain more antimony than sediments from streams that drain limestone-free areas (see Table III). Samples 35 and 87 show no increase of antimony content over the soil from line C; sediment sample 9 agrees closely in antimony content with the soil samples from the northerly part of line A; sediment sample 23 contains slightly more antimony than the soil samples of line B, probably because the west fork of the stream heads near the prospect; sediment samples 83, 84, 85 contain antimony in an amount closely approaching that in soil samples from lines E and F - a very diagnostic increase. Sample 86 is offshore beach sediment collected at low tide at a point about 100 yards from the mouth of the creeks, and indicates fairly rapid dispersal of antimony-rich sediments at tide-level.

Distribution of Antimony in Bedrock

Several samples of bedrock were analyzed for antimony by the regular field method. A sample of slaty limestone from the trench west of shaft No. 2 contained 15 ppm of antimony; a sample of brecciated and silicified limestone from shaft No. 3 contained 6000 ppm of antimony. Two samples of limestone from small limestone pods in the metasedimentary rocks near the beach contained 1 ppm and 2 ppm of antimony, respectively. A sample of schist from a schist band 6 feet thick near the old ore dump from shaft No. 1 contained 15 ppm of antimony. Although not conclusive, the results suggest that regionally the limestone contains approximately 1-2 ppm of antimony, which increases near the mineralized areas to approximately 15 ppm of antimony, and near orebodies may increase to as much as 6-10,000 ppm of antimony.

Two of these limestone samples were crushed and leached with warm dilute hydrochloric acid, and the insoluble residues examined under the microscope. The residue from the slaty limestone contained some clear quartz fragments, small sandy masses composed of siliceous fragments entirely, some graphite, and a few pyrite crystals as pyritohedrons. The residue from the altered limestone contained similar sandy masses, a greater abundance of quartz fragments, red oxides of iron, and very little graphite.

The results indicate to the writer that the brecciated and altered limestone was formed from slaty limestone containing sandy aggregates by the addition of quartz, and the loss of graphite. Antimony may have accompanied the quartz, or it may have been later. Evidence from exploration at shaft No. 1 indicates some quartz and stibnite were deposited contemporaneously.

Interpretation of Results

From the foregoing information certain inferences may be drawn with respect to concentrations of antimony that may be considered diagnostic of near-surface stibnite-bearing bodies in this district. Two normal, or background, concentrations must be assumed based upon the underlying bedrock - in limestone areas a background value of 30-40 ppm of antimony in soil immediately above bedrock must be assumed. Near mineralized areas in limestone a background value of 100-1000 ppm of antimony must be expected. This means that soil samples considered indicative of underlying stibnite ore must contain antimony in the range between 1000 and 10,000 ppm. In this study it proved expeditious to consider as "threshold" only values up to 1000 ppm, as near surface orebodies consistently gave values ranging up to 2-10,000 ppm. Obviously in actual exploration the dividing line between "threshold" and "anomalous" could be flexible, depending upon the immediate objective of the geochemical work. In this instance the immediate objective was to discover near-surface ore within reach of short drill holes only 20 feet long. Deeper orebodies might be indicated by antimony concentrations as low as 100 ppm, but such bodies were not within the immediate objectives of the present work.

In areas underlain by metasedimentary rocks, other than limestone, or metavolcanic rocks a background value of 10-15 ppm of antimony may be assumed, and anomalous concentrations indicating underlying stibnite ore probably will range up to 10,000 or more ppm of antimony.

The writer has been asked whether or not he considers any of his values as a true regional background value. The literature does not describe other attempts at geochemical prospecting using the antimony content of soils, so that little information is available to establish the "normal" range of antimony in soils. Obviously, before any geochemical technique may be applied successfully in a new area, it is necessary to know what concentration of each metallic constituent is considered normal for that area.

The results at Caamano Point, in the writer's opinion, reflect certain geologic, geomorphic and physical conditions that may not obtain elsewhere, and the writer considers his results are diagnostic only of what may be termed an "antimony area", where stibnite in small amounts is widespread in the limestone bedrock, but possibly is less and more restricted in the metasedimentary rocks and metavolcanic rocks. No attempt was made to establish a regional background value more than one-half mile from the prospect.

SUBSEQUENT EXPLORATION

Subsequently, the Tillicum Mining Company trenched and drilled the areas of abnormal concentrations of antimony northwest of the old workings, and confirmed the soil sampling results to an uncanny degree, as shown in Plate 3. A plot showing the location of the exceptionally antimonial soil samples in relation to percussion-drill holes intersecting stibnite exhibits remarkable correlation, even to outlining the trend of the mineralized zone, which possibly is related to the northwest-trending fault showing in surface trenches and underground openings. It is notable that this mineralized area cropped in a low saddle where muskeg and peat had accumulated to a depth of 4 to 6 feet. Shortly after the discovery was made, Mr. Roberts, General Manager, Tillicum Mining Company, wrote a letter in which he stated "the latter discovery can be credited 100% to the soil sampling, as most of the ore body so far found is overlaid by 2 to 5 feet of matted roots and muskeg", and "Whether or not this discovery proves of commercial importance, the way the soil sampling picked up this ore body, which is mostly rock capped, is atonishing".

Trenches and drill holes in the vicinity of Sample Nos. 51 and 52 also intersected disseminated stibnite ore. A 15-foot shaft sunk here, and drill holes from the bottom of the shaft, proved continuity to the mineralized zone of shattered limestone.

A shaft 44 feet deep, as shown on Plate 4, and drifts totalling 100 feet along the inferred strike of the ore zone, encountered disseminated stibnite ore throughout. The stibnite occurs as irregular thin replacement bodies in brecciated, silicified limestone, and as fracture fillings along thin veinlets in fractures in the limestone. In general, the grade of ore averages about 1.3 percent of antimony, although some drill holes cut zones a few feet thick that assay as much as 8 percent of antimony. The drifts were stopped with disseminated stibnite showing in each face. The orebody appears to be bounded on the west by the fault showing on the surface and in the 22 west crosscut in the north drift of the 40-foot level (see Plate 4). The ore possibly is related to shattering and replacement of the limestone incident upon movement along this fault, and the confining of hydrothermal solutions to the footwall by the gouge zone in the fault. Drill holes penetrating the hangingwall of the fault pass abruptly from stibnite-bearing limestone into pyritiferous rock devoid of stibnite. The amount of movement on the fault is unknown, but the fault appears to be the same as that exposed in the creek bed several hundred yards northwesterly from the new shaft. Stibnite-bearing limestone occurs sporadically along this fault, and at one place schist is faulted against limestone. It should be noted, however, that the original discovery at the prospect (containing massive stibnite), and the new discoveries northwest of the new shaft, are not aligned exactly along this fault. Consequently, this fault should not be regarded as the only regional "ore-bringer", and future exploration and prospecting should not be restricted to the area adjacent to the fault.

If the small schist band exposed in the eastern end of the trench north of the shaft is the same as that exposed in the south drift on the 44-foot level from the shaft, a small dragfold plunging northeasterly is indicated in the slaty limestone. Robinson (page 2) notes a dragfold at the orebody at No. 1 shaft, and postulates that this dragfold obviously influenced ore deposition. The dragfold at No. 2 shaft is rather small, it has been cut by the fault, and ore occurs both northward and southward from the fold. Possibly this fold exerted some influence on ore deposition, but the writer can offer no logical reason based on factual data to explain what that influence might be. Dragfolds have been observed at many places in the slaty limestones with no associated brecciation, dolomitization or stibnite ore.

CONCLUSIONS

In the writer's opinion, the major value of the geochemical work lies not in the amount or grade of ore in the new orebodies discovered, but in the degree of ease with which these bodies were discovered. Previous to the date of acquisition of the property by the Tillicum Mining Company, the prospect was held 36 years by Val Klemm who, during this time, did not succeed in uncovering additional ore zones other than the original discovery. The geochemical work guided subsurface exploration to three additional ore zones at a total cost of less than $750.00 in wages for time spent in the field, and for costs of chemical analyses. This enabled the operator to use money available for exploration in physical exploration of areas known to be favorable for the occurrence of stibnite, rather than to spend money in haphazard trenching and drilling.

In addition, the samples of stream sediments indicate that sediment-sampling of streams in an antimony province might rapidly delimit drainage areas favorable for prospecting. It is concluded that antimony ores, particularly stibnite, are very susceptible to detection by soil sampling methods, at least in residual soils, because the dispersion halo is somewhat restricted in extent, and anomalies in the soil lie close to the bedrock anomaly, or ore zone. In areas where bedrock is overlain by thick covers of muskeg, such as are common in Alaska, samples may be collected from the bedrock-soil contact very easily by the use of a pipe and plunger, and any dispersion halo of stibnite should be very close to the bedrock source. Some research currently is being done by the U. S. Geological Survey on the dispersion halos of mixed ores containing sulphides of antimony to establish the usefulness in geochemical prospecting of the antimonial constituents (Hawkes, H. E., unpublished). Such research may indicate that antimony sulphides can be used to "pinpoint" sulphide bodies that are indicated initially by the use of zinc or copper indicators. The volume of information available on geochemical prospecting is large, but the writer knows of no published information discussing the application of these techniques to antimony exploration, or to antimonial ores (Harbaugh, J. W., 1953).

Possibly the greatest value of the study will be the interest raised in Alaska in the use by the layman of geochemical prospecting techniques. The writer already has seen considerable interest aroused in these techniques as a direct result of the work at Caamano Point. Large areas of southeastern Alaska are covered with muskeg and thin glacial deposits, and conventional methods of prospecting are slow and costly. Geochemical prospecting should offer a new and cheap approach to prospecting these areas.

Recommendations for Future Work at Caamano Point

In the writer's opinion, the best method of exploration in this area would entail the following procedures: (1) soil sampling should be used to outline areas of highly antimonial soils, (2) a single trench then should be cut across the trend of the mineralized zone to determine bedrock relations, (3) a portable, gasoline-driven "X-Ray" diamond drill should be used to probe these zones to depths of 100 to 150 feet. In this way each occurrence of stibnite could be tested rather cheaply, and more costly exploration by shafts and drifts could be restricted to the most promising bodies.

During any exploration, close inspection should be made of linear topographic depressions to determine if they occupy fault zones, and to attempt to develop a structural pattern of fracture zones. Particular attention should be given to areas of brecciated and dolomitized limestone even though stibnite does not occur in surface crops in these areas.

Owing to the extreme brecciation of the limestone at the No. 2 shaft orebody, the ore solutions penetrated freely through wide areas. If the brecciated limestone had been overlain by a non-pervious bed, such as one of the schist bands intercalated in the slaty limestones, the solutions might have been confined, with consequent ore deposition over a restricted area to give higher grade ore. It would seem desirable, in future exploration of the general area, to trace stibnite float into the schist areas to the northwest. Faulting and fracturing in the schist would tend to localize avenues for circulating hydrothermal solutions. Float stibnite has been picked up several miles northwest of the known prospects, well into the schist area, which indicates that this portion of Cleveland Peninsula possibly contains considerable antimony. Samples of stream sediments might indicate favorable drainage areas to prospect initially.

REFERENCES CITED

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