A Geochemical Exploration for Antimony in Southeastern Alaska

By C. L. SAINSBURY

MINERAL RESOURCES OF ALASKA

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The application of geochemical techniques in an exploration for antimony ores

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A GEOCHEMICAL EXPLORATION FOR ANTIMONY IN SOUTHEASTERN ALASKA

By C. L. Sainsbury

ABSTRACT

Preliminary geochemical prospecting by the U. S. 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 concentration. It was conducted to aid, if possible, an exploration project of the Defense Minerals Exploration Administration. Samples were collected from soil and decomposed limestone-and-schist bedrock at depths ranging from 18 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; this proved the existence of stibnite ore. A shaft and drifts made in the most favorable area found 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 geochemical exploration as a first step in extending the known boundaries of mineralized areas and in directing initial physical exploration toward the most favorable areas of near-surface ore bodies.

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

INTRODUCTION

In 1952 the Geological Survey conducted geochemical exploration 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 (fig. 21). The prospect was formerly known locally as the Val Klemm antimony mine. Exploratory work before 1952 consisted of two shallow shafts at the site of the original discovery and several trenches and shallow cuts in bedrock, none of which disclosed additional stibnite ore. In 1950 the prospect was acquired by the Tillicum Mining Co., and in 1952 the Defense Minerals Exploration Administration negotiated a contract with that company for trenching and subsurface exploration.

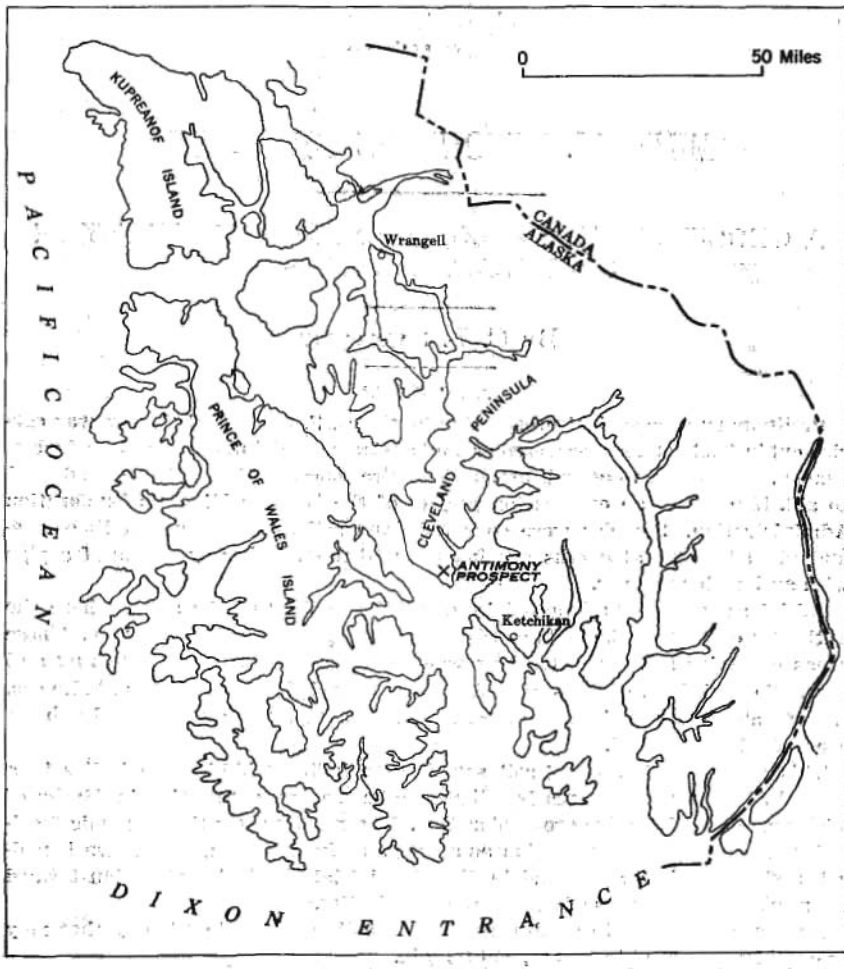

FIGURE 21.—Index map showing location of antimony prospect, Caamano Point, Alaska.

Although the prospect at Caamano Point had been mapped geologically,[1] the details of the structural controls of ore deposition were imperfectly known. Thick vegetation obscured the structure of the bedrock and made surface exploration slow, difficult, and costly. Such exploration was haphazard because the location of trenches was influenced more by the distribution of bedrock and thin, surficial deposits than by the geologic evidence of the existence of ore bodies. After the Survey devised a field method for determining trace amounts of antimony in soils and plants, geochemical methods were applied to the prospect at Caamano Point before the company began surface and subsurface exploration. The purpose was twofold:

[1] Robinson, G. D., 1943, The Caamano Point antimony deposit, Cleveland Peninsula, southeastern Alaska: Mimeo. rept. in files of U. S. Geological Survey.

1. To obtain factual criteria on the geochemical behavior of antimony in a typical Alaskan area of heavy rainfall and thick vegetation.

2. To delimit, if that were possible by geochemical methods, those areas most likely to contain bedrock concentrations of antimony, thus facilitating the location of trenches in favorable areas, which would result in a saving of Government funds.

To accomplish this purpose, the writer visited the prospect in September 1952 and collected 76 soil samples, spaced as shown on plate 21. The results of this preliminary sampling were encouraging, hence more samples were collected in March 1953. As a result, two areas with an abnormally high concentration of antimony in the soil were delimited. Subsequent trenching and drilling under the Defense Minerals Exploration Administration contract proved the existence of stibnite ore in both areas. During the summer of 1953 the Tillicum Mining Co. collected samples at the writer's request and found another area of high antimony concentration. Surface drilling showed that stibnite ore underlies the soil in this area (ore zone 4 on pl. 21).

The chief purpose of this report is to present the results of the geochemical exploration. The writer wishes to acknowledge the courtesies extended to him by George B. Roberts, general manager, Tillicum Mining Co., and the assistance of William Hibberd, Tillicum Mining Co., and R. C. Rowe, assayer for the Territorial Department of Mines. All samples were analyzed in the laboratory of the U. S. Geological Survey, Denver, Colo.

AREAL GEOLOGY

The areal geology of the southern part of Cleveland Peninsula is discussed by G. D. Robinson [2] and the geology shown in figure 22 is from Robinson's report, with minor additions by the writer. The Caamano Point prospect occurs in limestone interbedded with limy slate and subordinate phyllite of Mesozoic age. The rocks, isoclinally folded and overturned to the west, generally strike northwestward and dip northeastward, but local variations are common, especially in the limestone near the prospect. Three structural features are common to each area of stibnite deposition: (1) intense brecciation of limestone, (2) partial dolomitization of limestone and deposition of appreciable silica in fractures and by replacement of limestone breccia, and (3) minor steep faults striking northwestward to northward. The stibnite was deposited by replacement of limestone and as discrete veinlets in the fractures. Stibnite is the only ore mineral. It is exceptionally pure and contains only traces of arsenic, as shown by the spectrographic analysis of three typical ore samples.

[2] Robinson, G. D., op. cit.

VIEW OF A MUSKEG-COVERED AREA AT CAAMANO POINT

GEOCHEMICAL EXPLORATION

PHYSICAL CHARACTERISTICS OF SOIL

The lithic portion of the soil in the vicinity of the prospect is derived in part from reworked marine(?) glacial till and in part from weathered material of the underlying bedrock. The proportion of the two source materials varies from place to place. In the areas of limestone bedrock 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 most commonly are found only in stream channels or in holes in limestone. Most of the boulders and pebbles in the present streambeds 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. The soil profile, however, where observed immediately above limestone bedrock, consists of a layer of decayed organic matter grading downward into a yellow to red clay which contains 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 which overlies the bedrock. No glacial deposits are exposed in the banks of the streams in the vicinity of the prospect, and where such deposits are suspected they are restricted in areal extent, nowhere exceeding a few tens of yards. Muskeg and peat bogs several feet deep have formed on larger flat areas and are especially abundant in those areas of suspected reworked glacial material, where drainage is poor (pl. 20). Most samples collected from such areas came from the yellow clay zone above bedrock, although at a few places bedrock was below the reach of the 6-foot sampling tube. Normally, a guide to the absence of glacial material was the abundance of quartz fragments in the soil. These fragments, usually somewhat porous and completely unabraded, indicated that no glacial debris occurred in the soil profile. The muskeg layer ranges in depth from an inch or less to 8 feet, and the yellow to red clay zone normally ranges in thickness from 2 inches to almost a foot. This slight reddish color probably represents an initial concentration of iron, or the primary stage of the formation of a lateritic soil. Bedrock crops out sporadically on knolls and humps, and creek bottoms expose continuous bedrock.

If silicification were restricted to the areas near ore bodies only, the presence of abundant quartz fragments in the residual soil might be a 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

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away from the known ore bodies. The limestone near all ore bodies appears to be "massive breccia," as pointed out by Robinson.[3] This massive breccia remains a guide to further prospecting even though it probably 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. The pipe, from which the plunger extended slightly, was pushed by hand into the yellow clay zone. The plunger was then released and the pipe was pushed farther into decomposed bedrock or residual material. The pipe was then raised and the plunger was used to eject the sample. Three or four samples were collected from different holes at each station. By this method a sample was taken from the lowest soil zone and was not contaminated by the overlying soil because no material could fall into the hole. Each station was marked by a red flag bearing the station number. It was not necessary to survey stations with a transit because favorable areas were tested by physical exploration immediately after the samples were taken.

After each sample was collected, the pipe was cleaned by scraping the inside with a flattened stick. To determine the degree of possible accidental "enrichment" if a high-grade sample was followed by one of low grade, the following method was used: another sample was collected in soil of low antimony concentration, and the pipe was cleaned again. A second sample was then collected in soil of high antimony concentration and the pipe was recleaned. A third was taken where the first test sample had been collected. The results showed negligible contaminations.

METHODS OF CHEMICAL ANALYSIS

The methods of analysis used in this work were devised by the Geological Survey and are described in Circular 161 and in an open-file report entitled "Additional field methods used in geochemical prospecting by the Geological Survey." These methods are simple to perform; they call for reagents and apparatus that are cheap and readily available and require a minimum of technical training. The analyses are precise to a plus or minus 30 percent. Therefore, small differences in values obtained by these methods should not be regarded as significant.

[3] Robinson, G. D., op. cit., p. 4.

LATERAL DISTRIBUTION OF ANTIMONY IN RESIDUUM

Preliminary orientation traverses.—The initial step was the establishment of a preliminary range of values to indicate normal and anomalous concentrations of antimony in the soil. Accordingly, 71 soil samples were taken in lines as shown on plate 21, some radiating from the main prospect, and some along the strike of the limestone. These lines also were intended to be true prospect lines indicating possible extensions of the ore zone. In the analyses of the initial soil samples, no determinations greater than 2,000 ppm of antimony were made because this concentration seemed sufficiently diagnostic to indicate ore (table 2).

TABLE 2.—*Antimony content of preliminary soil and plant samples*

(See pl. 21 for location of soil samples)

[Analysts: H. E. Crowe, soil; Fred Ward, plant]

Soil samples		Soil samples		Soil samples	
Sample no.	Sb (ppm)	Sample no.	Sb (ppm)	Sample no.	Sb (ppm)
Line 1:		Line 4:		Line 7—Con.	
1	120	1	500	7	60
2	180	2	60	8	40
3	50	3	20	9	80
4	50	4	70	Line 8:	
5	20	5	30	1	>2, 000
6	10	6	10	2	>2, 000
7	30	7	20	3	300
8	20	8	20	4	900
9	20	Line 5:		5	>2, 000
10	10	1	80	6	80
11	10	2	60	7	140
12	20	3	600	8	60
13	100	4	60	9	50
14	20	5	50	10	100
15	10	6	250	11	40
Line 2:		7	60	Control samples:	
1	40	Line 6:		*A*	1, 200
2	20	1	40	*B*	>2, 000
3	80	2	90	*C*	1, 800
4	50	3	30	*D*	450
5	80	4	1, 000		
6	40	5	60	Plant samples [1]	
7	10	6	80		
8	5	7	60	*E*	4. 5
Line 3:		Line 7:		*E*	3. 5
1	40	1	40	*F*	2. 3
2	40	2	30	*F*	2. 5
3	20	3	20	*G*	. 6
4	40	4	70	*G*	. 4
5	60	5	120	*H*	1. 5
6	20	6	40	*H*	. 8

[1] Samples from inner bark of hemlock trees.

The results proved the feasibility of finding ore through geochemical methods by showing a high concentration of antimony in the soil near ore zones in comparison with the lower, or background, values obtained elsewhere. Two areas of apparently high antimony concentration in soils that could not be related to known ore zones were found during the preliminary studies.

Four samples of hemlock inner bark also were collected to ascertain whether this species of tree showed greater antimony content near the ore. The hemlock bark samples showed an increase in antimony concentration near the ore zone, and the writer believes that geobotanical sampling could have been applied successfully in this area. Soil samples were preferred, however, because they offered a greater contrast in total antimony content.

Reconnaissance traverses.—In 1953, additional reconnaissance traverses tested the regional distribution of antimony in soils overlying diverse rock types (fig. 22 and table 3). A significant variation in antimony content of the soil in relation to the composition of the underlying rock is apparent. The soil in the area traversed by lines *A*, *B*, and *C* (fig. 22) contains a relatively low concentration of antimony. Samples 1 and 2, line *A*, were collected from soil overlying limestone bedrock, and the remaining samples in line *A* were taken from soil overlying metamorphosed clastic sediments. The decrease in antimony content to 10 ppm corresponds with the lithologic change in the bedrock. All the samples in line *B* were collected from soil overlying schist, conglomerate, or metabasalt, and these samples also are low in antimony content. Line *C* begins in limestone or limy slate, and then traverses alternating thin bands of schist and limy slate into metamorphosed clastic sediments. The soil concentration of antimony again appears to decrease abruptly with the lithologic change from limestone to schist. Similar variations were apparent in line *D*.

Limestone is the predominant bedrock underlying the soil in the area traversed by lines *E* and *F*, and the antimony content of the soil in these lines is considerably greater than that in the other lines. The median value of 31 samples taken from soil overlying limestone bedrock in lines *E* and *F* is about 60 ppm, and the average antimony content, excluding as anomalous those values that are more than 120 ppm (i. e., more than twice as large as the median), is about 37 ppm.

Antimony content averages about 11 ppm in 30 samples taken in lines *A*, *B*, and *C*, excluding one anomalous value of 150 ppm of antimony obtained from soil overlying limestone near the prospect.

Detailed studies.—At the request of the writer, the Tillicum Mining Co. collected an additional 65 samples in a grid on about 15-foot centers in the most favorable area indicated by the samples on line 8 of the preliminary orientation traverses. Almost all these sam-

TABLE 3.—*Antimony content of soil samples from reconnaissance traverses (fig. 22)*

[Analysts: H. E. Crowe, J. H. McCarthy, and A. P. Marranzino]

Sample no.	Sb (ppm)	Sample no.	Sb (ppm)	Sample no.	Sb (ppm)
Line *A*:		Line *C*—Con.		Line *F*:	
1	60	32	<10	71	300
2	30	33	<10	72	600
3	15	34	<10	73	300
4	10	35 (sediment)	10	74	900
5	10			75	500
6	10	Line *D*:		76	150
7	10	36	20	77	180
8	10	37	10	78	30
9 (sediment)	10	38	<10	79	60
Line *B*:		39	<10	80	150
11	10	40	<10	81	75
12	10	41	<10	82	45
13	10	42	<10	Sediments:	
14	<10			83	120
15	<10	Line *E*:		84	90
16	<10	51	3,000	85	75
17	<10	52	3,000	86	10
18	<10	53	800	87	15
19	10	54	180		
20	10	55	120	Over "Hot-spot" near sample 52:	
21	15	56	60		
22	15	57	10		
23 (sediment)	15	58	120	88	3,000+
		59	10	89	3,000
Line *C*:		60	15	90	3,000
24	150	61	30	91	3,000
25	30	63	60	92	10,000+
26	<10	64	15	93	1,500
27	30	65	45	94	1,500
28	<10	66	30		
30A	<10	67	15		
30B	<10	68	<10		
31	10	69	45		
		70	75		

ples contained more than the average of 37 ppm of antimony obtained for the limestone as a whole. Values in excess of 10,000 ppm of antimony were obtained from many of these samples. Their relationship to subsequent physical exploration by trenching, drilling, or sinking of shafts is discussed later in this report.

VERTICAL DISTRIBUTION OF ANTIMONY IN SOIL PROFILE

Twelve groups of samples were taken to determine the vertical distribution of antimony in the soil profile. The results of this sampling indicate that two zones of antimony concentration tend to occur: one immediately overlying bedrock and one at the base of the humus layer, both separated by a zone of lower concentration. The writer believes that this would reflect an enrichment of the soil at the base of the humus caused by the decay of vegetation containing

antimony and an enrichment of the soil immediately overlying bedrock caused by the solution of limestone and a resulting concentration of the less-soluble antimony. The zone of lower concentration represents an area of leaching by capillary water and roots. Small fragments and needles of stibnite could be panned from bulk samples of decomposed material overlying bedrock in areas containing 10,000 ppm of antimony; this indicates that the stibnite is relatively inert. The occurrence of small fragments of stibnite in the soil is another indication that the soil immediately overlying bedrock is composed of the insoluble residues left from the solution of limestone or slaty limestone. The high antimony content of 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 overlying bedrock during the solution of a considerable thickness of limestone containing as little as 2 ppm of antimony. The solution of limestone was probably accelerated by the distinctly acid surface water normally derived from muskeg areas in Alaska.

DISTRIBUTION OF ANTIMONY IN FLUVIAL SEDIMENTS

Eight samples of stream sediment were taken within a radius of three-quarters of a mile of the prospect (fig. 22). Four of these samples, of sediments derived from limestone bedrock at and near the prospect, contain much more antimony than the four samples of sediments derived from limestone-free bedrock (table 3). Samples 35 and 87 show no increase of antimony content over that in the soil from line *C*; sediment sample 9 and the soil samples from the northern part of line *A* contain the same amount of antimony; sediment sample 23 contains more antimony than the soil samples from line *B*, probably because the west fork of the stream heads near the prospect; sediment samples 83, 84, and 85 contain antimony in about the same concentration as soil samples from lines *E* and *F*, a very diagnostic increase over samples from lines *A*–*D*. Sediment sample 86 is an offshore beach sediment collected at low tide at a point about 100 yards from the mouth of the creeks and indicates a fairly rapid dispersal of antimony-rich sediments at tide level.

DISTRIBUTION OF ANTIMONY IN BEDROCK

Several samples of bedrock were analyzed for antimony content by the standard field method. A sample of slaty limestone from the trench west of shaft 2 contained 15 ppm of antimony; a sample of brecciated, silicified, and dolomitized limestone from shaft 3 contained 6,000 ppm of antimony. One sample from small limestone pods in the metasedimentary rocks near the beach contained 1 ppm of antimony and

another contained 2 ppm. A sample from a schist band 6 feet wide near the old ore dump from shaft 1 contained 15 ppm of antimony. Although not conclusive, the results indicate that regionally the antimony content of the limestone is about 1–2 ppm, increasing near the mineralized areas to about 15 ppm and near ore zones to as much as 6,000–10,000 ppm.

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

The writer believes that the brecciated, silicified, and dolomitized limestone was formed from slaty limestone containing sandy aggregates by the addition of quartz and the loss of graphite. Antimony may have accompanied the silica or it may have been introduced later. Evidence from exploration at shaft 1 indicates that some quartz and stibnite were deposited contemporaneously.

INTERPRETATION OF RESULTS

Certain inferences that should be useful in future geochemical exploration in this area may be drawn with respect to the antimony content of the soil of this district.

The background content of the lowermost soil zone depends in large measure upon the composition of the underlying bedrock. In areas of unmineralized limestone, a background content of 30–40 ppm of antimony should be assumed. This background content decreases in soil overlying limestone-free rocks to less than 10 ppm.

Near mineralized areas in limestone, the antimony content of the lowermost soil zone ranges from 100 to 1,000 ppm. This range of content might properly be termed the "threshold value," and samples that are considered to be indicative of near-surface ore bodies should contain antimony in the range from 1,000 to 10,000 ppm, for in this study samples taken above the ore bodies that were trenched or drilled consistently gave such results. An antimony content within this range definitely is anomalous.

The dividing line between a threshold content and an anomalous content might be somewhat flexible, depending upon the immediate objective of the geochemical work. Here the immediate objective was to find near-surface ore bodies within reach of trenches and drill holes only 20 feet long, but deeper ore bodies might be indicated by samples with an antimony content as low as 100 ppm.

The literature does not describe other attempts at geochemical prospecting for the antimony content of soils, consequently little information is available to establish the "normal" range of antimony in soils. Before any geochemical methods may be used successfully, it is necessary to know the normal concentration of each metallic constituent in the area. The writer believes that the soil-sampling results at Caamano Point reflect certain geologic, geomorphic, and physical conditions that may not be found elsewhere, and they are diagnostic only of what may be termed an "antimony area," where stibnite in small amounts is widespread in the limestone bedrock, but perhaps is more restricted in the metasedimentary and metavolcanic rocks. No attempt was made to establish a regional background value more than ½ mile from the prospect at Caamano Point.

SUBSEQUENT EXPLORATION

In 1953 the Tillicum Mining Co. trenched and drilled the areas of anomalous concentrations of antimony northwest of the old workings and confirmed the soil-sampling results (pl. 22). A plot showing the relation of the soil samples containing unusually large amounts of antimony to the percussion-drill holes intersecting disseminated stibnite ore shows remarkable correlation. The plot outlines the trend of the mineralized zone which is possibly related to the northwestward-trending fault revealed in surface trenches and underground openings. It is notable that this mineralized zone crops out in a low saddle where muskeg and peat have accumulated to a depth of 4–6 feet. Shortly after the discovery, George B. Roberts, general manager, Tillicum Mining Co. (written communication, 1953), stated that

> * * * the latter discovery can be credited 100 percent to the soil sampling, as most of the ore body so far found is overlain by 2 to 5 feet of matted roots and muskeg. * * * 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 astonishing.

Trenches and drill holes in the vicinity of samples 51 and 52 also intersected disseminated stibnite ore. A shaft 15 feet deep, and holes drilled from the bottom of it, proved continuity to the mineralized zone of shattered limestone. Prior to the analyses of the soil samples, George B. Roberts and William Hibberd found altered limestone containing stibnite beneath the humus in this area.

A 44-foot shaft and drifts totaling 100 feet along the inferred strike of the ore zone disclosed disseminated stibnite ore throughout (fig. 28). The stibnite occurs as irregular thin replacement bodies in brecciated, silicified, and dolomitized limestone and as thin vein fillings in the limestone. The antimony content of the ore averages

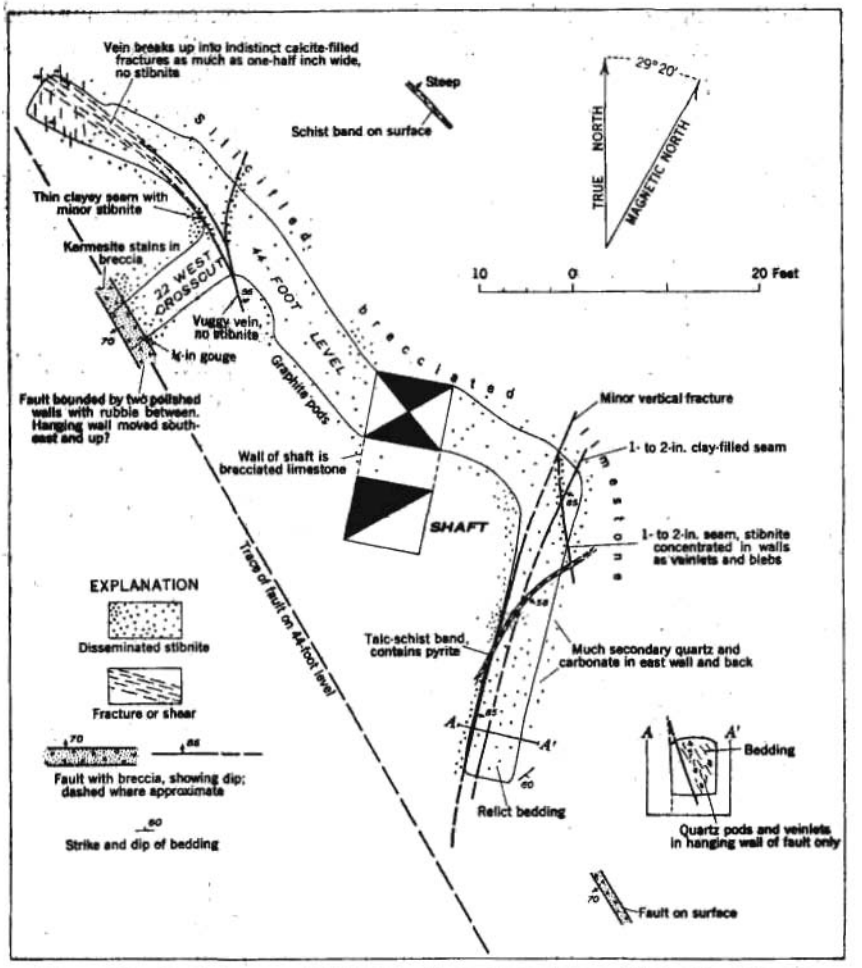


FIGURE 23.—Geologic map of 44-foot level, shaft 2, Tillicum Mining Co. property, Caamano Point, Alaska.

1.3 percent, although some drill holes cut zones a few feet thick that assay as much as 8 percent. Disseminated stibnite is exposed in each face of the drifts. The ore zone appears to be bounded on the west by the fault that is exposed on the surface and in the 22 west crosscut in the north drift of the 40-foot level (fig. 23). Possibly the ore is related to shattering and replacement of the limestone during movement along this fault and to restriction of hydrothermal solutions to the footwall by the gouge zone in the fault. Drill holes that cut through the hanging wall 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 one that is exposed in the creekbed several hundred yards northwest of the new shaft. Stibnite-bearing limestone occurs sporadically along this fault, and at one place schist is faulted against limestone. However, the ore body originally discovered at the prospect (containing massive stibnite) and the bodies later discovered northwest of the shaft are not alined along this fault. Therefore this fault should not be regarded as the only "ore channel" in the region and future exploration and prospecting should not be restricted to the area adjacent to the fault.

If the small schist band exposed in the east end of the trench north of the shaft is the same one exposed in the south drift on the 44-foot level from the shaft, a small drag fold plunging northeastward is indicated in the slaty limestone. Robinson [4] notes a drag fold at the ore zone at shaft 1, and believes that this drag fold influenced ore deposition. The drag fold at shaft 2 is small, it has been cut by the fault, and ore occurs both north and south of it. Possibly this fold exerted some influence on ore deposition, but such influence is unknown. Drag folds have been observed at many places in the slaty limestone with no associated brecciation, dolomitization, or occurrence of stibnite ore.

CONCLUSIONS

The chief value of the geochemical work on soils done at Caamano Point lies not in the amount or grade of ore contained in the new ore zones but in the ease with which they were discovered. Before the property was acquired by the Tillicum Mining Co., no ore zones beyond the original discovery were found during a 36-year period. The geochemical work on soils guided subsurface exploration to three additional ore zones at a total cost of less than $750 in wages for field work and chemical analyses. Thus the available money could be used for exploration in favorable areas rather than for haphazard trenching and drilling.

It is concluded that antimony ores, particularly stibnite, are detectable 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, samples may easily be collected from the bedrock-soil contact by the use of a pipe with an interior plunger, and any dispersion halo of stibnite should be near the bedrock source. Research is being done by the Survey on the dispersion halos of mixed ores containing sulfides of antimony to establish the usefulness of the antimonial constituents in geochemical

[4] Robinson, G. D., op. cit., p. 2.

prospecting (Hawkes, H. E., personal communication). The results may indicate that antimony sulfides can be used to pinpoint sulfide bodies that are located initially by zinc or copper indicators. The literature available on geochemical prospecting is large,[5] but the writer knows of no publications that discuss the application of these techniques to antimony exploration or to antimonial ores.

In addition, results of the analyses of stream sediments indicate that such sampling in an antimony province might rapidly delimit drainage areas favorable for prospecting.

Considerable interest was shown in geochemical prospecting techniques as a result of the work done 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 offers a new and inexpensive approach to the prospecting of these areas.

RECOMMENDATIONS FOR FUTURE WORK AT CAAMANO POINT

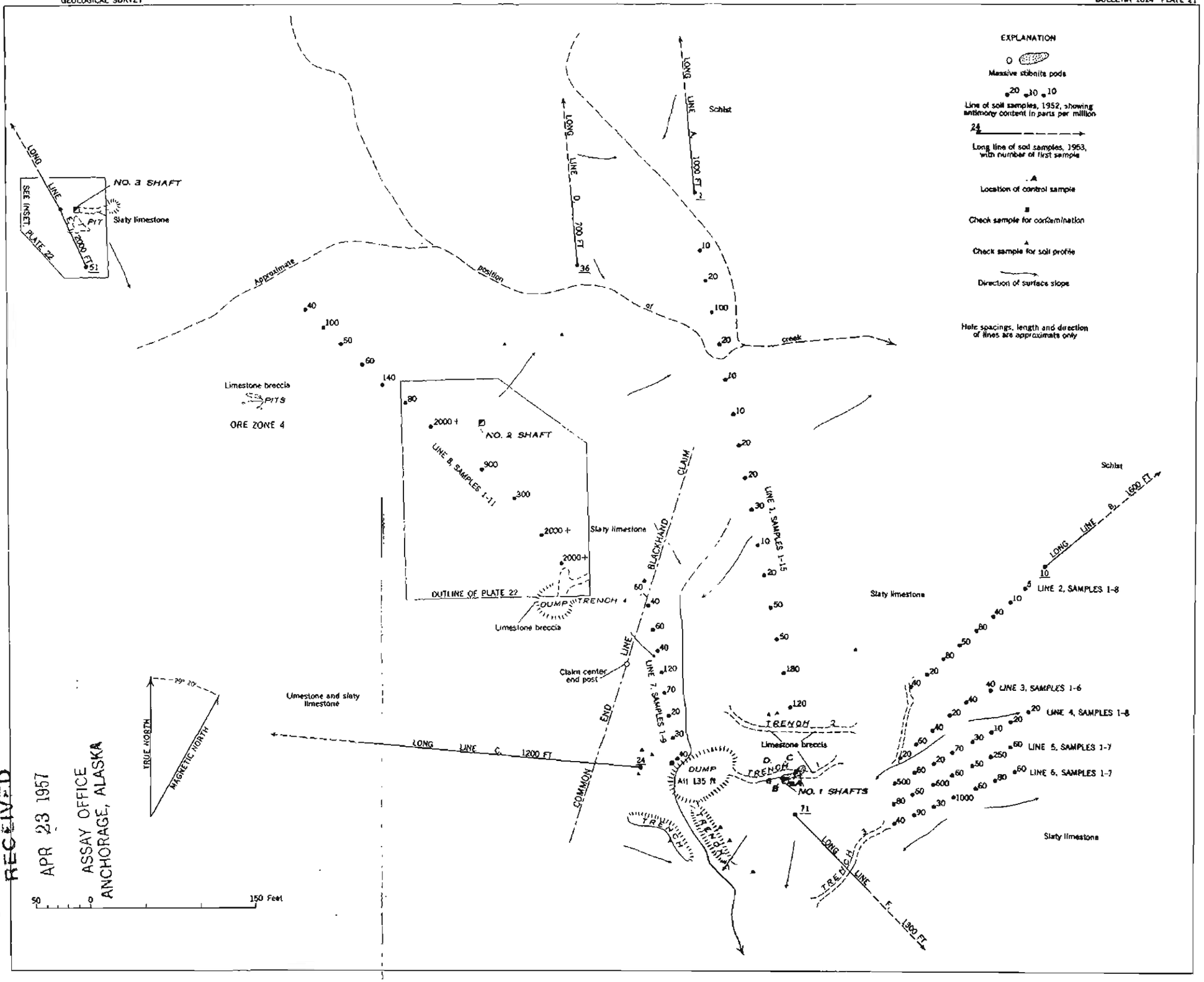
The best method of exploration in this area entails the following steps: Soil sampling should be used to delimit areas with abnormally high antimony concentration in the soil, a single trench should then be cut across the mineralized zone to determine bedrock relationships, and a portable, gasoline-driven "X-ray" diamond drill should be used to probe these anomalous zones to depths of 100–150 feet. In this way each occurrence of stibnite could be tested economically, and more expensive exploration by shafts and drifts could be limited to the most favorable areas.

During any exploration, linear topographic depressions should be closely inspected to ascertain whether they occupy fault zones and to determine a structural pattern of fracture zones. Particular attention should be given to areas of brecciated and dolomitized limestone, as noted by Robinson, even though stibnite does not occur as outcrops in these areas.

Owing to the extreme brecciation of the limestone at the shaft 2 ore zone, the ore solutions circulated freely through wide areas. If the brecciated limestone had been overlain by an impervious bed, such as one of the schist bands intercalated in the slaty limestone, the solutions might have been confined over a restricted area, with consequent higher-grade ore deposition. It would seem desirable, in future exploration of the area, to trace stibnite float into the schist areas to the northwest. Faulting and fracturing in the schist would

[5] Harbaugh, J. W., 1953, Geochemical prospecting abstracts through June 1952: U. S. Geol. Survey Bull. 1000–A.

tend to localize channels for circulating hydrothermal solutions. Float stibnite has been found several miles northwest of the known prospect, in the schist area, indicating that this part of Cleveland Peninsula probably contains considerable antimony. Samples of stream sediments might indicate favorable drainage areas for prospecting.



406252 O - 56 (In pocket)

MAP OF PRELIMINARY SOIL SAMPLE LINES, TILLICUM MINING COMPANY PROPERTY, CAAMANO POINT, ALASKA