Geology, Mineral Deposits, and Geochemical and Radiometric Anomalies, Serpentine Hot Springs Area, Seward Peninsula, Alaska

By C. L. SAINSBURY, TRAVIS HUDSON, REUBEN KACHADOORIAN,
and THOMAS RICHARDS

CONTRIBUTIONS TO ECONOMIC GEOLOGY

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A description of mineralized faults and veins near the granite stock of Serpentine Hot Springs and the geochemical and radiometric methods used to find them

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GEOLOGY, MINERAL DEPOSITS, AND GEOCHEMICAL AND RADIOMETRIC ANOMALIES, SERPENTINE HOT SPRINGS AREA, SEWARD PENINSULA, ALASKA

By C. L. SAINSBURY, TRAVIS HUDSON, REUBEN KACHADOORIAN, and THOMAS RICHARDS

ABSTRACT

Geologic mapping, analyses of samples of bedrock, and geochemical studies have disclosed the probable source of placer gold and tin on Humboldt Creek, Serpentine-Kougarok area, Alaska, and have shown mineralized bedrock in several areas on the east side of the granite stock at Serpentine Hot Springs. Gold, silver, mercury, arsenic, cobalt, copper, molybdenum, nickel, lead, antimony, tin, tungsten, and zinc occur in panned stream concentrates and in altered bedrock that is associated with steep faults, thrust faults, and quartz veins. Two mineralized and altered fault zones were sampled in detail; one contains float fragments of highly argentiferous galena (as much as 5,000 parts per million Ag). Anomalous amounts of metal in bedrock samples, in stream sediments, and in panned concentrates from stream sediments and rock samples suggest areas of mineralized bedrock outside the granite; radiometric anomalies lie within the granite and near the contact of the granite but have not been evaluated on the ground.

INTRODUCTION

In U.S. Geological Survey Circular 565 (Sainsbury and others, 1968), the large size and great quantity of placer cassiterite in Humboldt Creek on Seward Peninsula (fig. 1) were emphasized, and possible mineralized structures in bedrock southeast of the granite were discussed. During 1968, detailed mapping of Humboldt Creek and adjacent areas in the Serpentine-Kougarok area (pl. 1) was carried out as part of a program that included detailed geochemical studies and airborne geophysical surveys. Because a preliminary geochemical survey, using the −80-mesh fraction of stream sediments, failed to indicate the known placer cassiterite on Humboldt Creek, this creek

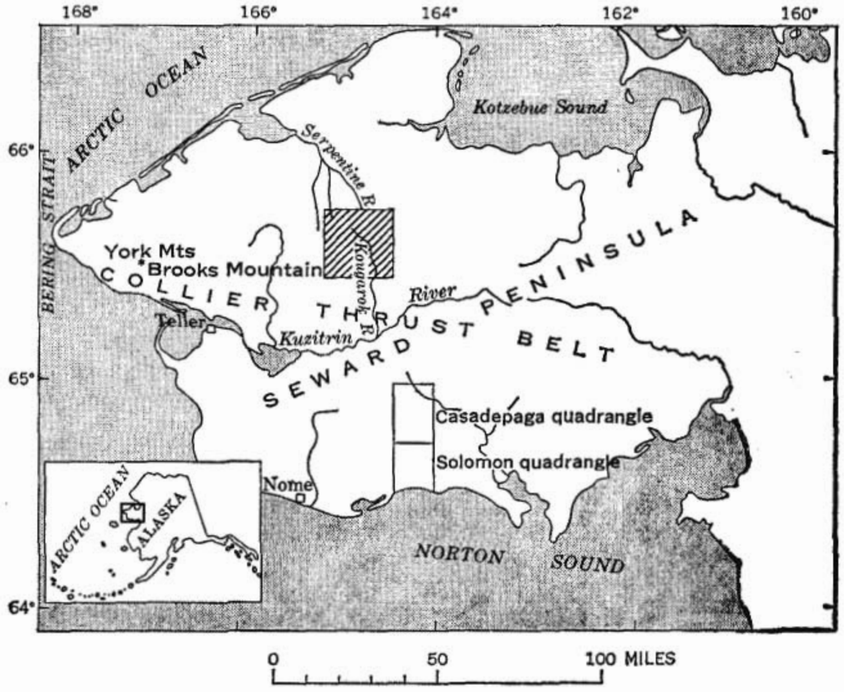

FIGURE 1.—Seward Peninsula, showing location of Serpentine-Kougarok area (patterned).

was used as a test area to compare the data obtained from stream sediments and the data from panned concentrates. All work discussed herein is part of the Heavy Metals program of the U.S. Geological Survey.

ACKNOWLEDGMENTS AND ANALYTICAL METHODS

Analytical results are an essential starting point for the interpretive part of this study. Analysts are specifically credited on individual tables in this report, but we particularly acknowledge here the efforts of D. J. Grimes, R. L. Miller, K. J. Curry, R. B. Tripp, and W. R. Vaughn.

Fieldwork was facilitated by the help of numerous individuals. We are especially indebted to Maurice Kelleher, James Isbell, Mr. and Mrs. Robert Emmons of the Alaska Department of Highways, and Mr. Carl Melton of the Federal Aviation Agency. All samples were prepared for analyses by Clifford Weyiouanna and Duane Barnard, geologic field assistants.

Bedrock samples were crushed to −¼-inch mesh in a jaw crusher, a split was saved, and the remainder was pulverized in a ceramic-plate pulverizer. A weighed portion of pulverized material was panned, and the panned concentrate was weighed and analyzed as a check against analyses of unpanned mineralized samples. Stream sediments were collected from behind rocks on stream bars, then air dried and screened through a 40-mesh plastic screen; each of the total samples was later pulverized to −200 mesh. Pan concentrates from Humboldt Creek were air dried, a weighed portion was retained for mineralogical studies, and the remainder was pulverized. After pulverizing each sample, the pulverizer plates were cleaned by pulverizing a teaspoonful of white quartz, and the resulting powder was added to the sample previously pulverized. This was done to prevent contamination of later samples, because laboratory experiments by J. C. Antweiler (oral commun., 1967) have shown that even small gold particles may smear onto the pulverizer plates and register in the following sample.

Samples were analyzed for gold by atomic absorption, for mercury by mercury detector, and for other elements by semiquantitative spectrographic analyses. Some duplicate splits of samples were analyzed for copper, lead, zinc, tin, and arsenic by wet chemical methods. With the exception of results from gold analyses, which were erratic, analytical results generally were in good agreement.

Only the salient features of the analytical data are presented on the maps that accompany this report. The individual analyses are presented as tables 2–4.

Analytical data were selected and plotted on plate 1 and in figure 2 according to the following method:

1. Background values of elements in various lithologic units were selected according to results of analyses of samples of unaltered rock units (table 1).
2. Only elements that are anomalously high in the selected specimens of argentiferous galena, or in samples of altered rock along faults and veins, are considered. These elements include gold, silver, mercury, arsenic, cobalt, copper, molybdenum, nickel, lead, antimony, tin, tungsten, and zinc.
3. Elements present in each sample in amounts above background values were noted, and a numerical value of the anomaly for each metal was determined by dividing the total content for that metal by the background value shown in table 1. This gives a ratio in which the background is represented by the number 1. If the numbers representing the concentration ratios are added and the sum of the backgrounds is subtracted, this gives a figure which represents the magnitude of the total anomaly at that

sample site. For instance, a sample that contains 15 ppm (parts per million) Mo, 100 ppm Sn, and 15 ppm Ag would be treated as follows: $15 \div 5 = 3$ (the concentration ratio), $100 \div 15 = 6.6$, $15 \div 1 = 15$, and $3 + 6.6 + 15 = 24.6$ (the total concentration ratio). The anomaly, however, is $24.6 - 3$ (the sum of the three backgrounds represented by the number 1 for each element present in more than background concentration), or 21.6.

4. Symbols are shaded to show the number of metals present in anomalous amount in that sample; the size of the shaded symbol is varied to show the total anomaly. The map symbol shows at a glance the salient features important in geochemical reconnaissance surveys—that is, the number of anomalous metals in the sample and the magnitude of the anomaly. The detailed analytical data are presented in tables 2–4.

AREAL GEOLOGY

The bedrock geology of the area is shown on plate 1, which synthesizes data obtained by all authors of this report.[1] Except for the granite, the distribution of the major lithologic units is controlled mainly by thrust faulting. The main lithologic units consist of (1) the granite stock, which is a porphyritic biotite granite, (2) intensely deformed and sheared metamorphic rocks of Precambrian age, and (3) younger carbonate rocks regionally metamorphosed to marbles with some relict beds and areas of limestone and dolomite. The older carbonate rocks are equivalent to rocks of pre-Ordovician age mapped in the York Mountains, about 80 miles west. In the York Mountains these rocks consist of thinly bedded dolomitic limestone and argillaceous limestone (Sainsbury, 1965); in the area discussed in this report, they are moderately metamorphosed to the stage in which the argillaceous bands are noticeably micaceous. The younger carbonate rocks, which originally consisted of medium- to thick-bedded light-gray to dark-gray limestone locally converted to dolomite along thrusts and normal faults, are now largely sugary-textured marbles in which original bedding is still discernible. These younger marbles are confined to thrust plates and are correlative with Paleozoic carbonate rock exposed discontinuously in the thrust plates of the Collier thrust belt (Sainsbury, 1969), which covers the entire Seward Peninsula. Fossils of probable Devonian age have been recovered from marbles in thrust sheets about 15 miles south of the area of this report, whereas fossils of Ordovician, Silurian, and Devonian age have been recovered from unmetamorphosed limestone in the York Mountains.

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[1] Travis Hudson is continuing a detailed study of the granite and the rocks surrounding it on the east, which will result in some modification of the geology shown on plate 1.

METAMORPHIC ROCKS

Two main units of high-rank metamorphic rocks (gneiss and chloritic schist) and one thick unit of moderately metamorphosed dark graphitic siltite, with numerous minor variants such as graphitic slate, schist, marble, and graywacke, are shown on plate 1. Probably the oldest rock is the orthogneiss which is exposed over several square miles northwest of the granite. The gneiss, which is gray to pinkish gray where fresh, is composed of quartz, pink orthoclase, and minor amounts of biotite and superficially resembles the granite. Southward, the gneiss grades into light-colored leucocratic schist and gneiss with residual marble beds largely converted to calc-silicate rock. The schist and gneiss is intruded and cut off by the granite.

The next oldest high-rank metamorphic rock unit, confined to the east side of the granite, consists of chlorite-epidote-amphibole schists with intercalated schistose marble and metamorphosed mafic intrusive rocks (metagabbro of table 1). Glaucophane and blue-green amphibole are common; these schists are retrograded blueschist facies rocks (Sainsbury and others, 1970), which crop out discontinuously over hundreds of square miles to the south and southwest and which probably are exposed in thrust slices as far as the glaucophane-bearing rocks described by Smith (1910) in the Solomon and Casadepaga quadrangles east of Nome. These rocks form part of the Nome Group, originally defined as of Paleozoic age (Brooks and others, 1901) on the basis of fossils collected from limestones within the chloritic schists. Mapping by Sainsbury from 1960 to 1967 has demonstrated that the fossiliferous limestones, formerly thought to be intercalated in these chloritic schists of the Nome Group, are thrust slices of younger (Paleozoic) limestones. The chloritic schists, which represent highly metamorphosed and deformed rocks that originally contained abundant iron and magnesium, are thought by Sainsbury to be of Precambrian age. The chloritic schists everywhere observed are intensely deformed and folded; in the area of this report, recumbent small-scale isoclinal folds are overturned to the west.

The moderately metamorphosed rock unit shown as metasiltite and related rocks on plate 1 exhibits several variants which are not differentiated in this report. These variants reflect original variations in lithology and changes in mineralogy due to regional metamorphism, intense shearing during thrusting, and thermal metamorphism. The original rock was a graphitic siltite composed of silt-sized quartz grains and abundant carbonaceous material, and a variable content of calcite. Thin beds of carbonaceous limestone, shale, graywacke, and quartz arenite are now represented by graphitic marble schist, slate, and cleaved rocks with abundant veinlets of white to vitreous quartz. In the thermal aureole around the granite, slate has gone to hornfels and biotite-tourmaline rock; calcareous units are converted to calc-silicate rock. All the described variants are included in the map unit (Kuzitrin Series of Brooks and others, 1902), although detailed mapping by Hudson on the east side of the granite has demonstrated that individual beds can be mapped. In this area, the graphitic rocks are intensely deformed, with small-scale isoclinal folds overturned to the west; the degree of deformation increases near thrust faults, as does the number of vitreous quartz veinlets.

The graphitic rocks are clearly of pre-Ordovician age in the York Mountains (Collier, 1902; Sainsbury, 1965), because they underlie thin-bedded argillaceous limestones, equivalent to those of this report. Because they can be traced eastward to merge with the graphitic rocks of the Serpentine-Kougarok area, all are considered to be of pre-Ordovician age. Sainsbury believes that they are probably of late Precambrian age, following the reasoning first advanced by Collier (1902, p. 17).

CARBONATE ROCKS

Two distinctly different types of carbonate rocks crop out east of the granite; both are in thrust-fault contact with older metamorphic rocks. Rocks of the older carbonate unit were described on page H5.

The younger carbonate rocks, confined to thrust plates east of Humboldt Creek (pl. 1), are moderately folded but are not schistose. Because of regional thermal metamorphism, they were largely converted to marble in which, however, original bedding can be seen. As is common in the York Mountains, about 80 miles west, the limestones were dolomitized near thrusts and normal faults prior to regional metamorphism. In the area of this report, the marbles near thrust faults locally have been replaced by silica, and the underlying rocks have been altered and stained. In the small klippe southeast of Humboldt Creek, xenoliths of slate are abundant locally and represent fragments of underlying rocks carried up along thrust slices.

IGNEOUS ROCKS

The igneous rocks that crop out in the area of plate 1 consist of the porphyritic biotite granite stock, the related small fine-grained granitic dikes that occupy joints in the granite and the surrounding rocks, and a few dark dikes of diabase and lamprophyre. None of the dikes have been traced in detail. The lamprophyres near the granite contain corroded xenocrysts of quartz and orthoclase, a characteristic of lamprophyre dikes near granite of the western Seward Peninsula (Sainsbury, 1969). Farther away, the dark dikes are typical diabase, unsheared and unaltered, which shows that they were injected after the deformation and thermal metamorphism of the enclosing rocks.

The granite was described by Moxham and West (1953). It consists of unfoliated biotite granite with orthoclase crystals as much as 1 inch long. A distinct border facies is marked by a color change from pink orthoclase outward to white orthoclase and by a slight decrease in grain size. The border facies is mapped only on the northwestern and southwestern boundaries of the granite, where a large fault zone is inferred largely on the basis of the truncated border facies. Other, more subtle variants are being mapped and sampled in detail by Travis Hudson.

The absolute age of the granite at Serpentine Hot Springs is unknown. Granitic plutons in the eastern Seward Peninsula have been assigned a Late Cretaceous age on the basis of potassium-argon age determinations (Miller and others, 1966). The granite at Brooks Mountain, in the York Mountains, has been dated as Late Cretaceous (Sainsbury, 1969), and the associated diabase and lamprophyre are younger and are considered to be of Late Cretaceous to early Tertiary age. At Serpentine Hot Springs, as in the York Mountains, ore deposition is younger than the injection of both the granite and the dike rocks.

STRUCTURE

The mapped area lies within the Collier thrust belt, and the distribution and structure of rock units older than the granite are controlled in large part by thrusts. Just east of the area of plate 1, effects of thrusting are so complex that mapping at a scale larger than mile-to-the-inch will be required to decipher the structure. On the basis of existing mapping, two alternate interpretations are possible of the major structure in the area of plate 1. The first, supported by dips in the graphitic slate on the west side of the area, is that the oldest metamorphic rock (gneiss) is exposed along the axis of a sharp fold that trends north and that younger slate is exposed on the west flank. The second interpretation, supported by the known thrusts and by the small-scale isoclinal folds overturned to the west, is that the slate is thrust over gneiss and over itself. Clearly, slate is thrust over slate off the southeastern part of the granite, and marble is in thrust-fault contact with older rocks.

After the thrusting, the granite was emplaced, and then the granite and the thrust plates were cut by several sets of steep faults. The faults conform generally to sets striking about north to N. 15° E., about N. 30° E., and about east—the youngest set strikes N. 15°–50° W. An intricate network of faults southeast of the granite is associated with major geochemical anomalies, and the main mineralized areas lie along altered faults that strike about N. 50° W.

MINERALIZED AREAS

Two main areas of mineralized bedrock were sampled in detail, after initial samples collected by Hudson in the area presumed to be favorable on the basis of work done in 1967 by C. L. Sainsbury, Reuben Kachadoorian, T. E. Smith, and W. C. Todd were found to be highly anomalous in metals. As here defined, "anomalous" values are those that exceed the maximum content found in unaltered rock units, as shown in table 1. One area represented by bedrock samples 56–61 (pl. 1) consists of an altered zone that strikes about N. 55° W. across a saddle southwest of the south headwaters of Humboldt Creek. Float of rusty fracture fillings and rusty quartz lies along the zone, which can be traced at least 2,000 feet. Bulk samples of float quartz and altered graphitic siltite along the zone contain anomalous amounts of many metals (table 2), and a grab sample of rusty float contains highly anomalous amounts of gold, silver, mercury, arsenic, copper, molybdenum, lead, antimony, and zinc, amounting to more than 1,000 times the total background value of these metals. These samples were collected over a width of 200 feet and a length of 1,000 feet along the flat saddle, where frost action has completely shattered bedrock to create a veneer of surface rubble. Hence, nothing can be stated as to the width of possible veins that exist within the altered zone beneath the frost-shattered rock. Samples that contained only a few metals in anomalous amount yielded panned concentrates that contained, in addition, many related metals in anomalous amount. The above suite of associated metals is that commonly found in the silver zone of tin deposits (Sainsbury and Hamilton, 1968, p. 329, 330).

In a second area, silver-rich galena crops out on the south side of the southwestern headwaters of Humboldt Creek. Here an altered and stained fault zone can be traced for at least 2,500 feet, and it is probably continuous for an additional 2,000 feet. Numerous samples, represented by sample localities 25, 26, and 55 (pl. 1), contain highly anomalous amounts of gold, silver, lead, mercury, arsenic, molybdenum, antimony, tin, copper, and tungsten, all of which are enriched in the hand specimens of argentiferous galena. Float fragments of galena occur only in a small area on the slope break of the drainage, in what could be an old prospect pit that is almost completely obliterated by creep. Samples of frost-riven float of altered graphitic slate and stained quartz taken over an area of 1,000 feet by 200 feet along the altered fault contained highly anomalous amounts of metal. Again, panned concentrates showed a great increase in number of anomalous metals. A sample of stained quartz

TABLE 1.—*Metal content, in parts per million, of unaltered rock units, Serpentine Hot Springs area*

[All analyses are semiquantitative spectrographic, except those for mercury, which are mercury detector. Semiquantitative spectrographic analyses are reported in parts per million to the nearest number in the series 0.5, 0.7, 1.0, 1.5, 3.0, 5.0, 7.0, 10, 15, which represent points on a geometric scale. The precision of a reported value is approximately +100 percent or −50 percent. Semiquantitative spectrographic analyses determined by J. C. Hamilton and K. J. Curry; mercury detector analyses, by R. L. Miller and W. R. Vaughn]

Rock unit	Number of bulk samples	Metal content									
		Hg	Mn	Ba	Co	Cu	Mo	Ni	Pb	Sn	Zn
Granite	1	0.04	150	150	<5	[illegible]	<5	5	70	15	<200
Granitic dikes	2	0.04–0.09	200–300	500	<5–7	15–20	<5	<5–7	70	<10	<200
Slate (graphitic schist map unit)	3	0.01–0.03	1,000–1,500	300–1,000	15	7–20	<5	50–150	10–30	<10	<200
Chloritic schist and metagabbro	3	0.01–0.02	300–700	200–300	5–20	50–100	<5	30–50	<5–10	<10	<200

collected 2,000 feet away along a narrow altered zone that is the probable continuation of the mineralized fault contained 15 ppm Ag, and anomalous gold, copper, and molybdenum (sample loc. 55, pl. 1). Continuity between these sample localities is assumed only, because talus mantles the slopes between.

Numerous other samples of altered zones contain anomalous amounts of several metals, especially in the highly faulted area on the southeastern side of the granite. The limited sampling suggests that faults that trend slightly east of north commonly contain quartz vein material that is auriferous but of low grade, whereas faults that trend about N. 50° W. are more highly mineralized with argentiferous galena.

Several samples of altered and silicified marble collected above the thrusts east of Humboldt Creek show anomalous amounts of several metals, as did samples of altered schist collected between the klippe of marble. No attempt has been made to outline the extent of the altered zones or the concentration of metal along these zones. Elsewhere in the Serpentine-Kougarok area, where silicified zones along thrust have been sampled, only minor amounts of copper, with traces of gold, were introduced with the silica. None of the copper-bearing silicified replacement zones elsewhere are closely associated with granite or with mineralized faults; hence, the authors attach more importance to the altered rocks adjacent to the thrust faults near Humboldt Creek because many different metals characteristic of the altered and mineralized rocks near the granite are found in altered rocks along the thrust faults near Humboldt Creek.

RADIOMETRIC ANOMALIES

Moxham and West (1953) showed that the granite contains small amounts of radioactive material disseminated throughout, principally as radioactive primary accessory minerals such as zircon, sphene, and allanite; hydrogoethite and two other, unidentified, secondary minerals also are radioactive. The radioactivity in the primary minerals is caused largely by thorium, whereas that in the secondary minerals is caused by uranium. Placer concentrates, obtained by Moxham and West from the surface of gravel bars, contained zircon, sphene, and allanite as the principal radioactive minerals. Moxham and West concluded (p. 8) that "The investigations in the Serpentine-Kougarok area failed to reveal either placer or bedrock deposits of radioactive material in quantities of present commercial interest."

An airborne magnetic and radiometric survey was made for the U.S. Geological Survey by Lockwood, Kessler and Bartlett, Inc. after completion of the fieldwork. Several radiometric anomalies were outlined and are reproduced on plate 1. None have been field checked. However, the following factors are significant:

1. Although several broad anomalies within the granite tend to correspond to topographic highs, the area with the highest radiation lies along the southeastern edge of the granite in an area not checked in detail by Moxham and West. The single uranium deposit known on the Seward Peninsula, at Brooks Mountain, about 80 miles west, consists of secondary uranium minerals that are associated with a lobe of granite (West and White, 1952). The similarity of geology and location of radiometric anomalies may be significant. Work by Travis Hudson in 1969 shows that the granite in this area may be a late-stage differentiate.
2. The radiometric anomaly does not coincide with known mineralized bedrock; hence, no direct correlation can be made between anomalies and ore deposits.
3. All the anomalies occur above the granite or the orthogneiss, which suggests that radioactive accessory minerals may be the principal source of the radiation.

Factors 2 and 3 tend to lessen the possible importance of factor 1.

RECONNAISSANCE GEOCHEMICAL SURVEYS

A reconnaissance geochemical survey in 1967, using only the −80-mesh fraction of stream sediments, did not show anomalous tin on Humboldt Creek, where cassiterite in nuggets as much as 3 inches in diameter was observed in sluice-box concentrates from placer gold mining. Consequently, alternative methods were applied in 1968 to determine the applicability of different geochemical techniques in this area, where heavy and chemically resistant minerals (gold and cassiterite) were expected to be found in association with base-metal sulfide minerals. These methods included collection and analyses of the −40-mesh fraction of stream sediments collected from gravel bars or in the lee of boulders, where resistant heavy minerals accumulate to some degree, of panned concentrates obtained from stream gravels, and of sluice-box concentrates obtained by passing about a yard of gravel through a portable sluice box.

The geochemical data, plotted according to the same method used for bedrock data, are summarized on plate 1 and in table 3. In general, both −80-mesh and −40-mesh fractions of stream sediments show only relatively low anomalies with respect to the background values of rock units in the drainage basins of the streams sampled. Anomalies in sediments must be interpreted on the basis of one to three metals in low amounts—generally much lower than five times background. This is in striking contrast to results obtained from the —40-mesh fraction of stream sediments collected near mineralized bedrock in the York Mountains, where highly anomalous amounts of tin, beryllium, copper, lead, zinc, arsenic, antimony, and tungsten were found (Sainsbury, Hamilton, and Huffman, 1968). Background values for tin in the York Mountains averaged less than 20 ppm; near lodes, stream sediments contained as much as 1,100 ppm. Hence, the failure of stream sediments to point to the lodes found subsequently in the drainages of Humboldt Creek, by sampling and analyses of altered bedrock, is noteworthy. The exploration geologist in search of mineral deposits in this part of Alaska, especially placer deposits, would do well to apply several of the known methods of geochemical exploration, especially panning.

DETAILED GEOCHEMICAL SURVEY OF HUMBOLDT CREEK

The results of detailed studies along Humboldt Creek are summarized in figure 2 and in table 4. To supplement the stream-sediment survey, numerous samples of concentrates were collected by panning stream gravels as well as alluvium in cutbanks. Concentrates were air dried and weighed, a split was saved for mineralogical work, and the the remainder of the concentrates was pulverized and analyzed by the same methods as those used for bedrock and stream-sediment samples (p. H3). The results are shown in figure 2. Part *A* of figure 2 includes the gold analyses; part *B* has gold excluded, for the simple reason that the magnitude of the total anomaly at many sample sites is controlled largely by gold. Exclusion of gold, which occurs in a highly anomalous amount in many panned concentrates, allows a more dependable comparison with the other geochemical results.

Figure 2 depicts several interesting facts. Tin was found in panned concentrates of surface stream gravels only in the east fork of Humboldt Creek, where several samples contain the metal in anomalous amounts. In the sluice-box concentrate (loc. 15, fig. 2; table 4), tin and several other metals were detected in highly anomalous amounts. The metals that were concentrated in the argentiferous galena (gold, silver, lead, arsenic, cobalt, copper, molybdenum, nickel, antimony, tungsten, tin, zinc, and mercury) are commonly associated only in the panned concentrate. If the total concentration of elements, in parts per million, is divided by the concentration ratio (weight of total sample divided by weight of concentrate), most of the anomalies in concentrates disappear; nevertheless, analyses of panned concentrates would lead one directly to the base of the known outcrop of galena from a point far downstream. Analyses of samples of stream sediments, however, would fail to do so, unless the samples were collected very near the lodes.

TABLE 3.—*Metal content, in parts per million, of stream sediments, Serpentine Hot Springs area, Seward Peninsula, Alaska*

[N, below detection limit; L, detected but below limit of dependable reading; ND, not determined; ......, no anomaly. All sample numbers with laboratory numbers preceded by ACB or ACM represent −80-mesh fraction of total stream sediments; all preceded by AHI represent −40-mesh fraction of total stream sediments. All analyses are semiquantitative spectrographic except those for Au, which are atomic absorption; those for Hg, which are mercury detector; and those in italic for Ag, Cu, Ni, Pb, Sn, and Zn, which are wet chemical. Analysts: K. J. Curry, R. L. Miller, R. B. Tripp, and W. R. Vaughn. *In boxheads, numbers beneath element symbols give background values and, in parentheses, N values*]

Locality No. (pl. 1)	Laboratory No.	Field No.	Au <0.02	Ag 1 (<0.5)	Hg 0.08	As L <150 (<200)	Co 20	Cu 100	Mo 5 (<5)	Ni 150	Pb 70	Sb L <150 (<200)	Sn 15 (<10)	W L (<200)	Zn L <150 (<200)	Metals present in anomalous amounts and their approximate concentration ratio	Total anomaly[1]
1	ACM-531	67-AKd-531	<0.02	1	0.36	<10	15	*15*, 30	N	*38*, 30	<*25*, 15	N	N	N	*56*, L	Hg, 4	3
2	533	533	<.02	N	ND	N	7	5	N	15	20	N	<*25*, 15	N	N	......	......
3	AHI-100	68-AKd-70	<.02	N	.03	L	15	15	N	30	10	N	L	N	L	......	......
4	ACM-536	67-AKd-536	<.02	N	ND	N	3	3	N	3	30	N	*60*, 300	L	N	Sn, 20; W, 1	19
5	535	535	<.02	N	ND	N	3	L 5	N	3	30	N	*30*, 150	N	N	Sn, 10	9
6	534	534	<.02	N	ND	N	5	3	N	7	20	N	10	N	N	......	......
7	538	538	<.02	N	ND	N	7	7	N	15	30	N	<*25*, 15	N	N	......	......
8	539	539	<.02	N	ND	N	7	5	N	15	30	N	10	N	N	......	......
9	540	540	<.02	N	ND	N	15	15	3	30	30	N	50	N	L	Sn, 3.3	2.3
10	548	548	<.02	*.6*	.05	10	ND	*18*	ND	*48*	*88*	ND	ND	ND	*110*	......	......
11	547	547	<.02	N	ND	N	15	30	N	50	15	N	N	N	N	......	......
12	546	546	<.02	N	ND	N	15	30	N	30	15	N	<*25*, N	N	N	......	......
13	545	545	<.02	N	ND	N	15	15	N	30	10	N	N	N	N	......	......
14	544	544	<.02	N	ND	N	20	50	7	70	30	N	N	N	700	Zn, 4.7; Mo, 1.2	2.9
15	AHI-087	68-AKd-38	<.02	N	.06	N	20	50	N	100	50	N	N	N	L	......	......
16	ACM-543	543	<.02	N	ND	N	15	20	3	30	30	N	10	N	L	......	......
17	541	67-AKd-541	<.02	N	ND	N	15	20	N	30	30	N	<*25*, N	N	L	......	......
18	542	542	.1	.7	ND	N	15	50	7	30	50	N	15	N	N	Au, 5; Mo, 1.4	4.4
19	AHI-086	68-AKd-37	<.02	N	.06	N	20	50	N	100	50	N	N	N	L	......	......
20	085	36	<.02	N	.04	N	15	15	N	70	70	N	N	N	N	......	......
21	083	34	<.02	N	.06	N	30	100	L	100	70	N	N	N	L	......	......
22	084	35	<.02	N	.04	N	7	15	N	15	70	N	L	N	N	......	......
23	ACM-521	67-AKd-521	<.02	N	ND	N	L 5	30	3	30	30	N	N	N	L	......	......
24	AHI-024	68-ASn-60	<.02	N	.11	N	20	30	N	100	15	N	N	L	L	Hg, 1.3; W, 2	1.3
25	ACB-232	67-AKd-232	<.02	*.7*	.05	<10	ND	*10*	ND	*34*	*26*	ND	ND	ND	*86*	......	......

See footnote at end of table.

TABLE 3.—*Metal content, in parts per million, of stream sediments, Serpentine Hot Springs area, Seward Peninsula, Alaska*—Continued

Locality No. (pl. 1)	Laboratory No.	Field No.	Au <0.02	Ag 1 (<0.5)	Hg 0.08	As L <150 (<200)	Co 20	Cu 100	Mo 5 (<5)	Ni 150	Pb 70	Sb L <150 (<200)	Sn 15 (<10)	W L (<200)	Zn L <150 (<200)	Metals present in anomalous amounts and their approximate concentration ratio	Total anomaly
26	ACB-233	233	<.02	.7	.06	<10	ND	13	ND	37	30	ND	ND	ND	110		
27	234	234	<.02	.3	.06	<10	ND	10	ND	31	30	ND	ND	ND	87		
28	AHI-026	68-ASn-63	<.02	N	.02	N	15	20	N	100	10	N	N	N	L		
29	ACB-236	67-AKd-236	<.02	.4	.06	<10	ND	12	ND	34	26	ND	ND	ND	82		
30	235	235	<.02	.6	.10	10	ND	13	ND	28	<25	ND	ND	ND	68	Hg, 1.25	.25
31	237	237	<.02	.5	.05	10	ND	14	ND	53	26	ND	ND	ND	77		
32	AHI-027	68-ASn-64	<.02	N	.02	N	10	15	N	70	L	N	N	N	L		
33	025	61	<.02	L	.02	N	15	15	N	70	15	N	N	L	L	W, 2	1
34	ACB-239	67-AKd-239	<.02	.9	.06	20	ND	15	ND	39	<10	ND	ND	ND	110		
35	AHI-023	68-ASn-59	<.02	N	.04	N	15	15	N	70	10	N	N	L	L	W, 2	1
36	ACB-240	67-AKd-240	<.02	.6	.14	10	ND	14	ND	33	25	ND	ND	ND	68	Hg, 1.75	.75
37	AHI-022	68-ASn-58	<.02	L	.03	L	15	15	N	100	10	N	N	L	N	W, 2	1
38	ACB-242	67-AKd-242	<.02	.4	.14	<10	ND	13	ND	35	25	ND	ND	ND	80	Hg, 1.7	.7
39	241	241	<.02	.4	.18	<10	ND	19	ND	24	<25	ND	ND	ND	80	Hg, 2.1	1.1
40	AHI-020	68-ASn-66	<.02	N	.04	N	15	70	N	100	15	N	N	N	N		
41	021	67	<.02	N	.05	N	15	20	N	70	15	N	N	L	N	W, 2	1
42	074	68-AKd-7	<.02	N	<.01	N	L	5	N	L	30	N	20	N	N	Sn, 1.3	.3
43	ACM-517	67-AKd-517	<.02	.2	<.01	<10	ND	<10	ND	6	<25	ND	ND	ND	36		
44	AHI-070	68-AKd-14	<.02	N	.02	N	5	7	N	5	50	N	70	N	N	Sn, 4.67	3.67
45	076	10	<.02	N	.04	N	15	60	L	100	70	N	N	N	L		
46	ACM-518	67-AKd-518	<.02	N	.04	N	1.5	20	3	30	30	N	<25, 15	N	L		
47	AHI-077	68-AKd-11	<.02	N	.01	N	10	15	N	50	100	N	N	N	N		
48	ACM-520	67-AKd-520	<.02	N	.04	N	3	3	N	7	30	N	20	N	N	Sn, 1.3	.3
49	AHI-075	68-AKd-9	<.02	N	N	N	7	30	7	7	100	N	20	N	N	Pb, 1.3; Sn, 1.3	.6
50	ACM-519	67-AKd-519	<.02	N	ND	N	7	10	N	15	30	N	15	N	N		
51	516	516	<.02	.7	.10	<10	ND	<10	ND	26	32	ND	ND	ND	97	Hg, 1.3	.3
52	AHI-080	68-AKd-15	<.02	N	.04	L	L	10	N	7	70	N	50	N	N	Sn, 3.3	2.3
53	ACM-515	67-AKd-515	<.02	.7	.08	<10	ND	<10	ND	17	28	ND	ND	ND	63		
54	513	513	<.02	.3	.06	<10	ND	10	ND	23	32	ND	ND	ND	87		
55	AHI-081	68-AKd-18	<.02	N	.02	N	10	30	N	70	100	N	L	N	L	Pb, 1.4	.4
56	ACM-514	67-AKd-514	<.02	.6	.04	20	ND	<10	ND	22	28	ND	ND	ND	100		
57	AHI-082	68-AKd-19	<.02	N	.02	N	10	20	N	60	70	N	L	N	L		
58	ACM-523	67-AKd-523	<.02	N	.03	N	5	10	3	15	30	N	N	N	N		
59	524	524	<.02	N	ND	N	7	7	N	10	30	N	<25, 15	N	N		
60	526	526	<.02	N	ND	N	3	1.5	N	3	30	N	15	N	N		

61	525	525	<.02	N	ND	N	3	1.5	N	3	30	N	15	N	N		
62	AHI-003	68-ASn-27	<.02	N	ND	N	7	7	N	7	15	N	10	N	N		
63	ACM-530	67-AKd-530	<.02	N	ND	N	7	3	N	15	20	N	20	N	N	Sn, 1.3	.3
64	AHI-004	68-ASn- 28	<.02	N	ND	L	5	7	N	7	15	N	L	N	N		
65	ACM-529	67-AKd-529	<.02	N	ND	N	7	3	N	7	30	N	15	N	N		
66	527	527	<.02	N	ND	N	7	3	N	7	30	N	15	N	N		
67	528	528	<.02	N	ND	N	7	3	N	7	30	N	<25, 15	N	N		
68	AHI-071	68-AKd- 2	<.02	N	.03	N	15	10	5	30	70	N	30	L	L	Sn, 2; W, 2	2
69	015	68-ASn- 51	<.02	N	.02	N	15	10	N	70	L	N	N	N	N		
70	261	269	<.02	L	.08	L	7	7	N	5	30	N	N	N	N		
71	ACM-512	67-AKd-512	<.02	.2	.08	<10	ND	*<10*	ND	*8*	*<25*	ND	ND	ND	*23*		
72	AHI-073	68-AKd- 6	<.02	N	.04	L	10	15	N	30	70	N	15	L	L	W, 2	1
73	ACM-511	67-AKd-511	<.02	.4	.09	<10	ND	*<10*	ND	*15*	*<25*	ND	ND	ND	*60*	Hg, 1.1	.1
74	AHI- 10	68-ASn- 46	<.02	N	N	.04	10	5	N	20	15	N	20	N	N	Sn, 1.3	.3
75	041	80	<.02	N	ND	N	7	10	N	30	15	N	N	N	N		
76	042	81	<.02	N	ND	N	5	5	N	70	10	N	N	N	N		
77	043	82	<.02	N	ND	N	10	5	N	20	10	N	N	N	N		
78	101	68-AKd- 71	<.02	N	.01	N	7	15	N	15	N	N	N	N	N		
79	ACM-537	67-AKd-537	<.02	N	ND	N	10	15	N	15	15	N	N	N	N		

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[1] Where duplicate values are reported, highest value was used to compute anomaly.

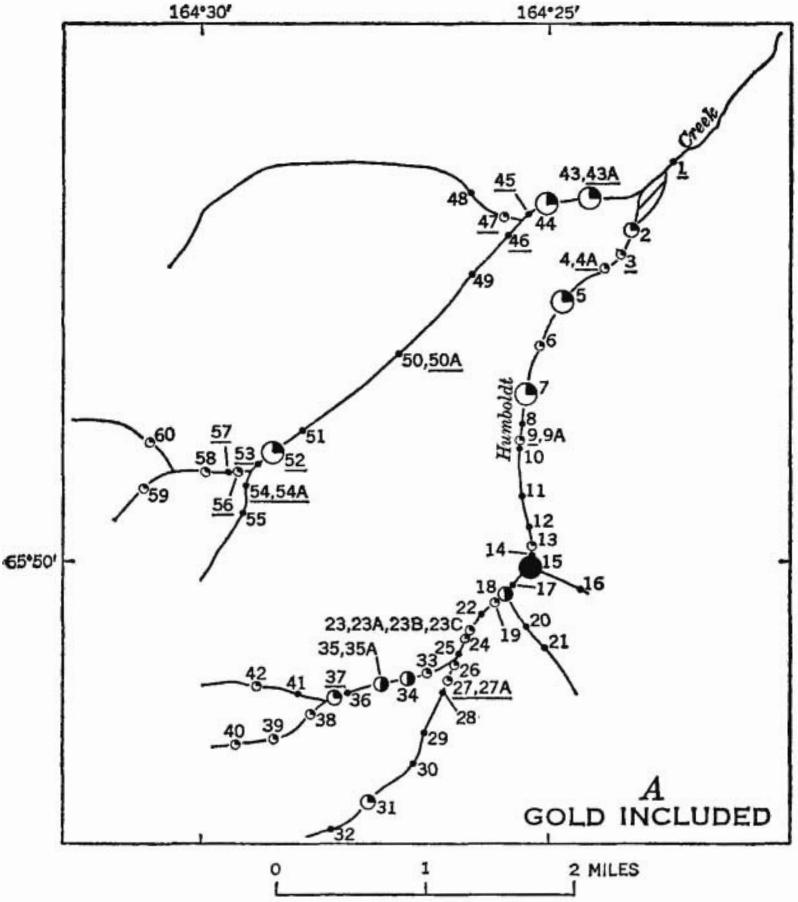
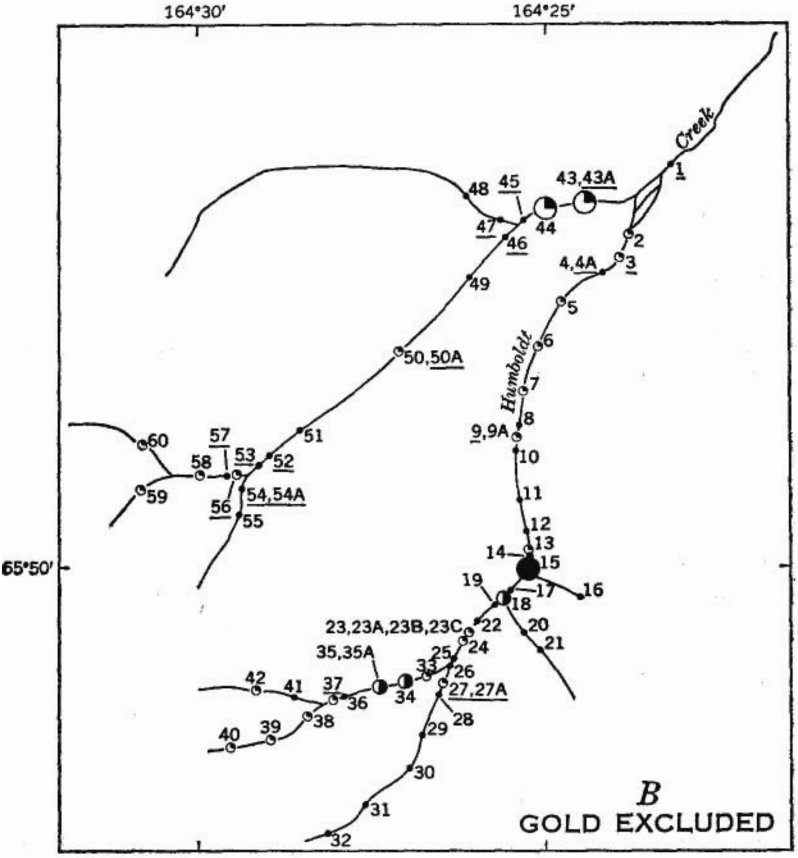


FIGURE 2.—Distribution of metals in panned concentrates and stream sediments, Humboldt Creek. Panned concentrates obtained from all localities; underscoring indicates that stream-sediment sample was also obtained.



EXPLANATION

SAMPLE LOCALITY AND NUMBER

•1
No anomalous metals

◔2 ◔37 ◔44
1-3 metals anomalous in amount

◑34
4-7 metals anomalous in amount

●15
More than 10 metals anomalous in amount

Size of symbol indicates sum of anomalous metals, in parts per million:
Small, in amount between 1 and 5 times background
Medium, in amount between 6 and 25 times background
Large, in amount greater than 25 times background

Of all the metals, mercury shows the most clear-cut, direct correlation with the total metal anomaly, although it seldom accounts for a large share of the total anomaly.

A marked inverse relationship exists between manganese and total trace metals in the altered zones sampled. Whether this relationship represents a selective leaching of manganese during supergene alteration of sulfides, or whether it represents leaching of manganese by ore solutions, is not known. In either case, the absence of manganese from mineralized samples is a direct indication of possible mineralized structures. Lyman Huff (oral commun., 1968) reported an inverse relation between manganese and copper near certain porphyry copper deposits he is currently studying.

SUGGESTIONS FOR EXPLORATION

Future work in the Serpentine Hot Springs area should include the following:

1. Detailed mapping and sampling of all observable alteration areas, including those along the thrust faults.
2. Determination of the bedrock source of metals leading to the geochemical anomalies in the west fork of Humboldt Creek (sample locs. 43, 44, fig. 2), in the west headwaters of the Pish River, and in the bedrock east of Humboldt Creek.
3. Trenching, and possibly drilling, of the two main mineralized zones, now known, or others that might be proved by mapping and sampling.
4. Evaluation, by churn drilling, of the tin and gold potential of placer deposits in the entire Humboldt Creek drainage, as well as in the upper reaches of Kennedy Creek, which heads against the mineralized area shown by sample localities 56–61 (pl. 1), and in the west fork of the Pish River.
5. Careful mineralogical work on samples of argentiferous galena to determine if the high silver values are caused by secondary enrichment, which, in this area, would probably occur only near the surface. If high silver values persist to depth, lode mining may be profitable even in this isolated part of Alaska.

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TABLE 4.—*Metal content, in parts per million, of stream sediments and panned concentrates of stream sediments, Humboldt Creek drainage, Serpentine Hot Springs area, Alaska*

[S, stream sediment; PC, panned concentrate; SC, sluice box concentrate; N, below detection limit; L, detected but below limit of dependable reading; NDA, not definitely anomalous; ND, not determined; ..., no anomaly. All analyses are semiquantitative spectrographic except those for Au, which are atomic absorption, those for Hg, which are mercury detector, and those in italic for Cu, Ni, Pb, and Zn and those lower than 200 ppm for As, which are wet chemical. Double entry indicates duplicate determinations—highest value is used to compute anomaly. Analysts: R. L. Miller, D. J. Grimes, R. B. Tripp, W. B. Vaughn, and E. E. Martinez. *In boxheads, numbers beneath element symbols give, in descending order, background value, L value, and detection limit*]

Locality No. (fig. 2)	Laboratory No.	Field No.	Sample type	Au	Ag	Hg	As	Mn[1]	Co	Cu	Mo	Ni	Pb	Sb	Sn	W	Zn	Metals present in anomalous amounts and their approximate concentration ratio	Approximate total anomaly	Concentration ratio of total sediment and panned concentrate
				<0.02 <0.02	1 0.5 <0.5	0.08 0.02	L 150 200		20 10	100 2	5 <5 5	150 2	70 <70 10	L 150 200	15 >10<15 10	L 150 (<200)	L 150 <200			
1	ACM-548	67-AKd-548	S, −80 mesh	<0.02	N	0.05, 0.03	*<10*	700	15	*20*, 10	N	*40*, 50	*<25*, 20	N	N	N	*85*, N	...	...	...
2	AHI-509	68-ATr-61	PC	.3	N	.04	L	700	15	7	L	70	L	N	30	N	L	Au, 15; Sn, 2	15	137
3	ACM-547	67-ASn-547	S, −80 mesh	<.02	N	.11, .28	*<10*	700	10	*16*, 10	N	*34*, 50	*<25*, 20	N	N	N	*74*, N	Hg, 3.5	2.5	...
4	AHI-508	68-ATr-59	PC	.04	N	.03	L	300	7	5	N	30	15	N	N	N	N	Au, 2	1	156
4A	371	69A	S, −40 mesh	<.02	N	.06	N	1,000	10	10	N	70	L	N	N	N	L	...	...	...
5	507	58	PC	1.9	N	.03	N	1,500	15	70	5	70	20	N	N	N	200	Au, 95; Zn, 1.3	94.3	140
6	506	57	PC	.06	N	.04	N	700	15	70	5	70	20	N	N	N	200	Au, 3; Zn, 1.3	2.3	150
7	505	56	PC	8.6	N	.02	L	700	15	50	L	70	15	N	15	N	200	Au, 430; Zn, 1.3	429.3	160
8	504	55	PC	<.02	L	.07	N	300	10	30	N	50	L	N	N	N	L	...	...	164
9	ACM-546	67-ASn-546	S, −80 mesh	<.02	N	.15	*<10*	1,000	15	50	N	70	20	N	N	N	N	Hg, 2	1	...
9A	AHI-503	68-ATr-54	PC	.06	L	.1	L	200	10	5	N	30	L	N	L	N	L	Au, 3; Hg, 1.3	2.3	95
10	370	54A	S, −40 mesh	<.02	N	.06	N	700	10	15	N	70	10	N	N	N	L	...	...	...
11	502	53	PC	.02	N	.08	N	300	15	70	L	70	10	L	N	N	L	Au, NDA	...	168
12	501	52	PC	.02	N	.06	N	300	15	20	L	70	L	N	N	N	L	Au, NDA	...	155
13	500	41	PC	.06	L	.02	L	300	15	20	L	50	15	N	L	N	200	Au, 3; Zn, 1.3	2.3	140
14	406	68-AKd-51	PC	<.02	N	.06	N	700	15	10	N	70	L	N	N	N	L	...	...	132
15	521	68-ATr-83A	SC	1,000	7	.11	200	1,000	70	150	15	100	100	L	>1,000	N	700	Au, 50,000; Ag, 7; Hg, 1.4; As, 1.5; Co, 3.5; Pb, 1.4; Sn, 66.7; Zn, 5	50,078.5	23,529
16	520	82	PC	<.02	N	.04	N	150	10	10	L	50	L	N	N	N	N	...	...	88
17	482	32	PC	<.02	N	.02	N	700	10	15	L	70	L	N	N	N	N	...	...	126
18	397	68-AKd-41	PC	<.02	L	.06	L	1,000	20	200	15	70	30	N	300	N	N	Cu, 2; Mo, 3; Sn, 20	22	107
19	483	68-ATr-33	PC	.04	N	.02	N	700	10	30	L	70	15	N	N	N	L	Au, 2	1	118
20	401	68-AKd-44A	PC	<.02	N	.09	L	3,000	10	15	N	50	L	N	N	N	L	Hg, NDA	...	134
21	405	48	PC	<.02	N	.08	N	500	15	50	L	70	15	N	N	N	L	...	...	184
22	484	68-ATr-34	PC	<.02	N	.02	N	300	10	10	L	50	15	N	N	N	L	...	...	119
23	409	68-AKd-52	PC	<.02	N	.01	N	1,500	15	20	7	100	15	N	N	N	300	Zn, 2	1	82
23A	408	53	PC	<.02	N	.04	N	500	15	7	L	70	10	N	N	N	L	...	...	64
23B	409	54	PC	<.02	N	.03	N	2,000	15	20	5	100	30	N	15	N	300	Zn, 2	1	174
23C	410	54A	PC	<.02	N	.02	N	3,000	15	50	7	100	30	N	N	N	500	Zn, 3.3	2.3	140
24	485	68-ATr-35	PC	<.02	L	.02	N	700	15	20	L	70	15	N	N	N	300	Zn, 2	1	140
25	104	18	S, −40 mesh	<.02	N	.04	L	5,000	20	15	7	100	20	N	N	N	N	...	...	...
26	411	68-AKd-55	PC	.08	N	.02	N	300	10	10	N	50	L	N	N	N	N	Au, 4	3	75
27	ACM-545	67-AKd-146B	S, −80 mesh	<.02	N	ND	N	3,000	20	70	10	100	70	N	N	N	500	Zn, 3.3	2.3	...
27A	AHI-105	68-ATr-19	S, −40 mesh	<.02	N	.04	L	1,500	10	10	N	100	15	N	N	N	N	...	...	...
28	413	68-AKd-57	PC	<.02	L	.04	N	700	20	50	5	50	15	N	N	N	L	...	...	104
29	495	68-ATr-44	PC	<.02	L	.06	L	200	10	10	N	50	L	N	N	N	L	...	...	138
30	496	45	PC	<.02	L	.02	N	200	15	30	L	70	10	L	N	N	L	...	...	90
31	497	46	PC	.3	L	.03	N	150	10	15	L	30	10	N	N	N	L	Au, 15	14	142
32	498	47	PC	<.02	N	.04	L	150	7	15	7	30	L	N	N	N	L	...	...	127
33	412	68-AKd-56	PC	<.02	N	.05	N	1,000	15	30	15	100	20	N	L	N	500	Zn, 3.3	2.3	160
34	486	68-ATr-36	PC	.1	N	.03	L	6,000	10	150	15	100	700	N	10	N	500	Au, 5; Cu, 1.5; Mo, 3; Pb, 10; Zn, 3.3	17.8	160
35	487	37	PC	<.02	.5	.12	N	2,000	100	150	10	200	70	N	N	N	500	Hg, 1.5; Co, 5; Cu, 1.5; Mo, 2; Ni, 1.3; Zn, 3.3	8.6	156
35A	488	37A	PC	<.02	N	.02	N	5,000	15	70	15	150	70	N	N	N	700	Mo, 3; Zn, 4.7	5.7	183
36	489	38	PC	<.02	L	.07	N	2,000	10	20	10	70	15	N	N	N	N	...	...	104
37	ACM-544	67-ASn-544	S, −80 mesh	0.14, .05	N	ND	N	3,000	20	70	10	100	70	N	N	N	500	Au, 7; Mo, 2; Zn, 3.3	9.3	...
38	AHI-494	68-ATr-43	PC	<.02	L	.06	L	150	10	30	10	50	70	L	N	N	300	Mo, 2; Zn, 2	2	120
39	493	42	PC	<.02	L	.04	N	700	15	70	10	70	150	L	N	N	500	Mo, 2; Pb, 2; Zn, 3.3	4.3	112
40	492	41	PC	<.02	L	.04	N	300	20	100	7	70	50	L	N	N	300	Mo, 1.4; Zn, 2	1.4	107
41	490	39	PC	<.02	N	.02	L	100	5	7	N	20	L	N	N	N	L	...	...	183
42	491	40	PC	<.02	.7	.04	N	150	15	50	15	50	70	N	N	N	L	Mo, 3	2	94
43	519	75	PC	.02	N	.02	N	150	10	10	5	30	20	N	>1,000	N	L	Sn, >67	>66	95
43A	374	75A	S, −40 mesh	<.02	N	.03	N	700	10	20	N	30	30	L	30	N	N	Sn, 2	1	...
44	518	74	PC	<.02	L	.09	N	700	10	5	L	50	15	N	500	N	N	Hg, 1; Sn, 33	32	200
45	ACM-539	67-AKd-143	S, −80 mesh	<.02	N	ND	N	700	10	50	N	30	30	N	L	N	N	...	...	...
46	540	144	S, −80 mesh	<.02, .05	N	ND	N	700	15	50	N	50	30	N	N	N	L	...	...	...
47	538	142	S, −80 mesh	.1	N	ND	N	700	10	50	N	30	30	N	L	N	N	Au, 5	4	...
48	AHI-517	68-ATr-71	PC	<.02	L	.07	N	700	10	15	N	20	15	N	15	L	N	...	...	140
49	516	70	PC	<.02	N	.04	N	300	7	7	N	50	L	N	N	N	L	...	...	160
50	515	68	PC	<.02	L	.02	N	150	15	7	N	50	20	N	15	N	L	...	...	134
50A	373	68A	S, −40 mesh	<.02	N	.02	L	1,500	15	15	10	50	30	N	L	N	N	Mo, 2	1	...
51	514	66	PC	<.02	.5	.01	N	300	10	10	N	30	15	N	10	N	L	...	...	134
52	ACM-541	67-AKd-145	S, −80 mesh	6.2, <.05	N	ND	N	700	15	30	N	50	70	N	15	N	N	Au, 310	309	...
53	None	68-AKd-39	S, −40 mesh	<.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	...	...	...
54	ACM-543	67-ASn-543	S, −80 mesh	<.02, <.05	N	ND	N	700	15	50	<5	50	70	N	N	N	N	...	...	...
54A	AHI-087	68-AKd-38	S, −40 mesh	<.02	N	.03	N	1,500	15	150	5	100	70	N	15	N	L	...	...	...
55	513	68-ATr-65	PC	<.02	L	.01	N	300	15	7	L	70	15	N	L	N	N	...	...	120
56	ACM-542	67-AKd-145A	S, −80 mesh	<.02, <.05	.7	ND	N	500	10	30	10	30	70	N	15	N	N	Mo, 2	1	...
57	AHI-086	37	S, −40 mesh	<.02	L	.06	N	3,000	20	50	N	100	50	N	L	N	L	...	...	...
58	510	68-ATr-62	PC	<.02	L	.04	L	700	10	30	7	50	30	N	30	N	L	Mo, 1.4; Sn, 2	1.4	167
59	511	63	PC	<.02	L	.03	N	300	15	30	L	70	100	N	50	N	L	Pb, 1.4; Sn, 3.3	2.7	125
60	512	64	PC	<.02	N	.06	L	700	15	150	N	30	30	N	L	N	L	Cu, 1.5	.5	130

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[1] Mn is useful in interpreting erratic metal values because of its scavenging action in ionic solution; Ba is often associated with the outer zones of mineralized areas.

377-497 O - 70 - (in pocket) No. 2