UNITED STATES DEPARTMENT OF INTERIOR

GEOLOGICAL SURVEY

Occurrence of platinum in gold samples from the Tolovana and Rampart mining districts, Livengood quadrangle, Alaska

By

John B. Cathrall[1], John C. Antweiler[1], and Elwin L. Mosier[1]

Open-File Report 87-330

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

[1]DFC, Box 25046, MS 973, Denver, CO 80225

1987

CONTENTS

Plates

Tables

Abstract

The possibility for discovery of platinum deposits is suggested by the occurrence of platinum in native gold samples from the Tolovana and Rampart mining districts north and west of Fairbanks, Alaska. A belt of mafic and ultramafic rocks, which may be the source rocks or may provide favorable host rock environments for platinum, passes through the two mining districts and extends northwestward an additional 100 miles. The discovery of platinum in samples of native gold together with the proximity of favorable source rocks suggests that well designed prospecting programs backed up by expertise in the determination of platinum might result in the discovery of platinum resources.

Introduction

Platinum was identified in placer and lode gold samples from the Tolovana and Rampart mining districts, Alaska, by optical emission spectrographic analyses. Both districts are areas of placer gold production. They are located north and west of Fairbanks and south of the Yukon river. The placer and lode gold samples were collected as a part of a joint study by the U.S. Geological Survey and the State of Alaska Division of Geological and Geophysical Surveys.

The Tolovana and Rampart mining districts are located in the northwestern part of the Yukon-Tanana Upland. The Tolovana district, located approximately 82 miles northwest of Fairbanks, Alaska near the town of Livengood, is accessible year round via State Highway 2, the Elliott Highway. The Rampart district, located an additional 42 miles west of Livengood, is accessible from Livengood via State Highway 2 to the town of Eureka from which a winter trail connects with the Rampart area.

Gold was discovered on Livengood Creek in the Tolovana district in 1914. In 1916, the Tolovana district produced 35,000 ounces of gold. Total gold production through 1964 was approximately 380,000 fine ounces from stream and bench placer deposits (Cobb, 1964). Gold production from bedrock deposits has been negligible. Much of the mining following the discovery was done by hydraulicking to remove overburden, a technique which is no longer used because it results in stream siltation. In current mining practice, the overburden is mechanically removed with scrapers, and the underlying gravel is stockpiled and then processed in a washing plant. The runoff is discharged into a settling pond where particulate matter is deposited.

Gold was discovered in the Rampart district in 1882 (Mertie, 1934) by the Schieffelin brothers, the original discovers of gold at Tombstone, Arizona. Total gold production through 1939 was 86,800 ounces from placers (Koschmann and Bergendahl, 1968). No workable lodes have been found in the district.

Geology

The southern half of the two mining districts, bordered on the south by the Beaver Creek fault, is underlain by three units of metamorphosed clastic sedimentary rocks. The northern half of the Tolovana mining district is bordered on the north by two major east-west faults, which may be an extension of the Tintina fault system, and is underlain by a metamorphosed carbonate chert unit. The Rampart district lies north of the Beaver Creek fault and overlies part of the east-west Tintina fault system. The three units of metamorphosed clastic sedimentary rocks and the metamorphosed carbonate chert unit are separated by an eastward-trending belt of serpentinites and associated mafic and ultramafic rocks and intruded by granitic rocks (Chapman and others, 1971) (plate 1).

The three clastic units consist of: a Jurassic-Cretaceous shale, graywacke and quartzite unit (KJs); a Jurassic-Cretaceous conglomerate, graywacke, and shale unit (KJc); and a Devonian conglomerate, graywacke, and shale unit (Dcl) (plate 1). An unconformity separates the Jurassic-Cretaceous flysch unit (KJc) from the Devonian clastic sequence (Dcl) (Allegro, 1984).

The carbonate chert unit (DOd) consists chiefly of dolomite, limestone, silicified carbonate rocks, and chert of Ordovician to Devonian age.

The serpentinites form an eastward- to northeastward-trending complex belt of outcrops which extends approximately 100 miles from the western edge of the Livengood (1° x 3°) quadrangle to the edge of the Yukon Flats and are parallel to the Tintina fault system in the Circle (1° x 3°) quadrangle.

The serpentinite belt includes mafic and ultramafic dike rocks, tectonic inclusions derived from intrusive and volcanic, sedimentary, and metamorphic rocks and rodingite. The inclusions show various degrees of alteration.

The mafic and ultramafic rocks, which parallel the serpentinite belt, include diorite, metadiorite, diabase, gabbro, basalt, metabasalt, greenstone, and pyroxenite. Both the serpentinite and the mafic and ultramafic units are of pre-upper Devonian age (Chapman and others, 1971).

In Tertiary time, intrusions ranging in composition from monzonite, quartz-monzonite, quartz diorite-granodiorite, and granite, were emplaced into these rocks.

Structure

The structure of most of the bedrock units in the mining district areas is complex and characterized by intense folding and structural imbrication. Because the contact between the serpentinite, mafic, ultramafic, and other rocks cannot be seen, it is not known if the igneous rocks were intruded or tectonically emplaced in the layered sequences (Weber and others, 1985). The serpentinites are believed to have been emplaced originally as subhorizontal sheets associated with regional thrust faults and their present outcrop pattern reflects subsequent upward dragging along high-angle reverse faults (Foster, 1968). The Paleozoic clastic, serpentinite, mafic, and ultramafic units exhibit a possible structural contact (reverse or thrust faults) with the carbonate-chert unit to the north in the Tolovana mining district area (Allegro, 1984).

There are impure, talc-rich contact zones in the mafic rocks in the Tolovana district, but the fact that serpentinite and mafic igneous clasts are found in the Devonian conglomerate unit near its contact with the mafic rocks suggests that the serpentinite complex was in place before deposition of the Devonian unit (Foster, 1966).

> Bundtzen (1983) states: "The diorite, gabbro, and greenstone appear to represent a hypabyssal suite characterized by initial multiple intrusions and subsequent tectonic dismemberment. The serpentinized ultramafic rocks generally are more strongly foliated and may be fractionates of the gabbro-diorite or of separate parentage."

The Tertiary granitic rocks occur chiefly as small discordant intrusions and are surrounded by zones of resistant hornfels rocks.

Sampling and analytical procedure

Miners, in both mining districts, provided samples of gold and associated heavy minerals from their sluice concentrates. A total of 59 emission spectrographic analyses using a technique described by Mosier (1975) were made on gold from 5 placer sites and 1 lode site. The elements determined and their lower limits of determination are listed in table 1. Spectrographic results were obtained by visual comparison of spectra derived from the sample against spectra obtained from standards made from pure oxides, graphite, and 99.999 percent metallic gold. Pure Al_2O_3 was added to the standards and samples as a codistillation agent. Standard concentrations are geometrically spaced over an order of magnitude of concentration as follows: 100, 50, 20, 10, and so forth. Samples whose concentrations are estimated to fall between those values are assigned values of 70, 30, 15, and so forth. Standard concentrations are based on a 5-mg gold sample weight. Because of the nature of native gold, it is often difficult to weigh exactly 5-mg samples and in many instances there was less than 5 mg of gold available for analysis. Therefore, the reported concentration values are corrected to reflect a 5-mg sample weight by the following formula:

$$\text{reported concentrations value} = \text{determined value} \times \frac{5}{\text{sample weight}}.$$

The trace-element content of native gold varies greatly from grain to grain, as well as from deposit to deposit, which creates a problem in determining the precision of the analytical technique. However, studies using artificial melts have shown that the variance of the analytical method was smaller than the natural variance of trace elements in native gold (Mosier, 1975).

Analytical results

The analytical results for lode and placer gold (table 2) are given in weight percent and are presented by localities. The USGS assigned sample number is given in sample column; letters indicate separate splits of the samples. When sufficient gold was available from a particular site, multiple analyses were made. For this study, fineness is defined as:

$$\text{fineness} = \frac{Au}{Au + Ag} \times 1{,}000.$$

The gold content was determined by difference, that is:

$$Au\% = 100-(Ag\% + X\%),$$

TABLE 1.--Lower limits of determination for the spectrographic analysis of gold based on a 5-mg sample

Element	Lower determination limit
	Percent
Silver (Ag)	0.001
Copper (Cu)	.0005
Zinc (Zn)	.005
Gallium (Ga)	.0002
Lead (Pb)	.0002
Arsenic (As)	.005
Antimony (Sb)	.002
Cadmium (Cd)	.0002
Bismuth (Bi)	.0002
Indium (In)	.0005
Mercury (Hg)	.002
Tellurium (Te)	.005
Nickel (Ni)	.0005
Cobalt (Co)	.0005
Tin (Sn)	.0005
Molybdenum (Mo)	.0005
Germanium (Ge)	.0005
Platinum (Pt)	.001
Palladium (Pd)	.0002
Barium (Ba)	.0005
Strontium (Sr)	.01
Zirconium (Zr)	.0005
Vanadium (V)	.001
Chromium (Cr)	.001
Yttrium (Y)	.0005
Lanthanum (La)	.002
Scandium (Sc)	.0005
Niobium (Nb)	.001
Boron (B)	.0005
Tantalum (Ta)	.005
Beryllium (Be)	.0001
Tungsten (W)	.005
Manganese (Mn)	.0001
Iron (Fe)	.001
Magnesium (Mg)	.0005
Calcium (Ca)	.001
Titanium (Ti)	.001
Silicon (Si)	.0002

where XX is the sum of elements other than gold and silver. If an element was not detected, two dashes (--) are entered in the table in place of an analytical value. The actual weight in milligrams of the gold sample analyzed is given under Au-SW. Because the sample weight often varies from the 5-mg weight designed for the method and because these are computer-generated data, many of the results listed in these tables carry nonsignificant digits to the right of the significant digits. The analysts did not determine these values to the accuracy suggested by the extra numbers as shown in table 1.

Discussion

The greatest amounts of platinum, with concentrations ranging from 45-73%, were found in gold samples mined from alluvium along Amy Creek in the Tolovana district (1, plate 1). These particular samples were hand-picked from gold concentrates because their steel-grey appearance suggested the possibility of platinum. The analyses show that some of the hand-picked grains are grains of platinum.

At the other localities, platinum was not suspected prior to analysis. At some or maybe all of the other localities, platinum may be alloyed with gold, or may occur as discrete grains that were not recognized prior to analysis. Platiniferous placer gold is known from several localities in Alaska (Mertie, 1969, p. 90) where no free platinum metals are known to occur.

Palladium occurs with platinum in most samples (table 2) and some of the other platinum group metals (iridium, osmium, ruthenium, rhodium) may also occur with platinum but were not present in sufficient amount to be determined by the emission spectrographic analyses. All six of the platinum metals should be present as native alloys of platinum metals (Mertie, 1969, p. 5) but in highly variable amounts.

Other elements that are likely to be enriched to some extent in samples that contain platinum are copper, iron, nickel, and sometimes cobalt and chromium. These elements are not necessarily indicator elements for platinum, but they may suggest an origin in mafic or ultramafic rocks that are platiniferous.

Conclusions

Platinum was identified in native gold samples from four placer sites in the Tolovana mining district (1-4, plate 1) and one placer site in the Rampart mining district (5, plate 1). Platinum was identified in the gold samples from the one lode gold site in the Tolovana mining district (A, plate 1). Platinum is difficult to prospect for, but its value and econimic and strategic importance justify exploration efforts. Native platinum can be easily overlooked in panning for gold because it may occur in tiny grains that can be panned away or are not easily identified as gold. Moreover, platinum grains are paramagnetic and may be removed by magnets that will remove magnetite from black sand concentrates. Gold refiners commonly do not pay for or identify platinum in gold concentrates, but may regard it as seigniorage. The discovery of lode deposits is even more difficult than identifying platinum in alluvial deposits. The market value of platinum is usually somewhat greater than that of gold, and the platinum group elements have great scientific, industrial, and strategic importance.

The identification of platinum in the gold samples described in this report is a positive indication that resources of the platinum metals group may exist in the two areas. Although the amount of platinum indicated by the analytical data is small, inquiry should be directed towards its source. Most platinum deposits are related to mafic and ultramafic rocks (Mertie, 1969, p. 16). The belt of mafic and ultramafic rocks that lies north of the Beaver Creek fault may be worth studying in detail. Platinum analyses are difficult and expensive but geochemical sampling for copper and nickel sulfides in addition to gold and silver may suggest areas in the belt of mafic and ultramafic rock where analyses for the platinum metals are justified.

References

Allegro, G. L., 1984, Geology of the Old Smoke Prospect, Livengood C-4 quadrangle, Alaska: State of Alaska Department of Natural Resources Division of Geological and Geophysical Surveys, Report of Investigations 84-1, pp. 10, 1 plate.

Bundtzen, T. K., 1983, Bedrock geologic outcrop map of the Livengood B-3 quadrangle, Alaska: State of Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Report of Investigations 83-6, 1 plate.

Chapman, R. M., Weber, F. R., and Taber, Bond; 1971, Preliminary geologic map of the Livengood quadrangle, Alaska: U.S. Geological Survey Open-File Report 71-66, 2 plates.

Cobb, E. H., 1964, Placer gold occurrences in Alaska: U.S. Geological Survey Mineral Investigations Resources Map MR-38.

Foster, R. L., 1966, The petrology and structure of the Amy Dome area, Tolovana mining district, east-central Alaska: University of Missouri, unpublished Ph.D. thesis, 227 p.

Foster, R. L., 1968, Potential for lode deposits in the Livengood gold placer district, east-central, Alaska: U.S. Geological Survey Circular 590, p. 18.

Koschmann, A. H., and Bergendahl, M. A., 1968, Principal gold producing districts of the United States: U.S. Geological Survey Professional Paper 610, p. 283.

Mertie, J. B., Jr., 1934, Mineral deposits of the Rampart and Hot Springs district, Alaska: U.S. Geological Survey Bulletin 844-D, p. 163.

Mertie, J. B., Jr., 1969, Economic geology of platinum metals: U.S. Geological Survey Professional Paper 630, p. 120.

Mosier, E. L., 1975, Use of emission spectroscopy for the semiquantitative analyses of trace elements and silver in native gold, in Ward, F. N., ed., New and refined methods of trace analysis useful in geochemical exploration: U.S. Geological Survey Bulletin 1408, p. 97-105.

Weber, F. R., Smith, T. E., Hall, M. H., and Forbes, Robert, 1985, Geologic guide to the Fairbanks-Livengood area, east-central Alaska, Alaska Geological Society, P.O. Box 101288, Anchorage, Alaska 95510, p. 44.

TABLE 2. Results of analyses of placer and lode gold samples from the Tolovana and Rampart mining districts, Livengood 1° x 3° quadrangle, Alaska

[Fineness = $\frac{Au}{Au + Ag}$ X 1000; X = sum of elements other than gold and silver;

% percent; Au-sw, sample weight in milligrams analyzed; 1-5, placer gold localities; A, lode gold locality; (--) element not detected; Elements Ga, Cd, Ir, Os, Ru, Rh, Sc, and Ta were not detected.

Site	Location	Sample	Pt	Pd	% Au	Fineness	Ag	Sum of X	Cu	Zn	Ga	Pb	As	Sb	Cd	Bi	Hg	Te	Ni
1	Amy Creek	3284QR	49.8	1.9920	41.7	999	0.0398	58.2	0.2988	--	--	.0029	--	--	--	--	0.0996	--	.0298
		3284	--	--	85.9	930	6.5	7.6	.0185	--	--	.0926	.0185	.0185	--	--	4.6296	--	.0093
		3284CA	--	--	86.3	902	9.4	4.3	.0188	--	--	.0376	--	.0038	--	--	3.7594	--	--
		3284CB	--	--	88.6	947	5.0	6.4	.0167	--	--	.1667	.0067	.0117	--	--	5.0000	--	.0033
		3284P	45.1263	.3610	41.3	884	5.4	53.3	.0271	--	--	.0903	.0181	.0090	--	--	5.4152	--	.0126
		3284QB	73.5294	2.0588	18.1	998	--	81.9	.2941	--	--	.0044	.0147	--	--	--	.0294	--	.0294
		3284FA	--	--	85.7	896	10.0	4.3	.0100	--	--	.0070	.0050	--	--	--	2.0000	--	.0050
		3284FB	--	--	91.5	928	7.1	1.3	.0204	--	--	.0305	--	--	--	--	.5092	--	.0031
		3284FC	--	--	93.0	935	6.5	.6	.0139	--	--	.0014	--	--	--	--	.2773	--	.0014
		3284MA	--	--	89.7	928	7.0	3.3	.0200	--	--	.0010	--	--	--	--	3.0000	--	.0010
		3284MB	--	--	86.0	906	9.0	5.0	.0627	.0090	--	.0896	--	.0018	--	.0002	4.4803	--	.0063
		3284MC	--	--	83.8	894	9.9	6.2	.0149	.0050	--	.0020	--	--	--	--	5.9642	--	.0010
		3284VA	--	--	85.4	899	9.6	5.0	.0144	--	--	.0029	--	--	--	--	4.7893	--	.0048
		3284VB	--	--	84.5	893	10.1	5.4	.0202	--	--	.0051	.0040	--	--	--	5.0607	--	.0030
		3284VC	--	--	86.8	897	10.0	3.2	.0200	--	--	.0150	--	--	--	.0002	3.0000	--	.0020
		3284YA	--	--	85.9	864	13.5	.6	.0270	--	--	.0040	--	--	--	--	.2695	--	.0020
		3284YB	--	--	88.0	888	11.1	.9	.0316	--	--	.0008	--	--	--	--	.4747	--	.0016
2	Livengood Creek	3229	2.1930	.0307	56.8	927	4.4	39.6	.0877	.0219	--	30.7018	--	.0219	--	.0658	4.3860	--	.1316
3	Ruth Creek	3257A	--	--	89.8	928	7.0	3.2	.0500	--	--	.0003	--	.0050	--	--	3.0000	--	.0020
		3257B	--	--	92.9	931	6.8	.3	.0146	--	--	.0049	.0293	--	--	--	.1953	--	--
		3257SA	--	--	92.0	929	7.0	1.0	.0700	--	--	.0002	--	--	--	--	.7000	--	.0005
		3257SB	.2778	.0037	85.0	868	13.0	2.0	.0926	--	--	.0278	.0093	--	--	--	1.2963	--	.0056
		3257VA	--	--	90.7	930	6.9	2.5	.0275	--	--	.0003	.2060	--	--	--	1.3736	--	.0014
		3257VB	--	--	80.7	871	11.9	7.4	.0238	--	--	.0005	--	--	--	--	7.1429	--	--
		3257F	--	--	79.7	799	20.0	.3	.0300	--	--	--	--	--	--	--	.1000	--	--

Site	Location	Sample	Pt	Pd	% Au	Fineness	Ag	Sum of %	Cu	Zn	Ga	Pb	As	Sb	Cd	Bi	Hg	Te	Ni
4	Wilber Creek	3231A	--	--	83.6	848	15.0	1.4	.0200	--	--	.0050	--	.0020	--	--	1.0000	--	--
		3231B	--	--	83.7	848	15.0	1.3	.0300	--	--	.0070	--	.0020	--	--	1.0000	--	--
		3231C	--	--	84.5	853	14.6	.9	.0291	--	--	.0019	--	--	--	--	.4854	--	.0019
		3231XA	--	--	81.6	829	16.9	1.5	.0169	--	--	.0225	--	--	--	.0006	.0562	--	.0056
		3231XB	--	--	82.7	837	16.1	1.1	.0538	--	--	.0538	--	--	--	--	.5376	--	.0022
		3231XC	--	--	84.5	852	14.6	.9	.0146	--	--	.0195	--	--	--	.0002	.4883	--	.0020
		3231RA	--	--	83.1	841	15.8	1.1	.0525	--	--	.0210	--	.0021	--	.0158	.5252	--	.0053
		3231RB	--	--	83.6	848	15.0	1.4	.0500	--	--	.0300	--	.0020	--	.0050	1.0000	--	--
		3231RC	--	--	83.7	848	15.0	1.3	.0500	--	--	.0100	--	.0030	--	.0015	1.0000	--	--
		3231SA	.1104	.0033	80.7	830	16.6	2.8	.0773	--	--	.0110	--	.0033	--	.0077	2.2076	--	.0017
		3231SB	--	--	80.0	835	15.8	4.2	.0737	--	--	1.0526	--	.0032	--	.0158	2.1053	--	.0211
5	Hunter Creek	3214A	--	--	95.8	970	3.0	1.2	.0700	--	--	.0050	--	--	--	--	.5000	--	.0005
		3214B	--	--	94.5	950	5.0	.5	.0500	--	--	.0015	--	--	--	.0003	.3000	--	.0007
		3214C	--	--	94.3	950	5.0	.7	.0500	--	--	.0010	--	--	--	--	.5000	--	--
		3214XA	--	--	95.6	971	2.8	1.6	.2825	--	--	.0019	--	--	--	--	.9416	--	.0008
		3214XB	--	--	90.0	910	8.9	1.1	.0178	--	--	.0013	--	.0018	--	--	.8929	--	.0004
		3214XC	--	--	93.9	951	4.8	1.3	.0145	--	--	.0029	--	--	--	.0002	.9671	--	.0005
		3214RA	--	--	83.8	923	7.0	9.2	1.0000	.0300	--	5.0000	.0040	.0100	--	.2000	.5000	.1500	.0100
		3214RB	--	--	80.8	890	10.0	9.2	.7000	.0300	--	5.0000	.0040	.0150	--	.0015	.5000	--	.0050
		3214RC	--	--	82.0	921	7.0	11.0	1.0000	.0500	--	5.0000	.0070	.0100	--	.0020	.5000	--	.0150
		3214SA	--	--	87.8	898	10.0	2.2	.0500	.0050	--	.7000	.0040	.0070	--	.0020	.5000	--	.0050
		3214SB	--	--	83.9	870	12.5	3.6	.2500	.0125	--	.6250	.0050	.0087	--	.0063	.6250	--	.0087
		3214SC	.0278	.0037	84.7	901	9.3	6.1	.5556	.0093	--	1.2963	--	.0093	--	.1852	.9259	.0926	.0130
		3214TA	.0500	--	91.0	929	7.0	2.0	.1500	.0100	--	.1500	.0050	.0150	--	.0020	.5000	--	.0038
		3214TB	1.0000	.0150	85.8	896	10.0	4.2	.5000	.0100	--	.5000	.0050	.0070	--	.0015	1.0000	--	.0070
		3214TC	.8178	.0234	87.8	915	8.2	4.0	.2336	.0058	--	.3505	.0082	.0117	--	.0012	1.1682	--	.0350
A	Old Smokey	3225A	--	--	87.4	895	10.3	2.3	.0103	--	--	.0021	.1029	--	--	--	.3086	--	.0103
		3225B	--	--	87.9	903	9.4	2.7	.0094	--	--	.0014	.1883	--	--	--	.4708	--	.0094
		3225C	--	--	86.3	896	10.0	3.7	.0070	--	--	.0030	.1000	--	--	--	.2000	--	.0100
		3225D	--	--	86.7	897	10.0	3.3	.0070	--	--	.0015	.1500	--	--	--	.2000	--	.0150
		3225XA	--	--	85.9	899	9.6	4.4	.0067	--	--	.0048	.1923	--	--	.0019	.1923	--	.0029
		3225XB	--	--	85.1	895	10.0	4.9	.0050	--	--	.0015	.2000	--	--	--	.5000	--	.0050
		3225XC	--	--	84.9	900	9.4	5.7	.0094	--	--	.0019	.4717	--	--	--	.1887	--	.0066
		3225XD	.0200	--	83.4	893	10.0	6.6	.0070	--	--	.0020	.3000	--	--	--	.5000	--	.0100

Table 2.--Continued

Site	Location	Sample	Co	Sn	Mo	Ge	Ba	Sr	Zr	V	Cr	Y	La	Sc	Nb	B	Ta	Be	W
1	Amy Creek	3284QA	.0039	.0139	--	--	--	--	.0009	--	--	--	--	--	--	--	--	--	--
		3284	--	.4630	--	--	.0005	--	--	--	.0014	--	--	--	--	--	--	--	--
		3284CA	--	.1880	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		3284CB	--	.8333	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		3284P	--	.2708	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.0181
		3284QB	--	.0088	--	--	--	--	.0012	--	--	--	--	--	--	--	--	--	--
		3284FA	--	--	--	--	.0015	--	--	--	.0015	--	--	--	--	--	--	--	--
		3284FB	--	.0051	--	--	.0010	--	--	--	.0102	--	--	--	--	--	--	--	--
		3284FC	--	--	--	--	.0005	--	--	--	--	--	--	--	--	--	--	--	--
		3284MA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		3284MB	--	.0045	--	--	.0006	--	--	--	.0009	--	--	--	--	--	--	--	--
		3284MC	--	--	--	--	.0010	--	--	--	.0015	--	--	--	--	--	--	--	--
		3284VA	.0014	--	--	--	.0004	--	--	--	--	--	--	--	--	--	--	--	--
		3284VB	.0010	--	--	--	.0006	--	--	--	--	--	--	--	--	--	--	.0001	--
		3284VC	--	.0005	--	--	.0020	--	--	--	--	--	--	--	--	--	--	--	--
		3284YA	--	--	--	--	.0007	--	--	--	--	--	--	--	--	--	--	--	--
		3284YB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	Livengood Creek	3229	.0219	.0877	--	--	.1316	--	--	--	.0088	--	--	--	--	.0022	--	--	.3070
3	Ruth Creek	3257A	--	--	--	--	.0005	--	--	--	--	--	--	--	--	--	--	--	--
		3257B	--	--	--	--	.0004	--	--	--	--	--	--	--	--	--	--	--	--
		3257SA	--	--	--	--	.0004	--	--	--	--	--	--	--	--	--	--	--	--
		3257SB	.0009	--	--	--	.0009	--	--	--	--	--	--	--	--	--	--	--	--
		3257VA	--	--	--	--	.0041	--	--	--	--	--	--	--	--	--	--	--	--
		3257VB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		3257F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site	Location	Sample	Co	Sn	Mo	Ge	Ba	Sr	Zr	V	Cr	Y	La	Sc	Nb	B	Ta	Be	W
4	Wilber Creek	3231A	--	--	--	--	--	--	--	--	--	--	--	--	--	.0082	--	--	--
		3231B	--	--	--	--	--	--	--	--	--	--	--	--	--	.0002	--	--	--
		3231C	--	--	--	--	--	--	--	--	--	--	--	--	--	.0001	--	--	--
		3231XA	--	--	--	--	.0022	--	--	.0011	.0011	--	--	--	--	.0003	--	--	--
		3231XB	--	--	--	--	--	--	--	--	--	--	--	--	--	.0082	--	--	--
		3231XC	--	--	--	--	--	--	--	--	--	--	--	--	--	.0001	--	--	--
		3231RA	--	--	--	--	.0007	--	--	--	--	--	--	--	--	.0002	--	--	.0185
		3231RB	--	--	--	--	--	--	--	--	--	--	--	--	--	.0002	--	--	--
		3231RC	--	--	--	--	--	--	--	--	--	--	--	--	--	.0002	--	--	--
		3231SA	--	--	--	--	--	--	--	--	--	--	--	--	--	.0002	--	--	.0055
		3231SB	.0011	--	--	--	.0007	--	--	--	.0016	--	--	--	.0011	.0001	--	--	.2105
5	Hunter Creek	3214A	--	--	--	--	.0010	--	.0004	--	--	--	--	--	--	--	--	--	--
		3214B	--	--	--	--	.0004	--	--	--	--	--	--	--	--	--	--	--	--
		3214C	--	--	--	--	.0010	--	--	--	--	--	--	--	--	--	--	--	--
		3214XA	--	--	--	--	.0007	--	--	--	--	--	--	--	--	--	--	--	--
		3214XB	--	--	--	--	.0004	--	--	--	--	--	--	--	--	--	--	--	--
		3214XC	--	--	--	--	.0019	--	--	--	--	--	--	--	--	--	--	--	--
		3214RA	.0005	.3000	--	--	.5000	--	.0005	.0500	.0010	.0007	.0200	--	--	--	--	--	--
		3214RB	.0007	1.5000	.0010	--	.0500	--	.0004	--	.0010	.0015	.0500	--	--	--	--	--	--
		3214RC	--	2.0000	--	--	.2000	--	.0300	.0500	.0009	--	--	--	--	--	--	--	.0070
		3214SA	.0005	.0050	--	--	.1000	--	.0030	--	--	--	--	--	--	--	--	--	--
		3214SB	--	.2500	--	--	.6250	--	--	--	--	--	--	--	--	--	--	--	--
		3214SC	--	.2778	--	--	.3704	--	--	--	--	--	--	--	--	--	--	--	--
		3214TA	.0005	.0200	.0007	--	.0200	--	.0150	--	.0009	.0005	.0030	--	--	--	--	--	--
		3214TB	.0010	.0200	--	--	.0200	--	.0200	--	.0015	.0005	.0030	--	--	--	--	--	--
		3214TC	.0006	.0584	--	--	.1752	--	.0058	--	.0058	.0006	.0058	--	--	.0004	--	--	--
A	Old Smokey	3225A	--	--	--	--	.0021	--	--	.0010	.0015	.0103	.2058	--	--	.0001	--	.0001	--
		3225B	.0005	--	--	--	.0094	--	.0066	.0009	.0019	.0471	.4708	--	--	.0002	--	.0001	.0038
		3225C	.0005	.0010	--	--	.0500	--	.0010	.0050	.0300	.0500	1.0000	--	--	.0003	--	.0001	.0070
		3225D	.0005	.0005	--	--	.0100	--	.0100	.0050	.0100	.1000	1.0000	--	--	.0003	--	.0001	.0040
		3225XA	--	--	--	--	.0029	.0096	.0007	.0010	.0019	.0014	.0048	--	--	--	--	--	--
		3225XB	--	--	--	.001	.0300	.0200	.0005	.0010	.0020	--	--	--	--	.0010	--	--	--
		3225XC	--	--	--	--	.0189	.0189	.0009	.0014	.0028	--	.0019	--	--	.0009	--	.0001	.0094
		3225XD	.0007	--	--	--	.0100	.0100	.0020	.0030	.1500	.0020	.0200	--	--	.0085	--	.0001	--

Table 2.--Continued

Site	Location	Sample	Mn	Fe	Mg	Ca	Ti	Si	Au-Sw
1	Amy Creek	3284QA	.0002	5.9760	.0039	.0019	--	0.0039	2.51
		3284	.0019	.9259	.0278	.0139	.0019	1.3889	5.40
		3284CA	.0003	.0376	.0094	.0094	.0019	.1880	2.66
		3284CB	.0008	.1167	.0167	.0117	.0033	.2500	3.00
		3284P	.0005	1.8051	.0361	.0181	.0181	.0903	2.77
		3284QB	.0003	5.8824	.0059	.0059	.0025	.0059	1.70
		3284FA	.0020	.2000	.0300	.0150	.0030	2.0000	5.00
		3284FB	.0015	.2037	.0204	.0071	.0071	.5092	4.91
		3284FC	.0006	.0647	.0139	.0046	.0014	.1848	5.41
		3284MA	.0003	.0500	.0100	.0050	.0015	.2000	5.00
		3284MB	.0009	.1792	.0134	.0090	.0009	.1792	5.58
		3284MC	.0007	.0298	.0099	.0070	.0099	.1988	5.03
		3284VA	.0007	.0479	.0144	.0048	.0048	.1437	5.22
		3284VB	.0007	.0506	.0101	.0152	.0015	.2024	4.94
		3284VC	.0005	.0500	.0100	.0050	.0009	.1000	5.00
		3284YA	.0004	.0404	.0202	.0067	.0027	.2695	3.71
		3284YB	.0005	.0316	.0158	.0032	.0016	.3165	3.16
2	Livengood Creek	3229	.0088	.8772	.0307	.0132	.0439	.4386	1.14
3	Ruth Creek	3257A	.0001	.0200	.0150	.0050	--	.1000	5.00
		3257B	.0001	.0146	.0010	.0020	--	.0195	5.12
		32575A	.0003	.1000	.0050	.0030	--	.1500	5.00
		32575B	.0003	.1296	.0093	.0056	.0019	.1852	2.70
		3257VA	.0007	.4121	.0096	.0041	.0012	.4121	3.64
		3257VB	.0004	.0714	.0071	.0048	--	.1190	2.10
		3257F	--	.1000	.0050	.0200	--	.0500	.50

Site	Location	Sample	Mn	Fe	Mg	Ca	Ti	Si	Au-Sw
4	Wilber Creek	3231A	.0010	.1000	.0200	.0030	.0010	.2000	5.00
		3231B	.0007	.0700	.0150	.0020	.0010	.2000	5.00
		3231C	.0010	.1942	.0097	.0029	.0049	.1942	5.15
		3231XA	.0034	.5618	.0562	.0112	.0169	.7865	4.45
		3231XB	.0016	.3226	.0108	.0032	.0016	.1613	4.65
		3231XC	.0020	.1953	.0146	.0020	.0029	.1465	5.12
		3231RA	.0315	.3151	.0158	.0053	.0032	.1050	4.76
		3231RB	.0150	.1500	.0150	.0020	.0050	.1500	5.00
		3231RC	.0010	.1000	.0100	.0050	.0020	.1500	5.00
		3231SA	.0011	.2208	.0110	.0022	.0009	.1104	4.53
		3231SB	.0526	.5263	.0158	.0053	.0021	.1579	4.75
5	Hunter Creek	3214A	.0015	.3000	.0150	.0050	.0050	.3000	5.00
		3214B	.0007	.0700	.0050	.0020	.0010	.1000	5.00
		3214C	.0005	.0700	.0100	.0020	.0020	.1000	5.00
		3214XA	.0014	.1883	.0141	.0028	.0028	.1883	5.31
		3214XB	.0009	.0893	.0045	.0018	--	.0893	5.60
		3214XC	.0010	.1451	.0068	.0029	.0048	.1451	5.17
		3214RA	.0150	1.0000	.0300	.0150	.1000	.3000	5.00
		3214RB	.0050	.7000	.0300	.0150	.0700	.5000	5.00
		3214RC	.0100	1.5000	.0500	.0150	.0500	.5000	5.00
		3214SA	.0020	.5000	.0200	.0050	.0200	.3000	5.00
		3214SB	.0188	.6250	.0375	.0375	.0625	.3750	4.00
		3214SC	.0093	1.8519	.0370	.0093	.1296	.2778	2.70
		3214TA	.0050	.7000	.0200	.0100	.0200	.3000	5.00
		3214TB	.0050	.7000	.0200	.0100	.0100	.3000	5.00
		3214TC	.0082	.8178	.0234	.0117	.0350	.2336	4.28
A	Old Smokey	3225A	.0010	1.0288	.0309	.0103	.0514	.5144	4.86
		3225B	.0007	.6591	.0282	.0094	.0942	.6591	5.31
		3225C	.0050	1.0000	.0500	.0300	.7000	.5000	5.00
		3225D	.0020	.7000	.0500	.0200	.5000	.5000	5.00
		3225XA	.0019	1.9231	.0962	.0144	.0673	1.9231	5.20
		3225XB	.0050	2.0000	.0700	.0300	.0500	2.0000	5.00
		3225XC	.0047	2.8302	.0943	.0472	.0660	1.8868	5.30
		3225XD	.0070	3.0000	.1500	.2000	.2000	2.0000	5.00