STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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Report of Investigations 84-1
GEOLOGY OF THE OLD SMOKY PROSPECT, LIVENGOOD C-4 QUADRANGLE, ALASKA

By
G.L. Allegro

STATE OF ALASKA
Department of Natural Resources
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GEOLOGY OF THE OLD SMOKY PROSPECT, LIVENGOOD C-3 QUADRANGLE, ALASKA

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ABSTRACT

Gold-antimony mineralization at the Old Smoky prospect on Money Knob near Livengood, Alaska, occurs in contact zones between Devonian sedimentary rocks and an intrusive suite consisting of biotite monzonite, feldspar porphyry, and felsic dikes. Post-intrusive hydrothermal alteration of the igneous and sedimentary rocks includes replacement by quartz, sericite, rutilated quartz and plagioclase, and epidote ± sericite. Supergene sericite, clay, and iron oxides have overprinted the earlier hydrothermal events. Gold, arsenopyrite, and stibnite mineralization was contemporaneous with the hydrothermal alteration. Areas of intense alteration are often localized along shear zones.

INTRODUCTION

The Old Smoky prospect is located on Money Knob near the headwaters of Olive Creek in the Livengood C-4 Quadrangle, 3 km southeast of Livengood, Alaska (fig. 1). Access to the property is by a mining road off Mile 79 of the Elliot Highway. The prospect was examined as part of a mineral-evaluation program of the Livengood area conducted by the Alaska Division of Geological and Geophysical Surveys (DGGS) during June and July, 1982. The author spent 5 days mapping and sampling the Old Smoky prospect by brunton and tape traverse at a scale of 1 in. = 10 ft. Field investigations were augmented with thin-section and stained cut-slab examination in the laboratory.

Cobalt, chromium, iron, manganese, nickel, cadmium, copper, and zinc analyses were performed at the DGGS laboratory by inductively coupled plasma atomic-emission spectrophotometry using aqua-regia digestions. Lead, gold, silver, molybdenum, and antimony analyses by atomic-absorption spectrophotometry using aqua-regia digests were also completed at the DGGS laboratory. Tin, tungsten, and mercury were analyzed by Bondar-Clegg and Company, Ltd., Vancouver, B.C., where tungsten was analyzed by colorimetry, mercury by cold-vapor atomic-absorption spectrophotometry, and tin by x-ray fluorescence.

ACKNOWLEDGMENTS

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REGIONAL GEOLOGY

Regional geologic mapping of the Livengood C-3 (Smith, 1983), B-4 (Albanese, 1983), B-3 (Bundtzen, 1983), and C-4 (Robinson, 1983) Quadrangles

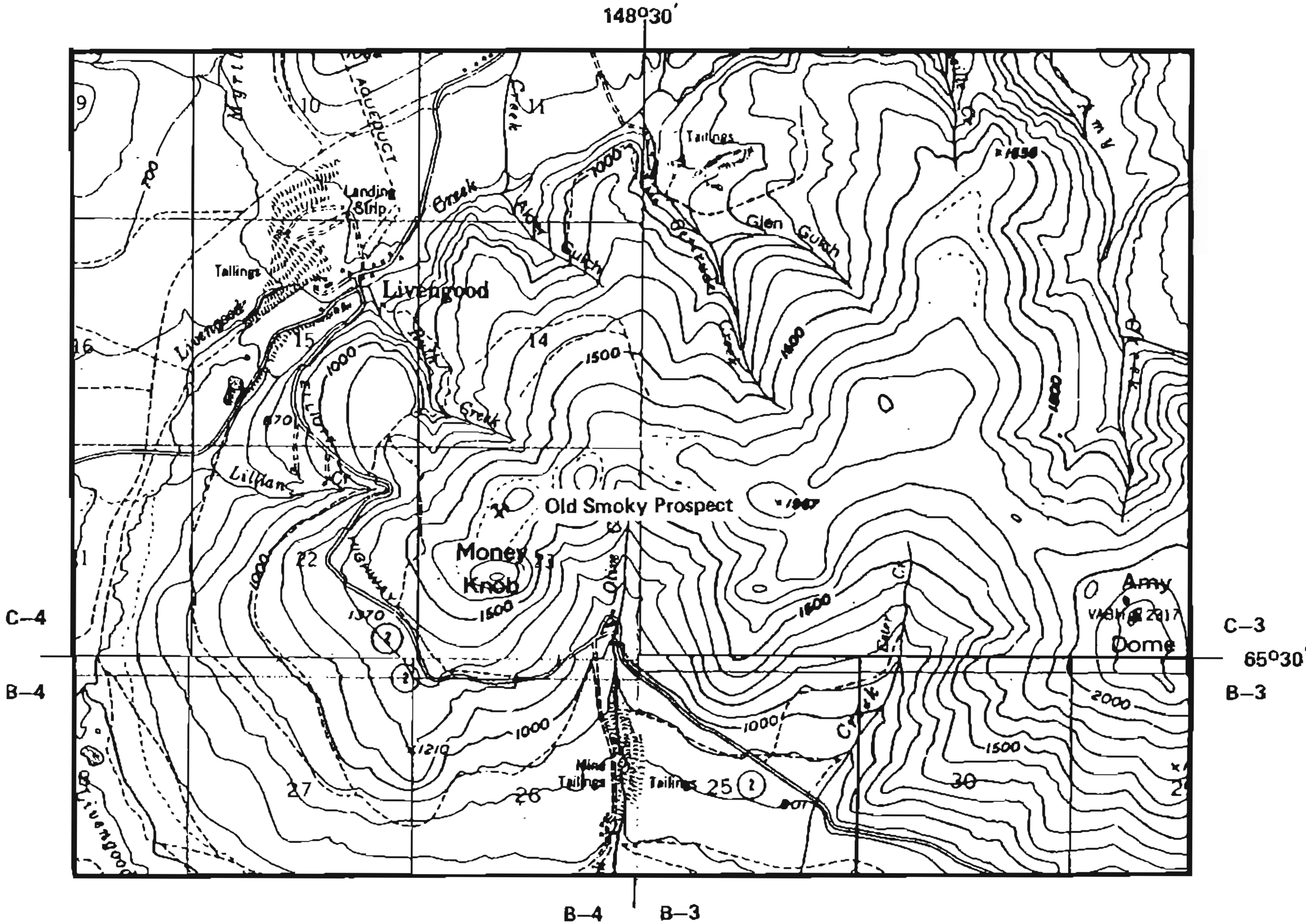

Figure 1. Location of Old Smoky prospect. Base enlarged from U.S. Geological Survey Livengood B-3, B-4, C-3, C-4 1:63,360 Quadrangles.

was completed in 1982. Stratified rocks range from Cambrian(?) or upper Precambrian to Cretaceous in age. The oldest rock units, found mainly south of Livengood, are northeast-trending, interlayered sequences of maroon and green argillite, black shale and limestone, bimodal quartz sandstone (grit), vitreous quartzite, and gabbro of Cambrian, late Precambrian or Ordovician age (Chapman and others, 1971). Northwest of this unit is a broad belt of Jurassic to Cretaceous flysch. A probable unconformity or faulted unconformity separates the Mesozoic flysch unit from underlying units including a Devonian clastic sequence composed of conglomerate, sandstone, shale, siltstones, chert, intermediate volcanic flows, and siliceous dolomite; this Devonian sequence is host to mineralization at the Old Smoky prospect. Fossils collected near the Old Smoky prospect are Middle Devonian in age and appear to represent a near-shore subtidal or intertidal(?) environment (R.B. Blodgett, personal commun., 1982). A mafic igneous complex apparently intrudes the Devonian clastic sequence. The Devonian terrane is bordered on the north, possibly across a structural contact (reverse or thrust fault), by an early Paleozoic chert terrane composed primarily of chert and minor basalt and limestone (Smith, 1983; Robinson, 1983). The chert terrane appears to grade upward into a unit of chert and Paleozoic clastics. Mafic volcanic and intrusive rocks of the Rampart Group border the Paleozoic chert and clastic rocks on the north. The structure of most bedrock units in the Livengood area is complex and characterized by intense folding and structural imbrication.

GEOLOGY OF THE OLD SMOKY PROSPECT

Open cuts at the Old Smoky prospect expose Devonian sedimentary rocks composed primarily of shale, argillite, fine-grained sandstone, and pebbly conglomerate (ss, arg, lsh). Hypabyssal igneous rocks (bmz, fp, fd) intrude the sedimentary rocks with narrow zones of thermal metamorphism occurring along the contacts. The contacts between the sedimentary rocks and intrusives are often sheared. The intrusive rocks are probably late Cretaceous to earliest Tertiary in age based on six radiometric age dates from felsic intrusives throughout the Livengood Quadrangle. The samples yielded potassium-argon ages ranging from 58.0 to 88.8 m.y. (Turner and others, 1975).

The igneous rocks include at least two intrusive phases. The most mafic phase is an equigranular, quartz-bearing, K-feldspar dominant biotite monzonite (bmz) composed of K-feldspar, plagioclase, biotite, augite, quartz, opaque minerals, and trace zircon, apatite, and sphene. This intrusive phase contains localized gradations into biotite syenite. A late-stage hydrous phase in the biotite syenite is implied by the presence of miarolitic cavities in feldspar segregations. A hypabyssal emplacement history involving deformation prior to final solidification is shown by medium-grained biotite and pyroxene crystals that are often bent, broken, and surrounded by a finer-grained groundmass of plagioclase laths and K-feldspar. Abundant xenolithic mafic clots composed primarily of biotite, pyroxene, and opaque minerals are also present.

A feldspar porphyry intrusive phase (fp) occurs within the biotite monzonite in the southern section of the open cut and adjacent to biotite monzonite in the northern section. Both sharp and gradational contacts between the two phases were noted in the exposed section. The feldspar porphyry is characterized by 15 to 25 percent large euhedral K-feldspar phenocrysts in a fine-grained groundmass of K-feldspar, plagioclase laths, quartz, biotite, pyroxene, opaque, and sphene. The proportion of groundmass K-feldspar to plagioclase ranges from 1:1 to 2:1. In the northern section, the feldspar porphyry grades into a fine-grained felsic phase devoid of phenocrysts.

Several felsic dikes and sills (fd) 3 cm to 2 m wide intrude the sedimentary rocks, often along bedding planes. The dikes are composed of K-feldspar and plagioclase laths with minor biotite and variable amounts of interstitial quartz. Contacts of the felsic dikes are often sheared.

ALTERATION

Most of the intrusive rocks and some of the sedimentary host rocks have experienced variable degrees of metasomatic hydrothermal alteration followed by lower temperature supergene alteration. Petrographic examination was used to evaluate rock type, mineral identification, and type of alteration experienced. Confirmation of mineral phases by X-ray methods was not attempted in this study. Criteria used to define hydrothermal alteration were non-isochemical mineral replacement, total destruction of original texture, presence of associated minerals forming a commonly repeated mineral assemblage, abundant veining, and relatively large grain size of the replacement phase. Four types of hydrothermal alteration resulted in massive replacement by: 1) quartz (silification), as partial to complete replacement by a dense network of quartz veinlets generally localized along contacts between the intrusive and sedimentary rocks; 2) hypogene sericite (sericitization) as fine- to medium-grained white mica in selvages along quartz veins, anastomosing sericite-opaque mineral veinlets, and patchy to massive sericitic replacement of feldspar, ferromagnesium minerals, and quartz; 3) deposition of trigonal nets of needle-like rutile often associated with secondary quartz and minor feldspar; and 4) epidote ± sericite as a replacement of calcic plagioclase and ferromagnesian minerals resulting in massive aggregates, pseudomorphs, veins, and vug fillings of epidote commonly associated with sericite, opaque minerals, and quartz.

Later supergene alteration has overprinted the earlier hydrothermal events. Low temperature supergene alteration can be distinguished from hydrothermal alteration by isochemical replacement, selective replacement that maintains original texture, lack of associated mineral phases such as quartz, alunite, and stable pyrite with the clay minerals, lack of vein control, and very fine grain size. Preferential replacement of the remaining ferromagnesium minerals, plagioclase and hypogene sericite by clay minerals is pervasive in many areas. Very fine-grained sericite preferentially replaces plagioclase and some K-feldspar as a fine dusting. Abundant iron oxide is found in many zones and may be the result of oxidation and leaching of overlying sulfide-bearing rocks, now removed by erosion. Granular saprolite with relict igneous textures commonly occurs in the intrusive rocks, particularly near shear zones in the biotite monzonite.

Biotite monzonite

Within fresh biotite monzonite, hydrothermal alteration has resulted in destruction of less than 10 percent of the primary minerals. Alteration consists mainly of secondary calcite occurring as replacement rims on pyroxene and biotite, with lesser amounts of epidote, hypogene sericite, and opaque minerals. Supergene sericite and clay minerals are present in variable degree. In most other areas, saprolitic weathering totally obscures earlier alteration.

Feldspar porphyry

All of the feldspar porphyry rocks examined have experienced intense hydrothermal alteration. In the groundmass, some samples contain up to 20 percent epidote, 5 percent sericite, and 1 percent rutile needles. Formation of rutilated quartz and some rutilated plagioclase seems to be an early alteration event and is limited to the feldspar porphyry, feldspar dikes, and a highly silicified zone at the contact of the biotite monzonite with sandstone. Epidote with sericite is the most common alteration and results in the formation of pseudomorphs of plagioclase, sphene, biotite, and pyroxene(?) by epidote, opaque minerals, sericite, and rutile. Epidote veinlets and quartz veins containing epidote and later iron oxides are common. Sericite veinlets containing local epidote and opaque minerals are present. In some samples of feldspar porphyry, supergene iron oxides account for as much as 60 percent of the rock. Clay alteration is also locally quite extensive. Although the groundmass of the feldspar porphyry was very susceptible to hydrothermal alteration, phenocrysts were relatively unaffected by this event, only the centers of the phenocrysts show abundant later sericitic and clay supergene alteration.

Felsic dikes

Alteration of some of the feldspar dikes is very similar to that seen in the feldspar porphyry.

Roof pendant

In the northern portion of the cut, a sequence of pebbly conglomerate and fine-grained sandstone forms a pendant in the feldspar porphyry. Hydrothermal fluids moving along the contact between the sedimentary rocks and the intrusive were apparently responsible for the near complete alteration of the sandstone and felsic intrusive. Samples from this area show large remnant quartz grains encased in a matrix of network veinlets of smaller bimodal quartz which is in turn surrounded by a very fine-grained quartz groundmass. Silicification was followed by the formation of many anastomosing sericite-opaque mineral veinlets composing up to 40 percent of the rock. Some epidote within quartz veins and sericite selvages on quartz veins also occur in this zone.

MINERALIZATION

Foster (1968) described the mineralization at the Old Smoky prospect as "narrow, northwestward-trending auriferous arsenopyrite-quartz veins" with samples from the veins containing 3 to 13 ppm gold. The prospect was also considered to be an antimony prospect at one time. Several barrels of stibnite were recovered and shipped out in 1969-1970 (unconfirmed) from the northern trench (T.K. Bundtzen, personal commun., 1984). Our investigations and sample data reveal the mineralization in the southern portion of the cut to be localized along the contact zones between the biotite monzonite and the surrounding sedimentary rocks and along a contact between biotite monzonite and feldspar porphyry. These contacts are commonly sheared and have apparently acted as conduits for mineralizing fluids. Channel and chip samples of arsenopyrite-stibnite quartz veins from these zones contained 1.0 to 29.8 ppm gold. Adjacent to the sheared contact zone, the intrusive rocks are either highly silicified with abundant rutile and some epidote, sericite, arsenopyrite, and minor stibnite, or contain epidote with sericite, rutilated quartz, and arsenopyrite. Other rocks from the contact zone show intense supergene effects such as clay alteration that obscures previous textures, deposition of covellite as disseminated grains and as rims on eroded arsenopyrite, and high concentrations of iron oxides. In some cases, these zones also contain gold. Green scorodite is present throughout the mineralized areas.

In the northern section of the cut, the most abundant mineralization is located along the contact area between the feldspar porphyry and a roof pendant of sandstone and shale. A sharp contact between the feldspar porphyry and sandstone was found in only one locality. Elsewhere, intensive silicification and sericitization of both feldspar porphyry and sandstone has totally obscured contact relationships. Along the contact, early silicification with associated pyrite was followed by the formation of dense anastomosing sericite and sericite-opaque mineral veinlets. This was followed by minor epidote, rutile, and iron oxides in quartz veins. Hand samples from this area have a chalky white to yellow cast due to the presence of stibiconite and sericite. A massive 1 m wide stibnite lens surrounded by a bleached sericite zone occurs along the northern contact of the roof pendant. Channel samples along this contact zone range from 0.5 to 4.3 ppm gold. Two grab samples of quartz veins in this area were also taken, one of which contained 2.9 ppm gold. Thus, gold mineralization in this area appears to be associated with the silicification and sericitization event and also with the later cross-cutting quartz veins.

Some gold mineralization is also associated with saprolitic zones in all the intrusive phases but these zones are not limited to shear zones or contacts. This mineralization was presumably introduced by migration of early hydrothermal fluids along fractures and joint planes, but textural features and alteration documenting this has since been obscured by weathering.

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Table 1. Rock sample analyses, Old Smoky Prospect, Livengood C-4 Quadrangle, Alaska.
(Hg in ppb; all other elements in ppm unless otherwise noted.)

Sample	Cu	Pb	Zn	Au	Ag	Mo	Sb	Sn	W	Hg	Co	Ni	Fe (%)	Mn	Cr	Sample type[a]	Description
0283	102	31	72	0.2	0.8	8	-	5	3	-	10	50	5.18	65	146	5-ft CC	Stibnite and arsenopyrite vein
0284	37	69	51	0.2	1.0	11	-	5	3	-	10	51	4.54	31	153	3-ft CC	Near silicified siltstone-intrusive contact
0285	28	14	39	0.1	0.3	8	-	5	5	-	10	54	4.91	31	178	4-ft CC	Siltstone-intrusive contact
0286	19	105	38	0.4	0.7	2	-	5	4	-	10	51	5.54	63	144	5-ft CC	Clay altered yellow stained intrusive
0287	18	116	68	0.1	0.5	2	-	5	30	-	10	50	6.42	90	118	5-ft CC	Iron stained porphyritic intrusive
0288	22	13	36	0.1	0.2	9	-	5	12	-	10	55	5.08	33	174	1-ft CC	Clay altered zone
0289	26	16	41	0.1	0.2	7	-	5	3	-	10	53	3.35	85	195	4-ft CC	Clay altered zone
0290	33	16	36	1.0	0.5	6	-	5	35	-	10	61	8.05	41	144	3-ft CC	Shear zone at intrusive - siltstone contact
0291	44	8	54	29.8	4.8	4	-	5	31	-	10	65	1.17	78	179	1-ft CC	Shear zone at intrusive - siltstone contact
0292	93	17	56	5.0	0.9	8	-	5	83	-	10	52	7.82	141	185	5-ft CC	Yellow and orange clay alteration zone
0293	36	39	80	0.1	0.4	9	-	5	25	-	10	54	4.71	75	245	5-ft CC	Yellow and orange clay alteration zone
0294	30	64	76	0.1	0.6	13	-	5	6	-	10	51	3.81	74	220	5-ft CC	Alteration zone near intrusive contact
0295	40	30	71	0.1	0.2	9	-	5	5	-	10	53	5.36	105	219	CC	Vertical altered zone
0296	16	12	19	0.7	0.2	13	-	5	3	-	10	51	3.77	37	154	10-ft CC	Altered intrusive
0297	15	7	16	0.1	0.2	3	-	5	4	-	10	54	2.29	36	233	5-ft CC	Intrusive
0298	186	45	33	0.8	0.7	3	-	5	3	-	14	48	6.67	100	126	1-ft CC	Altered intrusive contact
0299	29	23	57	0.1	0.1	7	-	5	8	-	10	51	4.60	120	163	1-ft CC	Vertical altered zone above intrusive contact
0300	13	8	5	0.4	0.2	3	-	5	2	-	10	50	2.22	10	183	4-ft CC	Feldspathic quartzite to quartzite
0301	17	5	11	0.2	0.2	3	-	5	2	-	10	63	2.43	31	186	1-ft CC	Quartz vein in sandstone
0302	30	19	35	0.3	0.6	3	-	5	3	-	10	54	5.30	173	104	5-ft CC	Felsic sill
0303	29	25	46	0.1	0.4	1	16	5	4	-	10	13	4.55	82	25	1-ft CC	Felsic sill in shale
0304	16	7	27	0.1	0.2	3	11	5	3	-	10	22	2.22	85	129	1-ft CC	Quartz vein in shale

Sample	Cu	Pb	Zn	Au	Ag	Mo	Sb	Sn	W	Hg	Co	Ni	Fe (%)	Mn	Cr	Sample type[a]	Description
0305	25	6	32	0.1	0.1	10	5	5	3	-	10	16	4.37	36	139	1-ft CC	Quartz vein
0306	18	12	16	0.8	0.4	7	10	5	3	-	10	10	3.13	34	69	3-ft CC	Feldspathic quartzite
0307	22	7	28	0.1	0.1	3	3	5	2	-	10	18	3.82	48	91	3-ft CC	Clay altered zone
0308	10	6	14	0.1	0.1	1	5	5	2	-	10	11	1.87	17	80	2-ft CC	White feldspathic sandstone
0309	13	3	10	0.1	0.1	2	3	5	3	-	10	10	1.06	15	144	2-ft CC	Interbedded quartzite and feldspathic sandstone
0328	13	7	24	0.1	0.1	2	2	5	4	-	10	12	4.07	27	116	1-ft CC	Quartz vein in felsic
0329	28	26	41	0.1	0.1	3	20	5	14	-	10	10	4.68	32	66	2-ft CC	Yellow and orange altered zone below soil
0330	41	37	82	4.4	0.5	6	5	5	8	-	10	32	3.88	216	117	3-ft CC	Yellow and orange altered zone
0331	19	27	37	0.1	0.1	6	12	5	11	-	10	10	1.28	19	23	4-ft CC	Yellow and orange altered zone
0332	25	25	58	0.1	0.1	5	7	5	3	-	10	21	3.22	44	68	1-ft CC	Vertical white altered zone in intrusive
0333	32	7	41	0.1	0.1	6	1	5	4	-	10	22	3.47	43	85	7-ft CC	Iron-stained sandstone and siltstone
0334	14	10	5	0.8	0.4	3	230	5	3	-	10	10	1.27	10	92	4-ft CC	Green-stained sandstone
0335	6	7	5	0.1	0.2	3	120	5	4	-	10	10	1.10	10	115	2-ft CC	Iron-stained sandstone
0336	77	16	9	1.7	0.2	5	4.9	5	4	-	10	16	1.82	10	112	4-ft CC	Altered intrusive
0337	100	11	34	4.3	0.4	1	31.9	5	5	-	10	37	1.63	47	45	3-ft CC	Altered intrusive
0338	5	9	5	0.8	0.4	1	203	5	3	-	10	10	1.20	10	119	6-ft CC	Clay altered silicified hornfels/intrusive
0339	5	5	5	0.5	0.2	4	296	5	4	-	10	10	1.20	10	81	5-ft CC	Clay altered silicified hornfels/intrusive
0340	6	27	5	2.0	0.3	5	1475	5	3	-	10	10	1.22	10	82	5-ft CC	Clay altered silicified hornfels/intrusive
0341	20	9	8	1.5	0.8	4	7	3	-	-	10	11	2.13	10	155	5-ft CC	Altered felsic intrusive
0342	74	118	56	1.9	0.6	4	-	3	-	-	22	51	2.50	36	103	5-ft CC	Altered felsic intrusive
0343	18	73	11	1.4	0.4	3	5	3	-	-	10	10	2.62	10	99	6-ft CC	Highly altered intrusive
0344	16	32	5	0.3	0.2	5	5	4	-	-	10	10	3.18	10	58	3-ft CC	Altered intrusive
0345	41	45	62	0.1	0.1	5	5	4	-	-	10	10	4.83	35	94	3-ft CC	Altered zone
0346	36	26	107	0.1	0.1	6	5	3	-	-	10	19	4.09	171	129	5-ft CC	Clay altered intrusive
0347	43	23	105	0.1	0.1	7	5	3	-	-	10	15	4.71	167	121	3-ft CC	Altered zone with iron staining along fractures
0348	42	22	97	0.1	0.1	7	5	3	-	-	10	22	3.93	277	140	5-ft CC	Altered biotite monzonite
0349	24	27	41	2.8	0.3	5	5	26	-	-	10	11	3.83	45	104	4-ft CC	Altered zone

Sample	Cu	Pb	Zn	Au	Ag	Mo	Sb	Sn	W	Hg	Co	Ni	Fe (%)	Mn	Cr	Sample type[a]	Description
2128	115	10	121	0.1	0.1	-	-	-	-	135	19	51	9.61	140	100	25-ft CC	Iron and clay alteration in vein within siltstone
2129	33	6	120	0.1	0.2	4	-	-	3	5	10	26	287	16	67	GS	Altered siltstone
2130	96	84	179	0.1	0.4	4	-	-	3	5	10	13	7.31	315	48	8-ft CC	Clay alteration in intrusive
2131	60	99	75	0.1	0.5	6	-	-	3	5	10	10	4.80	74	71	8-ft CC	Clay alteration
2132	46	74	69	0.1	0.7	3	-	-	4	5	10	10	3.97	25	70	8-ft CC	Clay alteration
2133	63	40	134	0.1	0.5	1	-	-	33	5	10	12	6.25	88	51	2-ft CC	Iron altered zone
2134	104	31	58	3.7	0.8	9	-	-	6	5	10	10	9.35	159	76	CC	Arsenopyrite in quartz vein in shear zone
2135	25	35	46	0.1	0.3	19	-	-	4	4	10	10	3.42	31	197	10-ft CS	Quartz vein
2136	19	9	26	0.2	0.3	5	-	-	6	5	10	21	3.82	70	160	5-ft CS	Quartz vein in argillite above intrusive
2138	38	9	71	0.1	0.2	3	-	-	3	5	10	33	4.51	162	196	CC	Quartz vein in shale
2139	73	6	5	2.9	0.5	17	-	-	3	5	10	14	2.17	10	203	GS	Quartz vein in sandstone
2140	9	17	6	0.3	0.2	5	-	-	4	5	10	10	1.48	10	199	GS	Quartz vein in altered zone
2141	24	24	33	0.2	0.1	9	-	-	22	5	10	10	3.38	17	79	GS	White altered zone with quartz veins

[a]CC - chip channel, showing channel length.
CS - channel sample, showing channel length.
GB - grab sample.
Cd analysed but not detected.
Cu, Pb, Zn, Au, Ag, Mo, Sb, Co, Ni, Fe, Mn, Cd, Cr analysed by DGGS lab, 1982 by M.A. Wiltse, D.R. Stein, N.C. Veach, M.R. Ashwell, T.A. Benjamin, M.K. Polly, W.W. Wickens, J.N. Drahos, G.R. Crotty, R.P. Erickson, and J.F. Spielman.
Sn, W, Hg analysed by Bondar-Clegg, Ltd, Vancouver, B.C.