USE OF HEAVY MINERALS IN EXPLORATION FOR SAPPHIRES, EMPRESS Cu-Au-Mo DEPOSIT, BRITISH COLUMBIA

G.J. Simandl, B.C. Geological Survey, P. Jones, Carleton University, J.W., Osborne, Westpine Metals Ltd., G. Payie, B.C. Geological Survey and J. McLeod, Cominco Ltd. Laboratory

KEYWORDS: Corundum, sapphire, heavy minerals, gold, base metals, exploration methodology.

INTRODUCTION

One of the most commonly used exploration methods in regional reconnaissance is the sampling of stream sediments. In most cases, stream sediment anomalies are due to mechanical dispersion of metallic or indicator minerals, and to a lesser extent, to transport of metals in solution followed by their precipitation or adsorption on iron oxides and hydroxides, clay particles or organic material. Stream sediment anomalies are generally restricted in extent and decrease rapidly down stream due to dilution by sterile sedimentary particles (Wilhelm and Artignan, 1988). In northern environments, heavy mineral sampling amplifies anomalies that could have been missed using stream sediments. Heavy mineral surveys have become an important component in exploration for base-metals, niobium, tantalum, gold, tin (Fletcher and Loh, 1996), barite, chromite, platinum group elements (Salpeteur and Jezequel, 1992), kimberlite pipes (Fipke, 1989 and Schulze, 1994) and other mineral commodities. This paper describes a heavy-mineral survey over the Empress, a copper-gold-molybdenum porphyry deposit located 225 kilometres north of Vancouver and 50 kilometres northwest of Goldbridge and the Bralorne mining camp (Figure 1). The primary objective of the survey was to determine if corundum mineralization described by Simandl *et al.* (1997) could be detected. A secondary objective was to test for the signature of the porphyry copper-molybdenum-gold deposit described by Osborne and Allen (1995).

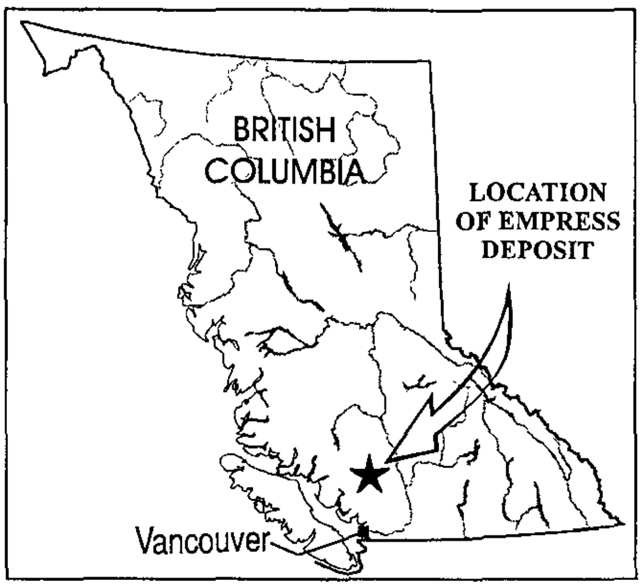

Figure 1. Location of the Empress Cu-Au-Mo deposit with an associated corundum occurrence.

Corundum is an alumina-rich mineral (Al_2O_3) that may be of variable color due to substitution of metal ions for Al^{3+}. It is usually gray, blue-gray, brown, yellow, green or colorless. Its gemstones are known by their colors, red for ruby and blue for sapphire. The red colour is linked to Cr^{3+} content, while blue and green corundum have significant contents of Ti^{4+}, Fe^{3+} and Fe^{2+} and in some cases V^{5+}, Co^{2+} or Ni^{2+} (Phillips and Griffen, 1981). Gem-quality corundum was documented in variety of geological settings and lithologies such as dikes and lava flows or intrusive rocks of alkaline affinity; strongly metamorphosed, alumina-rich sediments; partially melted gneisses; desilicated dikes of pegmatitic affinity in contact with marbles and ultramafic rocks (Simandl and Hancock, 1997). Most corundum gemstones are produced from placer or residual deposits derived by weathering and reworking of primary corundum-bearing rocks.

In the Empress deposit area, corundum, in association with andalusite-pyrophyllite rock, was reported in several drill holes (Lambert, 1989, 1991a and b) located south of Taseko River and east of Granite Creek (Figure 4a). A float boulder measuring approximately 15 centimetres in diametre containing coarse corundum was found in a nearby trench in 1990. New concentrations of angular and friable boulders, containing from trace to 1% of coarse corundum (greater than 3 millimetres), were found nearby during our visit to the property in 1996. Because the Empress property is largely overburden covered, the bedrock corundum potential is difficult to assess. However, the overburden contains corundum and should also be assessed as a potential source of sapphire.

A number of corundum occurrences associated with porphyry-type deposits are reported in the literature (Gustafson and Hunt, 1975; Lowder and Dow, 1978; Brimhal, 1977, Wojdak and Sinclair, 1984, and Price, 1986). In most cases, the corundum is either very fine grained or not described in detail. Except for recent studies by Simandl *et al.* (1997), the potential for gem-corundum mineralization in porphyry-type deposits has not been described.

GEOLOGICAL SETTING

The Empress deposit is located near the eastern margin of the Coast Plutonic Complex in rocks of the Tyaughton basin. The regional geology of the area has been described by Tipper (1978), Glover *et al.* (1986), McLaren and Rouse (1989) and Schiariazza *et al.* (1997).

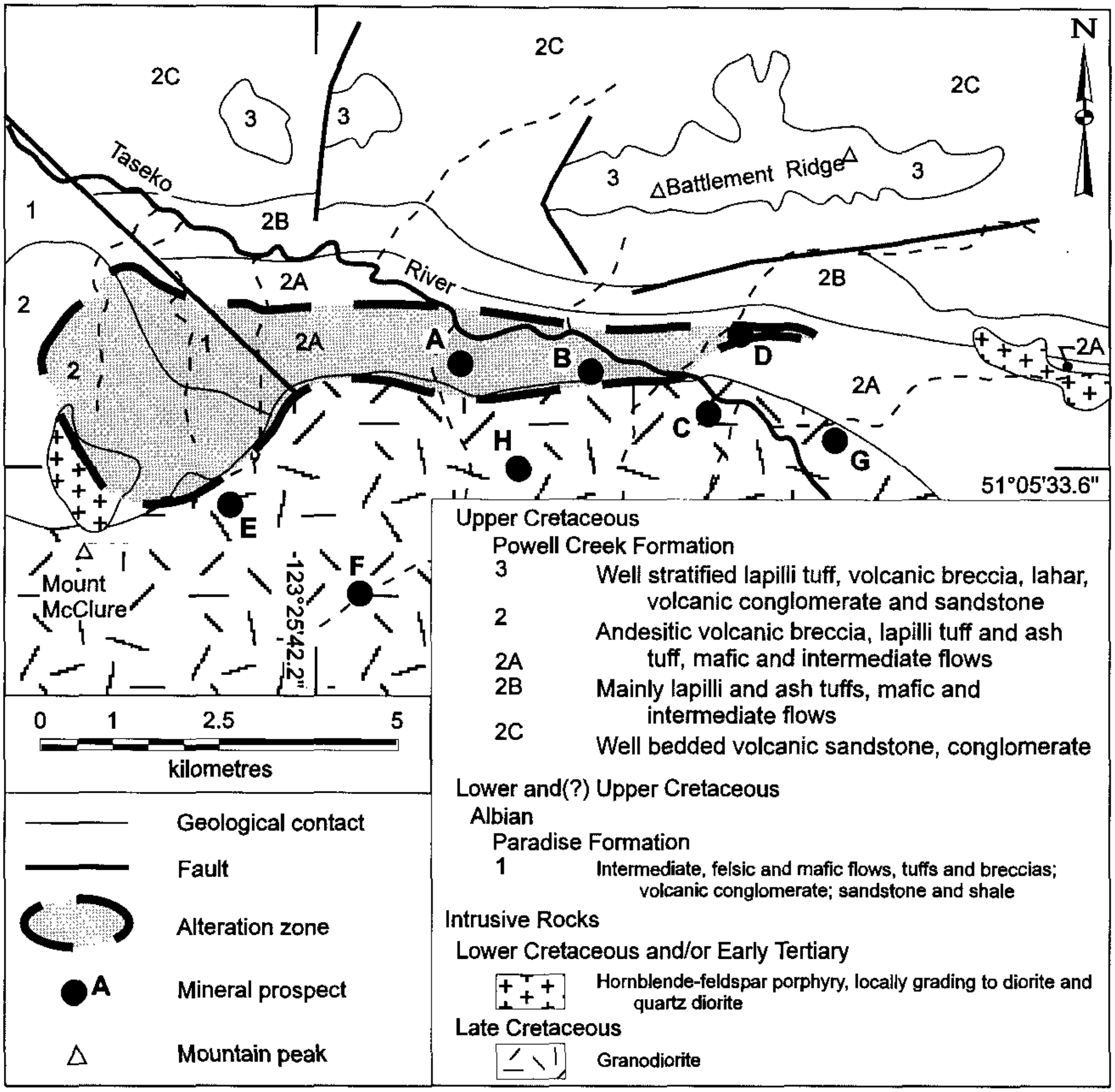

Figure 2. Geological setting of the Empress Cu-Au-Mo deposit (A) with an associated corundum occurrence; modified from Schiariazza *et al.* (1993). Other selected deposits occurring in the area are B - Bur, Minfile # 920- 039, Porphyry (Cu, Mo); C - Buzzer, Minfile # 920-038, Porphyry (Cu, Mo, Au, Ag); D - Taylor Windfall, Minfile # 920-028, Polymetalic vein (Au,Ag); E - Spokane, Minfile # 920-004, Porphyry (Cu, Au, Ag, W); F- Phair, Minfile # 920-029; G-Teek, Minfile # 920-063, (Cu); H - Mohawk, Minfile # 920-001, Porphyry (Cu, Ag, Mo);

Rocks outcropping in the deposit area belong to the Upper Cretaceous Powell Creek and Lower to Upper(?) Cretaceous Paradise formations. The deposit is located within an alteration zone that is 11 kilometres long and up to 3 kilometres wide (Figure 2). There are substantial changes in the nature and intensity of alteration within the outlined zone (McMillan, 1976; Bradford, 1985; Price, 1986). Because of the high degree of alteration of the few available outcrops, the nature of the protolith within the alteration zone in the Empress area is not well established. Large masses of Late Cretaceous granodiorite of the Coast Plutonic Complex outcrop south of the alteration zone. Smaller intrusions (Figure 2) of Early Cretaceous to Early Tertiary age consist of hornblende-feldspar porphyry which locally grades into diorite and quartz diorite.

DEPOSIT GEOLOGY

The Empress deposit occurs in an area with very little outcrop and nearly all information was acquired from drill core. There are three copper, gold and molybdenum-bearing zones totaling 10 004 000 tonnes grading 0.61 per cent copper and 0.789 grams per tonne gold using cut-off grade of 0.4 per cent copper (Osborne and Allen, 1995). Near surface, the contact between rocks of the Powell Creek Formation and the Late Cretaceous granodiorite is nearly sub-vertical. Drilling indicates that it is sub-horizontal at depth, towards the Taseko River. Westpine Metals Ltd. geologists divide the host rocks into four alteration assemblages and one intrusive unit: quartz rock, quartz-magnetite rock, plagioclase-quartz-pyrophyllite-andalusite rock, quartz-andalusite-pyrophyllite rock and granodiorite-quartz monzonite (Osborne and Allen, 1995). These rock types are the product of hydrothermal alteration of a volcanic or volcaniclastic protolith in a porphyry system (McMillan, 1976). A brief description of these lithological units follows.

Quartz rock (QR) is typically light grey and weathers brown. It consists of quartz grains (90 to 95 per cent), minor quantities of magnetite (1 to 5 per cent) and trace amounts of pyrophyllite, clay, chlorite, carbonate, titanite, pyrite and chalcopyrite. In various areas of the property, Westpine geologists interpret QR as an altered volcanic rock, explaining relict planar textures as banded rhyolite and welded tuff (Lambert, 1988, 1989, 1991a and b).

Quartz magnetite (QM) rock consists mainly of quartz and magnetite with chlorite and hematite as minor constituents. The magnetite content varies from 5 to 70 percent by volume, but typical content varies from 10 to 20 volume percent. The distinction between the QM and QR units is based on the magnetite content.

The plagioclase-quartz-pyrophyllite-andalusite (PQSA) unit consists of several distinct alteration assemblages that are too limited in extent to be treated separately at the current scale. The most characteristic lithology of this unit is relatively coarse-grained (2 to 150 millimetres), cream-colored, grey or white albite-rich, orthoclase-bearing lenses, layers or irregular masses (Hudon *et. al.*, 1996). These masses are rarely more than a few metres in apparent thickness in drill core. At surface, large blocks of this material are several metres across. They are intimately associated with pale green, fine-grained to aphanitic zones consisting mainly of muscovite, pyrophyllite, fine sericite and andalusite-rich areas that are highly irregular in shape. The pyrophyllite-andalusite zones are bluish grey. Corundum, magnetite and chlorite are the most common accessory minerals.

Corundum typically occurs in quartz-free zones within this rock unit. Detailed examination of corundum-bearing rocks indicates that this mineral is found adjacent to a light grey or pinkish, coarse-grained feldspathic rock comprised mainly of albite and strongly zoned orthoclase. Corundum comprises trace amounts to two percent of the rock over widths of 0.6 to 21 metres, with one intersection of 34 metres, most of it within andalusite-pyrophyllite-sericite rock. Usually, corundum occurs within andalusite but a few corundum grains are encased directly in feldspar. The corundum observed in drill core is dark to light blue in color and the grains are commonly less than two millimetres in size. However, blue-black, euhedral crystals up to 3 centimetres in length with hexagonal prism or steep hexagonal dipyramidal forms, approaching barrel-shaped crystals, occur in surface float overlying the 76 zone. A heavy mineral concentrate of overburden from the 76 zone contains dark-blue corundum and colorless corundum crystals that have commonly light blue patches or blue, hexagonal cores. Petrographic examination of corundum from the host rock indicates that most of the fine-grained crystals are microfractured or contain inclusions of pyrophyllite or diaspore. Some of the coarser crystals have relatively fracture-free zones several millimetres across that may be of gem quality. Individual corundum crystals are separated from the host by pale grey halos, 2 to 5 millimetres wide, that consist mainly of coarse muscovite. Some corundum grains within copper-gold mineralized zones are rimmed by sulphides (Simandl *et al.* 1997), others are zoned.

Quartz-andalusite-pyrophyllite (QAS) rock is equigranular with grains less than 1 millimetre in size to aphanitic. Minor mineral constituents include magnetite, clay, chlorite and gypsum. Weathered surfaces are typically yellow-stained from the weathering of pyrite and fresh surfaces are sugary and grey. This unit does not contain the coarse plagioclase observed in PQSA.

Granodiorite-quartz monzonite weathers buff and is white to bluish on fresh surface. It is medium to coarse grained and equigranular. It consists of feldspar, quartz, hornblende and biotite with minor titanite. This intrusive rock is the footwall to the deposit and forms the southern limit to the deposit.

Heavy Sediment Sampling and Laboratory Procedure

Sediments from the several active streams draining the deposit area (Figure 2) were sampled. Sample sites were chosen in areas that favoured the deposition of heavy sediments. Naturally concentrated gravel and fines were screened to less than 6 millimetres. The standard volume of sediment sampled equaled 7.0 litres. The samples were washed, removing light minerals and leaving an

Figure 3: Backscatter microphotograph of the corundum (dark) andrutile (pale) concentrate

enriched heavy sediment concentrate; the size of the samples was reduced to approximately 1/4 of their original volume. This on site pre-concentration was necessary to permit backpacking the samples to camp, as the program was not helicopter-supported.

Samples were dried in an oven and screened into -100 mesh, +100 to -20 mesh and +20 mesh fractions. The finest fraction was analysed for major and trace elements using INA and ICP.

The +100 to -20 mesh fraction was passed through a magnetic separator. Tetrabromethane (TBE) was subsequently used to separate minerals with a density greater than 2.96 g/cm^3 and methylene iodine (MI) was used to separate heavy minerals with density greater than 3.32 g/cm^3. The heavy liquid methodology used is similar to that described by Muller (1977). The mixture of mineral particles and appropriate heavy liquid is stirred inside a beaker to ensure complete wetting. The minerals with densities greater than heavy liquid (in our case TBE first and then with MI) sink. The float and sink are recovered and washed with acetone and all heavy liquids are recycled. Samples are dried at low temperature for 15 to 20 minutes

The heavy mineral concentrates (the sink from MI heavy liquid separation stage) were examined using a binocular microscope and transparent corundum was identified in 4 samples. Other heavy minerals readily identified include bright red-rutile, sulphides, epidote and magnetite. Selected grains were removed, placed on electrically conductive carbon tape, and coated with a 250 angstrom conductive film of carbon.

The grains were then placed in the vacuum chamber of the scanning electron microscope (SEM) and examined. Identification of smaller grains was made by examining the x-ray spectrum collected from each specimen. Corundum grains were confirmed in a number of samples by this method.

For each heavy element concentrate, a representative aliquot was selected, mixed with epoxy and glued to a standard petrographic glass slide. The epoxy was then cured on a hot plate and the slide ground to a thickness of about 40 microns. A series of polishing stages then followed to produce a polished thin section. These slides were then coated with conductive carbon and viewed in the electron microscope in back-scattered electron (BSE) mode. Minerals with a high mean atomic number reflect back more electrons than minerals with a low atomic number. These variations in brightness (grey-level) are most useful in discriminating between mineral species in polished thin sections. Within the context of this study, corundum appears dark grey when viewed in BSE mode. Rutile, Fe-oxides, and sulphides are much brighter (Figure 3).

In one mode of analysis, a digital image is collected by the X-ray analyser and the electron beam placed upon the grain or grains of interest. An X-ray spectrum is collected and the mineral identified from its spectrum. This combination of BSE imaging and X-ray analysis is effective in mapping a section and determines quantitative proportions of mineral constituents within a given sample.

Specimens were analysed on a JEOL 6400 digital scanning electron microscope interfaced to a Link Systems eXL x-ray analyser equipped with stage automation and digital beam control. Operating conditions were 20 kilovolts accelerating potential and a beam current of 2 nanometres.

A second mode of analysis employed involved automated counting and classification of grains. This included detection of grains from a digital image made by the x-ray analyser and the collection of a x-ray spectrum from each grain. A previously defined elemental window file for elements of interest is employed and the proportion of these elements of the total x-ray spectrum for each grain is determined. A series of criteria for each element as a proportion of the total x-ray spectrum collected are defined, based upon minimum and maximum values expected. A series of criteria for several elements are then used to define a mineral class. In the case of corundum, for example a criterion such as high Al (*e.g.* >70%) may be employed together with other criteria such as low Mg, Zn, and Fe. The additional criteria would block any other Al-bearing phases such as spinels from being incorrectly classed as corundum. The entire operation is controlled by the x-ray analyser computer which is interfaced to the electron microscope. It is a powerful tool for automating repetitive operations previously used to identify mineral grains.

Results

The stream sediment samples contained between 271 and 1557 grams of non-magnetic heavy fraction in category -20 to + 100 mesh after TBE separation. After MI processing this translated to 1.2 to 40 grams of heavy minerals denser than 3.32 g/cm^3.

The selected trace element composition of fine-fraction (-100 mesh) not treated by heavy liquids is presented in Table 1. The copper, molybdenum, gold and tungsten values are also displayed on Figures 4a, b, c and d. These results indicate that the metal concentrations in the Empress deposit area are high, and probably the deposit would have been detected using this methodology. Since most of the samples lie in the proximity of the deposit, and within regional-scale alteration zone (Figure 2) no background values are available. The high gold concentrations are particularly interesting, however, corresponding silver values remains below the detection limit. Follow-up work will be carried out to locate gold-bearing grains using the scanning electron microscope. Anomalous concentrations of tungsten are also of interest. Drill core was not analysed for tungsten during exploration of the Empress deposit.

Under the binocular microscope corundum occurs either as, transparent, angular grains that are grey, colorless or bluish, or as white, translucent aggregates of grains with a sugary appearance. Corundum was detected in 17 out of 26 samples (Table 2, Figure 4e) and represents 1-30 per cent of all heavy mineral particles denser than 3.32 g/cm^3.

TABLE 1
TRACE ELEMENT COMPOSITION OF HEAVY MINERAL CONCENTRATES
(PARTIALLY CONCENTRATED BY PANNING, NO HEAVY LIQUIDS USED).

Element	Au	44	As	Ba	Co	Cr	Cs	Mo	Sb	Cu	Pb	Ni	Mn	Fe*	Cd	Bi	V
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
Method	INA	INA	INA	INA	INA	INA	INA	INA	INA	TICP	TICP	TICP	TICP	TICP	TICP	TICP	TICP
Detection Limi	2	5	0.5	50	1	5	1	1	0.1	2	5	2	5	0.01	0.4	5	2
Field No.																	
TA96-1	11	<5	24	560	19	180	4	11	3.4	89	12	28	758	7.61	< .4	< 5	243
TA96-2	<2	<5	16	400	20	190	3	<1	4	34	< 5	31	969	11.5	< .4	< 5	422
TA96-3	242	<5	86	1800	21	130	<1	15	9.2	103	47	28	548	11.3	0.4	< 5	294
TA96-4	10	<5	41	400	27	640	<1	<1	4	86	81	32	1113	12.1	2.2	< 5	449
TA96-5	170	<5	48	200	27	680	<1	<1	3.6	67	69	34	1172	15.1	< .4	< 5	582
TA96-8	<2	<5	30	480	15	260	2	<1	2.9	78	40	27	941	9.24	< .4	< 5	339
TA96-10	<2	<5	31	290	17	210	2	<1	3	68	38	20	823	5.32	0.8	< 5	183
TA96-11	14	<5	35	560	20	470	<1	4	3.4	63	46	28	1041	12.7	0.5	< 5	476
TA96-13	1360	<5	<5	<50	23	490	3	<1	3.5	77	60	33	1111	14.3	0.8	< 5	541
TA96-14	1860	<5	9.2	490	14	230	<1	6	2.2	68	< 5	23	427	8.41	< .4	< 5	335
TA96-15	18	<5	13	440	14	120	3	6	1.9	128	17	24	461	6.42	< .4	< 5	233
TA96-16	4850	<5	23	600	14	210	3	15	3.1	122	18	23	484	7.53	< .4	< 5	288
TA96-17	1030	<5	16	480	9	120	2	<1	2	82	20	17	307	5.5	< .4	< 5	249
TA96-18	146	<5	19	440	14	300	4	<1	3.4	46	18	23	701	8.47	< .4	< 5	343
TA96-19	56	<5	32	590	18	150	4	3	4.6	77	16	20	618	6.62	< .4	< 5	197
TA96-75	460	<5	11	730	10	82	5	<1	3.6	35	21	18	591	5.05	1.7	< 5	177
TA96-76	<2	<5	15	450	13	140	2	9	3.1	39	58	20	614	7.07	1.3	< 5	277
TA96-77	71	<5	17	470	33	360	3	8	2.9	65	< 5	48	594	16.8	< .4	< 5	662
TA96-78	283	<5	21	450	56	610	2	22	3.4	64	25	71	750	24.8	< .4	< 5	982
TA96-79	11	<5	22	670	17	270	5	7	2.5	33	11	24	517	9.23	< .4	< 5	348
TA96-80	531	<5	21	100	40	620	4	12	3.4	63	13	59	771	22.3	0.9	< 5	1004
TA96-81	179	<5	44	500	17	210	5	12	7	50	13	31	323	9.38	< .4	< 5	286
TA96-82	1240	<5	35	500	27	480	3	4	10	77	< 5	47	393	13.6	< .4	< 5	448
TA96-83	307	<5	22	<87	5	88	5	<3	1.5	53	7	5	116	42.4	< .4	< 5	120
TA96-84	108	<5	37	820	57	480	3	22	4.5	97	34	77	693	20.8	< .4	< 5	764
TA96-86	285	<5	8.2	890	13	330	6	<1	4.1	209	20	21	291	8.03	< .4	< 5	328
Median	158		22	480	17.5	245	3	4	3.4	68	24	27.5	616	9.31	0.2		337
Mean	509		26	515	21.5	310	2.9	6.25	3.85	75.9	26.7	31.2	659	12.4	0.47		407
Std.dev	1012		17	335	12.8	188	1.61	6.7	2	36.6	21.9	16.6	280	8.08	0.53		231

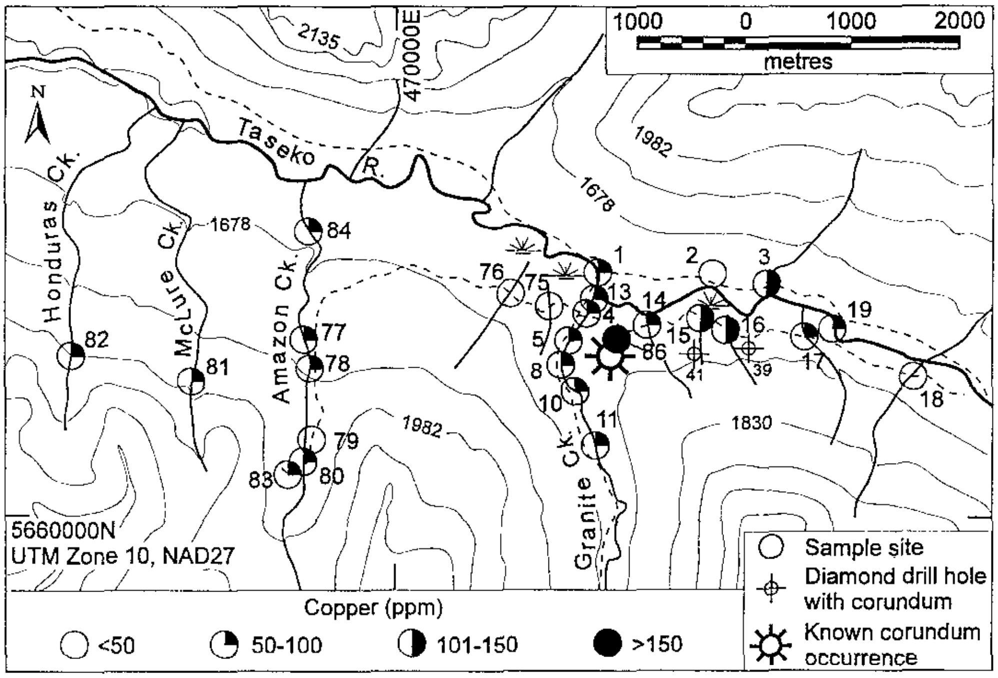

Figure 4a. Copper values in the heavy mineral fraction (-100 mesh size) from the Empress deposit area. Samples concentrated by panning.

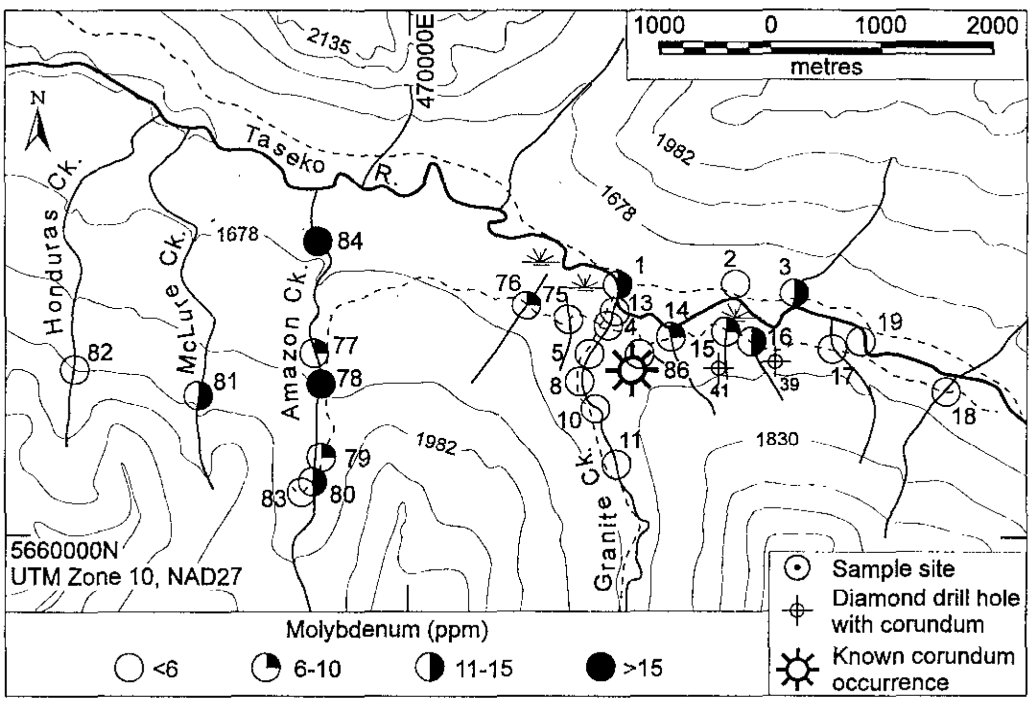

Figure 4b. Molybdenum values in the heavy mineral fraction (-100 mesh) of samples from the Empress deposit area. Samples concentrated by panning.

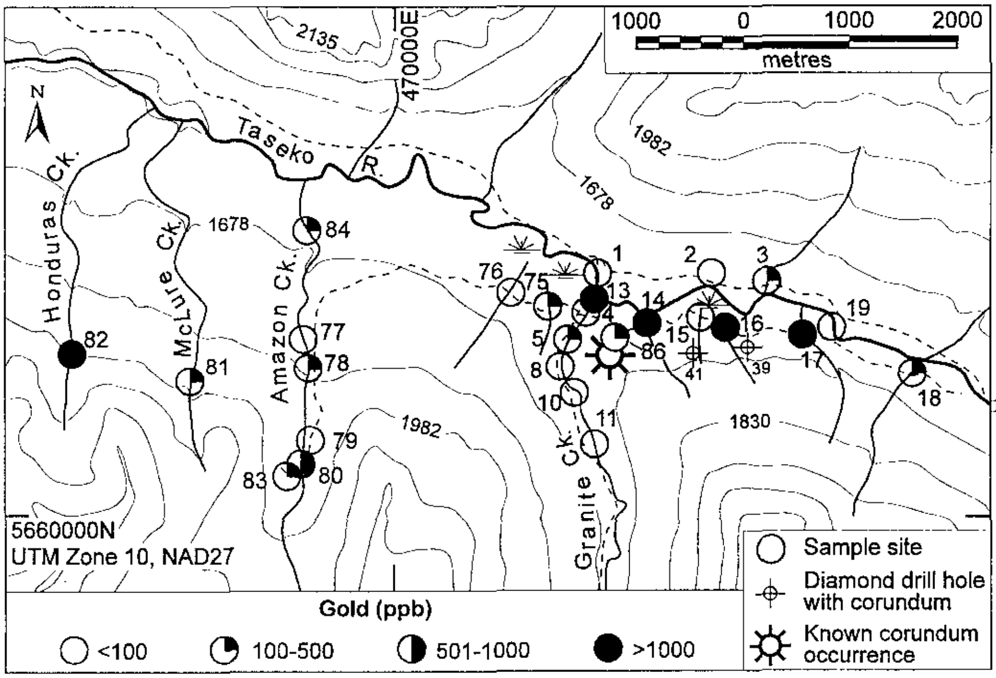

Figure 4c. Gold values in heavy mineral concentrates (-100 mesh grain size) of samples from the Empress deposit area. Samples concentrated by panning.

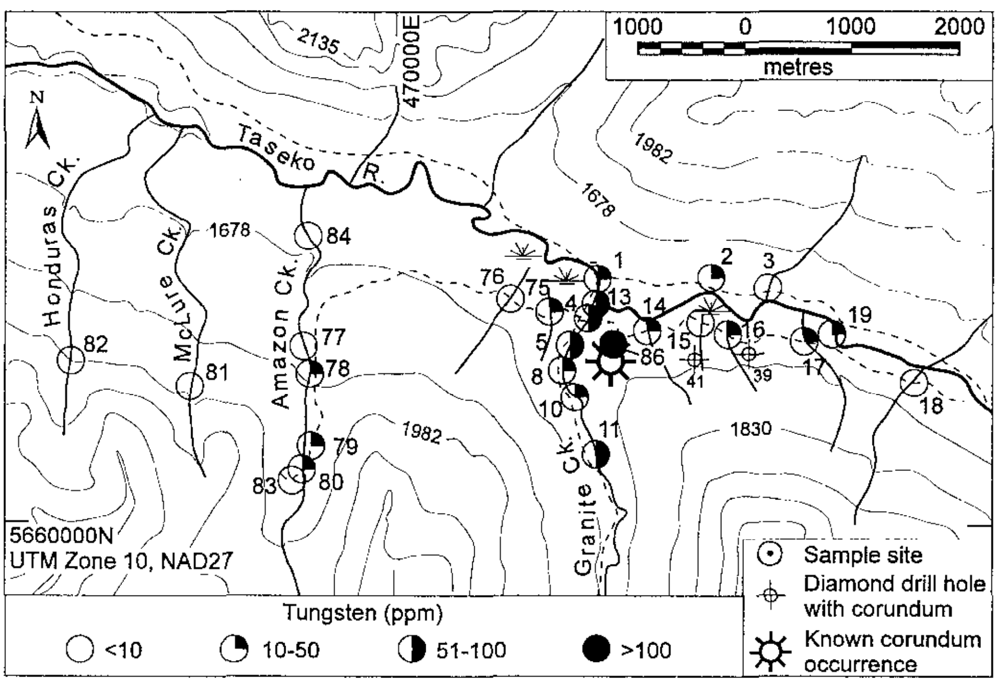

Figure 4d. Distribution of samples analysed for tungsten. Heavy mineral concentrate (-100 mesh fraction) was produced by panning only) , Empress deposit area. Samples concentrated by panning.

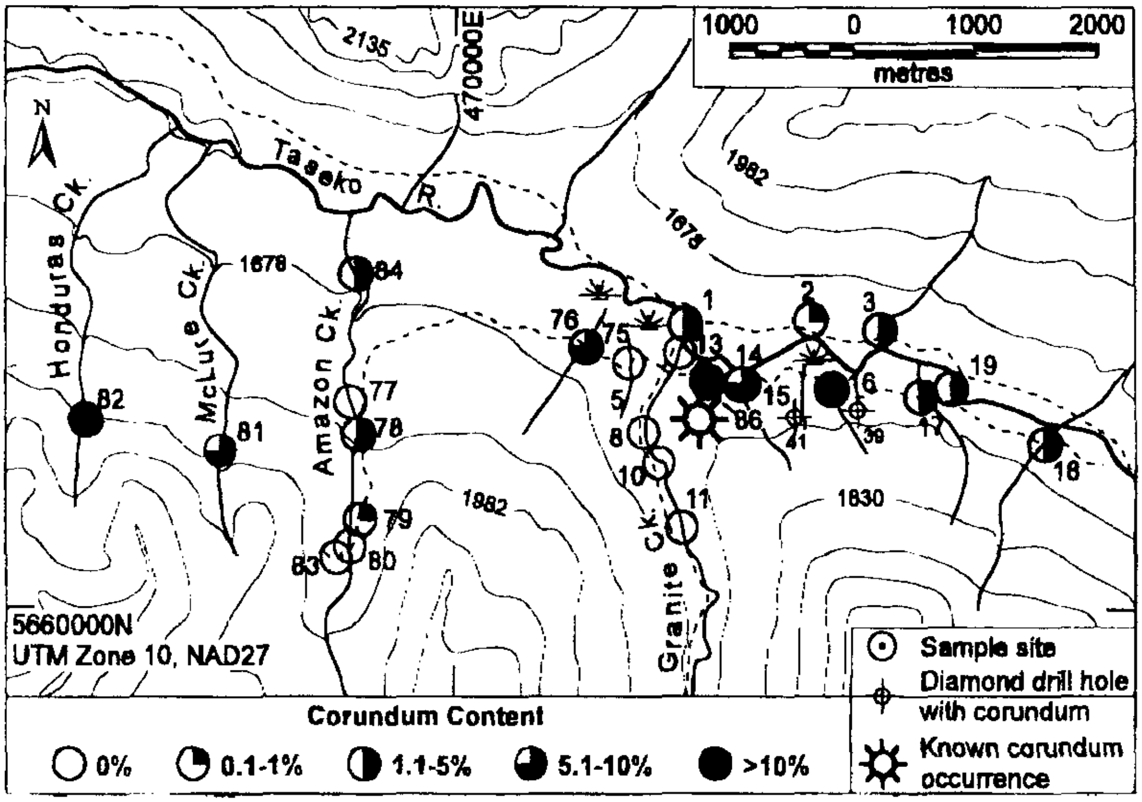

Figure 4e. Distribution of Corundum concentrations (pre-concentration by panning & heavy liquids); Empress deposit area.

Several samples contain a transparent variety of corundum, as colorless, blue or zoned (colorless with blue core) grains. The large number of composite grains and their angular shape indicate that corundum is locally derived.

The other minerals observed are yellowish and light green epidote (0 to 75 per cent), iron oxides other than magnetite (0-100 per cent), pink rutile (0 to 30 per cent), ilmenite (0-17.8 per cent), orthopyroxene (0 to 26 per cent), clinopyroxene (0 to 14 per cent), amphibole (0-7.8 per cent), titanite (0 to 7 per cent), aluminosilicate (0 to 7 per cent; kyanite and andalusite should have been removed during heavy liquid separation), barite (<1 per cent), zircon (0 to 1.8 per cent), allanite (<1 per cent) and unidentified silicate minerals. The variations in the proportion of the heavy minerals over a small area demonstrate the importance of large samples and the need for careful microscopic examination. Minerals that are characteristic of the metalliferous Empress deposit are pyrite, magnetite, chalcopyrite and pink rutile.

Of particular interest is the presence of scheelite detected in samples TA96-4, 10, 11, and 13 and coinciding with above normal tungsten contents in the fine fraction detected by chemical analysis. The sample TA96-82 is anomalous in corundum and gold. This sample was collected from the stream that drains the area of the Spokane porphyry Cu-Au-Ag-W prospect, where corundum was not previously reported.

In summary we can say that analysis of the -100 mesh fraction of panned mineral concentrate using 7 litre samples is adequate to detect corundum mineralization, if a relatively tight sampling pattern is used in the Taseko Lake area. The survey also detected the metallic signature of the Au-Cu-Mo deposit and points to areas where follow-up is warranted. However, larger samples would be necessary if the spacing between the samples was relaxed or if larger catchment areas were involved..

Sample	corundum	rutile	ilmenite	Fe oxides	epidote	opx	cpx	amphibole	titanite	Al-Silicate	u. silicate	barite	scheelite	zircon	pyrite	allanite
TA96-1	2.1	3.5	7.8	21.2	47.5	2.1	1.4	1.4	5.6	0.7	2.1				3.5	
TA96-2	1	5.5	15	13.5	44.4	11.1	1.6		2.4	1.6	0.8			0.8	0.8	
TA96-3	1.5	11.6	17.8	28.7	3.8	0.7	14.7		2.1	3.1	5.1	0.7			7	
TA96-4	0.5	0.5	2.8	10.3	68.5		4.7	4.2	5.1	1.4			0.5		1.4	
TA96-5		1.3	1.9	18	60	0.6	0.6	5.1	8.4					0.6	2.6	0.6
TA96-8			1.4	13.4	69	0.7		4.2	8.3	0.7				0.7		0.7
TA96-10			0.5	6.3	81	1.1		5.2	3.7	0.5			0.2	0.5	0.5	
TA96-11			1.3	7.2	75.1	0.6	0.6	7.8	3.9	0.6			0.3	0.6	1.9	
TA96-13			1.6	7.7	75.2	0.5	0.8	5.5	2.2	0.5			0.5		4.4	1.1
TA96-14	8.6	14.4	8	22.5	23.1	8.6	2.3	2	2.3	0.6	0.6			0.8	4.6	0.6
TA96-15	2.8	9.4	9.4	28.3	19.8	13.2	1.9	1.9	5.7	0.9	1.8				4.7	0.9
TA96-16	32.4	14	9.6	35.1	0.8	1.7	0.8		2.6						2.6	
TA96-17	1.8	30.9	13.6	37.2	9	0.9		0.9	2.7	2.7						
TA96-18	4.5	8.3	14.3	41.9	9.8	11.6	0.9	1.8	1.3		1.8			1.8		
TA96-19	1.8	3	7.9	18.3	44.5	1.2	7.3	3.6	4.3	1.2	3	0.6			4.8	
TA96-75		6.1	9.9	23.7	33.6	10.7		0.8	6.8	0.8	1.1			0.8	3.4	0.8
TA96-76	8.3	7.6	17.4	23.5	20.4	9.8	0.7	0.7	6	2.2					1.5	
TA96-77			12.6	34.2	2.7				6.3	4.5					38.7	
TA96-78	1.1	1.1	4.5	36.4		2.2			3.4	2.2	0.8				48.8	
TA96-79	0.8	6	12.8	37.6	4.3	26.5			6.8		1.4	0.8			0.8	0.8
TA96-80		25.3	6.3	32.4	2.1	0.7		0.7	4.9	0.7	2.4				21.8	0.7
TA96-81	7.9	1.4	5	70.5		7.2				4.3	1.4	0.3			0.7	0.7
TA96-82	11.9	11.1	8.7	50.8	3.1				3.9	7.1					2.4	
TA96-83				100												
TA96-84	2.2	4.5	6.8	18.9	5.3				2.3	1.5					57.6	
TA96-86	37.1	51.5	1.8	0.6	0.6	0.6	0.3	0.6	1.2	2.4	0.8				1.2	0.6
Median	2.2	6.85	7.9	23.6	20.4	1.7	1.15	1.95	3.9	1.4	1.4	0.65	0.4	0.75	3	0.7
Mean	7.43	10.85	7.95	28.39	30.59	5.35	2.76	2.90	4.26	1.91	1.78	0.60	0.38	0.83	9.80	0.75
Stand Dev.	10.85	12.39	5.29	21.21	28.86	6.67	3.94	2.21	2.12	1.69	1.23	0.22	0.15	0.41	16.54	0.16

Table 2:Mineral composition of heavy mineral concentrates denser than 3.32 g/cm^3; u.silicate = unknown silicate, opx = orthopyroxene, cpx = clinopyroxene.

CONCLUSIONS

Fine grains of corundum are present in most of the heavy mineral concentrates from the stream sediments collected in the Empress deposit area. Some of the corundum fragment recovered from the concentrate are transparent and colorless or blue, suggesting potential for gem-quality mineralization.

A next step in the assessment of the gem-corundum potential of the property would require collection and processing of large samples of overburden, with special attention paid to the size, shape and quality of the crystals recovered.

The methodology developed during this study can be used in exploration for gem-quality corundum in the Taseko Lake area and is well worth considering for other regions with appropriate modifications to the minimum size of the samples needed.

The source of the scheelite in the heavy mineral sediments near the Empress deposit, coinciding with the above background tungsten content in the panned samples, remains to be established.

ACKNOWLEDGEMENT

The manuscript benefited from reviews by Dr. David Lefebure of the B.C. Geological Survey and Dr. Suzanne Paradis of the Geological Survey of Canada. The SEM work was financed by Westpine Metals Ltd. and carried out at Carleton University, Ottawa. Kirk D. Hancock formerly with B.C. Geological Survey helped in the collection of stream sediment samples and with on site pre-concentration. Heavy liquid separation was carried out by Cominco Ltd. laboratory.

REFERENCES

Bradford, J.A. (1985): Geology and Alteration in the Taseko River Area, Southwestern British Columbia; unpublished B.Sc. thesis, *The University of British Columbia*.

Brimhall, G.H. (1977): Early Fracture-controlled Disseminated Mineralization at Butte, Montana; *Economic Geology*, Volume 72, pages 37-59.

Fipke, C. (1989): The Development of Advanced Technology to Distinguish between Diamondiferous and Barren Diatremes; *Geological Survey of Canada*, Open File 2124, Part 1, 90 pages.

Fletcher, W.K. and Loh, C.H. Transport of Cassiterite in a Malaysian Stream: Implications for Geochemical Exploration; *Journal of Geochemical Exploration*, volume 57, pages 9-20.

Glover, J.K., Schiarizza, P., Umhoefer, P. and Garver, J. (1986): Geology of the Warner Pass Area, British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File Map, 1987-3.

Gustafson, L.B. and Hunt, J.P. (1975): The Porphyry Copper Deposits at El Salvador, Chile; *Economic Geology*, Volume 70, pages 564-579.

Hudon, P., Simandl, G.J. and Martignole, J. (1996): Corundum from the Empress Deposit, British Columbia, Canada. Abstrasct. *GAC/MAC Annual Meeting*, Ottawa, Abstract Volume, page A-70.

Lambert, E. (1988): Report on the 1988 Exploration Project of the Taseko Property, Alpine Exploration Group; *Alpine Exploration Group*, unpublished company report.

Lambert, E. (1989): Geochemical and Diamond Drilling Program of the Taseko Property, Westpine Metals Ltd.; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 19350, 155 pages.

Lambert, E. (1991a): 1990 Diamond Drilling Program of the Taseko Property, Westpine Metals Ltd.; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 20889, 206 pages.

Lambert, E. (1991b): 1991 Diamond Drilling Program of the Taseko Property, Westpine Metals Ltd.; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 21985, 142 pages.

Lowder, G.G. and Dow, J.A. (1978): Geology and Exploration for Copper Deposits in North Sulawesi, Indonesia; *Economic Geology*, Volume 73, pages 628-644.

McLaren, G.P. and Rouse, J.N. (1989): Geology and Mineral Occurrences in the Vicinity of Taseko Lakes; *in* Geological Fieldwork 1988, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1989-1, pages 153-158.

McMillan, W.J. (1976): Granite Creek Property, 92O/3W: *in* Geology in British Columbia 1976, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, pages 67-84.

Muller, L.D. (1977): Laboratory methods of Mineral Separation; in: J.Zussman editor, Physical Methods in Determinative Mineralogy, 2nd ed., *Academic Press*, London, pages 1-34.

Osborne, W.W. and Allen, D.G. (1995): The Taseko Copper-gold-molybdenum Deposits, Central British Columbia; *in* Porphyry Deposits of the Northwest Cordillera of North America, T.G. Schroeter, Editor, *Canadian Institute of Mining, Metallurgy and Petroleum*, Special Volume 46, pages 441-450.

Phillips, W.R. and Griffen, D.T.(1981): Optical Mineralogy; *W.H. Freeman and Company*, San Francisco, 677 pages.

Price, G. (1986): Geology and Mineralization, Taylor-Windfall Gold Prospect, British Columbia, Canada; unpublished M.Sc. thesis, *Oregon State University*, 144 pages.

Salpeteur, I. and Jezequel , J. (1992): Platinum and Palladium Stream-sediment Geochemistry Downstream from PGE-bearing Ultramafics, West Andriamena Area, Madagascar; *Journal of Geochemical Exploration*, volume 43, pages 43-65.

Simandl, G.J. and Hancock, K.D. (1997): Sapphires/Rubies, Emeralds, and Precious Opal Deposit Models -Possible Applications to British Columbia, Canada. 99th Annual General Meeting of CIM, Abstract. *CIM Bullettin*, Volume 90, page 98.

Simandl, G.J., Hancock, K.D., Lambert, E., Hudon, P. and Martignole, J. and Osborne, W.W. (1997): The Empress Cu-Au-Mo Deposit- Gemstone and Industrial Mineral Potential in Geological Fieldwork 1996, Lefebure, D., McMillan, W.J. and McArthur, J.G., Editors, *British Columbia Ministry of Employment and Investment* , Paper 1997-1, pages 339-346.

Schiariazza, P., Glover, J.K., Umhoefer, P.J., Garver, J.I., Handel, D., Rapp, P., Riddell, J.M. and Gaba, R.G. (1993): Geology and Mineral Deposits of the Warner Pass Map Area (92O/3): *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geoscience Map 1993-10

Schiarizza P., Gaba, R.G., Glover, J.K., Garver, J.I. and Umhoefer, P.J. (1997): Geology and Mineral Occurrences of the Taseko-Bridge River Area; *British Columbia Ministry of Employment and Investment*, Bulletin 100, 291 pages.

Schulze, D.J. (1994): An Introduction to the Recognition and Significance of Kimberlite Indicator Minerals; in Kimberlites and their Indicator Minerals; short course notes, Cordilleran Section, Geological Association of Canada.

Tipper, H.W. (1978): Taseko Lakes (92O) Map Area; *Geological Survey of Canada*, Open File Map 534.

Wilhelm, E. and Artignan, D. (1988): L'analyse des Minéraux Lourds en Exploration Minière: Revue Critique et Propositions; *Chronique de la Recherche Minière*, Number 490, pages 47-53.

Wojdak, P.J. and Sinclair, A.J. (1984): Equity Silver Ag-Cu-Au Deposit, Alteration and Fluid Inclusion Studies; *Economic Geology*, Volume 79, pages 969-990.