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GOLD DISTRIBUTION IN THE COPPER MT.-INGERBELLE DISTRICT: AN INDICATION OF GOLD TRANSPORT MODELS

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Distribution of gold among three alteration types in the Copper Mountain-Ingerbelle district, British Columbia, parallels gold transport models proposed by Seward (1982) and Huston and Large (1988). The dominant alteration types in this district are: (1) K-feldspar-biotite-calcite-chalcopyrite-magnetite (potassic); (2) chlorite-epidote-pyrite-chalcopyrite (propylitic); and (3) calcite-hematite-magnetite-chalcopyrite (hematite-magnetite). Gold generally increases and silver generally decreases from type 1 to 3 (Huyck, 1987). Alteration types 1 and 2 are generally disseminated, while type 3 forms vein sets.

Gold distribution may be explained using the general model of Huston and Large (1988). In this model, high-temperature, high-fO_2, saline solutions transport gold as chloride complexes. Gold is most soluble in such solutions in equilibrium with hematite, and so is most concentrated in hematite-magnetite veins. Lower fO_2, and corresponding lower gold solubility, explains lower gold content in potassic alteration. At lower temperatures, in low-salinity fluids, gold is transported by sulfur complexes (Seward, 1982; Huston and Large, 1988) in equilibrium with pyrite. Such solutions may initially leach potassically altered rocks and deposit gold in propylitic alteration.

Such simple models of gold transport explain gold distribution in Copper Mountain-Ingerbelle and other districts. Sillitoe (1979) emphasized the importance of magnetite as an indicator of high fO_2 and gold content in porphyry-related districts. Specular hematite may indicate even higher fO_2 and gold grades within a district. Thus, favored targets for exploration in such districts are: (a) hematite-magnetite alteration and (b) propylitic alteration. Recent discoveries of Pothook (near Afton) and QR (near Cariboo-Bell) also fit the gold behavior described for Copper Mountain-Ingerbelle.

GOLD-BEARING, MAGNETITE-RICH ALTERATION IN THE VIRGINIA AREA, COPPER MOUNTAIN ALKALINE PORPHYRY COPPER DEPOSIT, BRITISH COLUMBIA

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Exploration drilling during 1990 has delineated a copper orebody with an anomalously high-gold, vein-related, magnetite-rich alteration in the Virginia area at the Copper Mountain porphyry copper deposit. Gold is associated with sulfides in magnetite-pyrite-chalcopyrite±calcite veins. The magnetite varies from fine-grained matrix in a breccia with sulfide-bearing clasts to bladed rosettes intergrown with chalcopyrite and pyrite. The delicate bladed textures indicate open space filling within veins. Crosscutting relations indicate that this alteration preceded pyrite-epidote (propylitic) and late calcite veining. The veins are strongly controlled by E-W-trending structures.

This magnetite-rich alteration is similar to a previously reported hematite-magnetite alteration in the nearby Voigt camp. Both have high concentrations of iron oxides, are commonly brecciated, are vein-related and require sulfides for gold enrichment. Distinctions are the lack of hematite and the large tonnage in the Virginia area relative to the Voigt camp.

This new evidence suggests that the magnetite-rich veins were early relative to propylitic alteration, and that hematite is not required for gold enrichment. The affiliation of gold with this specific alteration parallels a more general magnetite-gold association in porphyry copper systems in the Phillipines.

ALTERATION AND PRECIOUS METAL DISTRIBUTION IN THE COPPER MOUNTAIN-INGERBELLE DISTRICT, BRITISH COLUMBIA

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The Copper Mountain-Ingerbelle district includes disseminated and vein-related mineralization. Within the dominantly disseminated areas, this district contains less gold and similar silver relative to other alkaline porphyry systems in British Columbia. Silver-gold ratios vary from 4.5 to 24. The main alteration assemblages are: (1) K-feldspar-biotite-chalcopyrite± bornite or pyrite (potassic) and (2) epidote-chlorite-chalcopyrite-pyrite (propylitic). Minor phyllic alteration occurs locally. The vein-related mineralization, with silver-gold ratios of less than one, is associated with chlorite-chalcopyrite-hematite-magnetite-pyrite (hematite-magnetite) alteration.

In the disseminated areas, silver is highest in the bornite-stable alteration. Gold increases slightly from the bornite-stable to the pyrite-stable (potassic and propylitic) alteration. Silver occurs mainly in solid solution within the sulfides, particularly in bornite. Gold occurs erratically within the sulfides and as electrum associated with pyrite ± chalcopyrite. Gold zonation differs from other alkaline porphyry systems, where gold is commonly associated with bornite. Either gold was initially low in this system or gold initially in bornite has been redistributed by later fluids related to propylitic or phyllic alteration (as at the Bell deposit).

Gold is highest in the vein-related, hematite-magnetite alteration, which resulted from transport by either thio-gold or chloride-gold complexes.

MAGNETITE IN ALKALINE CU, AU PORPHYRIES: MAGMATIC OR HYDROTHERMAL.

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The high magnetite content of British Columbia alkaline porphyry Cu,Au deposits, in addition to being a metallotect of significance in geophysical exploration, may reflect a deep, probable upper mantle source of host alkaline magmas.

Alkaline magmatism was essentially synchronous with amalgamation of the large island arc terranes of Quesnellia and Stikinia with oceanic Cache Creek and Slide Mountain terranes to form Intermontane Superterrane in the Early to Middle Jurassic. Whereas no clear consensus exists on the petrogenesis of these enigmatic plutonic suites, modern tectonic analogues in the southwestern Pacific indicate collisional oversteepening of subduction that accompanies an abrupt transition from calc-alkaline to alkaline, shoshonitic (high K) magmatism signifies the rapid ascent of magma with minimal underplating, assimilation or differentiation. Alternatively, the generation, ascent and high-level emplacement of alkaline magmas may have been due to decompression melting of the upper mantle as a result of deep faulting related to either rapid orthogonal or oblique subduction, coupled with transcurrent displacement and transtensional faulting during superterrane amalgamation. In either case, plutonic control by profound interterrane faults is implied.

Magnetite-rich parts of Copper Mountain, Afton and Mount Polley orebodies demonstrate textures of magmatic origin, similar to classic examples at Kirunavaara, Sweden and El Laco, Chile. *Other common magnetite morphologies include primary disseminations in the igneous* hostrocks, endo- and exoskarns and hydrothermal veins with or without sulphides. The elevated PGE-content of sulphide ore supports a mantle source similar to that of coeval and possibly cogenetic PGE-rich zoned Alaskan-type intrusions in eastern Quesnellia, i.e. Tulameen complex, Polaris suite.

Magmatic volatiles rich in CO_2 and PO_4 assisted in the segregation of an immiscible magnetite-rich fluid from the viscous felsic melt, its ascent and emplacement as pipes, dykes and breccias early in the mineralization sequence. Magmatic Na+, K+ and Cl- metasomatism accompanied emplacement of magnetite-sulphide skarns. Hydrothermal vein magnetite-sulphide-Au assemblages and accompanying argillic-propylitic alteration result from the interaction of meteoric waters with Cl-rich magmatic fluids.

Reference: Cordilleran Geology and Exploration Roundup 1991; Program and Abstracts;

Table 1

Platinum Group Elements and Precious Metals in UTr-LJur
B.C. Alkaline Porphyry Cu,Au Deposits,
K.M. Dawson, Mineral Resources Division, Geological Survey of Canada,
Cordilleran Roundup, January 1991

Deposit / Sample	Au ppb	Ag ppb	Cu %	Pd ppb	Pt ppb	Os ppb	Ir ppb	Rn ppb	Rd ppb
Copper Mountain, Princeton, B.C.									
(1) Sulphide Concentrate Jan.'85	5500	na	ca.20	1400	130	52	0.5	<5	<4
(1) Sulphide Concentrate July'87	4700	na	ca.20	700	100	<3	<.1	<5	<2
(1) Pit 2, bornite in Ksp-biot pegmatoid	1900	na	c 2-3	340	470	<3	0.4	<5	14
(1) Pit 2, massive cpy vein	110	na	ca.5	160	17	<3	.1	9	11
(2) Pit 2, sulphide concentrate	5100	50,000	28.4	2735	125	na	na	na	na
(2) Pit 2, sulphide concentrate	4500	51,000	27.9	2800	155	na	na	na	na
(2) Glory Hole, born-cpy vein	4200	420,000	40	3250	50	na	na	na	na
Ingerbelle, Princeton, B.C.									
(2) Cpy vein	7850	62,000	25.6	<3	<25	na	na	na	na
(2) cpy vein	6200	61,000	24.2	<3	<25	na	na	na	na
Galore Creek, B.C.									
(2) Pyrox. basalt, cpy	15400	64,000	2.8	<3	25	na	na	na	na
(2) Leucosyenite breccia, cpy	960	29,000	7.5	225	25	na	na	na	na
Mt. Milligan, B.C.									
(3) Pilot plant Cu concentrate	32800	91,900	18.3	450	50	na	na	na	na
(3) Main orebody typical ore	660	1,000	0.23	20	<20	na	na	na	na
(4) Calc-alk Cu,Mo deposits Armenian SSR, Cu concent.	na	na	na	470	13	-	-	-	-
(4) Armenian SSR, Cu ore	na	na	na	35	12	-	-	-	-

References

(1) L.J. Hulbert, GSC, personal comm., 1991
(2) F.E. Mutschler et al., Trans Geol. Soc. S. Africa 88, 1985
(3) Placer Dome Inc., internal report
(4) L.J. Cabri, CIM Sp. Vol. 23, 1981, Table 3.

Table 2

Platinum Group Elements and Precious Metals in North American Cordilleran Alkaline Porphyry and Vein Systems (Cret.-Eoc.)
K.M. Dawson, Mineral Resources Division, Geological Survey of Canada
Cordilleran Roundup, January 1991

Deposit / Sample	Au ppb	Ag ppb	Cu %	Pd ppb	Pt ppb	Os ppb	Ir ppb	Ru ppb	Rd ppb
Franklin camp, (Eoc.) Grand Forks, B.C.									
Maple Leaf CuAg PGE Au (1) interstitial sulph. in monzonite n=8	106-1038	na	na	1499-5,740	92-12,470	na	na	na	na
(1) cpy + born concentrate n=4	18,000	na	na	30,000	31,000	240	5.5	<5	29
(2) cpy in syenite	130	51,000	1.1	<3	<25	na	na	na	na
(2) cpy in syenite	260	75,000	1.1	<3	<25	na	na	na	na
Greenwood, B.C. (Eoc.) Sappho Cu,PGE,Au									
(1) cpy veins in shonkinite n=15	99-671	na	na	556-4250	893-3330	na	na	na	na
(2) cpy in pegmatitic shonkinite-monzonite	510	60,000	6.2	1230	1250	na	na	na	na
(2) " " " " " "	340	55,000	5.5	405	780	na	na	na	na
La Plata Mtns, Colorado Allard Stock (Cret.)									
(2) cpy in pegmatite, Allard	47	45,000	8.4	165	250	na	na	na	na
(2) cpy in syenite, Copper Hill	1230	130,000	18	1920	2880	na	na	na	na
(2) sulphide conc. Copper Hill	1740	160,000	27	2320	3935	na	na	na	na
Goose Lake Mont; Copper King Mine (Cret.)									
(2) cpy in syenite	370	38,000	9.7	1270	2520	na	na	na	na
(2) cpy in syenite	130	82,000	18	2850	5300	na	na	na	na
(2) cpy in pegmat. syenite	190	81,000	22	6430	13600	na	na	na	na
(2) sulphide concentrate	830	110,000	32	1355	1660	na	na	na	na
(2) sulphide concentrate	43	100,000	31	3970	165	na	na	na	na

Table 2 cont'd

	Au	Ag	Cu %	Pd	Pt
Shasket Creek Wash Comstock Mine (Cret?)					
(2) cpy, bn in syen. pegm.	220	7900	1.3	<3	25
(2) " " " "	176	53000	4.0	10	140
(2) sulphide concentrate	99	78000	36	190	3450
(2) " " " "	200	87000	35	225	3940
Pyramid L. Nev (Mes.) Sulphide concentrate	360	1500	8.1	3	<5

References

(1) L.J. Hulbert, GSC, Personal Comm., 1991
(2) F.E. Mutschler et al., Trans. Geol. Soc. S. Africa 88, 1985