THE ORIGIN OF THE NATIVE SILVER VEINS AT COBALT, ONTARIO

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Abstract

The native silver deposits of the Cobalt area represent major concentrations of Ag, Ni, Co, As, Sb, Bi, Cu, Hg, and a number of other elements. Analyses are given which suggest that these ore and gangue elements may have had their source in Keewatin interflow sedimentary beds, with minor contributions from certain volcanic flows. The veins appear to be "extracts", derived probably by diffusion from these metal-rich rocks.

Introduction

The origin of native silver deposits containing nickel-cobalt arsenides has long been an enigma mainly because these particular types of deposits occur in such a variety of geological settings (Boyle 1968a). Yet they all show similar chemical and mineralogical features, and one would think that the processes of their formation and the source of their ore and gangue elements would show some uniformity. Correlation of the Cobalt deposits with those in different parts of the world suggests that such a uniformity does exist, especially as regards the source of their constituent elements. This source in many places is pre-existing sulphides either in massive deposits or disseminated throughout sedimentary and/or volcanic rocks. In particular at Cobalt, we have concluded that the native silver veins are late extracts derived principally from the Keewatin sulphide-rich interflow sediments, with minor contributions of some elements from the volcanic flows (Boyle 1968b ; Boyle *et al.* 1969 ; Dass 1970).

The Source of the Vein Elements at Cobalt

Analyses of the various rocks at Cobalt are given in Tables 108 and 109. It will be noticed that the rocks richest in the vein elements, particularly As, Sb, Ag, Hg, Bi, Cu, Pb, Zn, Ni, and Co are the Keewatin interflow sediments. Certain of the volcanic flows may also have been an adequate source of Ni and Co. The Nipissing diabase, which has been traditionally

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TABLE 108. AVERAGE ELEMENTAL COMPOSITION OF ROCKS, COBALT AREA, ONTARIO
All values in parts per million.

Rock type	Locality & Age	Pb	Zn	Cu	As	Sb	Mo	W	Ni	Co	Bi	Mn	Hg	Ag	Au
Basic to intermediate lavas (greenstones)	Cobalt area Keewatin	5	135	100	10	<2	≃1	<4	122	56	<0.05	2,500	0.03	0.25	0.008
Lamprophyre	Cobalt area Pre-Algoman	<2.5	83	6	3	<2	<1	<4	50	30	<0.5	3,000	0.03	<0.5	<0.01
Lamprophyre	Cobalt area Post-Algoman	<2.5	35	125	<1	<2	<1	<4	1,500	100	<0.05	2,000	0.03	<0.5	<0.01
Granite	Cobalt area Algoman (Lorrain granite)	15	25	6	<1	<2	1	<4	2	<10	<0.05	70	0.03	<0.5	<0.01
Syenite	Casey township Algoman	12	40	2	<1	<2	<1	<4	70	10	<0.05	700	0.02	<0.5	<0.01
Nipissing quartz diabase (sill)	Cobalt area	<2.5	65	90	<2	<2	1	<4	128	40	<0.05	2,000	0.03	0.11	<0.01
Olivine diabase (dykes)	Cobalt area Keweenawan	<2.5	40	64	<1	<2	<1	<4	100	50	<0.05	2,000	0.03	<0.5	<0.01
Interflow sediments: graphitic schist, slate, chert	Cobalt area Keewatin	500	500	400	80	5	3	<4	130	80	0.83	500	0.30	3.0	0.05
Conglomerate	New Liskeard area Timiskaming	12	105	57	4	<2	<1	<4	150	30	<0.05	1,500	0.02	<0.5	<0.01
Greywacke and slate	Haileybury-New Liskeard area Timiskaming	12	75	45	5	<2	<1	<4	125	25	<0.05	1,000	0.02	<0.5	<0.01
Conglomerate	Cobalt area Huronian Coleman Member	5	25	22	<5	<2	<1	<4	60	30	<0.05	500	0.10	<0.1	<0.01
Greywacke, quartzite, and arkose	Cobalt area Huronian Coleman Member	<5	20	20	<5	<2	<1	<4	60	25	<0.05	500	0.10	<0.1	<0.01
Greywacke, slate and quartzite	Cobalt area Huronian Firstbrook Member	<2.5	43	8	3	<2	2	<4	88	25	<0.05	515	0.03	<0.5	<0.01
Quartzite and arkose	Cobalt area Huronian Lorrain Formation	<2.5	5	2	<1	<2	<1	<4	20	<10	<0.05	20	0.03	<0.5	<0.01
Limestone, dolomite	Haileybury area Ordovician	<2.5	6	2	<1	<2	≃1	<4	<2	<5	<0.05	365	0.03	<0.5	<0.01
Limestone, dolomite	New Liskeard area Silurian	<5	10	8	<2	<5	<1	<4	5	<5	<0.05	250	0.03	<0.5	<0.01

Note: Average values have been computed from analyses of composite samples of rocks well removed from sites of known mineralization.

thought to have provided the ore and gangue elements, is remarkably low in some of the essential vein elements, particularly Ag, As, Sb, and Hg.

Mercury is a unique element in the Cobalt deposits, being universally present in the native silver and allargentum in amounts as high as 5 per cent. The only rocks in the Cobalt area containing anomalous amounts of mercury are the Keewatin interflow sediments. We consider this fact more than fortuitous and suggest that the most likely source of the mercury in the silver veins is the interflow sediments.

Correlation of the Cobalt Deposits with those in Other Areas

Support for our thesis that the vein elements at Cobalt were derived from pre-existing sulphides in the interflow sediments is found in the relationships of native silver deposits to rocks containing pre-existing sulphides in other areas of the world (Boyle 1968a).

The native silver veins of Kongsberg, Norway cut fahlbands that are heavily impregnated with pyrite, pyrrhotite, chalcopyrite, arsenopyrite, cobaltite, and galena. Those at Jachymov in Czechoslovakia are also closely associated with heavily pyritized phyllites and schists, and a similar situation prevails at Annaberg in Saxony where the rich native silver veins intersect gneisses containing an abundance of finely disseminated sulphides, including pyrite and chalcopyrite.

Table 109. Range in Elemental Content of the Sulphide-Rich Parts of the Keewatin Interflow Sediments

Element	*Percentage*
Fe	5–16
S	5–30
C	0.1–5
Cu	0.1–1.5
Zn	1–8
Pb	0.3–6
Ni	0.01–0.02
Ag	0.05–2 oz/ton
Au	0.03–0.4 ppm
Hg	up to 50 ppm[1]
U	<0.3 ppm

[1] Mercury analyses by I.R. Jonasson.

The silver veins in the Thunder Bay district of Ontario cut diabase and pyritiferous phyllites and schists, and those in the Great Bear Lake area, Northwest Territories are localized in areas where pyritiferous tuffs are abundant.

One particularly significant occurrence of native silver veins cutting massive sulphide deposits is that described from Broken Hill, Australia by Lawrence (1968). There, mercurian antimonial silver and allargentum, Ni-Co arsenides, and other sulphosalts and sulphides occur in a siderite vein that cuts the great lead-zinc lodes. Lawrence concluded that the silver vein was derived by leaching of its constituent elements from the pre-existing sulphides, sulphosalts, and other minerals in the Main Lode Horizon.

Conclusions

Our view of the origin of the native silver veins at Cobalt is that the ore and gangue elements were derived principally from the Keewatin sulphide-rich interflow sediments, with minor contributions from the volcanic flows. The veins appear to us to represent late extracts derived probably by diffusion from these metal-rich rocks. Mobilization of the elements probably took place as a result of the injection of the Nipissing diabase.

Support for our thesis comes from the fact that a metal source is readily available stratigraphically below the deposits at Cobalt, and that a number of other similar deposits throughout the world show a close genetic relationship to pre-existing sulphides.

REFERENCES

ALBEE, A.L. (1962) : Relationships between the mineral association, chemical composition and physical properties of the chlorite series. *Am. Mineral.* **47**, 851-870.

ALDRICH, L.T. & WETHERILL, G.W. (1960) : Rb-Sr and K-Ar ages of rocks in Ontario and northern Minnesota. *J. Geophys. Res.* **65**, 337-340.

ATKINS, F.B. (1969) : Pyroxenes of the Bushveld intrusion, South Africa. *J. Petrol.* **10**, 224-249.

BAILEY, S.W. (1966) : The status of clay mineral structures. pp. 1-23, *Clays and Clay Minerals*, Proc. Fourteenth Nat. Conf. Clays, Clay Mins., Pergamon Press, New York.

——— & BROWN, B.E. (1962) : Chlorite polytypism : I. Regular and semi-random one-layer structures. *Am. Mineral.* **47**, 819-850.