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VINCIENNITE IN THE MAGGIE PORPHYRY COPPER DEPOSIT, BRITISH COLUMBIA

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ABSTRACT

Quartz–pyrite–tennantite veinlets peripheral to the ore zone at the Maggie porphyry copper–molybdenum deposit, British Columbia, contain the tin-bearing sulfides mawsonite, stannoidite, and vinciennite [ideally $Cu_{10}Fe_4Sn(As,Sb)S_{16}$]. The Maggie stannoidite contains up to 2 wt.% As; the vinciennite is Sb-free and has high copper and low sulfur contents compared to the requirements of the ideal formula.

Keywords: porphyry copper–molybdenum deposit, tennantite, tin-bearing sulfides, arsenic, microprobe analyses, Maggie deposit, British Columbia.

SOMMAIRE

Des veinules de quartz – pyrite – tennantite, périphériques à la zone minéralisée du gisement à porphyre de cuivre – molybdène de Maggie, en Colombie-Britannique, contiennent les sulfures d'étain mawsonite, stannoïdite et vinciennite [idéalement $Cu_{10}Fe_4Sn(As,Sb)S_{16}$]. La stannoïdite de Maggie possède jusqu'à 2% en poids d'arsenic; la vinciennite ne contient pas de Sb, mais elle montre une forte teneur en cuivre et une faible teneur en soufre par rapport aux exigences de sa formule idéale.

Mots-clés: gisement à porphyre de cuivre – molybdène, tennantite, sulfures d'étain, arsenic, analyse à la microsonde, gisement Maggie, Colombie-Britannique.

INTRODUCTION

Vinciennite $Cu_{10}Fe_4Sn(As,Sb)S_{16}$ was described by Cesbron *et al.* (1985) as a new mineral species found in quartz and quartz–barite veinlets in a pyrite deposit at Chizeuil, Saône-et-Loire, France, and in a polymetallic deposit at Huaron, Peru. The description by Cesbron *et al.* allowed us to recognize immediately that vinciennite is the unidentified mineral that had been noted to occur in small amounts at the Maggie property, a porphyry copper–molybdenum deposit about 15 km north of Ashcroft and about 80 km northeast of the Highland Valley deposits in south-central British Columbia.

OCCURRENCE

The Maggie deposit is centred in a series of Early Tertiary, dyke-like, porphyritic, granitic intrusive bodies that penetrated Late Paleozoic sedimentary and volcanic rocks of the Cache Creek Group. The copper–molybdenum zone, approximately 1300 × 300 m in surface dimensions, contains about 181 million tonnes grading 0.28% Cu and 0.029% Mo (Miller 1976). The copper sulfides have a zonal arrangement in which a core of chalcopyrite plus minor bornite progresses outward to chalcopyrite, then to chalcopyrite ± tennantite; peripheral to these is the assemblage tennantite – sphalerite – galena (Jambor 1976). Veinlets of the peripheral assemblage are late in the depositional sequence and cut the copper–molybdenum mineralization and some pyrite veinlets.

In Maggie drillhole M33 at 189.8 m (see Jambor 1976), the peripheral assemblage occurs in quartz–pyrite veinlets that are up to 6 mm wide, but typically are only 1 to 2 mm wide. The veinlet pyrite is coarsely crystalline and contains scattered blebs of pyrrhotite. Tennantite occurs abundantly along the boundary of pyrite grains. Associated with some of the tennantite are extremely complex, fine-grained intergrowths of chalcopyrite–bornite and lesser amounts of chalcopyrite–bornite–digenite. Also present are small amounts of galena and sphalerite; as well, small scattered grains of tin-bearing sulfides, one of which is vinciennite, occur sparingly in the other sulfides, especially tennantite.

TIN-BEARING SULFIDES

The Maggie tin-bearing sulfides are mawsonite $Cu_6Fe_2SnS_8$, stannoidite $Cu_8(Fe,Zn)_3Sn_2S_{12}$, and vinciennite $Cu_{10}Fe_4SnAsS_{16}$. All are brownish to orange in reflected light. Vinciennite, however, is distinctively orange relative to the other tin-bearing sulfides and bornite, and also is characterized by a weak though readily discerned anisotropism. Grain size reaches a maximum of about 30 × 70 micrometres, and grain contacts are usually smooth and simple. An X-ray pattern of the vinciennite, obtained using a 57.3-mm Gandolfi camera, showed slight contamination by tennantite, but otherwise the *d*-values and intensities are in good agreement both with the published data of Cesbron *et al.* (1985), and with a newly acquired X-ray pattern of vinciennite from the Saône-et-Loire locality. The cell dimension of the pseudocubic mineral from both localities is identical within experimental error.

Mawsonite in the Maggie assemblage occurs sparingly as anhedral grains up to 15 × 30 micrometres. The brownish color, very strong reflection pleochroism, and strong anisotropism serve to optically distinguish this mineral from vinciennite and stannoidite. Although lamellar twinning in mawsonite is not always evident (Markham & Lawrence 1965), this feature is conspicuous in the Maggie mineral, both in polarized and unpolarized light.

TABLE 1. MICROPROBE COMPOSITIONS OF MAGGIE TIN-BEARING SULFIDES

	mawsonite		stannoidite			vinciennite			
	gr.3	gr.4	gr.8	gr.2	gr.1	gr.A	gr.5	gr.6	theor.
wt.% Cu	43.7	44.6	39.7	40.8	40.4	42.2	42.6	42.6	40.59
Fe	13.0	12.8	9.1	8.4	8.5	14.0	13.2	13.2	14.27
Zn	n.d.*	n.d.	3.6	3.7	3.7	0.4	0.7	0.5	-
Sn	13.8	13.7	16.4	15.9	15.9	8.2	8.3	7.8	7.58
As	n.d.	n.d.	1.5	1.8	2.0	4.3	4.5	5.3	4.79
S	29.6	29.3	29.3	29.3	29.5	31.4	31.3	31.3	32.77
	100.1	100.4	99.6	99.9	100.0	100.5	100.6	100.7	100.00
formula ratios									
	17 atoms		25 atoms			32 atoms			
Cu	5.98	6.09	8.16	8.36	8.26	10.49	10.60	10.58	10.00
Fe^{3+}	2.01	1.99	2.00	1.95	1.97	3.00	3.00	3.00	4.00
Fe^{2+}	-	-	0.13	-	-	1.06	0.74	0.73	-
Zn^{2+}	-	-	0.72	0.74	0.74	0.10	0.17	0.13	-
Sn^{4+}	1.01	1.00	1.80	1.74	1.74	1.09	1.11	1.04	1.00
As^{5+}	-	-	0.26	0.31	0.35	0.90	0.95	1.12	1.00
S^{2-}	8.00	7.93	11.93	11.89	11.94	15.46	15.44	15.41	16.00

*not detected, with limit of detection ~0.05 wt.% for Zn and 0.15 wt.% for As; also n.d.: Pb, Ag, Sb, Cd, In.

Stannoidite is uncommon but occurs in grains up to 35 × 35 micrometres. It is optically distinguishable by its strong anisotropism and by its brownish pink color, which is much less orange than that of vinciennite. In one case stannoidite is largely surrounded by a vinciennite rim about 6 micrometres wide. A Gandolfi X-ray pattern did not unequivocally confirm the identification of the Maggie stannoidite, principally because of contamination by tennantite and because of the similarity of the patterns of stannoidite and mawsonite. This similarity, however, when combined with the optical character and microprobe compositions (Table 1 and Kissin & Owens 1979) leaves little doubt that the mineral is stannoidite.

Compositions

Analyses of the Maggie tin sulfides were obtained with a MAC Model 400 microprobe operated at 20 kV and a specimen current of 0.025–0.030 microamperes. Standards and X-ray lines used were chalcopyrite (Cu$K\alpha$, Fe$K\alpha$, S$K\alpha$), synthetic Cu_2FeSnS_4 (Sn$L\alpha$), synthetic $CoAs_2$ (As$K\alpha$), synthetic ZnS (Zn$K\alpha$), and synthetic $Cu_{11}FeSb_4S_{13}$ (Cu$K\alpha$, S$K\alpha$). The results of the analyses (Table 1) show that the Maggie mawsonite is close to the theoretical composition of $Cu_6Fe_2SnS_8$, wherein Cu is monovalent, Fe is trivalent, and Sn is tetravalent. In contrast, both ferrous and ferric iron are present in stannoidite: $Cu^{1+}{}_8Fe^{3+}{}_2Fe^{2+}Sn^{4+}{}_2S^{2-}{}_{12}$ (Yamanaka & Kato 1976). In the Maggie stannoidite a small amount of arsenic is present and seems to increase as Sn decreases (Table 1). This type of substitution is much more evident in the microprobe results of Springer (1968), who reported substantial substitution of (Sb,As) for Sn in stannoidite (hexastannite). In the Maggie stannoidite the divalent position occupied by zinc is appreciably lower than Zn + Fe = 1, but Cu exceeds the 8 atoms required in the ideal formula.

The theoretical composition of vinciennite $Cu_{10}Fe_4Sn(As,Sb)S_{16}$ suggests that some of the ions are heterovalent. Pentavalent states for arsenic and antimony, analogous to the assignments in chatkalite $Cu_6Fe(Sn,Sb,As)_2S_8$, can be assumed (Kovalenker *et al.* 1981). Partitioning of possibly heterovalent Cu and Fe is highly speculative, but it is noteworthy that the Maggie vinciennite contains a small amount of zinc not found in the type mineral. The presence of Zn^{2+} may be an indication that at least one of the iron atoms in vinciennite is divalent, as is the case in stannoidite. The most significant difference, however, is that the Maggie vinciennite has high copper and low sulfur contents relative to those of the theoretical formula (Table 1).

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