

ROQUESITE AND Cu-*In*-BEARING SPHALERITE FROM LÅNGBAN, BERGSLAGEN, SWEDEN

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ABSTRACT

Roquesite, CuInS_2 , is the first reported indium mineral from Långban. The coexisting sphalerite shows oscillatory zoning in Cu and In contents, and may form a partial binary solid solution $\text{Zn}_{2-2x}\text{Cu}_x\text{In}_x\text{S}_2$. Indium and copper were concentrated to form roquesite during the mobilization process of older sulfide-rich material at relatively high temperatures.

Keywords: roquesite, indium, sphalerite, Långban, Sweden.

SOMMAIRE

La roquesite CuInS_2 est le premier minéral d'indium trouvé à Långban. La sphalérite coexistante, qui montre une zonation périodique en Cu et In, forme probablement une solution solide binaire incomplète $\text{Zn}_{2-2x}\text{Cu}_x\text{In}_x\text{S}_2$. L'indium et le cuivre ont été concentrés pour former la roquesite lors de processus de mobilisation de sulfures plus anciens à températures relativement élevées.

(Traduit par la Rédaction)

Mots-clés: roquesite, indium, sphalérite, Långban, Suède.

INTRODUCTION

The rare indium mineral roquesite, CuInS_2 , has been described from Charrier (Allier), France (Picot & Pierrot 1963), the Akenobe mine, Japan (Kato & Shinohara 1968), Mount Pleasant, New Brunswick (Sutherland & Boorman 1969), central Kazakhstan, U.S.S.R. (Yarenskaya & Slyusarev 1970), col du Lautaret (Hautes-Alpes), France (Picot 1973) and the Urup deposit (northern Caucasus), U.S.S.R. (Kachalovskaya *et al.* 1973). During an investigation of some sulfide minerals from the well-known mines of Långban, Bergslagen

province, central Sweden, roquesite was found in sample RM 670226 of the Swedish Natural History Museum. Indium had not previously been reported from Långban; it can now be added to the list of more than 30 elements that are present in major quantities in at least one mineral species (Moore 1970).

MINERALOGY

Sample RM 670226 consists of magnetite replaced by Cu-bearing minerals, mainly bornite and chalcocite, which locally form myrmekitic intergrowths. Galena, digenite, roquesite, sphalerite and native bismuth are present as small inclusions in bornite and chalcocite. Wittichenite, Cu_3BiS_3 , has been formed as a reaction rim (up to 20 μm wide) around native bismuth. Magnetite contains small inclusions of chalcopyrite, bornite and digenite. Blue-remaining covellite is present as an alteration product. The sample has been described in some detail in connection with other sulfide specimens from Långban (Burke 1980).

Roquesite occurs as small roundish grains (maximum diameter 30 μm) in bornite and chalcocite. In reflected light roquesite shows a brownish-grey color, similar to wittichenite but with a reflectivity only slightly higher (its *R* is about 22%) than magnetite. The mineral is isotropic and has a polishing hardness higher than for bornite and lower than for sphalerite.

Roquesite is always associated with Cu-*In*-bearing sphalerite, which is optically homogeneous in reflected light. In transmitted light these sphalerite grains show irregular cores consisting of oscillatory-zoned, darker and lighter brown sphalerite and homogeneous rims of light yellow to colorless sphalerite. Sphalerite grains not associated with roquesite are entirely colorless.

TABLE 1. MICROPROBE ANALYSES (WEIGHT %) OF ROQUESITE AND SPHALERITE

	ROQUESITE*	SPHALERITE **					
	1	2	3	4	5	6	7
Zn	-	66.5	64.5	60.4	57.2	51.8	51.1
Cu	26.65 ± 0.4	0.2	0.9	2.7	4.0	6.0	6.9
In	47.9 ± 0.2	-	1.3	3.5	5.5	9.1	10.4
Fe	0.4 ± 0.1	0.1	1.1	0.3	0.6	0.6	0.7
Cd	-	0.3	0.3	0.4	0.4	0.4	0.4
S	26.0 ± 0.15	33.0	32.4	32.0	32.0	31.1	31.0
Total	100.95	100.1	100.5	99.3	99.7	98.9	100.5
Number of ions based on a total of 4 (roquesite) or 2 (sphalerite)							
Zn	-	0.99	0.97	0.92	0.88	0.81	0.80
Cu	1.01	0.003	0.01	0.04	0.06	0.10	0.11
In	1.01	-	0.01	0.03	0.05	0.08	0.10
Fe	0.02	0.002	0.02	0.005	0.01	0.01	0.01
Cd	-	0.003	0.003	0.003	0.003	0.003	0.004
S	1.96	1.00	0.99	1.00	1.00	0.99	0.98

* Average value and range of six analyses

** Colorless sphalerite (analyses 2 & 3), light brown sphalerite (analyses 4 & 5), dark brown sphalerite (analyses 6 & 7)

Electron-microprobe analyses were carried out with a Cambridge Instruments Microscan 9. As the oscillatory zones in the core of the sphalerite grains have a width of less than 1 μm , their true composition could not be measured, but Cu and In oscillate sympathetically in step traverses across the zones of lighter and darker sphalerite. Analyses of roquesite and of differently colored sphalerite are given in Table 1. Apparent concentrations were ZAF-corrected with a modified Springer (1967) program and with the Microscan 9 on-line program.

DISCUSSION

Data have been published on the limited solubilities of indium (0.15 wt. % at 600°C) and copper (less than 1 wt. %, even at 800°C) in sphalerite (Boorman & Sutherland 1969, Craig & Kullerud 1969), but no quantitative data are available on the system sphalerite-roquesite. Oen *et al.* (1980) have described oscillatory-zoned crystals in the pseudoternary system stannite-sphalerite-roquesite-hydrothermal solution, in which crystallization temperatures of Cu-In-rich sphalerite are assumed to be intermediate between those of stannite-rich sphalerite and pure sphalerite. The occurrence in Långban of zoned sphalerite crystals having Cu and In contents with atomic proportions close to 1:1 (Table 1) confirms the assumption of Oen *et al.* (1980) that sphalerite and roquesite form a discontinuous binary solid solution series similar to the series sphalerite-stannite. The rims and grains of colorless sphalerite with low Cu and In contents are related to later stages in which crystallization took place at lower temperatures.

The sulfide minerals of Långban belong to period C in the model of Magnusson (1930): vein fillings and the impregnation of older ores with sulfides. Boström *et al.* (1979) suggested an exhalative-sedimentary origin for the Långban ores; the early stages of ore formation probably consisted of sulfide deposition, followed by iron- and manganese-oxide deposition. Subsequent folding and metamorphic events caused recrystallization of the ores and mobilization of sulfide-rich materials, which intruded the ores (Boström *et al.* 1979).

High concentrations of indium usually occur in cassiterite-sulfide deposits and in copper-pyrite polymetallic deposits, both of hydrothermal or exhalative-sedimentary origin. In all previously described occurrences, In-bearing minerals are associated with Sn minerals (cassiterite, stannite, mawsonite). In this respect Långban forms an exception: the only Sn mineral reported from this deposit is wickmanite, a late-stage low-temperature mineral (Moore & Smith 1967). A number of trace elements in the Långban ores were evidently concentrated in individual minerals during the mobilization process, which occurred at relatively high temperatures (Burke 1980).

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