dation of iron carbonate. In the second case it is assumed that a reaction that is usually attributed to contact metamorphism can also take place in the wet way at a temperature low for metamorphism but yielding products that are warm to the touch.

STANNITE, ITS ASSOCIATED MINERALS AND THEIR PARAGENESIS

G. M. Schwartz, *University of Minnesota*

Introduction

Recently in examining polished surfaces of stannite with a reflecting microscope the writer was impressed by the variety of included minerals, and by the uniform nature of the associations in specimens from the various districts. Further studies were made on all the available specimens with the results noted here. The writer is indebted to Dr. E. Steidtmann of the University of Wisconsin for the use of some of the material.

Occurrence of Stannite

Stannite is listed in textbooks of mineralogy as a rare mineral due to its known occurrence in but few districts. However, it occurs in considerable amounts locally in these districts especially in Bolivia. Dana[1] lists stannite from several places in Cornwall, England, Zinnwald in the Erzgebirge, and the Cronebare Mine, County Wicklow, Ireland; also from Bolivia and the Black Hills, S. D. It has been described from Tasmania and Australia,[2] from the Bolivian[3] tin-silver deposits, and from one locality on the Seward Peninsula, Alaska.[4]

[1] Dana, E. S., System of Mineralogy. Sixth Edition, p. 83 and App. I.

[2] Andrews, E. C., The Geol. of the New England Plateau, New S. Wales. *Geol Sur. Rec.*, **8**, 146, 1905.

Hartwell, C. The Occurrence of Stannite in Australia. *Australian Min. Standard*, **10**, 577, 1908.

Petered, W. F., Catalogue of the Minerals of Tasmania, *Tasmanian Dept. of Mines*, 67, 1910.

[3] Stelzner, A. W., Die Silber-Zinnerzlagerstatten Bolivias. *Z. deut. Geol. Ges.*, **49**, pp. 53-142, 1899.

Singewald, J. F. and Miller, B. L. The Mineral Deposits of South America. McGraw-Hill Book Co., **1919.**

[4] Knopf, A., Geol. of the Seward Peninsula Tin Deposits. *U. S. Geol. Sur.*, Bull. **358**, 18, 1908.

Stannite has been noted to occur with pyrite, arsenopyrite, chalcopyrite, cassiterite, wolframite, galena, sphalerite, etc. Davy[5] has given an especially complete description of its associations in the Bolivian deposits. The polished surfaces examined in this study were on specimens from Cornwall, Tasmania, and Bolivia. The following opaque minerals were found included in the stannite; pyrite, arsenopyrite, chalcopyrite, sphalerite, wolframite, and frankeite. The table in Figure 1 shows the associations

	Stannite	Arsenopyrite	Pyrite	Chalcopyrite	Sphalerite	Wolframite	Frankeite
Cornwall, England	●	●		●	●	●	
" "	●	●		●	●	●	
" "	●	●	●	●	●	●	
" "	●	●		●	●	●	
" "	●	●	●	●	●		
" "	●	●		●	●	●	
Zeehan, Tasmania	●	●	●	●			●
" "	●	●	●	●			●
" "	●	●	●	●	●	●	●
Oruro, Bolivia.	●		●				
Unknown	●		●	●			
Unknown	●	●	●	●			
* Bolivia.	●	●	●	●	●		●

FIG. 1. Shows in tabular form the minerals found as inclusions in stannite from various regions. (*) From Davy, *Econ. Geol.*, **15**, 491.

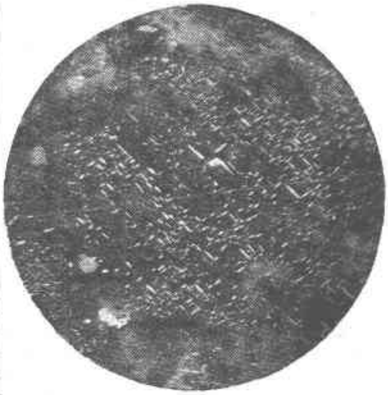

FIG. 2. Micrograph of oriented chalcopyrite inclusions in stannite which has been etched; Cornwall, England. Magnification 130 X.

in the various specimens. Other minerals occur with stannite, but only those found included in it are discussed in this paper. It was found that there is a fairly definite paragenesis of the minerals noted and this agrees essentially with that given by Davy for the Bolivian deposits.

The earliest minerals to crystallize were pyrite and arsenopyrite which occur as more or less corroded and isolated grains. In one case pyrite was completely enclosed by arsenopyrite as if of somewhat earlier origin, but, in general, the two are contemporaneous and are surrounded by stannite. Wolframite was found in several specimens and is apparently earlier than stannite as the latter mineral is found cutting or enclosing it. Chalcopyrite is

[5] Davy, W. M., Ore deposition in the Bolivian tin-silver deposits. *Econ. Geol.*, **15**, 463-496, 1920.

apparently contemporaneous and also later than stannite. It is the most characteristic associated mineral and occurs as irregular areas, minute inclusions, and veinlets in the stannite; also as borders along the contact of stannite with other minerals in a manner indicating a late formation. In general, the disseminated chalcopyrite appears to be contemporaneous with the stannite and under high power the inclusions appear to be aligned with the crystal structure of the stannite. (See Fig. 2.)

Sphalerite occurs in a manner similar to that of chalcopyrite except that there is less definite evidence of its formation later than stannite. The two are probably nearly contemporaneous. On the polished surfaces of the Tasmanian specimens a white mineral occurs as a distinctly later generation than the stannite. It is found principally as veinlets, in many places with chalcopyrite, and is clearly a replacement as residual grains of stannite remain in it. The mineral did not occur in large enough amounts to enable a blowpipe determination but microchemical tests indicated it to be frankeite, ($Pb_5Sn_2Sb_2S_{12}$). If the identification is correct the order is the reverse of that found by Davy in the Bolivian deposits where it preceded stannite.

Conclusions

The following points have been brought out by this study. Stannite has characteristic included minerals which are practically the same for various regions. The paragenesis and relations of these included minerals are also uniform for the various districts. The paragenesis is, as a rule, pyrite and arsenopyrite, wolframite, stannite and sphalerite, chalcopyrite, frankeite. Stannite, sphalerite, and chalcopyrite are in part contemporaneous. The above facts indicate that stannite is formed under rather definite and limited conditions which accounts for its occurrence in but few places. Analyses of stannite given by Dana show a variable zinc content. Stelzner gives an analysis of Bolivian stannite which has less than 1% zinc. The fact that inclusions of sphalerite are common in the Cornwall occurrence suggests that the zinc content may be due to inclusions rather than to zinc in the molecule. Other irregularities of composition may be explained in this manner as the inclusions may be very minute and would escape detection except under high magnification.