

A TIN-BEARING ORE FROM THE COAL RIVER AREA, YUKON TERRITORY

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ABSTRACT

A tin ore from the Coal River area, Yukon Territory contains stannite, franckeite and geocronite. A polished section study of these minerals and the paragenesis of the ore are described. Some reflectivity and x -ray powder diffraction data are given.

Introduction and Acknowledgments

Specimens of a tin-bearing ore were recently obtained from the Coal River area, Yukon Territory, through the kindness of Mr. H. D. McLeod. The author wishes to thank Dr. J. E. Hawley, to whom the specimens were submitted, for the opportunity of studying and reporting on the ore and for critically reading the manuscript, he also wishes to express his gratitude to Dr. L. G. Berry for his good advice and invaluable help.

Location and Field Occurrence

The occurrence is stated to be "on the head waters of the east branch of the Coal River in the south-eastern part of the Yukon Territory". (Approximate longitude and latitude: $126^{\circ} 21'$ west, $61^{\circ} 25'$ north.) The ore forms masses in a 1–8'' wide calcite vein which is emplaced along a low-angle fault in evenly-bedded slates.²

Mineralogy of the Ore

The ore is unusual for its high content of the rare, tin-bearing sulpho-salt franckeite, and the occurrence of stannite and geocronite which are rare minerals in the North American continent. The other sulphide minerals present are pyrite, sphalerite and galena. The identification of franckeite, geocronite and stannite was checked by x -ray powder photographs of the minerals. The gangue is composed of quartz and carbonate.

Pyrite (FeS_2) is not an important constituent of the ore. It generally forms very small anhedral grains, average grain diameter around 0.03

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mm., with occasional coarser patches whose grains are up to 0.25 mm. across. The interstices of the finer-grained pyrites are commonly filled with quartz and rarely with the other sulphides. While there is still much quartz interstitial to the larger pyrite grains, more sulphides, mostly sphalerite with minor stannite, are present in the interstices.

Sphalerite (Zn,Fe)S occurs in grains of all sizes up to 2 mm. across. The grains are usually anhedral due to replacement and corrosion by later sulphides, or because they are formed along the grain boundaries of pyrite grains as recorded above. Outside the pyrite areas sphalerite is mainly present as grains or clusters of grains in franckeite-rich areas and can rarely be found in galena.

It has the resinous yellow aspect of low iron sphalerite. Under high power small rounded bodies of stannite can be seen arranged in a seriate exsolution texture in many of the sphalerite grains.

During the course of reflectivity measurements on the sulpho-salts, the reflectivity³ of the sphalerite was determined to be 17.4%. This agrees very well with Folinsbee's (1949) "best value" of 17.8%.

Stannite (Cu₂FeSnS₄) is a minor constituent of the ore forming brown-grey anhedral grains up to 0.7 mm. across with an average diameter of 0.5 mm. Smaller grains which show a spatial relation to sphalerites in the franckeite-rich areas, have a granularity of about 0.15 mm. and as a rule are "welded" on to the periphery of sphalerite grains. The stannite is slightly harder than the associated sphalerite. In most grains of stannite minute exsolution blebs of sphalerite with a seriate texture can be detected by the use of very high magnifications.

X-ray powder photographs indicate that this is normal stannite and not one of the rare, and still unnamed, minerals of the same composition investigated by Ramdohr (1944). Spacings of the x-ray powder diffraction pattern are given in Table 1.

Ramdohr (1950), Schneiderhöhn (1952) and Uytendogaardt (1951) record that stannite shows a distinct but weak reflexion pleochroism in oil. Examination of the stannite in this ore failed to reveal any change in colour or tone, in oil or air, upon rotation of the polarizing nicol. The anisotropism is however very pronounced, and as noted by the first two authors it is much stronger in oil than in air. The polarization colours are grey to brown-grey; no blue or violet tint, as recorded by Uytendogaardt, could be detected in this stannite.

The polarizing microscope also revealed that the grains usually possess

³Reflectivities, for white light in air, were measured with a photo-electric exposure meter according to the method used by Folinsbee (1949), but employing galena instead of pyrite as a standard of comparison.

TABLE 1. X-RAY POWDER PATTERN DATA FOR STANNITE, FRANCKEITE AND GEOCRONITE IN THE COAL RIVER ORE.

Stannite			Franckeite			Geocronite		
<i>I</i>	$\theta(\text{Cu})$	$d(\text{meas.})$	<i>I</i>	$\theta(\text{Cu})$	$d(\text{meas.})$	<i>I</i>	$\theta(\text{Cu})$	$d(\text{meas.})$
$\frac{1}{2}$	8.3°	5.34Å	4	10.3°	4.31Å	3	11.9°	3.74Å
$\frac{1}{2}$	9.25	4.80	8	13.1	3.40	6	12.6	3.53
$\frac{1}{2}$	11.55	3.85	$\frac{1}{2}$	14.2	3.14	7	13.2	3.38
1	12.85	3.47	10	15.4	2.90	7	13.9	3.21
10	14.3	3.12	$\frac{1}{2}$	18.3	2.46	4	14.7	3.04
4	15.5	2.88	$\frac{1}{2}$	20.1	2.24	7	15.5	2.88
$\frac{1}{2}$	16.7	2.68	6	21.7	2.08	10	19.9	2.26
$\frac{1}{2}$	18.6	2.42	3	25.0	1.82	5	21.2	2.13
$\frac{1}{2}$	19.1	2.36				3	22.1	2.05
$\frac{1}{2}$	20.5	2.20				5	23.1	1.96
$\frac{1}{2}$	21.8	2.08				10	24.7	1.84
8	23.8	1.91				7	25.7	1.78
3	25.7	1.78						
7	28.15	1.63						
1	29.55	1.56						
3	34.6	1.36						
5	38.4	1.24						
1	39.4	1.21						
$\frac{1}{2}$	40.4	1.19						
1	40.7	1.18						
5	44.0	1.11						
3	53.8	0.96						
2	57.3	0.92						
$\frac{1}{2}$	57.65	0.91						
2	63.7	0.86						
2	64.6	0.85						
2	68.4	0.83						
2	68.8	0.83						
2	79.6	0.78						
2	80.5	0.78						

Plus many more weak lines

NOTE: No back reflexions were obtained for franckeite or geocronite, and the measurements are not compensated for film shrinkage.

a coarse lamellar twinning, but lack the finer microcline-like lattice pattern of twinning. This indicates that the stannite probably crystallized as the low temperature, normal, tetragonal form, Ramdohr (1944).

The etch tests agree with those published by Short (1940), and the reflectivity of 27.8% is nearly identical with Folinsbee's (1949) best value of 27.6%.

Galena (PbS) is found in the polished sections to form coarse-grained galena-rich patches with grains up to 0.5 cm. across, and areas of small grains interstitial to sphalerite, stannite, franckeite and rarely pyrite. The ore is argentiferous but no particles of silver were seen in the galena.

Franckeite ($\text{Pb}_5\text{Sn}_3\text{Sb}_2\text{S}_{14}$) is the major constituent of the ore. In polished sections it has the characteristic plumose texture of the sulpho-

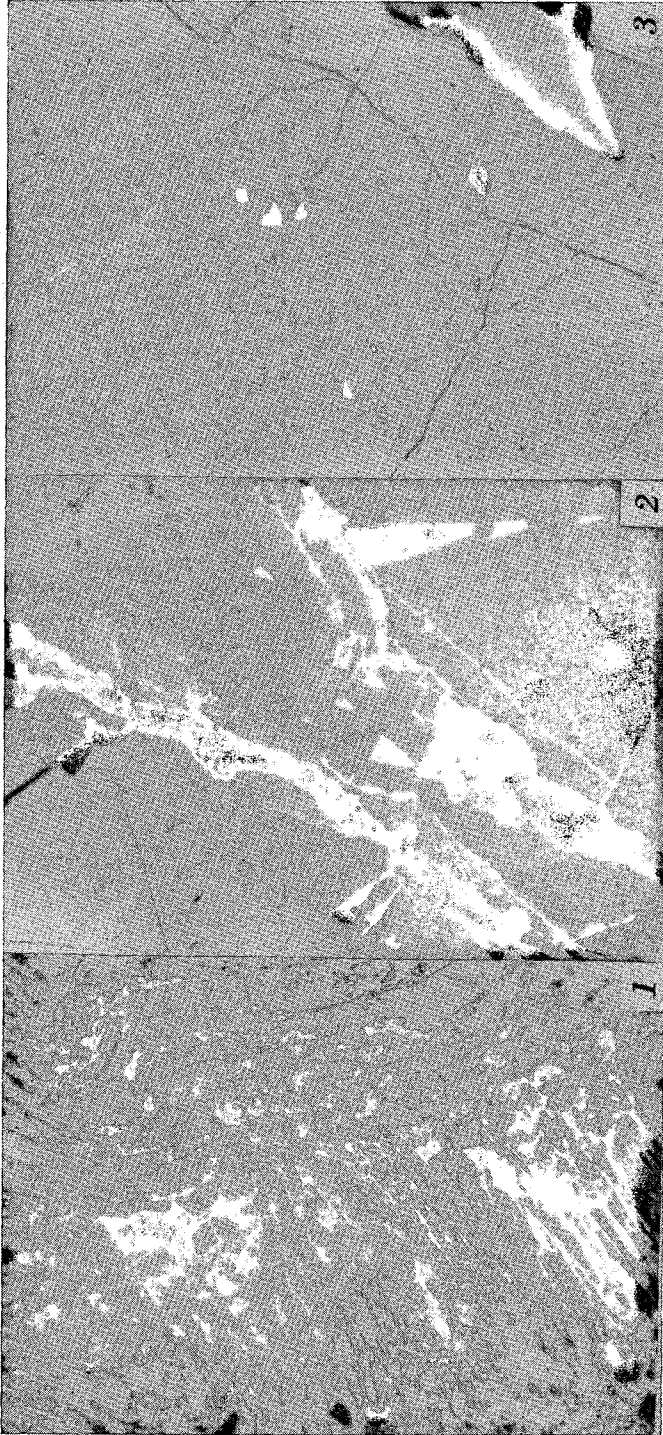


FIG. 1. Francieite showing well-developed plumose texture. Ordinary light. x 50.

FIG. 2. Francieite (darker grey) formed along fractures in galena. Partially crossed nicols. x 50.

FIG. 3. Surface of a large geocronite grain showing fractured appearance. Darker grain is sphaerite. Ordinary light. x 50.

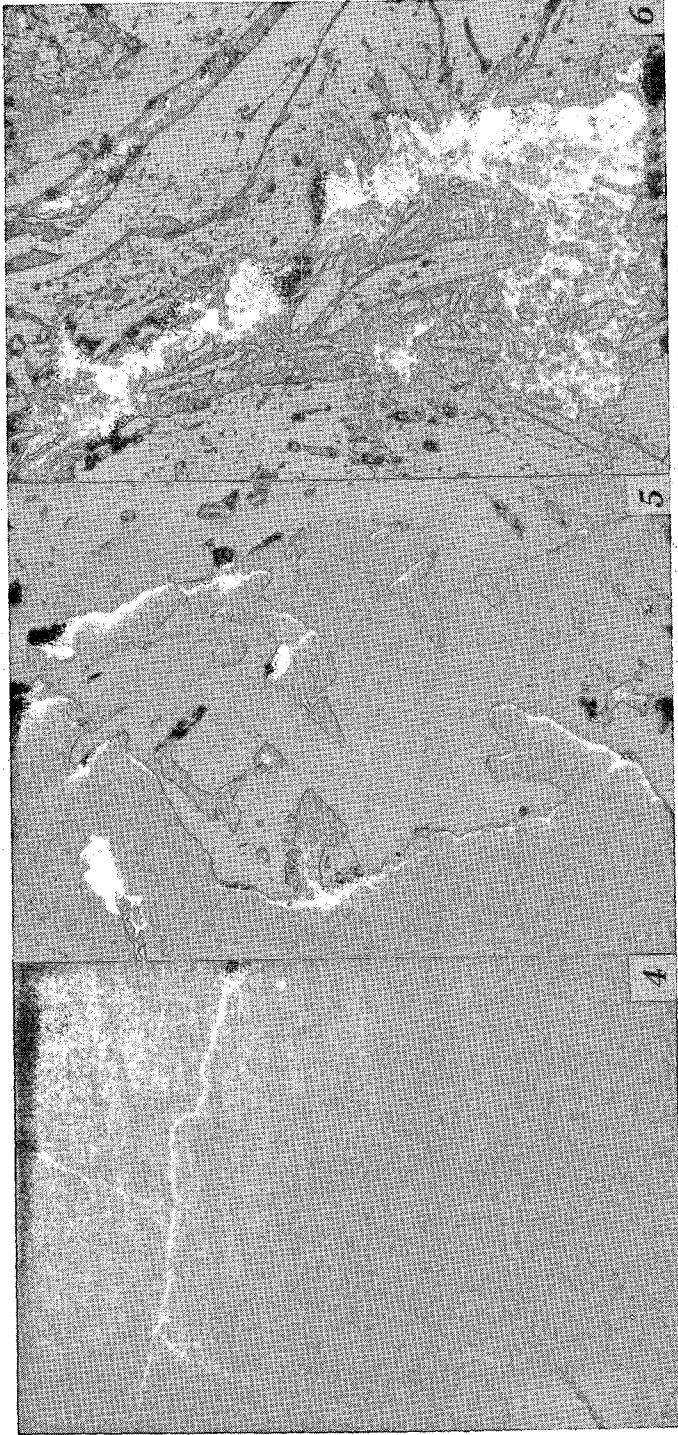


FIG. 4. Erratically developed lamellar twins in geocronite. Partially crossed nicols. x 115.

FIG. 5. Franckeite (white) replacing sphaalerite (grey). Note cleavage continuity in sphaalerite "islands". Ordinary light. x 50.

FIG. 6. Fracture zone in franckeite along which calcite (dark grey) has been introduced. (Black areas are holes in the section.) Ordinary light. x 50.

salts (Fig. 1); probably representing sections through fibrous aggregates of prismatic crystals. These elongated grains are frequently bent like some of the franckeite at Llallagua described by Turneure (1935), they range from very tiny grains up to 1.5 mm. long. Other franckeite grains are emplaced along cracks in galena (Fig. 2). Random grains of franckeite can always be found in galena, and as in the plumose aggregates they show a tendency to develop crystal outlines.

In air the franckeite is a grey-white, but this colour is distinctly greyer in oil and the mineral then stands out better against galena, compared with which it is distinctly greyer. The reflexion pleochroism is very weak in both air and oil, the colours are grey-white to grey-white with a brown tint.

There is some confusion in the literature with regard to the anisotropism of franckeite—due possibly to work on different material. Palache, Berman & Frondel (1944), Ramdohr (1950) and Schneiderhöhn (1952) recorded it as weak; Short (1940) described it as strong and Uytendogaardt (1951) as distinct. In this ore the franckeite is distinctly anisotropic in air; polarisation colours light grey to dark grey, the light grey having a brown tint. In oil the anisotropism is even more marked with the same colours. The lamellar twins noted by most of the above authors are also developed in this franckeite.

It is much softer than the associated sphalerite but slightly harder than the galena, as demonstrated by drawing a needle across their mutual boundaries. The reflectivity is 34.7% (Folinsbee (1949)—34.9%). Measurements of the x-ray diffraction pattern are given in Table I. The etch reactions agree with those given by Uytendogaardt (1951). As Douglass (1954) has shown that boulangerite, geocronite and jordanite, contrary to the general belief, give negative results with HNO_3 , an attempt was made to check the reaction with franckeite. With a large drop which covers grain boundaries and cleavage cracks, the reaction is rapid and vigorous, as found by other workers. Unfortunately the franckeite in this ore is so fine-grained, and has its cleavage so well developed, that the author found it impossible to produce a drop sufficiently small to avoid covering any grain boundaries, cleavage cracks or fractures in the grains. The best result was obtained with a drop which crossed only one cleavage crack. This took over 30 seconds to commence reacting with the franckeite and it seems probable that franckeite too is *sensu stricto* negative to HNO_3 . When held close to the surface of concentrated HNO_3 it is strongly tarnished after 3–5 minutes; this was useful in distinguishing small grains of geocronite in the franckeite, which do not react with HNO_3 fumes.

Up to the present franckeite has only been reported from several localities in Bolivia and two in Tasmania. The Coal River ore more closely resembles the Tasmanian than the Bolivian ores. The only detailed description of franckeite in Tasmanian ores is that of Stillwell & Edwards (1943). They record it as present in minute quantities in the tin ores of Renison Bell. Here it replaces and encloses stannite and they consider it to have formed from a reaction between stannite and late silver-lead solutions.

In the Coal River ore there are many unreplaced residuals of stannite in franckeite and it was no doubt emplaced at the expense of much stannite, however in this ore it was also formed by the replacement of galena.

Geocronite. The formula of geocronite, a lead arsenic sulpho-salt, is still uncertain—Douglass, Murphy & Pabst (1954). According to these workers it is isostructural with jordanite, and probably the intermediate member of a series in which jordanite is the arsenic end-member; the antimony end-member being not yet known. The x -ray powder photograph (measurements of the diffraction pattern are given in Table 1) will not differentiate between these two minerals, and they consider it doubtful that they can be distinguished by polished section observations. Unfortunately they do not record the reflectivity values of their material. Folinsbee (1949) gives reflectivity values of 40.9% for geocronite and 38.4% for jordanite. The mineral in the Coal River ore gives a value of 40.7%. In view of the excellent agreement between the reflectivity values obtained on the other minerals and those given by Folinsbee, and the absence of other arsenic minerals in the ore, the mineral is tentatively identified as geocronite.

The polished section properties of this geocronite, including its strictly negative reaction to HNO_3 , are entirely in accord with the findings of Douglass (1954). By drawing a needle across their contacts the hardness is found to approximately equal that of franckeite. No cleavage was seen and the surface has a distinctive fractured appearance (Fig. 3). The colour in oil and air is galena white, no reflexion pleochroism was observed. The anisotropism is more distinct in oil than in air, under both conditions the colours are light grey with a brown tint to dark grey, but the brown tint is emphasized by oil immersion. Lamellar twins are erratically developed in the geocronite (Fig. 4).

The geocronite was only found in two polished sections. In one of these there is a large grain about 3 mm. across with a few small ones around it; these are set in a franckeite-rich area. The other contained some small grains, again associated with franckeite.

Paragenesis

The paragenetic sequence is as follows

Pyrite	Galena
Quartz	Franckeite
Sphalerite	Geocronite
Stannite	Calcite

Pyrite was the first mineral to form. It was followed by quartz and sphalerite which corrode the pyrite grains and fill their interstices. The sphalerite occasionally corrodes the quartz and was presumably later. Many sphalerite grains contain exsolution bodies of stannite and it is probable that these minerals were formed at much the same time. Stannite sometimes surrounds, corrodes and embays sphalerite grains; smaller stannites are often "welded" on to sphalerite grains. Much of the stannite contains exsolution bodies of sphalerite, material which may have originally been in solution in the stannite or which it may have dissolved during the replacement of sphalerite. The later minerals have corroded both sphalerite and stannite to such an extent that the relationships between these two minerals are much obscured, making it impossible to determine how many of the discrete stannite grains, that show such a distinct spatial association with sphalerite, were formed by exsolution from them.

Galena was the next-formed mineral. It corrodes, rims and replaces sphalerite in which it also fills fractures. Much of the galena appears to have been replaced by franckeite, which forms subhedral grains so readily that the residual galena, now filling franckeite grain interstices, gives the impression of being later; many of these "residuals" are however corroded by the franckeite. Franckeite, with minor geocronite, also replaced galena along small fractures (Fig. 2). Thus it appears to have been emplaced largely at the expense of galena. In addition to galena it replaced stannite and sphalerite. Replacement of the latter mineral often results in beautiful examples of island and mainland replacement textures (Fig. 5).

Fracturing of some degree appears to have taken place during much of the ore formation. Galena fills fractures in sphalerite and franckeite does the same in galena. But the mineral most affected by brecciation is franckeite itself. Fracture zones occasionally traverse the franckeite and the grains are then bent and broken into fragments of all sizes; late calcite has been introduced along these fractures and often encloses the broken franckeite (Fig. 6).

The little geocronite present formed after the franckeite which it cross-cuts and embays. It corrodes sphalerite and stannite and is emplaced with franckeite along fractures in galena.

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