dolomite it might cause random disordering and could account for the unsystematic variation in *d*-spacings measured by XRD.

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Carlsbergite, CrN, in troilite, FeS, of the Sikhote Alin meteoritic iron

IN the course of an optical study of the metallography of the Sikhote Alin iron meteorite we encountered an unusual 'feathery' feature (fig. 1) penetrating into massive troilite, FeS, as a directional array of fine lamellae, starting from the interface between the troilite and the matrix of kamacite (b.c.c. α Fe-Ni). The feature has been identified by modern electron optical techniques as carlsbergite, CrN. This is the second instance of carlsbergite in an iron meteorite of group IIB, but the first instance of carlsbergite in association with troilite in an iron of any group.

The sample of Sikhote Alin is a 1.1 kg slice No. 1590/5 presented by the Committee of Meteorites of the Russian Academy of Science. It consists predominantly of kamacite with a nickel content of 5.9 wt % with macroscopic inclusions of troilite, schreibersite, $(FeNi)_3P$, and cohenite, $(FeNi)_3C$. Carlsbergite was encountered as a microscopic feature within several troilite particles but the detailed study was conducted on one lens-shaped troilite particle measuring approximately 9 mm × 2.5 mm. In all instances the troilite is fractured. Under polarized light it appears essentially uniform, but X-ray back-reflection photographs suggest that it is polycrystalline. It is incompletely sheathed with a thin shell of schreibersite. Microscopic particles of carbide and 'spikes' of haxonite, $(FeNi)_{23}C_6$ are a common feature within the kamacite at the kamacite-troilite interface. The troilite contained occasional blocks of daubreelite, $FeCr_2S_4$, but no chromite was observed. It is noteworthy that the carlsbergite occurs only where there is a break in the swathing schreibersite such that the troilite comes into direct contact with the kamacite.

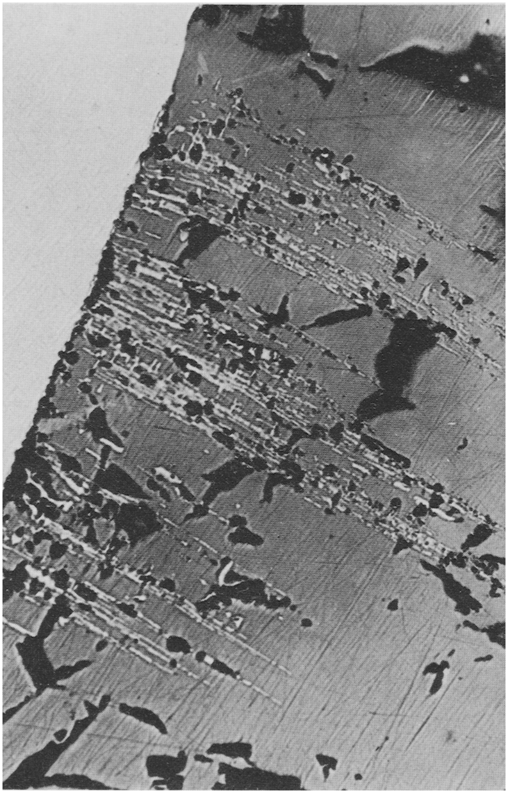

FIG. 1. Feathery growth of carlsbergite, CrN, in troilite (dark) at interface with kamacite (white). Black regions in troilite are cracks. Note that schreibersite is not present at this interface. Field of view 0.158 mm × 0.103 mm.

Analyses for sulphur and metallic elements were made on the unetched sample using a Cambridge Instrument Stereoscan S180 with a Kevex analysis facility which automatically sums detected elements to 100% but does not cope with light elements. Point analyses were made in the bulk troilite and in the feathery material and its adjacent troilite in fig. 1. Only minor Cr was recorded in the troilite. Point analyses of the feathery constituent were erratic due to its small width (2-3 μm) and fractured condition, but consistently gave Cr readings of the order 75%, far in excess of the 37% Cr encountered in the daubreelite of the same troilite body. Low variable levels of Fe and S appeared to be associated with the feathery feature, but these were believed to originate from the surrounding troilite matrix due to lack of spatial resolution of the technique. Chromium was the only metallic element shown to be present.

The presence of pure chromium in a troilite matrix appeared highly improbable, hence a search was made for light elements such as N or C using the unetched sample on the Cambridge Instrument Microscan 5 at Sheffield. The results for Cr and N across the feathery feature show a direct correlation between the two elements. No significant N levels were detected in the bulk troilite nor within the adjacent kamacite. A scan for C was also undertaken but no correlation between C content and the feathery features could be established. We therefore conclude that the feathery feature is a precipitate of carlsbergite, CrN, in the troilite.

Carlsbergite was first identified in meteoric iron by Buchwald and Scott (1971). It has hitherto been encountered only as a minor precipitate within the kamacite phase where it occurs as small, isolated, oriented platelets, typically $30 \times 5 \times 2$ μm. Buchwald (1975) has reported it in the kamacite of group IVA irons; in the low Ni members of group IIIA irons; in seven (Murphy, North Chile, Hex River, Lombard, Uwet, Lick Creek, and Smithonia) of the forty-three known irons of group IIA and also in one (Nenntmansdorf) of the fourteen irons of group IIB. The metallography of the group IIA irons is complicated by the fact that in most of them the troilite appears to have been melted by a shock event and in many of them there is recrystallization of the kamacite to a greater or less extent. It may be significant that apart from Hex River (where there is melting of the troilite and *incipient* recrystallization of the kamacite) the reports of carlsbergite in IIA irons are so far restricted to meteorites in which the kamacite and troilite are not significantly altered by shock or reheating effects. However, we have taken the opportunity to re-examine the condition of the troilite in the sample of Lombard which was previously studied by Axon and Waine (1972) and we confirm that the troilite there is unmelted and is not associated with carlsbergite. In contrast to the IIA meteorites, the irons of group IIB do not generally show melted troilite. Sikhote Alin is the only IIB iron currently available to us and it would appear desirable to examine the troilite of the other IIB irons for the effects noted here.

Although the identification of carlsbergite in the troilite of Sikhote Alin is established, an explanation of its paragenesis is less certain. However, it does appear that the precipitates formed at a late stage of the pre-terrestrial history of the meteorite, subsequent to the precipitation of schreibersite on part of the troilite–kamacite interface. The metallographic features suggest that the carlsbergite precipitation may have been induced in the troilite by a stress mechanism and the location of the feature at otherwise 'clean' portions of troilite–kamacite interface suggests that the troilite (daubreelite) may have provided the source of chromium and the kamacite may have provided the source of nitrogen for this product.

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Some observations on the mineralogy and genesis of chalcophanite

THE zinc-containing manganese oxide chalcophanite $ZnMn_3O_7 \cdot 3H_2O$ occurs in trace amounts in the manganese oxide ore deposits of Groote Eylandt (Ostwald, in press). The mineral was initially identified on the basis of its optical properties, association with known manganese oxide minerals, and its X-ray energy spectrum which showed strong peaks for Mn and Zn. Recently the writer identified a cavity filling of polycrystalline chalcophanite sufficiently large for investigations of chemical composition and X-ray powder data. The occurrence also showed features which suggest the mechanism of formation of the mineral in this particular occurrence.

Occurrence and mineralogy. The mineral occurs as cavity linings and botryoidal aggregates up to 0.5 mm in dimensions in a lateritized siliceous cryptomelane outcrop. The cavity containing the chalcophanite also originally contained a yellowish siliceous clay which has been largely removed by surface leaching. The chalcophanite occurs as masses of micron-sized crystallites with random optical orientation. In places this fine-grained chalcophanite has recrystallized to radiating tabular crystals up to 20 μm in length and 5 μm in width. These tabular crystals represent prisms flattened parallel to the basal plane, as evidenced by the presence of abundant (0001) cleavages (fig. 1). The mineral shows very well-defined bireflection in shades of grey and white. Anisotropism is also extreme but without definite colours. Individual grains are too small and too full of cleavages for reflectivity and microhardness determinations.

Before the removal of the clay infilling, the chalcophanite occurred as a layer between siliceous cryptomelane ore and clay, with the growing faces of its crystallites projecting into the clay, and as aggregates within the clay. SEM-EDS examination indicated that this clay also contained traces of Zn and Mn, and EPMA determinations were carried out. Microanalyses on three areas of chalcophanite and average microanalysis of the clay are shown in Table I. Results of X-ray diffraction analysis on small samples of chalcophanite and clay removed from the polished sections are listed in Table II. These indicated that the clay mineral is essentially a 7 Å kandite-type clay. No other mineral phases were identified in the clay by X-ray diffraction. To determine the relationship, if any, between the chalcophanite and the zinc-containing manganiferous clay, EPMA line scans were made across the minerals. These showed that the recrystallized chalcophanite–clay junction was sharp and well defined but the junction between the dense finer-grained chalcophanite and clay was characterized in some places by a zone intermediate in chemical composition between chalcophanite and clay. This is illustrated in the EPMA line scans in fig. 2.

Detailed optical study of this region indicates that it has the general appearance of clay rather