Geol. Soc. Malaysia, Bull. 8, December 1977, pp 131–136.

The nature and genesis of chalcopyrite with included pyrite framboids from Bylco Azira Mine, Puchong, Selangor, Malaysia.

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The Bylco Azira mine is a deep opencast one, approaching 100 ft. in depth, from which cassiterite is being recovered from those portions of the placers that largely occur between the pinnacles of the marble bedrock, and so were inaccessible to the dredges which had previously operated there. The mineral is also recovered from certain lodes and veins in the mine.

On the floor of the mine two major lodes are exposed that pinch and swell and vary in thickness from c. 1 to c. 4 ft. Associated with these is a swarm of veins with a markedly different strike from that of the former, but the age relationship between the lodes and veins is still in doubt.

The veins are characterised by the presence of cassiterite and pyrite, whilst the lodes contain, in addition to cassiterite and quartz, an impressive suite of sulphides, that probably includes stannite. In any event, a stannite-rich block was found near one of them and peripheral material from this, when examined in polished section, provided the data for this note.

The polished sections from the block consist of cassiterite and quartz associated with early pyrite and arsenopyrite, and somewhat later sphalerite, stannite, (tetrahedrite?) and chalcopyrite. In particular, the earlier sulphides are markedly veined and replaced by the later ones. The paragenesis and texture of this ore will be treated in detail in a later note. In this note the writers will confine themselves to the nature and genesis of a most interesting sulphide rim as revealed in the polished sections.

THE NATURE OF THE RIM (FIGS. 1 AND 2)

The rim in question is composed of Chalcopyrite which displays a delicate colloform texture whose character was much more obvious after the specimen had been etched for 30 secs. with 1:1 HCl and $KClO_3$.

Enclosed within this rim are randomly distributed pyrite framboids whose diameters differ widely and range from c.10 to c.100 microns. These framboids consist of an aggregate of pyrite cubes which may or may not be well-ordered. Locally, in addition, swarms of small pyrite crystals, of the same sizes as those composing the framboids, are in evidence. These, in the writers' view, were derived from framboids that were disinteregrated as a result of the force of crystallisation to which they were subject when the gel, that was the parent of the chalcopyrite host, crystallised. Rarely, also, small aggregates of randomly oriented pyrite crystals occur that are appreciably larger than those of the

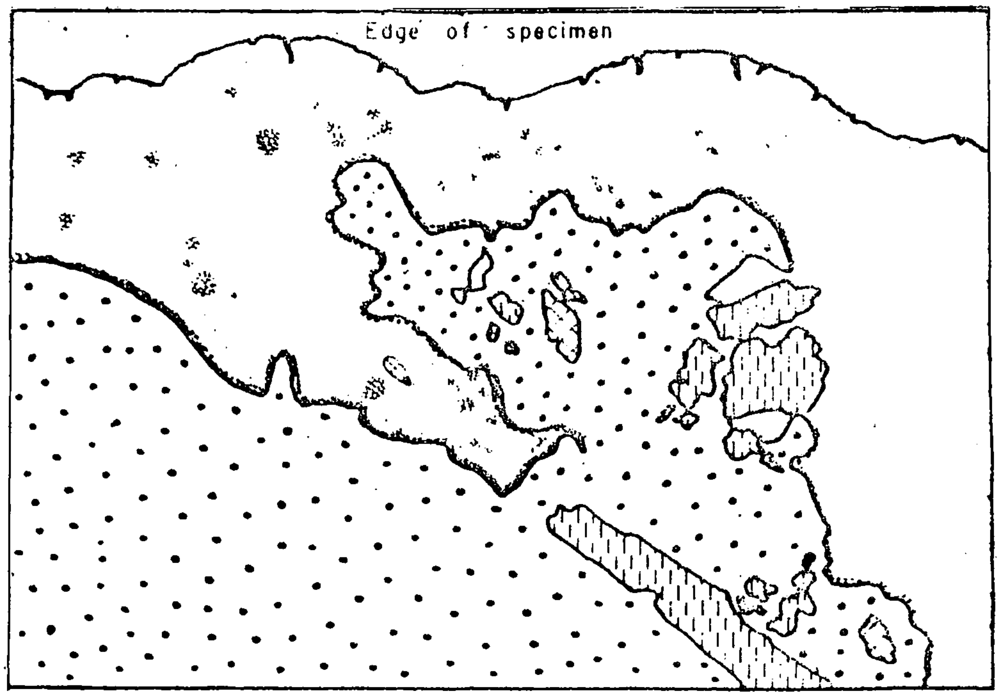


Fig. 1

600 μ

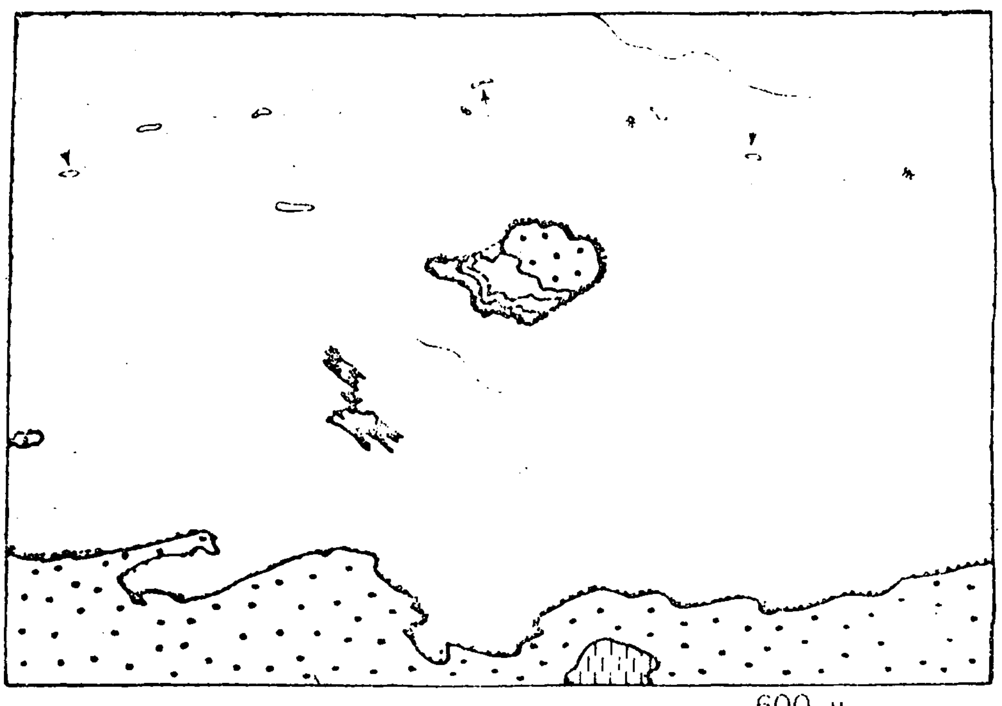
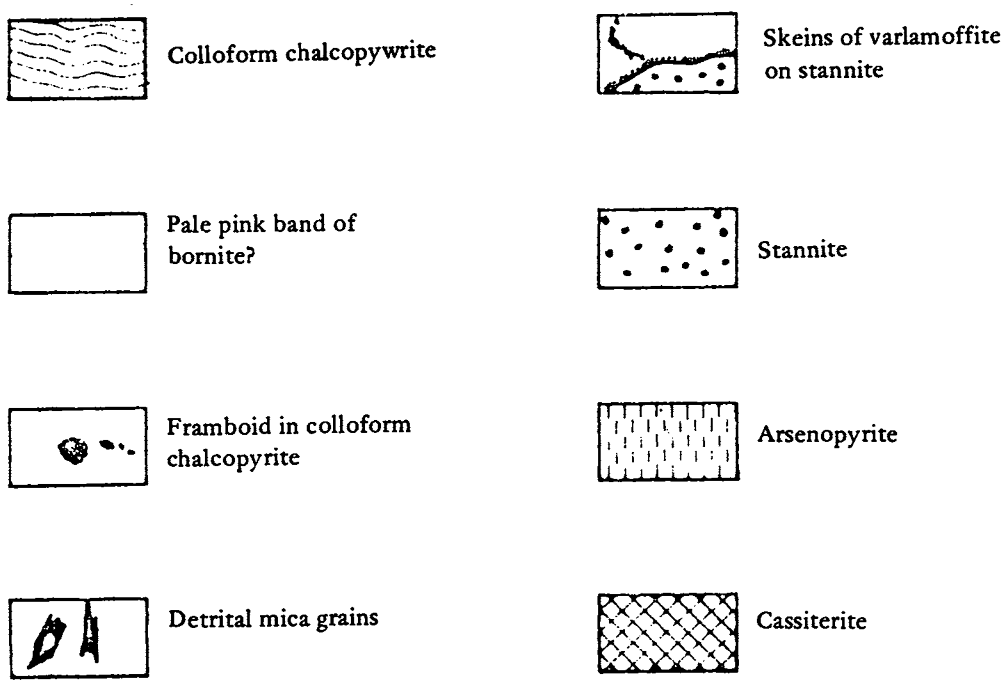


Fig. 2

600 μ

Figures I and II: Legend and caption *



Figures 1 and 2, drawn from polished sections, show the relationships of the colloform chalcopyrite rim to the minerals that it is investing. Figure I shows portion of the rim that contains captured framboids while figure II shows islets of stannite. The smaller islets (arrows) are oriented parallel to the local chalcopyrite bands and this orientation may be due to forces acting during the development of the chalcopyrite rim. Note that detrital mica grains are cought in the band also.

framboids and a few, scattered, irregularly-shaped islets of stannite are to be seen. Fig. 3

Whilst this colloform chalcopyrite may fringe a variety of different minerals, it is generally found closely associated with chalcopyrite that lacks a colloform texture and is devoid of framboids, and these two 'varieties' of chalcopyrite are separated by a very thin pale pink band which has been provisionally identified as bornite. This inner, framboid-free chalcopyrite has clearly rim-replaced and embayed a number of other sulphides, but, in particular, pyrite and stannite. During the replacement of the stannite the tin of the latter was converted to skeins of minute bodies, that are almost certainly varlamoffite, and that now ornament the chalcopyrite. Examination of the polished sections does not enable one to decide whether the agents responsible for this replacing chalcopyrite and its bornite (?) edge were supergene or hypogene ones.

GENESIS OF THE RIM

The marginal disposition of the colloform chalcopyrite and the presence of pyrite framboids within it give strong reason for believing that the copper/iron sulphide is of supergene origin and that it was probably deposited initially as a gel. There is nothing to support the view that it originated by replacement of any of the components of the ore.

It is held that rapid downcutting by elements of the local drainage system during the Quaternary phase of low sea-level allowed exposed sulphides of the lodes and veins to be stranded in the zone of oxidation. Subsequently a general rise in sea-level, with accompanying rapid accumulation of sediments in a then sluggish drainage system, in which swamps developed, created a reducing environment which prevented the sediment-covered parts of the sulphide lodes from suffering any further decomposition. The organic-rich reducing horizons in the sediments also provided an environment in which, during the early stages of diagenesis, pyrite framboids and individual pyrite crystals developed by reaction between biogenic sulphide ions and elemental sulphur and the ever-present soluble ferrous iron.

It is supposed that during this time the sulphides, in those parts of the lodes that were in the zone of oxidation above the water-table, were decomposed, yielding oxysalts, and providing copper, sulphate, etc., ions, that in part descended, approximately along the line of the lodes, into the reducing environment of the sediments, (Probably a portion of the liberated ions also descended with the lodes and were fixed as internal secondary sulphides by those supergene processes that are fairly well understood and that are discussed at length in most modern text-books of ore-deposits. We are not concerned with these lode-internal events in this paper). Then externally moving copper and iron ions reacted with biogenic sulphide ones (and elemental sulphur?) producing a copper/iron sulphide gel that locally invested the lode. It is thought that the development of this gel was by displacement of the fine components of a carbonaceous, pyrite-bearing (framboids, etc.) mud, and that the nature of the deposition was such that although the fine components of the mud could be, and were, rejected by the developing rim, the pyritic bodies, being much larger, were simply by-passed and engulfed by the gel. Subsequently this gel crystallised to chalcopyrite, and at this stage, as noted earlier, some of the framboids were completely disorganised by the forces of crystallisation to which they were subjected.

The large stannite islets that occur in the rim may be the high points of the irregular surface of the parent ore-body, but it is more probable that they are simply mechanically detached fragments of ore that were sitting on the parent at the time of ore development and were of such a size that they could only be by-passed by the advancing chalcopyrite. On the other hand it is believed that the small stannite islets that are orientated parallel to the chalcopyrite bands are detached fragments of the parent orebody that were so small that they were moved by the developing sulphide gel (Fig. 2).

As there is no good reason for believing that during the phase of rim-sulphide development the water associated with the sediments was brackish, one is forced to the conclusion that the parents of the biogenic sulphide ions were sulphate ones that were derived from the oxidising parts of the lode and/or from sulphur-bearing plant proteins.

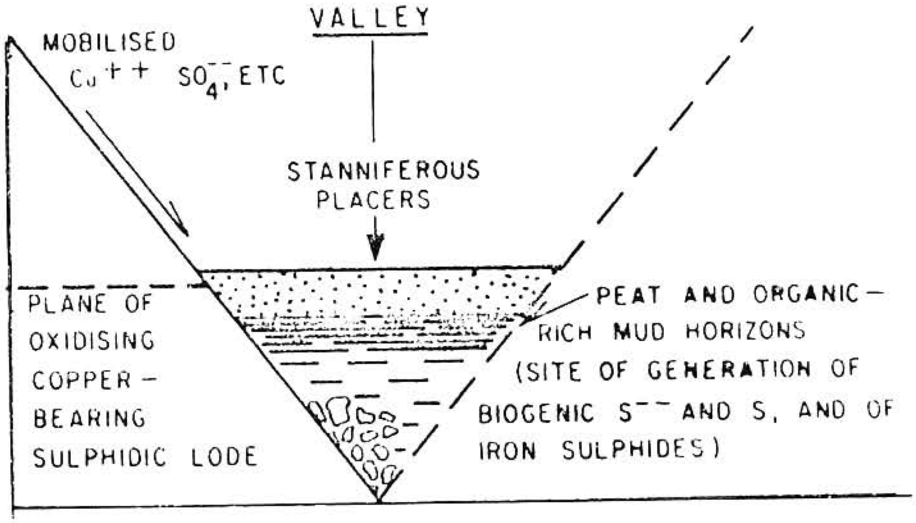
Figure 3 is a diagrammatic representation of the writer's views of the genesis of the calcopyrite under review.

FIG. 3

DIAGRAM INDICATING THE POSTULATED GENESIS OF SUPERGENE CHALCOPYRITE IN THE PLACER MATERIAL AT BYLCO AZIRA MINE, PUCHONG, SELANGOR. (K.F.G. HOSKING, OCT., 1975)

ZONE OF OXIDATION

GENERATION OF OXY-SALTS AND GOSSAN. MOBILISATION OF Cu^{++}, SO_4^{--} IONS (AND OTHERS)



ZONE OF REDUCTION

CONTAINING:–

(i) PRIMARY SULPHIDES STRANDED DURING RAPID DOWN-CUTTING OF RIVER, THEN PROTECTED BY RAPID ACCUMULATION OF SEDIMENTS AND ESTABLISHMENT OF A REDUCING ENVIRONMENT.

(ii) POSSIBLY SUPERGENE SULPHIDES FORMED BY REPLACEMENT OF PRIMARY ONES.

(iii) POSSIBLY EARLY PRODUCTS OF OXIDATION OF LODE (NOW STRANDED IN A REDUCING ENVIRONMENT)

(iv) ACCUMULATIONS OF IRON-SULPHIDES (FRAMBOIDS, SULPHIDISED PLANT MATERIAL) GENERATED IN THE ORGANIC – RICH HORIZONS. (BIOGENIC S. AND S. INVOLVED)

(v) SUPERGENE CHALCOPYRITE DEPOSITED BY REPLACEMENT OF ORGANIC – RICH, FRAMBOID – CONTAINING MUD, ADJACENT TO LODE SULPHIDES PROPER [BIOGENIC S^{--} (AND S?) INVOLVED)

(vi) DETACHED LODE FRAGMENTS, PERHAPS, IN PART EMBEDDED IN CHALCOPYRITE RIM