OCCURRENCE OF SULPHIDE MINERALS IN MARBLES ASSOCIATED WITH GRANITIC ROCKS AROUND CHANDO, PALAMAU DISTRICT, BIHAR

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Received May 25, 1964

(Communicated by Dr. C. S. Pichamuthu, F.A.S.C.)

ABSTRACT

Thin stringers and lenslets of sulphide minerals replacing marbles along cracks and fissures are found around Chando (23° 58' 36" N, 84° 6' 12" E) in Palamau District, Bihar. Marbles and the paraschists represent the oldest rocks of the area. The marbles occur as more or less circular pockets within granite gneiss country. The minerals are mostly simple sulphides of Fe, Cu, Zn and Pb. The most abundant minerals are bornite and chalcopyrite. Two types of association are common—(a) chalcopyrite-bornite solid solution and (b) bornite-chalcocite solid solution. Myrmekite-like texture in bornite-chalcocite is noteworthy where chalcocite has largely replaced pyrite leaving behind minute remnants. In bornite, chalcopyrite has exsolved as blades along (111).

A mineral is detected which closely resembles 'Orange Bornite' (Orcel, 1937, 1943—supposed composition Cu₉FeS₆) with yellowish orange colour and a higher reflectivity than bornite. It does not extinguish completely, but shows a greenish-pink colour and a mixed ± reaction with KCN and HNO₃.

The ore minerals show little or no secondary alterations. The source of the solution probably seems to be that from which the granite was derived and the solution might have supplied the metals along the fissures and cracks of the marble occurring within the granitic country. In course of replacement the sulphide solution produces beautiful 'delta textures'.

INTRODUCTION

Thin stringers and lenslets of sulphide minerals are encountered in marbles around Chando (23° 58' 36" N, 86° 6' 12" D) in Palamau district, Bihar.
The area is in the vicinity of Daltonganj town in Bihar. The village Chando is on the western side of a small hummock (1008 ft. general elevation 702 ft.) in a gently undulating country west of the Kechki railway station.

Previous literature and publications regarding this particular marble are not available. K. P. Rode (1948), B. Banerjee (1954), S. P. Dasgupta (1956), S. K. Guha (1956) and D. Bose (1963), had worked in the adjoining areas and their conclusions regarding stratigraphic position of certain rock units and their morphologic variations have been taken into account for correlation. Sulphide mineralisation is reported for the first time in this paper and their geologic set-up and mineragraphic and textural features described, and genesis discussed.

From surface observations, the ores seem to be of little economic value. The purpose of this article is to focus attention on the interesting suite of sulphide minerals.

**Geology**

The marbles are found as pockets (more or less circular in shape with maximum diameter of 500 ft.) within granitic rocks. The paragachs and the marbles are the oldest rocks of the area. The different types of marbles, especially the dolomitic varieties within the granite gneiss country, are at places traversed by cross-cutting veins and small bands of metabasic rocks which are definitely later than the marbles. The metabasics include meta-gabro, meta-norite and meta-dolerite. The predominant minerals in metabasics are calcic plagioclases, pyroxene (augite, hypersthene) and uralite hornblende. The general dip of the marbles is high (70°-80° S.W. in most cases).

**Lithology**

Intercalation of dark clots and bands of silicate minerals like diopside, forsterite, tremolite, etc., with dolomitic and calcitic materials has given rise to a banded appearance. The thickness of the bands varies from a fraction of an inch to 4 or 5 ft. The common minerals found in the marbles are calcite, dolomite, diopside, forsterite, tremolite and serpentine.

**Petrography**

The colour of the marble varies from milky white to dark green and greyish white. The silicate minerals produce darkening of colour in the marble. The diffused metallic elements in the sulphide-rich portions also cause darkening. The forsterite-rich marbles consist of a mosaic of equant grains of calcite and dolomite producing a granoblastic texture. The grain
size of the minerals varies largely. The purer variety poor in silica contains forsterite, the impure one a good amount of silicate minerals—diopside, talc, tremolite, etc. The grains of forsterite are isolated, idiomorphic and conspicuous in thin sections. Forsterite has very often altered to serpentine (chrysotile) in the serpentine marble. But in the forsterite marble where the sulphide mineralisation has taken place there is little serpentinisation. These rocks are clearly produced by metamorphism of impure dolomitic limestone which represents the calcareous facies of sedimentation.

**Nature of Ore Mineralisation and Their Extent**

Within the marbles, swarms of minute stringers and lenslets of sulphide minerals occur sometimes locally enriched forming pockets by the coalescing of a few lenslets and in other instances they might be simple incrustations. The neighbouring parascists, however, are devoid of such mineralisation. The marbles, especially the forsterite-marbles, in preference to parascists are the venue of replacement and deposition. The lithological control of mineralisation in quite clearly seen.

**Reflection Microscopy of the Ore Minerals**

The polished surfaces of the ores were examined under an ore-microscope using high power oil immersion objectives, and the mineral intergrowths, replacement features, and other textures studied. The minerals identified are the simple sulphides like bornite, chalcopyrite, chalcocite, sphalerite, neodigenite, covellite and pyrite.

Pyrite is rare in the specimens and is mostly replaced by chalcocite; its sides are fractured and corroded. Sphalerites generally occur independently and show oriented inclusions of chalcopyrite specklings. The sphalerite shows yellowish-brown internal reflection and cleavages along (110) are observed when the microscope tube is raised or lowered. Some sphalerites show a triangular pitted-surface. Chalcopyrite is next in abundance to bornite. It occurs as blades arranged parallel to (111) of bornite and sometimes bornite lamellae are observed in chalcopyrite. Chalcopyrite is green under crossed-nicols and is faintly anisotropic. Bornite is the predominant mineral with a beautiful pink colour and very weak anisotropism. Cleavages in two directions parallel to (100) and (111) are observed.

A mineral is observed which closely resembles 'orange bornite' (Orcel, 1937, 1943, supposed composition being Cu₆FeS₄). It has a yellowish-orange colour and higher reflectivity than bornite. The extinction is not
complete; only a greenish colour and a mixed ± reaction with KCN and HNO₃ is noted.

Neodigenite is grey-blue in colour and distinctly darker than chalcocite. The reflectivity of neodigenite is definitely lower than chalcocite. In certain sections chalcocite with a bluish-white colour is prominent. It is very difficult to identify chalcocite when it thoroughly replaces pyrite. Covellite is indigo-blue in colour with extremely pronounced anisotropism. In several cases galena is dirty white in colour with triangular pits on its surface.

**Nature of Association**

Two types of association are frequent:

1. Chalcocite-bornite.
2. Chalcopyrite-bornite.

As minute specks and inequant grains of detectable size pyrite occurs in almost all the sections.

**Chalcocite-Bornite Association**

In this association there is a regular solid solution series between chalcocite and bornite. Myrmekite-like texture between the above two minerals is striking and in different regions cauliflower-like texture is also evidenced. The myrmekitic intergrowth in particular is composed of twisting tongues of the two sulphides with sharp and smooth contacts. This intergrowth is notable for an entire lack of any significant orientation of their component minerals (Schwartz, 1938). Covellite is preferentially present in chalcocite as a reaction product and also due to alteration. Though bornite replaces sphalerite in (110) plane or by sending tongues, chalcocite rarely replaces sphalerite. Specks of chalcopyrite occur oriented in sphalerite along (111) direction.

When chalcocite and bornite form myrmekite-like texture, chalcocite largely replaces pyrite leaving behind minute remnants of the latter.

**Chalcopyrite-Bornite Association**

This association is the most common. Exsolution in either way has been formed—bornite in chalcopyrite or chalcopyrite in bornite. In the specimens where chalcopyrite predominates, blades or lamellae of bornite develop in the (111) planes of chalcopyrite. Similarly if bornite predominates, chalcopyrite forms blades in the (111) planes of bornite. This indicates the simultaneous crystallisation of these two minerals.
Chalcocite sometimes forms at the expense of bornite and lines the margin of the bornite grains. Galena might preferentially replace either chalcopyrite or bornite and rarely sphalerite or pyrite.

**Processes of Replacement**

Many of the dolomite minerals are replaced along their cleavages. The replacement is most common at the junction of two sets of cleavages and the contact between the ore and the dolomite becomes sharp and well-defined. When the replacement takes place without any preference for the weak planes embayments and delta textures are produced. The presence of delta textures points to the fact that the solution in course of replacement could not transport the replaced material and the replacement was arrested. It seems that certain sulphides like sphalerite and pyrite have grown by volume by volume replacement, because the ore minerals exhibit a solution effect around their sides. This can be explained by Riecke's principle (Ramberg, 1952). Many of the ore minerals replace each other following weak crystallographic planes. Sphalerite is replaced by bornite along (110) plane.

**Sequence in Time and Place**

There is a crude zoning observable in certain stringers and lenslets. Pyrite generally occurs on either side of the stringer wall. Then towards the centre sphalerite is present and traversing sphalerite in the central region is a mixture of bornite and chalcocite. Sometimes galena may occupy central zone and it replaces easily either chalcopyrite or bornite and in some cases sphalerite and pyrite. From the nature of the association and texture, it is probable that there existed a temperature gradient within the ore minerals (Kullerud, 1959).

The paragenesis as determined from the mineral association and texture is given below:

<table>
<thead>
<tr>
<th></th>
<th>Pyrite</th>
<th>Chalcopyrite</th>
<th>Bornite</th>
<th>Sphalerite</th>
<th>Neodigenite</th>
<th>Chalcoeite</th>
<th>Galena</th>
<th>Covellite</th>
<th>Azurite</th>
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<tbody>
<tr>
<td>Time</td>
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The probable source of the ore-bearing solutions seems to be that from which the granite was derived. The solution must have carried the metals along fissures and cracks of the marbles occurring within the granitic rocks. During the metamorphism of the impure dolomitic limestones, forsterite formed in the temperature region of 600°C or a bit more. The serpentine formation is ascribed to the hydrothermal alteration of forsterite at a temperature below about 500°C. In the presence of water vapour forsterite is stable at low pressure above 400°C; below that it undergoes a change to a mixture of serpentine and brucite. The hydrothermal alteration of forsterite to serpentine (chrysotile) is not common in the sulphide-bearing marbles as most often unaltered fresh forsterite are present. However, partial serpentinisation of forsterite is noticed in some of the sections. The influx of solutions carrying sulphides has not affected forsterite. The sulphides have often failed to replace and embay forsterite; instead, they have often swerved round the latter. The serpentinised olivines in some instances are nevertheless replaced along the mesh structure produced during the alteration and often thin films of sulphides are found occupying, as coatings and cementing sheet, the forsterite fractures. The absence of chondrodite, fluorite and tourmaline indicate that fluorine and boron, those common agents of pneumatolysis, are not involved in the metamorphism of dolomitic limestones. The crystallisation of pyrite started in the serpentinisation stage and continued afterwards when the environment was cooled sufficiently for the formation of other sulphides. The sparse mineralisation in the marble can be explained by the low metal content of the mineralising solution. These sporadic and lean sulphide stringers and lenslets are genetically related to the granite. The starting point of temperature of formation might be taken in the neighbourhood of 500°C when the pyrite began to form at the serpentinisation stage. The bornite-chalcopyrite intergrowth (at 475°C, Schwartz, 1931) also points to a relatively high temperature of formation. In decreasing temperature, chalcopyrite unmixed in sphalerite (350–400°C, Buerger, 1928) and at a much lower temperature bornite exsolved in chalco-cite (175–225°C, Schwartz, 1928, Buerger; 1941); This temperature gradient is the reflection of the gradual cooling of the deposit.

Acknowledgements

The work was carried out under the guidance of Prof. S. Deb, Head of the Department of Geological Sciences, Jadavpur University. The authors are indebted to him for his encouragement, suggestions and criticisms.
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EXPLANATION OF PLATE XI

Fig. 1. Crescent-shaped replacement of bornite-chalcocite in serpentinised forsterite. Polished section, ×70.

Fig. 2. Oriented exsolution of chalcopyrite in sphalerite (base). Polished section, ×840.

Fig. 3. Chalcopyrite (light grey) exsolved in bornite. Polished Section, ×220.

Fig. 4. Replacement of bornite-chalcopyrite (lower middle) by sphalerite (left grey) and galena (white). Polished section, ×70.

Fig. 5. Two blebs of bornite in galena replacing bornite exsolved in chalcopyrite base. Polished section, ×220.

Fig. 6. Veins of galena (white) replacing bornite. Polished section, ×220.

Fig. 7. Myrmekitic exsolution of bornite in chalcocite (base light grey). Polished section, ×480.