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A NOTE ON LINNAEITE-MILLERITE INTERGROWTH IN COPPER ORES OF AGNIGUNDALA, GUNTUR DIST., A.P.

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Introduction: The note records the occurrence of linnaeite-millerite exsolution intergrowths in copper ores of Agnigundala which have not been hitherto reported from India. The copper deposits of Agnigundala consist of replacement veins and irregular replacement bodies enclosed in calcareous quartzites of Nallamalai Series of Upper Cuddapah as classified by King. Massive, hard and brilliant chalcopyrite is the chief ore mineral; bornite is fairly abundant. Small amounts of chalcocite, pyrite and pentlandite are present. In mineragraphic study of some of the ore samples, both linnaeite-millerite and bornite-millerite intergrowths are recorded. Oxidised products chiefly azurite and cuprite, and carbonates like malachite, are scattered throughout the occurrences. On surface and at shallow depths, box-work of limonite is fairly abundant.

Mineragraphy: Mineragraphic study of these ores reveals that the chalcopyrite and the bornite are the main constituents; the other minerals occur as accessories.

Chalcopyrite grains are euhedral in habit, brass yellow in colour and weakly anisotropic. Chalcopyrite shows high reflectivity and polishes easily. The chalcopyrite grains within bornite occur as oriented inclusions, mostly irregular in shape with varying sizes.

Bornite has pinkish brown colour and moderate reflectivity. It takes good polish, and under crossed nicols it is isotropic.

Chalcocite is bluish white in colour with moderate reflectivity and weak anisotropism. It occurs as fine agregates in association with chalcopyrite and bornite showing replacement relation towards them.

Pyrite generally occurs as irregular or idiomorphic grains, yellowish white in colour and shows high reflectivity and isotropism. It is being replaced by bornite, chalcopyrite and chalcocite.

Pentlandite takes good polish and is light creamy in colour, highly reflective and isotropic. It occurs occasionally in association with linnaeite-millerite; and also replacing chalcopyrite and linnaeite-millerite exsolution grains.

Linnaeite is white with creamy tint, highly reflective, lower than that of millerite but higher than chalcopyrite and isotropic. It takes good polish and is harder than the chalcopyrite and bornite and softer than millerite.

Millerite has pure yellow colour and has moderate bireflectance but distinct in oil (yellow to light brownish yellow). It takes good polish. Under crossed nicols it shows strong anisotropism, light yellow to bluish or greyish yellow, and straight extinction.

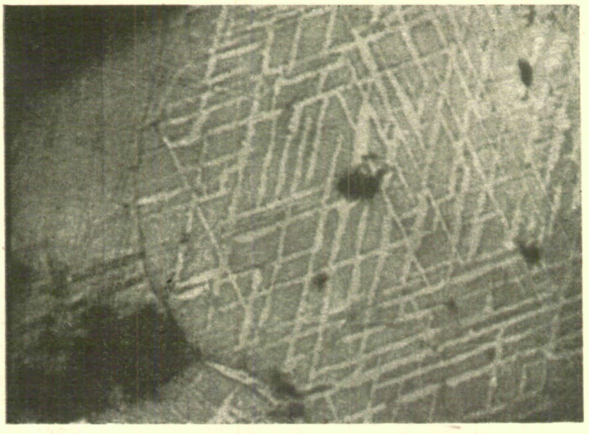

Figure 1. Exsolution intergrowth of linnaeite-millerite. Millerite (light grey) blades occupying three sets of cleavage planes in linnaeite (dark grey) × 250. Oil. Uncrossed.

Intergrowth textures between linnaeite and millerite are crystallographic, the blades of millerite are oriented along the (100) planes of linnaeite. Oriented intergrowth between linnaeite-millerite along (100) plane is the result of unmixing and exsolution.

Occurrence: Intergrowths of linnaeite-millerite are commonly found to occur in association with chalcopyrite and bornite. The textural studies indicate that there is more than one generation of millerite. The most predominant type occurs as orientated blades of intergrowth with linnaeite, and normally occur in two or three sets (Fig. 1). The exsolution intergrowths of millerite are being replaced by chalcopyrite and bornite from the margins of linnaeite-millerite intergrowth, Generally the blades of millerite are preferably replaced by chalcopyrite and bornite leaving the linnaeite unreplaced (Fig. 2).

The second generation millerite is present as radiating rods and also as irregular grains. These forms of millerite occurrences are generally concentrated towards the grain boundaries of chalcopyrite, and also occur within the chalcopyrite. Millerite is also found as exsolution intergrowth with bornite, in which millerite blades occur in two or three sets.

Origin: The crystallographic control in the disposition of millerite blades in linnaeite suggests unmixing origin. Exsolution of millerite along (100) planes of linnaeite is perhaps quite common, because the unmixing occurs at lower temperatures as suggested by Ramdohr (1955). Occurrences of linnaeite-bornite exsolution textures have been recorded by Edwards (1939) from Mount Lyell copper deposits, Tasmania. Intergrowth of linnaeite-chalcopyrite was noted by Rao (1967) from copper ores of Siegerland, West Germany. However, in the Agnigundala deposits

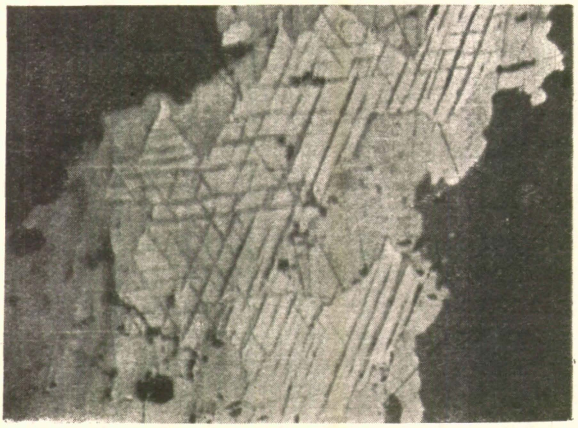

Figure 2. Millerite in the exsolved texture of linnaeite-millerite is being replaced by chalcopyrite (grey) leaving linnaeite (white) unreplaced. Chalcopyrite and bornite (black) surround the grain, showing 'rim replacement'. × 250. Oil. Uncrossed.

other than linnaeite-millerite and bornite-millerite intergrowths have not been observed. Blades of millerite are frequently replaced by chalcopyrite and bornite, which also enclose the grains of linnaeite-millerite exsolution intergrowths. These relations suggest that the unmixing and exsolution of linnaeite-millerite took place in the early phases of copper mineralisation. However some of the millerite is younger than linnaeite-millerite intergrowths which might have crystallised earlier than chalcopyrite, and also formed exsolution intergrowths with bornite.

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