The metallographic structure of the iron meteorites Arltunga, Kopjes Vlei, Murnpeowie, Braunau, and Rancho de la Pila

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Summary. From a metallographic examination it is suggested that Rancho de la Pila is a shock-hardened octahedrite; Murnpeowie is a cosmically reheated meteorite of unusual composition; Kopjes Vlei may have been produced by the reheating of a shock-hardened hexahedrite either cosmically or on earth; Braunau shows signs of preterrestrial reheating but Arltunga is a nickel-rich ataxite with no signs of metabolic alteration.

THE new edition of the [British Museum] 'Catalogue of Meteorites' (Hey, 1966) lists Arltunga, Kopjes Vlei, and Murnpeowie as metabolites. Cosmic alteration of Braunau has been reported by El Goresy (1965) and alteration of Rancho de la Pila was suspected by the author. Specimens of each meteorite have been made available from the British Museum Collection (through the courtesy of the Keeper of Minerals and Dr. Max Hey) and have been examined metallographically.

Arltunga [B.M. 1937,245] is a nickel-rich ataxite that shows no signs of metabolic alteration. The 49-g specimen in the British Museum shows a structureless frosty surface when etched in 1 % Nital and examined without magnification. There is no ablation deposit, no zone of heat penetration, and no macroscopically visible phosphide or sulphide in this specimen. On microscopic examination troilite is encountered as a rare micro-constituent in the form of square, circular, or lath inclusions with microscopic swathing kamacite; rhabdite is not encountered but microscopic schreibersite is common at the centres of the minute spindles of kamacite that, together with fine non-acicular plessite, constitute the microstructure. The microstructure is free of Neumann bands and, when allowance is made for the sulphide and phosphide inclusions and the absence of macroscopically visible kamacite, bears a reasonable similarity to the microstructures of Monahans and Nordheim published by Perry (1944).

Kopjes Vlei [B.M. 1950,252] has recently been examined by Smales, Mapper, and Fouché (1967) who found that in terms of its content of trace elements it was almost identical with a number of hexahedrites but differed considerably from the shock-hardened ataxite La Primitiva. Unfortunately there does not seem to be a published nickel analysis of Kopjes Vlei. Smales, Mapper, and Fouché published a photograph of a heavily etched microsection and stated that such a structure might be produced by heating a hexahedrite. Unetched microspecimens of this meteorite show a number of microscopic holes and fissures in the kamacite and a light etch (4 seconds 2 % Nital) reveals an equiaxed grain structure with a grain diameter of 0·2–0·3 mm and a subgrain structure with subgrain diameters about one-tenth of this. Chromite is present as small rare inclusions but both the grain and subgrain pattern is decorated with small rounded particles of phosphide, which, on more extensive etching, dissolve out to give the structure published by Smales, Mapper, and Fouché. The microstructure of Kopjes Vlei is somewhat ambiguous but it is much more like the structure produced by reheating shock-hardened acicular kamacite than that produced by heating normal kamacite (Axon, 1967). It is possible that in Kopjes Vlei the recrystallization of the kamacite was produced either by the thermo-mechanical effects of high intensity shock or by shock followed by reheating. It is not possible to say whether the reheating was of cosmic or terrestrial origin but, in any case, this meteorite can properly be regarded as a metabolite. Minor Neumann bands occur within some of the grains and may have arisen during entry through the earth's atmosphere or at a later date.

Murnpeowie [B.M. 1934,52] was reported by Spencer (1935) as a granular metabolite the original structure of which was perhaps a coarsest octahedrite. However, the analysed nickel content of 6·3 % places Murnpeowie in the sparsely populated composition range between the hexahedrites and the octahedrites and the trace element content as reported by Smales, Mapper, and Fouché (1967) is not characteristic of either hexahedrites or coarsest octahedrites. Spencer's 773-g specimen has been reprepared for metallographic examination. On the macroscopic scale it shows the zone of heat penetration and the three areas of different reflectivity that Spencer reported and, under specific conditions of illumination, a pseudo-octahedral macrostructure can be made to appear. However, microexamination entirely fails to reveal any taenite or relics of taenite and the pseudo-octahedral structure arises from oriented grains of recrystallized kamacite. The microstructure of Murnpeowie,

at locations away from the zone of heat penetration and from the region of mechanical damage that the specimen suffered when it was removed from the main mass, consists of coarse equiaxed and lamellar crystals of kamacite, which show Neumann bands within the grains and a 'frothy' precipitation of a phosphide–carbide aggregate along some lengths of grain boundary. The phosphide–carbide aggregate is present only on a microscopic scale and appears to have precipitated from solid solution after the formation of the recrystallized kamacite structure. There are no rhabdites and no macroscopically visible compounds in the British Museum specimen. The three areas of different reflectivity are areas within which different orientations of recrystallized grains occur and the line that separates the differently oriented areas shows no relics of a previous γ grain boundary but is rather more probably the line along which the original structure suffered a mechanical shear displacement. Thus Murnpeowie appears to be a metabolite in the sense that it shows recrystallization of a mechanically deformed structure but the unusual nickel content suggests that it is not a metamorphosed version of one of the common types of hexahedrite or octahedrite.

Braunau [B.M. 90217] weighs 32 g and contains a region of heat penetration zone but in some places it is badly deformed by hammering. The Neumanns show signs of reheating and some are decorated with rhabdite precipitates. A small region of this specimen, which unfortunately is located near to terrestrial deformation, shows sign of sulphide alteration similar to that found in Willamette. It would be worth examining specimens of Braunau that had not be subject to mechanical damage on earth but the work of El Goresy (1965) indicates that Braunau has probably been subjected to pre-terrestrial alteration.

Rancho de la Pila [B.M. 55253] is an octahedrite in which the kamacite has been altered to an acicular shock-hardened form by shock waves of greater than 130 kb intensity. In this respect it resembles Trenton but differs from Trenton in showing coarser granular plessite, which sometimes has incomplete rims of taenite at the boundary of contact with the Widmanstätten kamacite. In Rancho de la Pila rhabdites are visible within the shock-hardened Widmanstätten bands of kamacite and occasionally within the coarse granular plessite; however, the more usual form of phosphide in the coarse plessite is microscopic schreibersite.

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