# CENTER FOR METEORITE STUDIES

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Canyon Diablo

**A COARSE OCTAHEDRITE**

**FROM**

**BLOODY BASIN, ARIZONA**

**PETER B. BUSECK and CARLETON B. MOORE**

# A Course Octahedrite from Bloody Basin, Arizona

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## INTRODUCTION

The Bloody Basin meteorite was found at the intersection of the Verde River and Red Creek in the Bloody Basin Recreational Area, Yavapai County, Arizona: Latitude 34°10'N., longitude 111°43'W. The nearest inhabited town is Cave Creek, some 20 miles distant over primitive roads. It has a total weight of 5074 grams. The main mass is preserved in the Arizona State University Meteorite Collection.

The meteorite was found by Arthur Morrison of Prescott, Arizona, on September 12, 1964, while on a hunting trip. The actual fall of the specimen was not observed and historically recorded. It is fairly regular in shape with dimensions of 5 x 5 x 3 1/2 inches. Its surface features are typical of iron meteorite finds in desert environments. The surface has slight thumbmark-like depressions and is covered with a scaley limonitic crust. An unusual feature is that patches of sandstone and burned wood are attached to its surface. This opens the possibility that the meteorite was used by Indians in the area as part of a fireplace or for some similar purpose. However no evidence of physical working of the specimen is evident. Indian ruins are quite common along the Verde River, and it is quite possible that it was carried to this location from its original place of fall. However, evidence that Indians collected or moved meteorites over considerable distances in Arizona has never been observed.

Macroscopic observation of a cut, polished and etched piece indicates that the Bloody Basin meteorite is a coarse octahedrite. A striking feature of the structure is well formed Neumann bands on several kamacite grains.

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## CHEMISTRY

A chemical analysis, using techniques similar to those given by Moss, Bothwell and Hey (1958), of the meteorite by a volumetric dichromate method for iron, or gravimetric dimethylglyoxime precipitation of nickel, and a colorimetric determination of cobalt using nitroso-R-salt as the indicator gave the following results: iron 91.0%, nickel 7.1% and cobalt 0.53%. The density of the meteorite is 7.52. These values are very similar to specimens of the Canyon Diablo meteorite. Specimens recently analyzed in our laboratory by the same analytical techniques range between 90.00% and 91.86% for iron, 6.99 and 7.58% for nickel and 0.46 and 0.58 for cobalt. The densities of the Canyon Diablo specimens range from 6.99 to 7.98.

## MINERALOGY

Kamacite--The most abundant phase in the Bloody Basin octahedrite is kamacite, which occurs in coarse, irregular crystals (over one centimeter in diameter). The most striking feature of the kamacite is the great number of Neumann bands it contains (Fig. 2) (23-2), best shown when the polished surface is weakly etched with 2% nital or picral. According to Uhlig (1955), these mechanically produced twins are probably the result of strong mechanical deformation at temperatures below 600°C and perhaps even below 300°C. He suggests that the presence of Neumann lines indicates the meteorites were subjected to violent impacts. It is interesting, although certainly not unusual, that these Neumann lines show effects of deformation--minor bending and quite common evidence offsetting or displacement along the Neumann lines, almost as if they were small faults (Fig. 3) (24-2; 23-18). This is confirmatory evidence that the meteorite was subjected to considerable stresses. The Neumann lines do not extend into the kamacite crystals within the plessite fields, suggesting that the deformation occurred previous to kamacite exsolution.

Taenite--although far less abundant than kamacite, taenite is also present, mainly in long, thin lamellae, many of which have exsolved kamacite to form plessite (Fig. 4) (23-10). In some instances the kamacite lenses within the plessite are fairly coarse (Fig. 5) (24-10) but in other cases the kamacite is so fine as to be almost unrecognizeable. In this instance the plessite fields (the finer kamacite occurs in the thinnest taenite bands--unless they are cross sections of flat plates) contain intergrowths of rounded to very long, thin platelets of material that is presumably kamacite. These intergrowths resemble perlitic steels (Fig. 6) (24-12) (cf. Perry plates A,B,C) or eutectoid textures (Fig. 7) (25-2). In all instances, when the specimens are etched, the outer rim of the taenite or plessite is essentially unetched, whereas the inner part is strongly attacked (Fig. 8) (25-12). This indicates the higher Ni content along the rims (the Fe could diffuse out more readily than from the centers of the taenite) that has been clearly and quantitatively demonstrated by electron microprobe studies on other, similar meteorites (see, for example, Wood, 1964).

Schreibersite--follows taenite and kamacite in abundance. It occurs in two forms: small euhedral crystals--rhabdites--and larger, irregular masses. The rhabdites are uniformly distributed with the kamacite but are absent in taenite (Fig. 9) (25-19). They are generally small (0.02 mm in diameter, average) and euhedral, varying in cross section from diamond shaped to rectangular or rhombohedral to long, slender rods (Fig. 10) (25-8). In all instances the faces are clearly defined and regular. The rhabdites probably preceded the Neumann lines, as the latter cross the rhabdites, in some places producing minor fracturing within the schreibersite.

The larger masses of schreibersite have much more irregular shapes than the rhabdites--in some cases being almost vermicular (Fig. 11) (24-4). They do not have euhedral crystal faces and do not occur in masses even nearly as small as the rhabdites. This schreibersite is generally slightly fractured, apparently being much more brittle than the other phases of Bloody Basin. It is very commonly associated with the taenite lamellae. Although a clear explanation is lacking, it is a matter of some interest why there should be two such dissimilar occurrences of the same mineral, so closely associated and yet genetically apparently unrelated. Troilite, graphite, goethite--outside of such alteration products as goethite, no other phases occur in important amounts. The few fractures cutting the specimen do contain alteration products and, in addition, small highly angular fragments of schreibersite and very minor amounts of troilite and graphite. These fractures were, in fact, the only places where these minerals were observed under the microscope, although some graphite occurs on the outer edges of the main meteorite mass. The occasional sulfide and graphite grains are also highly angular. It is possible that the altered fracture zones were originally crosscutting veins which contained these minerals, at least in minor amounts. Being more porous, presumably these fractures then were selectively altered.

## SUMMARY

Bloody Basin appears to be a very normal coarse octahedrite. It was found approximately 80 miles from the Barringer Meteorite Crater, the site of the Canyon Diablo coarse octahedrite. As the Canyon Diablo meteorites are very numerous and have been widely transported the natural question that arises is whether Bloody Basin is not in fact just another Canyon Diablo specimen.

Mineralogically, the Bloody Basin meteorite resembles an unusual phase of Canyon Diablo. Although Neumann lines are absent in rim specimens of Canyon Diablo, they are abundant in a few of the Plains specimens. Likewise, although rhabdites are rare in rim specimens they are fairly common in plains specimens, although only very rarely as abundant as in the Bloody Basin meteorite. Finally, troilite, graphite and irregular, larger schreibersite masses do occur in varying amounts within Canyon Diablo. Thus, on the basis of the mineralogy and related textures, it is possible that the Bloody Basin sample is a specimen of an unusual type of the Plains variety of Canyon Diablo. This possibility is supported by the similarity in chemical composition and density of the two meteorites. If this hypothesis is true then a remaining question is--Did the meteorite originally fall within the Bloody Basin area? or was it transported there by the Indians? The latter is a distinct possibility although there is no evidence of other samples having been so transported.

ACKNOWLEDGEMENTS

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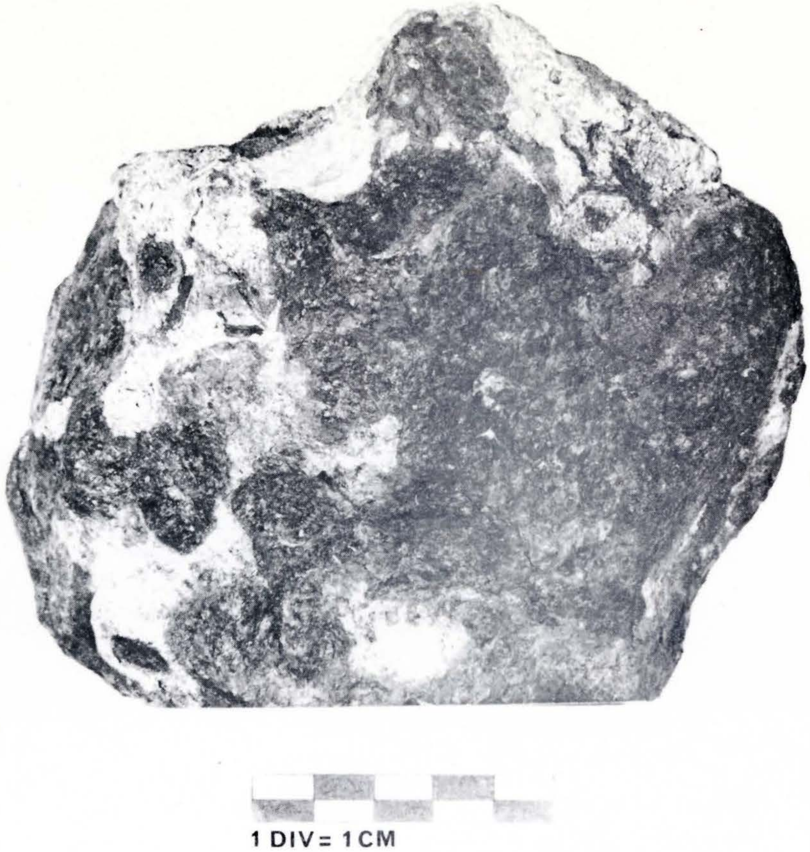
References Cited

Moss, A. A., Hey, M. H., and Bothwell, D. I., 1958, Methods for the Chemical Analysis of Meteorites, I-Siderites: Mineralogical Magazine, v. p. 802 - 816.

Wood, J. A., 1964, The cooling rates and parent planets of several iron meteorites: Icarus, v. 3, p. 429 - 459.

Uhlig, H. H., 1955: "Contribution of metallurgy to the origin of meteorites. Part II--The significance of Neumann bands in meteorites." Geochim. et Cosmochim. Acta, 7, 34 - 42.




FIGURES

Fig. 1 - Macroscopic view of the Bloody Basin meteorite. Note the areas with sandstone attached (white) and the small pieces of charcoal (black) within these areas.

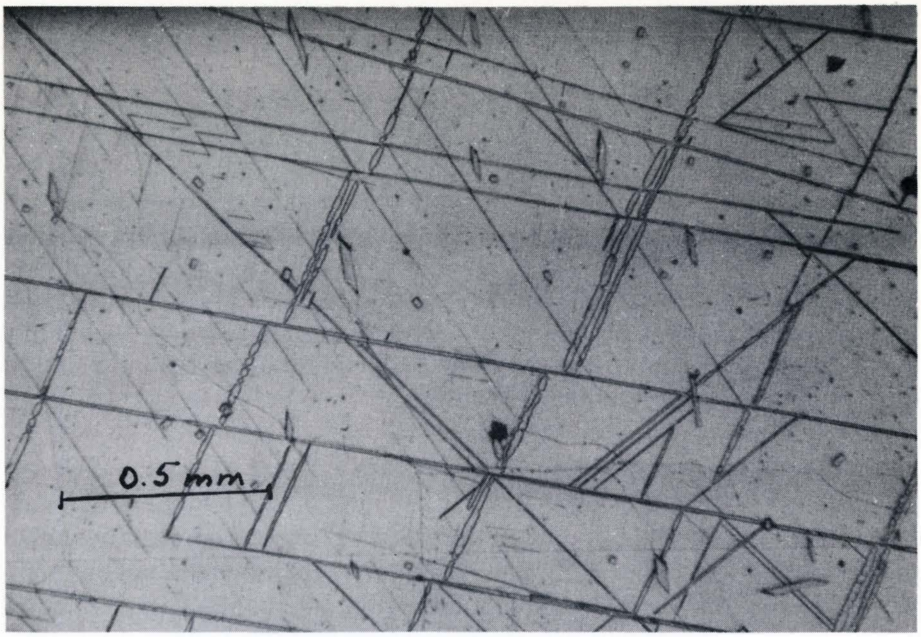



Fig. 2 - Kamacite containing at least 6 directions of Neumann bands. The small diamond shaped bodies are rhabdites. Etched. (43X)

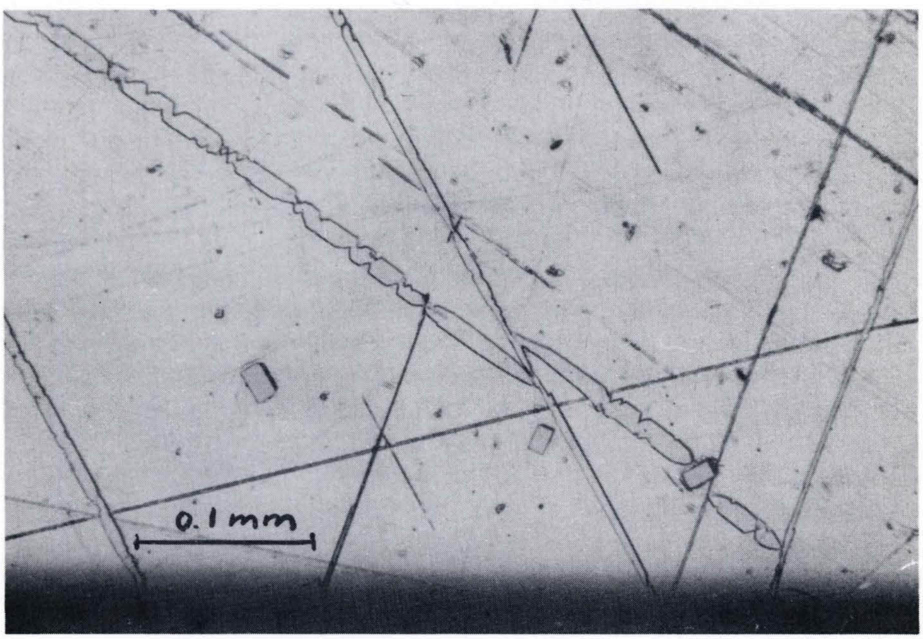



Fig. 3 - Neumann bands showing offset along a "microfault". Indicates the meteorite was subjected to deformational forces. Etched. (oil immersion, 180X)

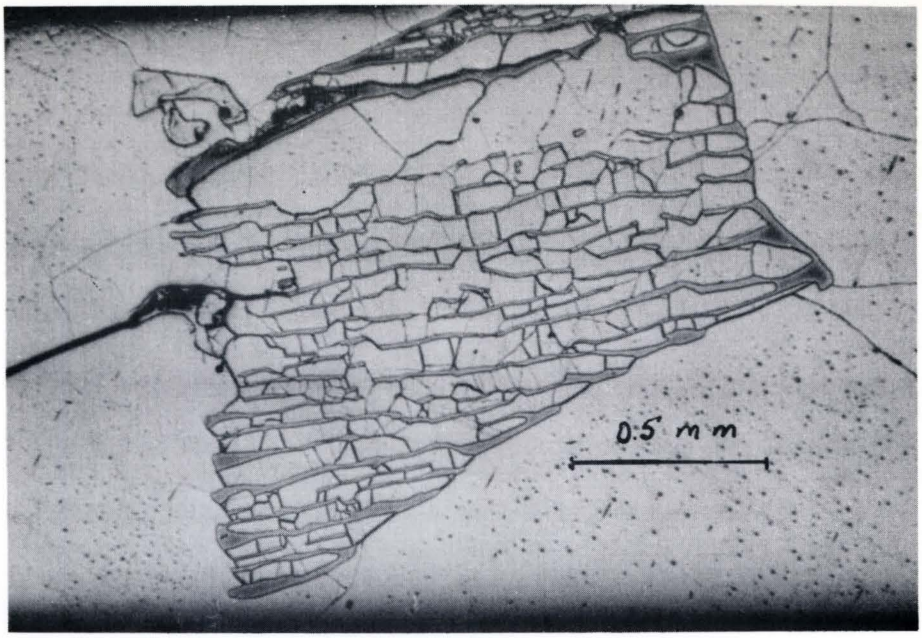



Fig. 4 - Coarse plessite: taenite lamellae within large kamacite grain. Etched. (43X)

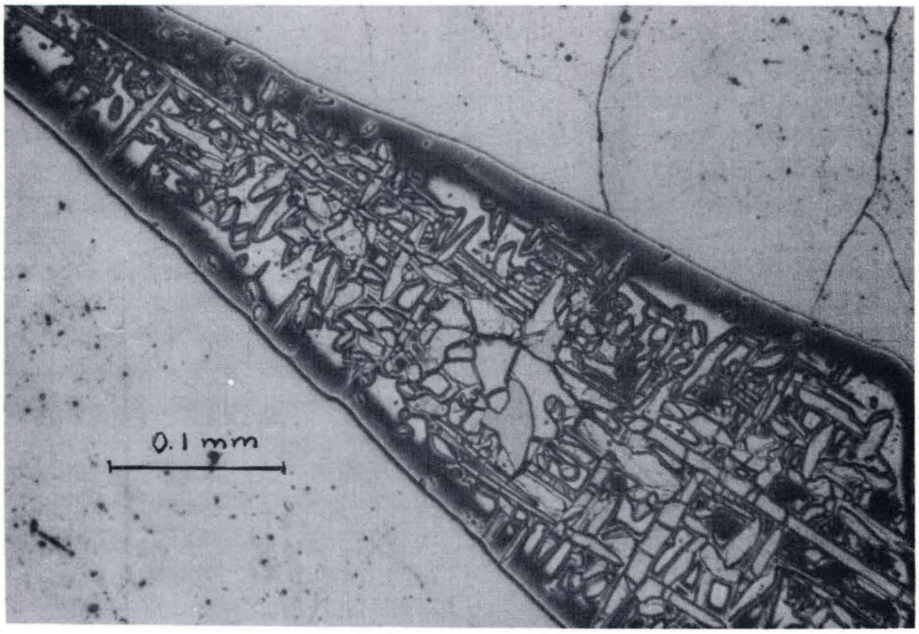



Fig. 5 - Individual plessite lamella showing coarse kamacite (lense-shaped) within taenite matrix. Surrounding grains are kamacite. Etched. (oil immersion, 180X)

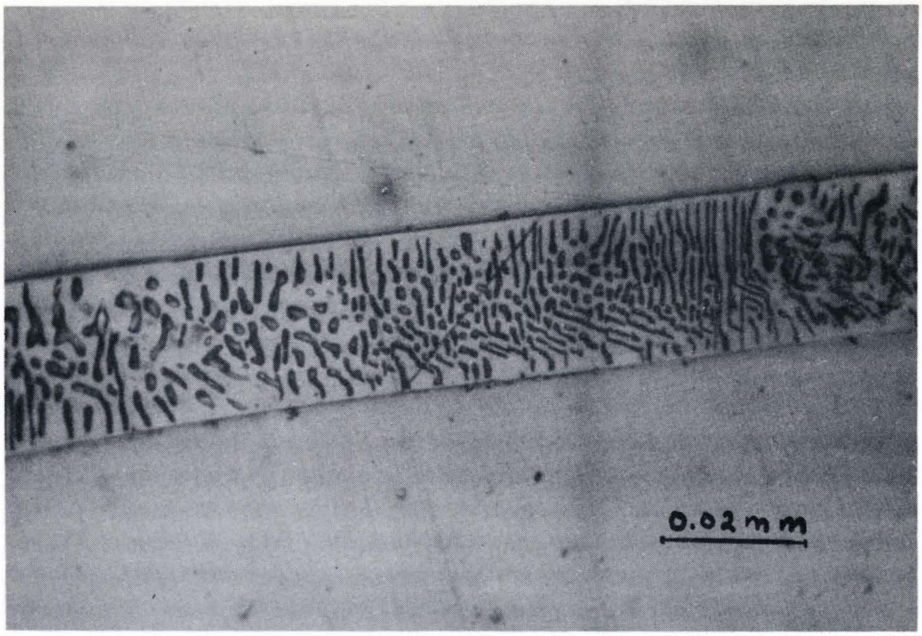



Fig. 6 - Fine plessite lamella containing rounded grains of kamacite within taenite host. Note resemblance to pearlitic steels. Surrounding grains are kamacite. Etched. (oil immersion, 830X)

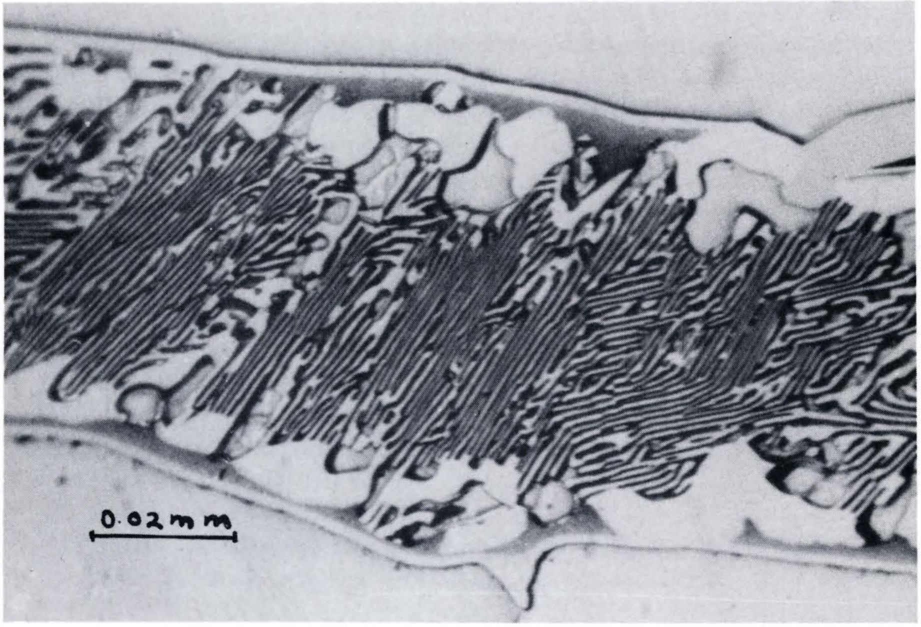



Fig. 7 - Section of a fine-grained plessite lamella surrounded by kamacite. Note the thin exsolved plates of kamacite, forming a eutectoid texture. Contains minor schreibersite. Etched. (oil immersion, 830X)

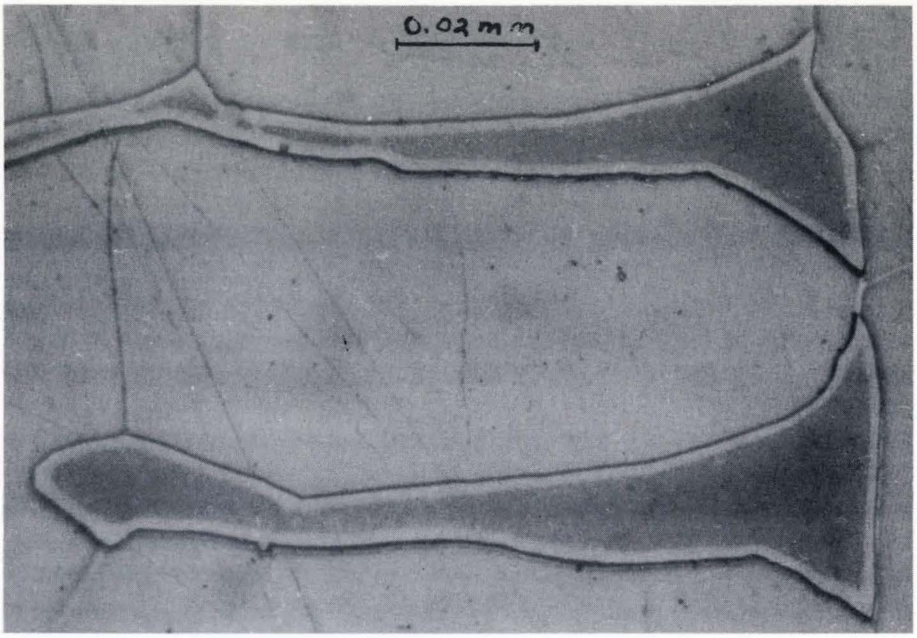



Fig. 8 - Taenite lamellae within kamacite. Differential etch shows qualitatively the higher Ni content occurring near the rims of the lamellae. Etched. (oil immersion, 830X)

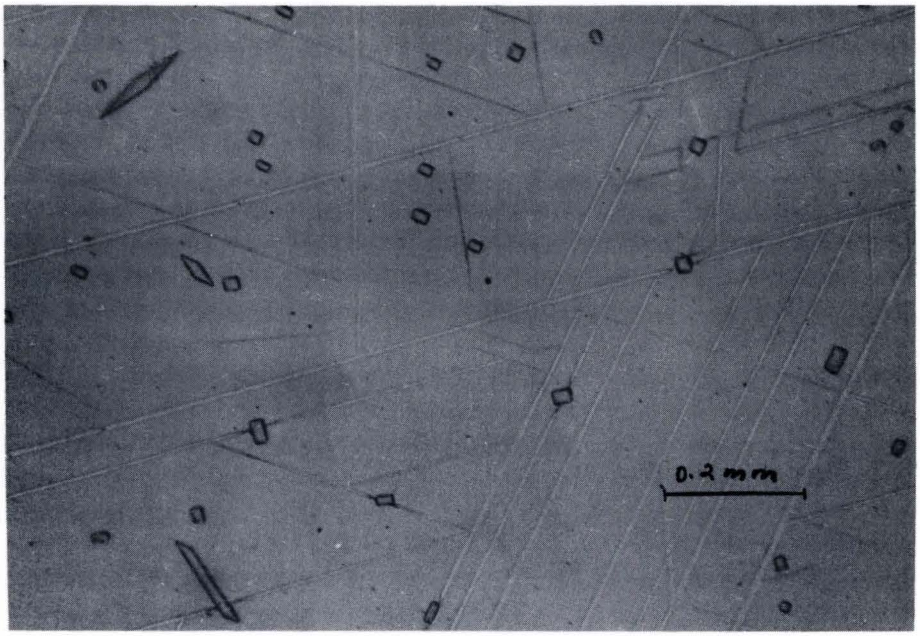



Fig. 9 - Euhedral schreibersite crystals (rhabdites) enclosed within kamacite. Note the Neumann bands. Etched. (80X)

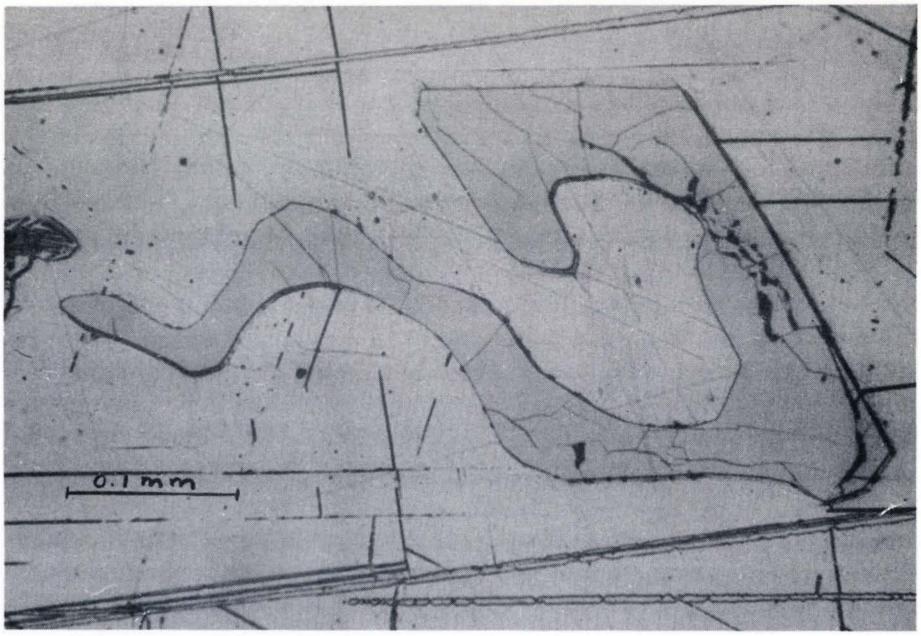



Fig. 10 - Irregular, slightly fractured crystal of schreibersite showing some well-developed crystal faces. Etched. (oil immersion, 180X)

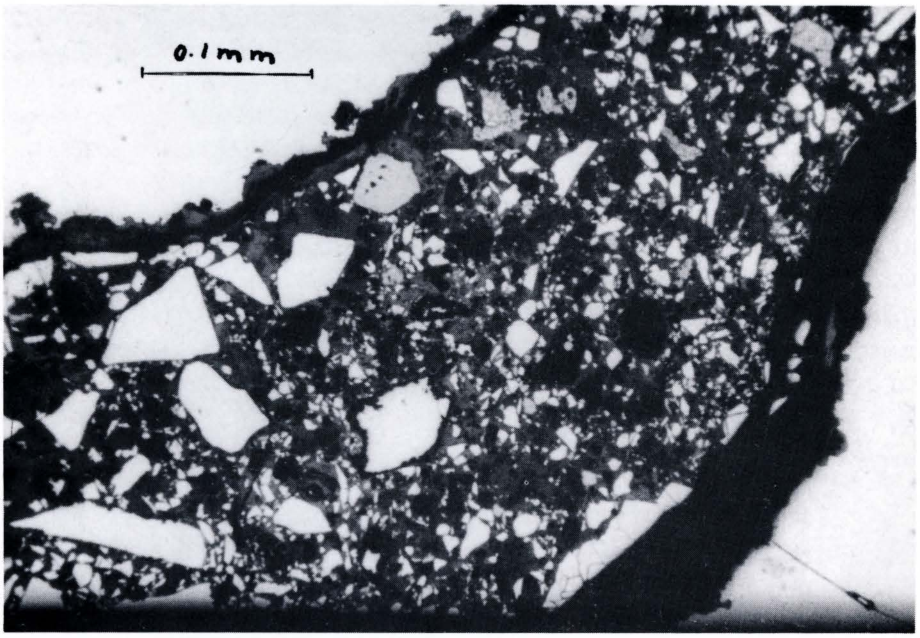



Fig. 11 - Portion of fracture cutting across kamacite. Contains angular grains of schreibersite (white) troilite (very light gray) and "limonite" (dark gray matrix). (oil immersion, 180X)