**Mbosí, Rungwe District, Tanzania**

9° 6'25"S, 33° 2'0"E

Medium octahedrite, Om. Bandwidth 0.80±0.10 mm. Distorted Neumann bands. HV 215±20.

Anomalous. 8.74% Ni, about 0.15% P, 0.12% C, 2.5 ppm Ga, 26.9 ppm Ge, 6.5 ppm Ir.

**HISTORY**

A large mass, partly embedded in the soil but not associated with a crater, was reported in 1930 by W.H. Nott, a private surveyor, who promptly pegged the area as a base metal claim. The mass had, however, been known for generations by the natives, to whom the mass was taboo. The mass was discovered on the western slope of Marengi Hill about 10 miles southeast of the Mbozi mission station in Rungwe District. It was partly excavated and a few specimens were removed by hacksawing. Grantham et al. (1931) and Stanley (1931) described the material with analyses and numerous photographs and photomicrographs. Axon (1962a) reexamined the structure and gave additional photomicrographs. The mass has recently been fully excavated and a concrete plinth has been placed under it, without moving the mass. It was declared a protected monument by the Tanzania government in 1967. It is located about 70 km west-southwest of Mbeya and is reached by the Great North Road and a circle road branching off from this at Vwawa, before reaching the Tanzanian-Zambian border station of Tunduma. This information and the coordinates given above are from Sassoon (1967).

**COLLECTIONS**

Main mass of about 16 tons in situ. Washington (779 g), Tempe (487 g), London (465 g), Chicago (326 g),

![Figure 1128](image1)

**MBOSI - SELECTED CHEMICAL ANALYSES**

Stanley (1931) also reported 0.013% Cl, and Grantham et al. (1931) reported lawrencite. In the present examination no lawrencite was found, so it is concluded, as in a number of similar cases, that the chloride is in all probability mainly of terrestrial origin, introduced from circulating ground water during a long terrestrial exposure.

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<th>Ga</th>
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<td>0.11</td>
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<td>Wasson &amp; Kimberlin 1967</td>
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<td>2.54</td>
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DESCRIPTION

The mass is elongated and pointed at one end. Its extreme length is about 325 cm, and the maximum width and height are, respectively, about 150 and 120 cm. Since its shape is highly irregular the weight estimates have been given variously as 12-15 t (Grantham et al. 1931), 25-27 t (Stanley 1931) and 12 t (Sassoon 1967). From modern photographs in the Smithsonian Institution the present author would estimate the weight to be 16 tons (±10%). The mass is considerably corroded. Scattered through the rubble several feet from the mass were found nickeleriferous iron oxide shales up to 6 mm thick, evidently weathered debris carried somewhat down the 5° slope. Fusion crust and heat-affected rim zones have not been reported and were not found in this study, neither on the Tempe, nor on the U.S. National Museum specimens. These are roughly chiseled and hacksawed fragments that continue to corrode under normal room conditions, probably caused by the terrestrial chloride intrusion.

Etched sections display a medium octahedrite structure of slightly distorted, long (w ~ 35) kamacite lamellae with a width of 0.80±0.10 mm. The kamacite has numerous Neumann bands and these are frequently distorted. The presence of lenticular deformation bands was also noted, but since the specimens were near the surface and somewhat damaged by the probe-detaching operation it is not known whether this is a genuine part of the structure. The Vickers hardness (100 g) of the typical-kamacite lamellae of the interior is 215±20, in accordance with an irregular work hardening due to (cosmic) deformation.

Taenite and plessite cover about 50% by area. The plessite is particularly common as comb plessite fields which frequently reach large sizes as, e.g., 8 x 4 mm. It is noteworthy that these fields almost lack the normal, heterogeneous frame of taenite. The comb plessite does in places resemble pearlite, with about 5 µ wide taenite combs and 50 µ kamacite. It is also noteworthy that cohenite is present in about 20% of all the fields, mostly as irregular amoebae, 10-100 µ across, which are partially intergrown with taenite lamellae. Already Spencer (reported in Grantham et al. 1931) had suggested that the peculiar minerals were cohenite, but Axon (1962a) could not confirm the observation and described the minerals as schreibersite. In this examination the cohenite identification was corroborated by microprobe work and hardness testing. In one pearlitic plessite field more than 100 individual cohenite crystals were massed, differently oriented and thus not part of any single sponge-like, monocristalline body. Haxonite is also present locally but apparently in very minor amounts.

Some of the smaller plessite fields have numerous precipitates of acicular kamacite, which range from 1-20 µ in width. Plessite is further common as dense, martensitic structures and the cohenite crystals indicate that the carbon is far from being homogeneously distributed; it is mainly present in the taenite-plessite regions, and it is only significantly concentrated in 10-20% of these.

Schreibersite is abundant as 10-25 µ wide grain boundary precipitates and as 2-20 µ vermicular bodies inside the plessite fields. It is monocrystalline, but heavily brecciated and sheared because the hard, brittle crystals have had to accommodate to the plastic flow of the adjacent metal. Rhabdites are very common as sharp prisms, 2-10 µ across. Also these are sheared and often arranged en echelon because of the plastic flow of the metal. The bulk phosphorus content is probably 0.15% and, thus, higher than the analytical values quoted above.
Figure 1132. Mbosi (U.S.N.M. no. 2599). An unidentified inclusion in a kamacite lamella. A preliminary examination suggests that it consists of a tridymite center and a pyroxene or olivine mantle. Terrestrial corrosion has invaded the fissure below. Polished. Scale bar 500 μ.

Troilite is present as 0.05-10 mm nodules. Only small ones were seen in micropolished sections. These appear to have recrystallized to aggregates of 2-5 μ anisotropic grains. A 100 μ bleb was composed of alternating parallel, 1μ thick daubreelite and troilite lamellae and had served as nucleus for a 20 μ thick rim of precipitating schreibersite.

A 3.5 mm spherule of silicates (?) with faint birefringence was noted, but not identified. It was situated as an isolated bleb in the kamacite, not associated with any troilite or graphite. Graphite was not observed at all.

The specimens are penetrated by corroded fissures, 50-300 μ wide, which are partly filled with laminated, terrestrial oxides. At least some of these fissures, which follow the phosphate-laden grain boundaries, appear to have been present before the meteorite hit the Earth. The terrestrial agents thus had relatively easy play. Corrosion has also selectively attacked the metal around the rhadites and the acicular alpha needles of the plessite fields. The natives in the district apparently had no legend of its fall (Granham et al. 1931), which supports the opinion that Mbosi is terrestrially old.

Mbosi is structurally anomalous. Medium octahedrites (0.8 mm) with 8.7% Ni would normally have much more phosphide, and cohenite would be absent. The plessite morphology of Mbosi is influenced by the presence of carbon and, thus, is different from most other meteorites with 8.7% Ni. Chemically, Mbosi is anomalous because of its Ga-Ge-Ir concentrations. Its only relative appears to be Emsland.

Specimen in the U.S. National Museum in Washington:
779 g part slice (no. 2599, 17 x 8 x 1 cm)
"Mejillones (1875), Atacama; Brecciated hexahedrite." Additional masses, but of a stony-iron type, had been found somewhat more southerly in the 1860s. They were also provisionally called Mejillones (Fletcher 1889: 243; Wülfing 1897: 230; Farrington 1903: 107; 1907: 120), and it was believed that the iron specimens were fragments of the stony-irons. Later examinations have, however, definitively proved that the stony-irons belong to an independent mesosiderite shower, called Vaca Muerta (see, e.g., Hey 1966: 501). However, as late as in the 1930s (Schwarz & Baur 1936) Vaca Muerta specimens were described under the name Mejillones, and Horback & Olsen (1965: 275) still have a Vaca Muerta specimen erroneously listed as Mejillones. Similar mislabelings may be present in other collections, too.

The type specimens of the two allegedly different Mejillones irons are today preserved in Paris and Washington.

The Paris specimen was a fragment of 164 g. It constituted half of the specimen which was briefly examined by Domeyko & Daubrée (1875). Domeyko, in Santiago, gave an inappropriate analysis and stated that a mass of unknown weight was found late in the year 1874 on the (then) Bolivian side of the border, near the coast of Mejillones. Domeyko had received about 300 g chiseled from the meteorite by Captain Vidal Gormaz, and he was optimistic about procuring the whole mass on some later occasion. Apparently he never succeeded. Half of his specimen was sent to Paris, where it was briefly mentioned on numerous occasions by Daubrée and Meunier (e.g., 1884: 133; 1893a: 75). The quotation "a cart would be required for its carriage" is not from the original description by Domeyko & Daubrée (1875), but from a later work (Domeyko 1879: 132), where all the known Chilean meteorites were briefly described. The big mass alluded to could probably have weighed anything upwards of 50 kg, if the report is taken at face value. The meteorite has, however, never again been reported, and all that is known at present is the sample of 151 g in Paris. The additional specimens listed by Hey (1966: 299) do not come from Domeyko's material but from Washington's Mejillones mass (Harvard's 65 g sample No. 514, which was acquired by exchange with the Smithsonian Institution in 1924) and from Vaca Muerta (Chicago's 185 g).

The other more authenticated specimen, is a 14.53 kg sample in Washington originally described by Merrill (1924b). It was found by Chilean miners near Mejillones, between 23° and 24°S, about 9 km from the sea. It appears that it was originally found prior to 1905 but was purchased in 1905 by H. A. Ward, when he, on his last trip to Chile, obtained knowledge of it. It was unrecorded in scientific literature until Merrill in February 1924 acquired the mass by exchange with Ward's Natural Science Establishment. He gave an analysis and photographs of the exterior shape and of etched slices and suggested that the Mejillones meteorite of Domeyko & Daubrée (1875) was identical with the new one described by him.

Mejillones was included in the surveys of hexahedrites by Henderson (1941a; 1965). Perry (1944: plate 11) presented two photomicrographs, and Goldberg et al. (1951) gave a brief description together with their analysis. Recently the trace elements and the structure were reexamined by Wasson & Goldstein (1968) who gave a photomicrograph and concluded (i) that Mejillones was different from other Chilean hexahedrites, and (ii) that Mejillones (1875) and Mejillones (1905) appeared to be samples of the same meteorite. All modern investigations have been on material from the Washington specimen, while the Paris material is virtually unknown.

In the present examination both Paris and Washington type specimens were studied. It is concluded that they Figure 1134. Mejillones (U.S.N.M. no. 734). A full slice showing the recrystallized hexahedrite. The heat-affected α₃-zone can be followed along a significant part of the periphery. Three diffuse gray dots are due to imperfections in the photographic plate. Deep-etched. Scale bar approximately 2 cm.

Figure 1135. Mejillones (U.S.N.M. no. 734). To the left, the edge of one of the many large schreibersite inclusions. It is surrounded by concentric zones A-D as discussed in the text. Compare Figure 215. Etched. Scale bar 200 μ.
belong to one and the same, rare, meteorite type, discovered in 1874 in the coastal district behind the town of Mejillones, Antofagasta. Mejillones has the coordinates given above. A more precise location may be the "pampa 9 km from the sea, between the Morro de los Guaneros de Mejillones and Caleta Herradura Grande" (Merrill 1924b), but accessible maps were not sufficiently detailed to pinpoint this locality and derive the coordinates. It could not be definitively determined whether Mejillones was a shower which had produced two or more samples, or whether only one 15 kg specimen was ever found. In the latter case the original 1879 report must have wildly exaggerated the size of the meteorite.

**COLLECTIONS**

Washington (12.2 kg; 273 g), Ann Arbor (330 g), New York (311 g), Moscow (243 g), Madrid (236 g), Canberra (196 g), all cut from the Washington specimen. Paris (151 g), Chicago (2 g), from Domeyko’s specimen.

**DESCRIPTION**

The following is based upon specimens in Washington, Paris, Chicago and Moscow. The 14.33 kg Washington mass is an entire monolith, originally measuring about 27 x 14 x 9 cm, now about 22 x 14 x 9 cm, after some six slices have been cut from one end. A 20 x 10 cm almost flat side is perhaps a cleavage face from atmospheric splitting similar to the ones present in Boguslavka and Mayodan. The mass is weathered and irregularly covered with terrestrial corrosion products, in which both phosphides and γ-particles survive, locally, as discrete blebs. In places a weathered, warty fusion crust can be distinguished, and upon sections the heat-affected α₂ zone is preserved along part of the periphery. The α₂ zone varies but is up to 2 mm thick and displays micromelted phosphides in its exterior part. Its hardness is 190±10; this decreases in the recovered transition zone to 155±10, and then increases again to typical interior values of 190 (hardness curve type II). Mejillones does not show the characteristic rippled and pitted surfaces, developed on many other North Chilean irons on prolonged exposure to the corrosive environment. Mejillones has, on the average, lost only 1 mm by weathering. It is quite out of the question that it should have fallen 1905, as stated on an old label (Merrill 1924b). Its terrestrial age probably amounts to hundreds or thousands of years, considering the arid climate.

Some material had been broken away from one sharp edge before the mass came to the Smithsonian Institution. The fracture surface measures about 6 x 2 cm, but it is estimated that, at the most, 200 g can have been taken from this edge. Merrill (1924b) noted that material had also been removed from a corner; since this has been cut away now with the slices it is impossible to estimate the amount of material removed. He estimated, however, that no more than about 200 g could have been removed totally, before he examined the mass. There is a remote possibility that the material which Domeyko & Daubrée (1875) examined came from these exact points. A final conclusion could probably be arrived at if the Paris material were sent to Washington for a "confrontation" with the main mass.

The Paris sample, originally 164 g, now consists of 151 g (No. 652), since several grams have been lost in cutting, finishing and analyzing, and 2 g have been exchanged with Ward and are now in Chicago. The present three slices can be reassembled to an irregular mass, measuring about 3 x 3 x 3 cm. The macro- and microstructure of the material is identical to that of the Washington material in all details, so the following description is valid for all samples.

Etched sections display a highly anomalous structure of equiaxed kamacite grains 0.01-1 mm in diameter (HV 190±20). Scattered inclusions of irregular schreibersite

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**MEJILLONES – SELECTED CHEMICAL ANALYSES**

Wasson & Goldstein (1968) found with the electron microprobe a rather inhomogeneous kamacite with 5.76% Ni and 0.27% P. The high P-concentration was partly due to a large number of small phosphide precipitates, partly to phosphorus in solid solution in the kamacite.

<table>
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<tr>
<th>References</th>
<th>Ni</th>
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<td>Wasson 1969</td>
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Figure 1136. Mejillones. Detail of zone D, Figure 1135. Fine amoebae of taenite (gray, with internal islands of kamacite) and angular massive phosphide crystals (darker gray) are located on the grain boundaries of equiaxial kamacite. Etched. Scale bar 30 μm.
bodies (HV 925±25) mar the sections. In concentric zones around the schreibersite the kamacite grains rapidly change in size and composition. Typical is the following development: around a row of broken schreibersite crystals, each 60 x 300 μ in size, the nearest zone (D) 200 μ wide, consists of 10-20 μ kamacite grains, rich in cavernous 5 μ γ-particles and massive 5 μ phosphide particles. Next is a 500 μ zone (C) with 50-100 μ kamacite grains with few γ-particles, but with massive 5 μ phosphide wedges on the grain boundaries and 2-10 μ rhabdites in the interior. Succeeding this is a 200 μ wide zone (B) of 50-200 μ kamacite grains with numerous oriented platelets, 20 x 1 μ, probably rhabdites, in the interior. Finally, comes zone A, the bulk of the meteorite, composed of 0.5-1 mm equiaxed kamacite grains, which are divided in 20-50 μ cells by subboundaries. In the grain boundaries are several phosphide particles, and minute aggregates of phosphides and taenite are to be found in the interior.

Confusing particles, or aggregates of particles, occur scattered through the bulk of the mass, both upon grain boundaries and in the grain interiors. Upon routine polishing and etching they frequently pop out and leave pinholes in the surface, often with square or hexagonal outlines, only a few microns across. Upon careful polishing, the surface appears free of holes; the component responsible for the holes turns out to be an angular phosphide a few microns across, which is often associated with a minute γ-particle. The phosphide is slightly fractured and evidently shows little coherency with the metallic matrix since it so easily falls out. The particles have the same general size and distribution as rhabdites in normal hexahedrites, so there is little doubt that they represent altered rhabdites. In a microprobe examination, their composition was found to correspond to the rhabdites of Coahuila, however, with somewhat less nickel, supporting the conclusion from the morphological examination.
Fig. 1141. Mejillones (U.S.N.M. no. 734). A troilite-daubreelite aggregate. This particular one survived the shock event better than most others in Mejillones, probably because a major portion was daubreelite (D). The troilite is recrystallized. Slightly crossed polars. Scale bar 20 μ.

Large schreibersite bodies, typically 10 x 0.5, 2 x 0.2, or 3 x 1 mm in size, occur as irregular, broken crystals. They display several reentrant portions, as if partially dissolved, and they may be monocrystalline or composed of several 50-300 μ units. Their zoned surroundings were described above. It appears that they have momentarily been reheated to near the melting point whereby nickel and phosphorus diffused 200-500 μ outwards, and here reprecipitated and formed separate phosphide and taenite particles during an unequilibrated cooling.

Troilite-daubreelite aggregates of the usual lamellar developments (e.g., Coahuila) were once present. At the time of the event that altered rhabdites and schreibersites, the sulfides fused and, if previously surrounded by a schreibersite rim, they penetrated this and partially dissolved it. The present irregular blebs are intricate intergrowths of metal, daubreelite, anisotropic iron sulfide and schreibersite in the 2-50 μ range, and present an extreme alteration relative to the preexisting normal, equilibrated aggregates. The blebs are surrounded by zones of varying kamacite grain size, similar to, but not as well developed as, B to D above.

Graphite occurs as spheroidal — often zoned — aggregates, 25-150 μ across. The spherules are composed of anisotropic, radiating crystallites and are sometimes bordered by a 20 μ zone of isotropic carbon. The spherules are most common in zone B, where they may derive from cohenite which previously formed minor rims upon the schreibersite.

Mejillones is, chemically, an ordinary hexahedrite of group IIA, closely related to, e.g., Walker County, Bingera and North Chile (page 917). The macroscopic distribution of phosphides and sulfides resembles the distribution in typical unaltered hexahedrites, such as Walker County and Coahuila. The secondary structure is, however, entirely different.

Fig. 1142. Mejillones (U.S.N.M. no. 734). X-ray scanning pictures of taenite and phosphide particles in zone D, Figures 1135 and 1136. Note the typical internal filling of kamacite in the central taenite particle. Electron, PKα and NiKα pictures, at 30 KV. Scale bar 25 μ.

The polycrystalline nature of the ferrite and the unequilibrated surroundings of phosphide and sulfide inclusions may best be interpreted as the result of a violent shock with associated relaxation heating, which altered an original normal hexahedrite to a "nickel-poor ataxite." Thereby the sulfides melted and solidified to unequilibrated fine-grained textures: the phosphides partially dissolved, and the dissolved matter reprecipitated as discrete particles in zones around the parent inclusion; the cohenite decomposed, and carbon precipitated in spherulites; and the bulk of the metal recrystallized, whereby preexisting Neumann bands, if at all present, disappeared. The present kamacite grain size is small near the original inclusions where a large number of disseminated taenite and phosphide particles prevented grain growth. The cooling must have been sufficiently rapid to prevent equilibration of Fe, Ni and P; taenite ought thus not to be present at all, considering the Fe-Ni-P phase diagrams presented by Buchwald (1966) and Doan & Goldstein (1969).

Finally, when the meteorite penetrated the atmosphere, a few intercrystalline fractures developed and some grains in the fracture zone deformed by a twinning mechanism, whereby Neumann bands formed.

An earlier view held by me and quoted by Hey (1966: 300) that Mejillones has been artificially reheated was based upon a preliminary examination of an inferior sample. Experiments in the laboratory, comparisons with other meteorites, and the presence of heat-affected α₉ rims upon Mejillones show, however, unambiguously that the heat-alteration is of a cosmic nature. Chico Mountains, Forsyth County, Wathena and Bingera are other original hexahedrites which display variations over the same theme.

Specimens in the U.S. National Museum in Washington:

12.3 kg main mass (no. 734, 22 x 14 x 9 cm)
273 g slice (no. 734, 9 x 8 x 0.6)