fissures along which weathering could easily proceed to produce 0.1-1 mm wide limonite veins. It takes only little imagination to conceive that these cracks could have been formed simultaneously with another large crack that led to the formation of another, much larger and still undiscovered fragment, the mass which was reburied by the farmers.

Plymouth is a medium octahedrite, rather normal in its primary structure but anomalous in its secondary, reheated structure. It is somewhat similar to Sandtown and Casimiro de Abreu, perhaps representing a stage intermediate between those two in reheating intensity. The temperature appears to have been of the order of 500-600° C and must have been maintained for a long time, or have recurred a number of times. Chemically, Plymouth is intermediate between group IIIA and group IIIB, resembling, e.g., Casimiro de Abreu, Campbellsville and Aggie Creek.

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

181 g part slice (no. 203, 6 x 5.5 x 0.8 cm)
26 g part slice (no. 2995, 5 x 4 x 0.2 cm)
393 g almost full slice (no. 2996, 12 x 6 x 1 cm)

Point of Rocks (iron), New Mexico, U.S.A.

About 36½°N, 104½°W

A fragment of 23.4 g of an octahedrite, allegedly found in 1956 near Point of Rocks, Colfax County, is in Albuquerque (La Paz 1965: 110). An analysis by Wasson (1971, personal communication), showing 8.36% Ni, 21.1 ppm Ga, 41.4 ppm Ge and 0.46 ppm Ir, indicates that the material belongs to a very common type of medium octahedrite of which several large meteorites from the American Southwest are known. In particular, it should be checked to see whether the fragment could have been detached from Drum Mountains, Quinn Canyon, Bartlett or Spearman.

Pojoaque. See Glorieta Mountain

Ponca Creek. See Ainsworth

Pooposo, Bolivia

Approximately 18°20′S, 66°50′W

Coarse octahedrite, Og. Bandwidth 2.6±0.6 mm.

Probably group I, judging from the structure. About 6.6% Ni, 0.2% P.

Probably another fragment of the meteorite listed as Bolivia, page 335.

HISTORY

A mass of unknown weight was briefly mentioned by Berwerth (1912: 237). According to letters in the British Museum (Prior 1923a; Hey 1966: 289), the mass was obtained in 1910 by the mineral dealer J. Böhm from a missionary who had brought it from the Pooposo Estate in Bolivia. Böhm evidently sold the main mass to Vienna, while a sample was purchased by the British Museum.

COLLECTIONS

Vienna (main mass), London (26 g).

ANALYSES

From a cursory examination it appears that the mass must contain 6.6±0.2% Ni and 0.20±0.05% P.

DESCRIPTION

The main mass in Vienna weighs about 12 kg and measures 20 x 15 x 10 cm in three perpendicular directions. It is weathered and shows indications at one end of severe deformation, apparently due to the application of tools in order to split the mass. The fractured surface is very rough. It is not known where the other part of the mass is.

The deep-etched sections display a coarse Widmanstätten structure of bulky, short ($\frac{L}{W} \sim 6$) kamacite lamellae with a width of 2.6±0.6 mm. Local grain growth has created almost equiaxial kamacite grains, 5-15 mm across. Within these, scattered taenite lamellae and plessite fields are located, in addition to what is present along grain boundaries. The total amount of taenite plus plessite is estimated to be 1-3%.

Schreibersite occurs irregularly as 0.5-1 mm wide lamellae and cuneiform crystals. Troilite was seen as a 10 x 6 mm nodule.

Pooposo is an inclusion-rich coarse octahedrite of a rather common type, related to Seeläsgen, Sardis and Cosby's Creek, and no doubt a normal member of the resolved chemical group I.

Considering its supposed Bolivian origin, it is quite interesting that the only other known iron meteorite from Bolivia is a coarse octahedrite, Bolivia, page 335. Both irons were apparently acquired by some unknown missionary at approximately the same time, about 1900, and brought out of Bolivia. Since the two masses may, thus, have the same origin and show the same structure and degree of weathering, it appears probable that they belong to the same shower-producing fall. A modern examination and complete analysis of Pooposo is recommended in order to solve this problem finally.

Prambanan, Soerakarta, Java

Approximately 7°32′S, 110°50′E

Finest octahedrite, Off. Bandwidth 125±50 μ. Artificial α_2 matrix.

Probably anomalous. About 9.4% Ni, 0.16% P.

All specimens in collections have been artificially reheated above 900° C.

HISTORY

This meteorite is only insufficiently known through a small fragment of 1/4 kg which was sent to the Netherlands from Soerakarta in 1865. It was described by Baumhauer (1866) who presented five galvanoplastic figures of polished and deep-etched surfaces. He noted that his fragment allegedly had been detached from a large block, about one meter in diameter, which was preserved in the *Kraton* (the Sultan's palace) of Soesoehoenan in Soerakarta. The mass served as an iron source for the natives; when they wanted metal for particularly good weapons and tools they heated the mass to a red heat and hot-chiseled fragments from it. The mass had been moved to the palace court in 1797, but had evidently been known some time before. When Baumhauer reported the meteorite, another much smaller mass had already been wholly consumed for the fabrication of kris. It appears that four beautifully finished daggers somehow found their way to the Ethnographical Collection in Vienna (Zimmer 1916), but I do not know whether they have been examined. Rosenhain (1901) and, more recently, Smith (1960: 35) only appear to discuss kris made of alternating layers of soft iron and steel.

Cohen (1897a: 43; 1905: 308) reexamined the iron and presented a revised analysis. Brezina & Cohen (1886-1906: plates 15 and 16) discussed the crystallographic relationships and published six photomacrographs. Berwerth (1914: 1081) concluded correctly that the microstructure of Prambanan was due to artificial reheating.

COLLECTIONS

Budapest (104 g), Vienna (48 g), Greifswald (38 g), Hamburg (32 g), Strasbourg (16 g), Chicago (16 g), London (8 g), Bonn (7.5 g), Stockholm (2.6 g), Washington (2.3 g), Berlin (2.3 g), Paris (1 g). A slice, 7 x 6.5 x 0.5 cm in size, labeled "Prambanan 1797; 1866, no. 1499" in Delft, and weighing about 150 g, may or may not be authentic material, which should be checked, considering the scarcity of material.

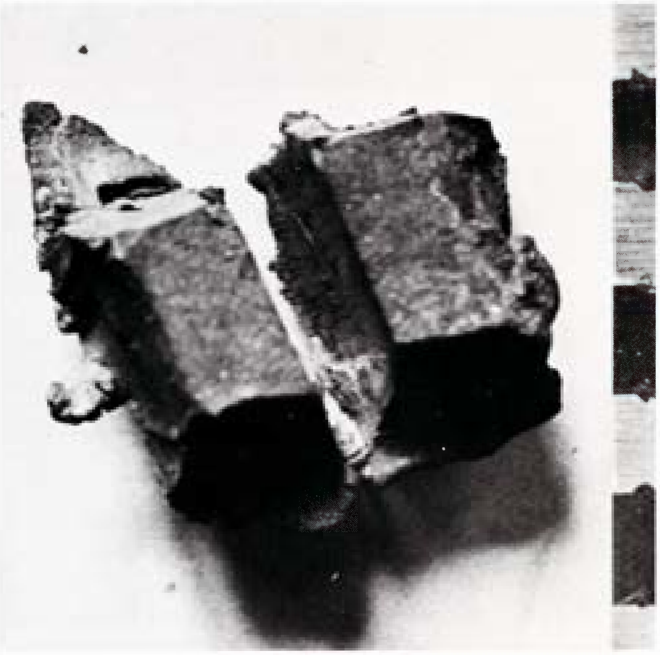

Figure 1391. Prambanan (Vienna no. H3,286). Forged and hot-chiseled bar produced by a Malayan blacksmith from the Prambanan meteorite. Scale in cm.

ANALYSIS

Sjöström in Cohen (1905) found 9.39% Ni, 0.97% Co, 0.16% P and 90.03% Fe. The iron should be reanalyzed and the trace elements determined.

DESCRIPTION

Since very little material is preserved the following examination is fragmentary. It appears that all specimens presently in collections are cuttings from the 1/4 kg specimen which Baumhauer (1866) described, except perhaps Vienna No. H3286, which is extremely interesting, since it presents an intermediate stage in the Javanese handling of meteoritic iron. It appears that the iron, after having been detached from the meteorite, was first forged into bars, 15-20 mm square which served as semimanufactured articles. From such bars appropriate amounts of iron were hot-chiseled and forged flat. They were then compounded with flat strips of iron or steel and bent edgewise into a compact serpent-like form, as described by Rosenhain (1901). After further sandwiching and final forging, the blades were shaped by taper grinding to expose sections of the various layers and the blade etched in fruit acids. The Vienna specimen is a fragment of a meteoritic bar, intended for kris production and with a chisel indentation that almost separates the bar into two parts.

The small specimen in Washington has been heated and partially forged. The primary structure which is still faintly visible indicates that Prambanan is a finest octahedrite. The kamacite lamellae are long ($\frac{L}{W} \sim 50$) and narrow, 125±50 μ; their width can only be measured approximately because the taenite edges are diffuse. The probe shows that the kamacite contains 7.5±0.5% Ni. Taenite and plessite cover about 75% by area, and schreibersite is – or, rather, was – present in several of the kamacite lamella intersections as 0.1-0.2 mm blebs. The original structure resembles Bacubirito, while the relationship to group IVA irons as Chinautla, or to Butler, another iron with narrow, long kamacite lamellae or spindles, seems to be very restricted.

A secondary, artificial structure is superimposed upon the primary structure; this is the reason for the difficulty in comparing Prambanan to other irons. The taenite is partly or wholly dissolved, and the previously existing duplex plessite fields are rather homogenized. The heat treatment which must have taken place at 900-1000° C resulted in the formation of polyhedric austenite grains, 50-200 μ in diameter, in the former kamacite, as well as in the taenite and plessite areas. Upon cooling, each of these grains transformed to the typical, serrated α_2 patterns. On the electron microprobe the nickel concentration was found to range from 7.5% in previous kamacite lamellae to 15% in previous taenite areas with diffuse boundaries between them, confirming the partial dissolution and homogenization due to extensive reheating. The phosphides are also dissolved; but the homogenization is no better than the previous locations of the phosphide bodies may be identified. The microhardness of the artificial α_2 phase ranges from 225 to 375, mainly depending upon the actual composition with respect

Figure 1392. Prambanan (Chicago no. 1,160). Artificially altered structure. The parallel horizontal ghost-lines indicate forging. All kamacite has been through the $\alpha \rightarrow \gamma \rightarrow \alpha_2$ transformation. The plessite fields show diffuse interfaces with kamacite. Etched. Scale bar 200 μ. See also Figure 132.

to phosphorus and nickel. The highest values are found in the previous phosphide locations, in accordance with experimental hardness curves on Fe-Ni-P alloys (Buchwald 1966: 18).

A 1 mm wide zone along the edge of the specimen exhibits a high temperature intercrystalline oxidation attack that mainly follows the new austenite grain boundaries. At least two different oxides are present, and iron-sulfur-oxygen eutectics are present in other grain boundaries. Faint ghost-lines parallel to the external faces and spaced 8-15 μ apart indicate slight hot working of the specimen; the Widmanstätten lamellae are slightly distorted.

Prambanan's original structure was – as far as it can be learned from small fragments of severely damaged material – that of a finest octahedrite; its structure and composition suggest a relationship to Bacubirito. A modern analysis for main and trace elements would be helpful in solving the question.

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

2.3 g artificially reheated and slightly forged fragment (no. 1116, 16 x 5 x 3 mm)

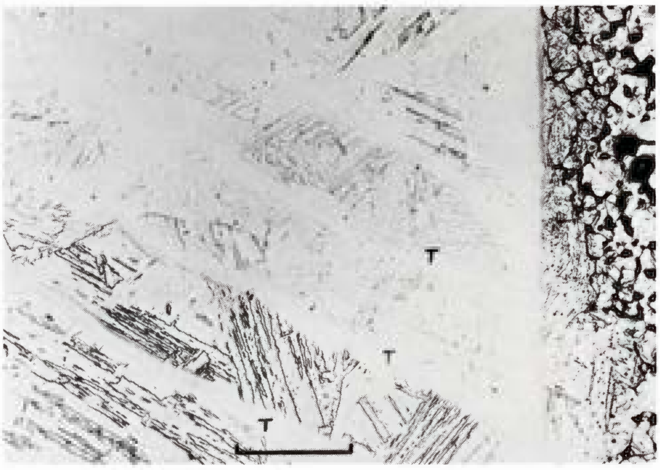

Figure 1393. Prambanan (Chicago no. 1,160). Aritifically altered comb plessite and kamacite with terrestrial corrosion products (right). The three major taenite lamellae (T) appear white and blurred because of imperfect annealing. Upon cooling, unequilibrated α_2 structures formed. Etched. Scale bar 200 μ.

Premier Downs. See Mundrabilla

Providence, Kentucky, U.S.A.

38°34'N, 85°14'W; 240 m

Medium octahedrite, Om. Bandwidth 1.15±0.15 mm. HV 355±25.

Group IIIA. 8.25 Ni, 0.50% Co, about 0.23% P, 20.2 ppm Ga, 41.5 ppm Ge, 0.39 ppm Ir.

HISTORY

A mass of 6.80 kg was found in 1903 in an orchard where it had become exposed at the surface of the ground. W.T. Yeager, the discoverer, was unaware of its true character but kept it as a curiosity because of its weight. In 1938 it was purchased by the University of Kentucky where it was described by Young (1939), who also presented a photograph of the weathered exterior. In 1966 the main mass was deposited in the U.S. National Museum. Jain & Lipschutz (1969) estimated that the mass had been exposed to shock intensities of 130-400 k bar.

The locality is W.T. Yeager's farm, about one mile southwest of Providence, in eastern Trimble County. The corresponding coordinates are given above.

COLLECTIONS

Washington (5.49 kg), Harvard (299 g).

DESCRIPTION

The mass is irregularly box-shaped with an average size of 17 x 10 x 9 cm. It is considerably weathered and covered by 0.2-2 mm thick crusts of terrestrial oxides. No fusion crust and no heat-affected α_2 zone could be identified on

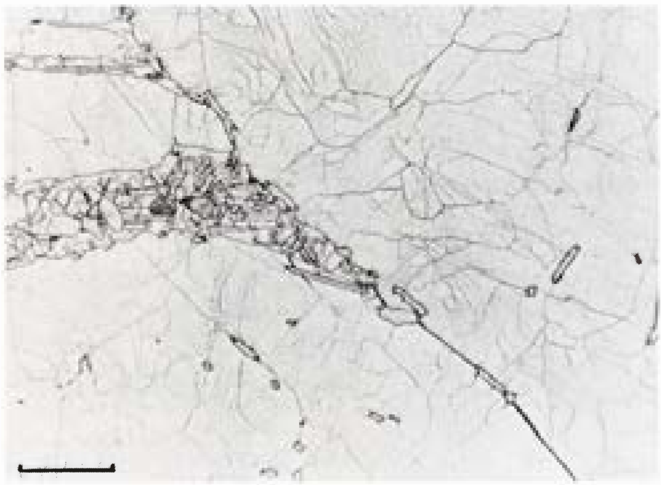

Figure 1394. Providence (U.S.N.M. no. 2568). Medium octahedrite of group IIIA which has been exposed to slight cosmic annealing. Etched. Scale bar 200 μ. See also Figure 194.

the several sections. A large troilite nodule is located right in the surface, only the inner half sphere, about 2 cm in diameter, being preserved. If Providence had been a recent, well-preserved fall the troilite location would have been indicated by a cavity from partial, atmospheric ablation. As it now is, with the troilite flush with the surface, we may conclude: first, that at least 4-5 mm metal has been removed around it by weathering; second, that troilite is slower to corrode than the metal surrounding it.

Etched sections display a medium Widmanstätten structure of straight, long ($\frac{L}{W} \sim 25$) kamacite lamellae with a width of 1.15±0.15 mm. The kamacite structure is unusually complex. It shows vestiges of Neumann bands, an unusually dense clustering of decorated subboundaries, and an indistinct mixture of hatched ε-structure and blurred Neumann bands – all in the same place. The microhardness is very high, 355±25. The first Neumann band generation has almost disappeared due to movement of subboundaries but may still be identified in many places. The subboundaries form tangles within tangles, or concentric systems, or parallel systems which frequently are parallel to the preexisting Neumann bands. Diffusion has been sufficiently active to precipitate a number of 0.3-1 μ phosphide blebs upon the subboundaries. It appears that, after the first phase of Neumann band production plus incipient recrystallization had occurred, another event took place – possibly another shock – whereby the described structure was superseded by an indistinct ε-Neumann band mixture. The high microhardness may particularly reflect this structure.

Figure 1395. Providence (U.S.N.M. no. 2568). A vertical grain boundary connects two schreibersite crystals. Subboundaries are prominent in the kamacite on either side. Diagonally a set of annealed indistinct Neumann bands. Etched. Scale bar 100 μ.

Taenite and plessite cover about 35% by area. Most common are comb plessite and acicular plessite of the type seen in, for instance, Bear Creek and Narraburra. Some fields are subdivided into cells, 0.2-1 mm in diameter, and within each cell the short, rod-shaped taenite blebs are pretty well spheroidized to small units, 3-20 μ in diameter. The taenite has a hardness of 380±20, and it is rather homogeneous with no duplex fields and little martensitic transformation.

Schreibersite is uniformly distributed, always as small bodies. It occurs as 20-50 μ wide grain boundary veinlets and as 5-25 μ blebs inside the plessite. A few larger grains, 1 x 0.4 mm in size, may be found centrally in the kamacite lamellae. Very characteristic are the island arcs of 10-20 μ thick bodies which are located regularly about 5-15 μ

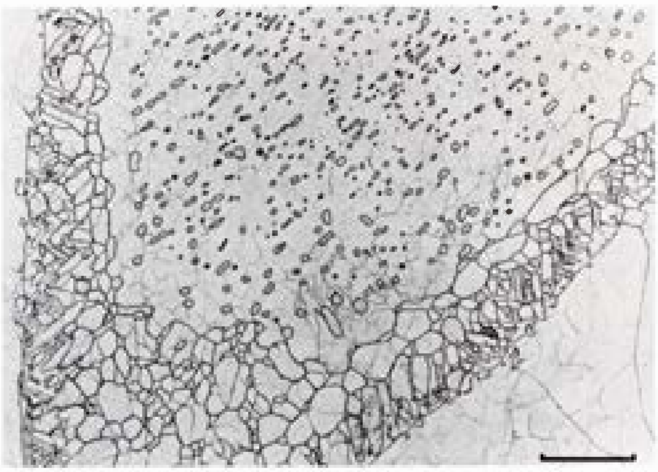

Figure 1396. Providence (U.S.N.M. no. 2568). An annealed plessite field. Minute phosphide particles occur along the edge as an imperfect island arc. Etched. Scale bar 200 μ.

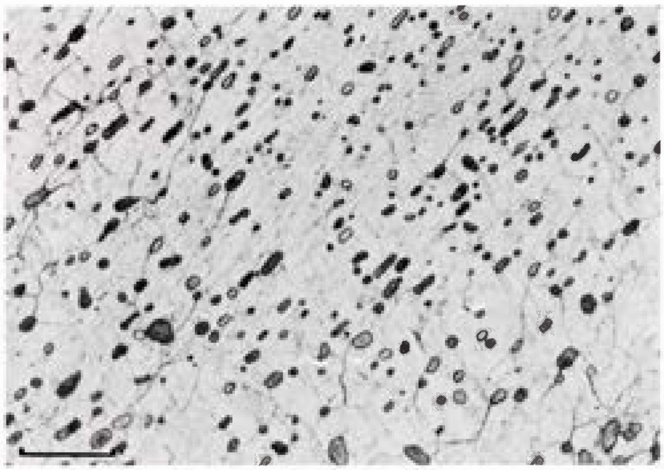

Figure 1397. Providence. Detail of Figure 1396. Spheroidized taenite particles (dark) and a few phosphide particles (light). Etched. Scale bar 100 μ.

PROVIDENCE – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Lovering et al. 1957		0.50				21	120		19	33		
Scott et al. 1973	8.25								20.2	41.5	0.39	

Figure 1398. Providence (U.S.N.M. no. 2568). Grain boundary with schreibersite crystals (S). Kamacite with decorated slipplanes and subboundaries. Etched. Scale bar 100 μ.

outside the taenite and plessite fields. Finally, rhabdites are extremely common as well developed and often branched prisms, 5-30 μ thick, in the kamacite. The bulk phosphorus content is estimated to be 0.20-0.25%.

Troilite was only seen as the large nodule in the surface, mentioned above. Small daubreelite bodies, 5-10 μ across, occur scattered in the kamacite.

Some early plastic deformation and shearing of the rhabdites appear to have been followed by an annealing period that healed the fractured phosphides.

Corrosion has altered the surface significantly; oxide penetration along the Widmanstätten boundaries has caused

Figure 1399. Providence (U.S.N.M. no. 2568). Angular prismatic rhabdites in kamacite rich in subboundaries. Etched. Scale bar 100 μ.

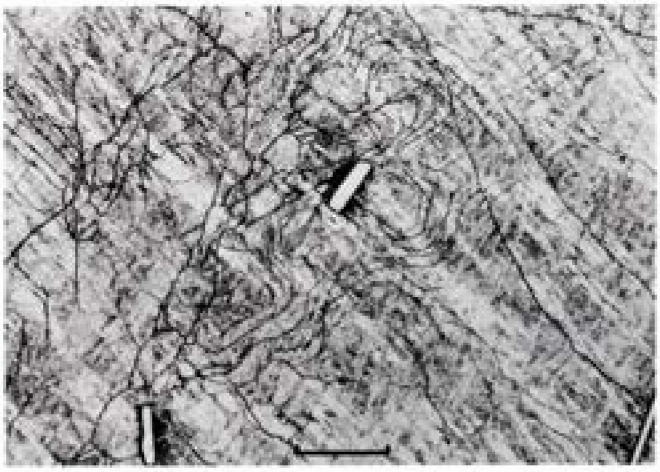

Figure 1400. Providence (U.S.N.M. no. 2568). Shock-hatched kamacite with numerous subboundaries and two rhabdite crystals. Etched. Scale bar 100 μ.

the surface to exfoliate locally. Phosphide precipitation has sensitized the subboundaries and caused them to corrode selectively in a 1-2 cm wide zone near the surface. Also the nickel-poor regions adjacent to rhabdites and larger schreibersite bodies are selectively corroded.

Providence is a medium octahedrite with a primary, normal structure related to, e.g., Aggie Creek, Rowton and Drum Mountains. Its secondary structure is rather unique but may represent a stage on the way to the fully recrystallized structures, as seen in, e.g., Roebourne and Ruff's Mountain.

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

670 g slice (no. 1340, 8 x 7 x 1.6 cm)
4,644 g main mass (no. 2568, 10.3 x 9.5 x 9.5 cm)
178 g part slice (no. 2573, 9 x 7 x 0.5 cm; previously mislabeled Frankfort)

Puente del Zacate, Coahuila, Mexico

Approximately 27°52'N, 101°30'W; 500 m

Medium octahedrite, Om. Bandwidth 1.05±0.15 mm. Deformed Neumann bands. HV 215±10.

Group IIIA. 8.08% Ni, 0.55% Co, 0.19% P, 20 ppm Ga, 40 ppm Ge, 1.4 ppm Ir.

HISTORY

A 30.7 kg mass, labeled as a Coahuila hexahedrite in the Institute of Geology, Mexico City, was identified in 1929 by Nininger as a separate fall. Nininger was permitted to cut and study it, and published his results a few years later (1931c) together with photographs of the exterior and of etched slices. According to the label and to Haro (1931: 80), the mass had been discovered in 1904 at Puente del Zacate between Muzquiz and La Garza, in the district of Monclova. Even though this locality has turned out to be difficult to identify on modern maps of the scale 1:500,000, there is no reason at all to assume that the mass came from the distant Coahuila discovery site, a supposition frequently seen in the literature. In a recent letter to the author, Dr. Nininger recalls, "Officials in Instituto Geologia in 1929 told me that the location was near a bridge a few kilometers from Santa Rosa de Muzquiz." Under the circumstances, the best approximation to the locality may be near the bridge across Arroyo Garza, 2 km southeast of Muzquiz. The coordinates given above are calculated accordingly.

Nininger & Nininger (1950: 87, 116 and plate 10) briefly mentioned the mass and gave a photomacrograph. Jaeger & Lipschutz (1967b) saw evidence of shock-induced structural alterations, corresponding to pressures of 130-400 k bar. Schultz & Hintinberger (1967) determined the various noble gas isotopes, while Voshage (1967) reported a $^{40}K/^{41}K$ cosmic ray radiation age of 690±85 million years.

The following brief note by Castillo (1899: 9 and 10) referring to a 63 kg mass is of interest:

> "Coahuila. Meteorite from Santa Rosa, village of Muzquiz. This meteorite weighs 63 kg and has an almost spherical shape. When attacked with acid it gives Widmanstätten figures and does not rapidly rust as do the Xiquipilco (i.e., Toluca) irons. It was donated by Ingenieur Blas Balcarcel to the School of Engineers in Mexico City, and it is still preserved in the collection of this school."

It appears that this particular mass has neither been discussed nor later described, and there is a chance that it still rests in the School of Engineering. The remote possibility exists that it is a paired fall with Puente del Zacate.

COLLECTIONS

Mexico City, Instituto Geologico (about 20 kg), Washington (2.3 kg), Chicago (495 g), London (455 g), Tempe (204 g), Adelaide (28 g).

DESCRIPTION

The mass was roughly lenticular in shape and had the average dimensions of 26 x 24 x 11 cm. The main mass in Mexico City now measures 17 x 24 x 11 cm and exhibits a cut and polished face, 23 x 10.5 cm in size. The mass is severely corroded and continues to corrode under normal museum conditions. In several places its surface is exfoliating along Widmanstätten planes, and no fusion crust and heat-affected α_2 zone are left. Instead, the mass is irregularly covered with 0.1-1 mm thick crusts of limonitic material.

Etched sections display a medium Widmanstätten structure of slightly undulatory, long ($\frac{L}{W} \sim 25$) kamacite lamellae with a width of 1.05±0.15. The kamacite exhibits

PUENTE DEL ZACATE – SELECTED CHEMICAL ANALYSES

Since Hawley's material was somewhat oxidized, his analysis has here been recalculated on an oxide-free basis. Hawley reported 0.02% Cl, no doubt a constituent introduced with the ground water.

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Hawley in Nininger 1931c	7.92	0.56	0.23	500	1800	540	800					
Goldberg et al. 1951	8.21	0.63							17.2			
Lewis & Moore 1971	7.99	0.49	0.15	160								
Scott et al. 1973	8.20								20.6	40.5	1.4	

unusually dense tangles of subboundaries, which are decorated with 0.5 μ phosphides and frequently form subparallel or concentric cells. The kamacite displays an indistinct mixture of Neumann bands and ε-structure. The bands are apparently decorated along both sides with submicroscopic precipitates, an observation which is supported by the fact that the Neumann bands are selectively corroded near the surface. The microhardness is 215±10. It increases locally in shear zones, e.g., around the troilite nodules, to 250.

Taenite and plessite cover about 40% by area. Comb and net plessite are the most common types; the fields may contain relatively large (3 x 4 mm) areas of spheroidized taenite in which the individual taenite spherules are 5-20 μ in diameter. A well developed field will exhibit a yellow or darkened taenite rim (HV 275±10) followed by a transition zone of acicular martensite (HV 350±25). Then we find dark-etching martensite plates precipitated parallel to the bulk Widmanstätten structure (HV 325±25) and finally varieties of the dark-etching, duplex structures with 0.5 μ γ-grains (HV 260±20). Large fields have a fully decomposed interior with a hardness only slightly above the surrounding kamacite lamellae.

Schreibersite is common as 30-90 μ wide grain boundary veinlets, as 10-50 μ blebs inside the coarser plessite fields and as 10-20 μ wide islands situated 10-20 μ outside the taenite and plessite. Rhabdites occur everywhere as 1 μ prisms.

Troilite is common as lenticular to rhombic nodules that range from 0.5-5 mm in diameter. A few large nodules 15 mm across, are also present. According to Nininger (1931c), the Tempe specimen (No. 94b) contains a 16 mm nodule in which a 7 mm hard, black crystal with hexagonal outlines is embedded. It would be interesting to have the mineral, which may be chromite or a phosphate, identified. The troilite is monocrystalline, but is somewhat deformed plastically and exhibits multiple twinning. It also contains

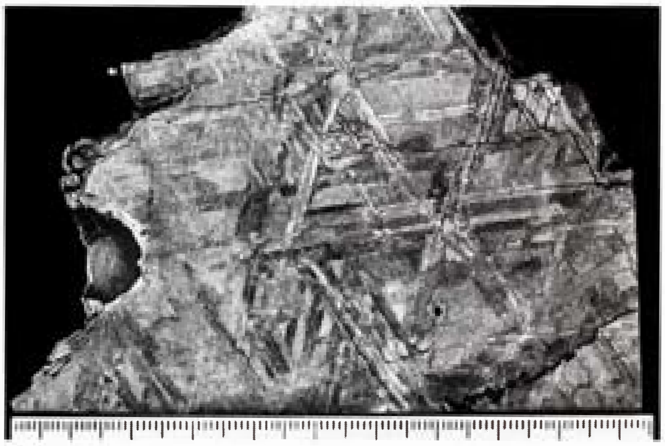

Figure 1401. Puente del Zacate (Tempe no. 95b). Medium octahedrite of group IIIA. A rhombic troilite nodule (black) occurs within swathing kamacite, below center. At the left edge half of a troilite nodule is preserved; within it is an unidentified hexagon of a coke-gray mineral.

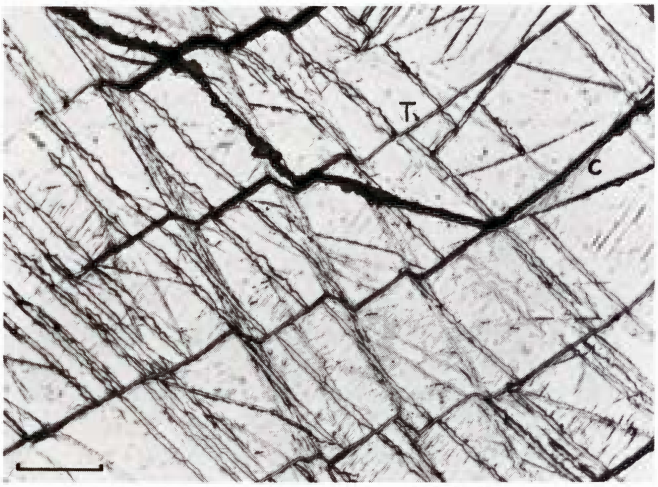

Figure 1403. Puente del Zacate (Tempe No. 94b). Dense arrays of Neumann bands and several narrow taenite lamellae (T), which have been displaced along flights of steps. Limonitic corrosion products (C) fill the cracks along some Neumann bands and taenite lamellae. Etched. Scale bar 50 μ.

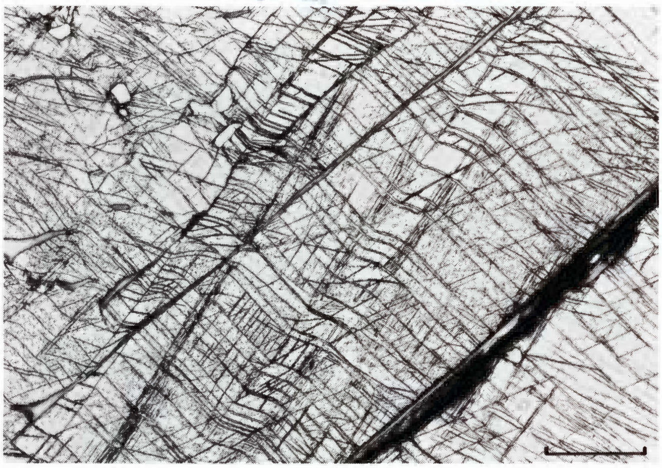

Figure 1402. Puente del Zacate (Tempe No. 94b). In places the meteorite is heavily deformed. The Neumann bands and the taenite lamellae are bent and sheared, and fine fissures (lower right) extend along cracked schreibersite vienlets. Etched. Scale bar 300 μ.

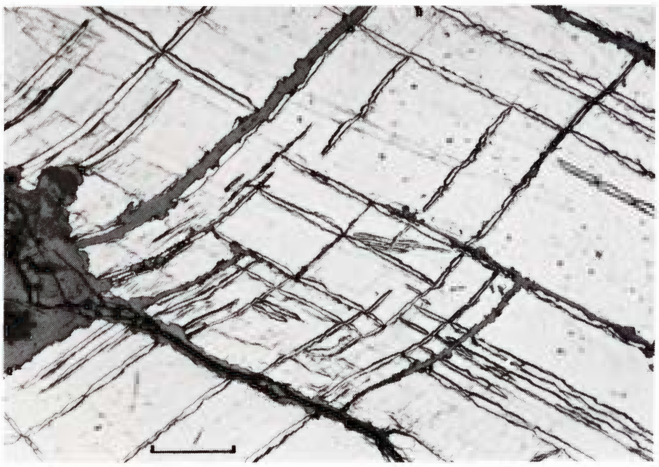

Figure 1404. Puente del Zacate (Tempe No. 94b). A corroded crack (left) from which very narrow fissures extend along several Neumann band directions. The fine fissures are corroded (dark gray). Etched. Scale bar 50 μ.

about 5% daubreelite as narrow, parallel lamellae. Discontinuous rims of 5-25 μ thick schreibersite are present around some of the troilite crystals, and 1 mm wide rims of swathing kamacite are normally present.

The mass is penetrated by many fractures which follow the Widmanstätten planes and appear to be preatmospheric. Corrosion penetrates along them, particularly following the brecciated phosphides. However, some additional deformation along the surface is due to chiseling and hammering.

Puente del Zacate is a medium octahedrite which is related to, e.g., Charcas, Dexter, Briggsdale, Rowton, Kyancutta and Frankfort. It is a normal member of group IIIA.

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

2,300 g weathered slice (no. 907, 23 x 10.5 x 2 cm)
5 g polished section (no. 2288, 28 x 10 x 2 mm)

Puerta de Arauco, La Rioja, Argentina
28°53′S, 66°40′W

Polycrystalline, fine octahedrite, Of. Bandwidth 0.35±0.10 mm. Group unknown. Analysis unknown.

HISTORY

A mass of 1.53 kg was found in 1904 in a pass crossing the Andes Mountains and was donated by Dr. Max Schmidt to the La Plata Museum. It has been described as a brecciated octahedrite with 6.61% Ni (Ducloux 1908; Kantor 1921: 2 figures; Radice 1959; Hey 1966), but the brief notes I have added below show that this is an inappropriate classification and that good sections should be analyzed and examined on an early occasion.

COLLECTIONS

There are 1,113 g and a model of the uncut meteorite in the La Plata Museum. Apparently more than 400 g of this rare meteorite have been lost or used up!

CHEMICAL ANALYSIS

Only the erroneous one by Ducloux (1908) is known.

DESCRIPTION

From the model and the remaining main mass, the meteorite may be seen to be pear-shaped and very smoothly rounded with the maximum dimensions of 9.5 x 6.5 x 6.5 cm. The pointed end has been removed; there remains the solid "body" of the pear, 6.5 x 6.0 x 5.5 cm in size and weighing 1,113 g. On this, an insignificant trough at one end suggests the presence of a few regmaglypts, 15-20 mm across. They have, however, been smoothed out and almost deleted by a long atmospheric flight. A pit, 15 x 20 mm, indicates where a troilite-silicate (?) nodule was partially ablated away in the atmosphere. The mass is slightly hammered, and an original paper-thin black fusion crust is partly worn away, partly rusty. It has been said that the meteorite was seen to fall about the middle of 1904 (see references above). In my opinion, the fall is older – perhaps as old as Keen Mountain or Boogaldi, meteorites that it resembles in exterior shape and state of preservation.

The only available section was the cut end of the meteorite itself. It was deep-etched a generation ago and of little use. It appears, however, that it reveals a polycrystalline fine octahedrite with a bandwidth of 0.35±0.10 mm. It displays some troilite nodules, e.g., 7 x 2.5 mm in size, and rosetta-shaped schreibersite (?) crystals up to 7 mm long. According to Ducloux (1908), chromite and olivine are present.

From these very unsatisfactory notes, which, however, will hopefully provoke some new and accurate work on this forgotten meteorite, it may be concluded: (i) Puerta de Arauco did not fall in 1904; (ii) it is not a brecciated octahedrite with 6.6% Ni, but rather a polycrystalline fine octahedrite with 10±2% Ni; and (iii) it may be a new type – or perhaps a rare one – related to Woodbine, Mesa Verde, Hassi-Jekna, Victoria West or Repeev Khutor.

Pulaski County
See Canyon Diablo (Pulaski County)

Puquios, Atacama, Chile
27°10′S, 69°53′W

Medium octahedrite, Om. Bandwidth 0.75±0.15 mm. Neumann bands-ε. HV 225-360.

Group IID. 9.96% Ni, 0.7% Co, about 0.35% P, 71 ppm Ga, 89 ppm Ge, 12 ppm Ir.

PUQUIOS – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Eakins in Howell 1890	9.83	0.71	0.17	400	900		400					
Smales et al. 1967						39	257	3.3	64.8	90		
Wasson 1969	10.08								77.0	87.9	13	
Crocket 1972											11	20

HISTORY

A mass of 6.56 kg was found by Mr. Ravenna near Puquios in 1885. It was purchased by Ward on his South American visit in 1889, and it was described by Howell with an analysis by Eakins (1890). Howell noted that this iron was particularly interesting because definite faulting was present to an extent never before seen in irons. Comparing the various sections prepared in Ward's Establishment, he concluded that the displacement along the largest fault was 3 mm, and he could follow this fault through the meteorite in successive sections for at least 6 cm. Also, Brezina (1896: 282) noted the shear zones. Both authors gave a few figures of the exterior and of etched sections.

COLLECTIONS

New York (1,621 g endpiece), Vienna (1,363 g), Chicago (318 g), Munich (277 g), Dorpat (219 g), Harvard (208 g), London (166 g), Budapest (131 g), Ottawa (108 g), Washington (90 g), Berlin (63 g), Amherst (62 g), Prague (53 g), Paris (48 g), Yale (39 g), Sarejevo (38 g), Rome (29 g), Strasbourg (26 g), Vatican (17 g), Bonn (17 g).

DESCRIPTION

The mass had the approximate average dimensions of 24 x 11 x 7 cm and weighed 6.56 kg. Its shape was compared to an indented, rhombic prism by Howell (1890). The end specimen in New York possesses two distinctly different surface morphologies. About one half is covered with normal regmaglypts, 1.5-2 cm in diameter and about 0.5 cm deep. A trifle of the original fusion crust is still preserved locally, but it is in a weathered condition. The opposite half is of a checkered appearance, the surface being covered by a dense network of small pits, and the regmaglypts being partially obliterated. The pits are 1-1.5 mm in diameter and 0.5-1 mm deep, and sharp edges separate the individual pits. Sections perpendicular to the two surface types reveal that the heat-affected α_2 zone (HV 180±10) is present under the former as a 0.5-2 mm thick rim with micromelted phosphides in the exterior part. However, no heat-affected zone is present under the checkered part. These observations are best explained if we assume that the meteorite was originally wholly covered with normal regmaglypts from flight; a subsequent long, terrestrial exposure selectively attacked half of the surface and here removed about 2 mm. It appears plausible that the meteorite lay partially embedded in the Atacama Desert and that only the exposed part corroded during periodic rains and *camanchaquas* (page 927).

Etched sections display a medium Widmanstätten structure with straight, sheared kamacite lamellae ($\frac{L}{W} \sim 15$) with a width of 0.75±0.15 mm. The kamacite has Neumann bands but shows local patches of crosshatched ϵ-structure and of shear zones with dense systems of sliplines. The microhardness of the three types is 235±20, 275±30 and 325±35, respectively; the hardest patches occupy the smallest volumes.

Taenite and plessite cover about 30% by area, mostly as comb plessite and acicular plessite. In this, the α-needles, about 10 x 2 μ in size, form a Widmanstätten felt against a dark-etching, martensitic background. The taenite has brownish edges and martensitic transition zones against an interior that may be a coarse, duplex $\alpha + \gamma$ mixture. The taenite and plessite fields are often sheared and displaced up to 2 or 3 mm; the microhardness of the sheared, kneaded taenite is 425±25, an unusually high hardness for taenite.

Schreibersite forms scattered skeleton crystals, typically 10 x 1 mm in size, which are enveloped in 0.7-1.5 mm wide zones of swathing kamacite. Its hardness is 910±25. Schreibersite further occurs as 10-50 μ wide grain boundary veins and as 10-100 μ irregular blebs inside plessite. Rhabdite is ubiquitous in the kamacite lamellae as 2-10 μ

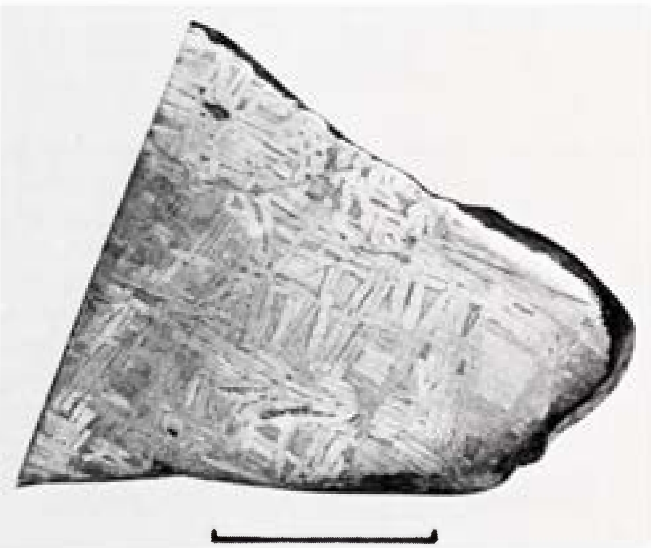

Figure 1405. Puquios (Prague No. 278, of 53 g). Medium octahedrite of Group IID. Schreibersite skeleton crystals with swathing kamacite are indistinctly seen. Deep-etched. Scale bar 30 mm.

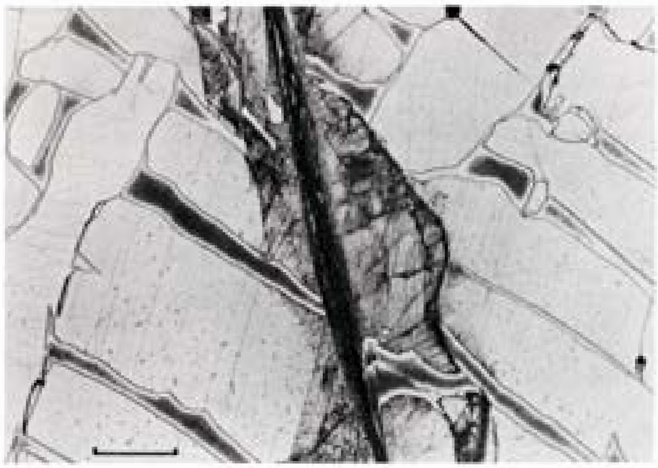

Figure 1406. Puquios (U.S.N.M. No. 153). A view of one of the shear zones. The shear is extremely heavy within a narrow zone, about 100 μ wide. From the main zone, less distinct shear zones fan out. Etched. Scale bar 500 μ.

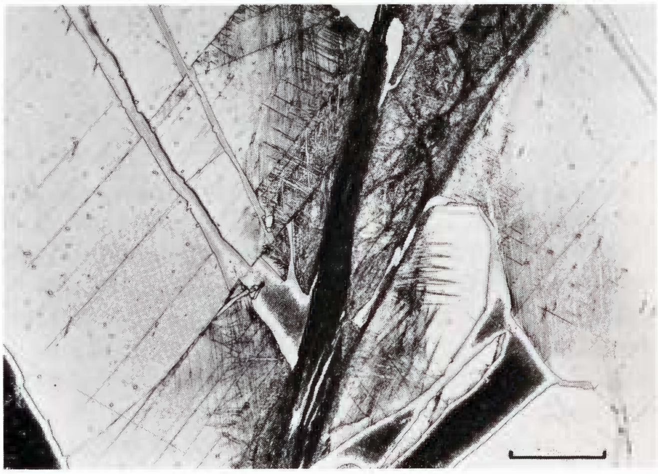

Figure 1407A. Puquios (U.S.N.M. No. 153). Another shear zone than the one seen in Figure 1406. The central parts are heavily kneaded kamacite and taenite. Farther away, the kamacite displays shock-hardened ϵ-structures, and tapers away into unaltered kamacite. Etched. Scale bar 300 μ.

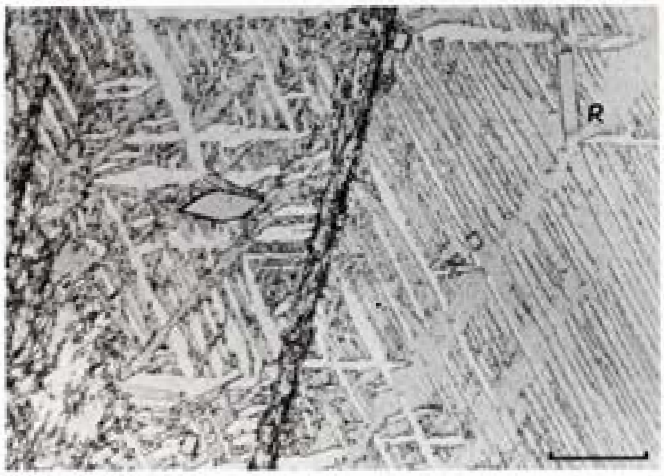

Figure 1408. Puquios (U.S.N.M. No. 153). Detail of a shock-hardened transition zone such as the one shown in Figure 1407A. Within the dark central band the deformation has led to severe shearing. Note the five prismatic rhabdite crystals (R). Etched. Oil immersion. Scale bar 20 μ.

Figure 1407B. Puquios (U.S.N.M. No. 153). Detail of a shear zone with very heavy displacements. The central plessite field shows altered taenite rims with distinct striping caused by violent deformation. Etched. Oil immersion. Scale bar 20 μ.

Figure 1409A. Puquios (U.S.N.M. No. 153). Detail of another shear zone in which the taenite (center) has been severely altered. Shock-hatched kamacite and plessite with martensitic interior in the right part of the picture. Etched. Scale bar 50 μ.

thick prisms. The bulk phosphorus content is estimated to be about 0.35%, rather than 0.17% as indicated in the old analysis.

Troilite is pretty scarce, occurring only as a few 0.1-2 mm irregular nodules. They contain minor amounts of parallel daubreelite bars and are often associated with schreibersite. The troilite is shock-melted and rapidly solidified to 2-10 μ fine iron-sulfur eutectics with frayed edges against the surrounding metal.

Microcracks, particularly along the phosphides, are rather common; they form 10-100 μ wide, straight fissures which are normally filled with terrestrial corrosion products.

Visual examination of the specimens shows that the macroscopic shear zones are parallel or almost parallel and are spaced 10-20 mm apart, with a maximum of 5 shear zones occurring on any one section. The individual shear zones are 50-100 μ wide, and the displacement along them is up to 3 mm. Between these major zones there are numerous microscopic ones, parallel to the first set, but only 1-10 μ wide and with displacements of only 10-100 μ. In addition, a number of shear zones cross the primary ones at oblique angles, thereby subdividing the whole mass into rhombic wedges. The mass was probably confined by other material when the event that deformed the mass took place, otherwise one would expect the mass to have broken up. The event was preatmospheric and was violent enough to shock-melt the troilite, but the relaxation heat was too small to recrystallize or anneal any part of the kamacite. The deformation was primarily a sudden cold working and, therefore, led to a conspicuous increase in the hardness of the metallic phases.

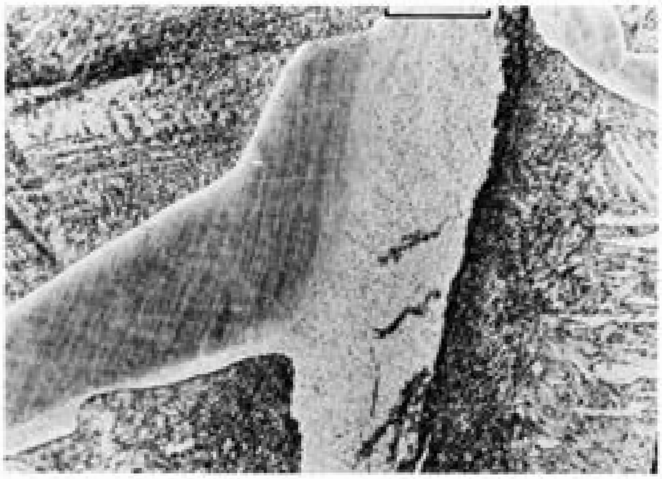

Figure 1409B. Puquios, detail of Figure 1409A. The altered taenite (center) appears to be fine-grained duplex. The brown-stained taenite to the left is heavily sheared and displays light deformation bands. Compare Figure 1407B. Oil immersion. Scale bar 20 μ.

Puquios is a medium octahedrite which is structurally related to Mount Ouray, N'Kandhla and Carbo. Chemically, it forms a natural member of group IID.

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

20 g part slice (no. 153, 2.5 x 2 x 0.5 cm)
70 g part slice (no. 3008, 4.5 x 4 x 0.6 cm)

Puripica. See North Chile (Puripica)

Putnam County, Georgia, U.S.A.

33°20'N, 83°24'W

Fine octahedrite, Of. Bandwidth 0.28±0.04 mm. ε-structure. HV 295±12.

Group IVA. 8.05% Ni, 0.34% Co, 0.04% P, 2.19 ppm Ga, 0.13 ppm Ge, 2.0 ppm Ir.

HISTORY

A weathered mass of 72 pounds (about 32 kg) was discovered in a cultivated field in 1839. It was taken to the blacksmith who attempted to break it upon an anvil but could remove only the outside crust, whereupon the stubborn mass was thrown into the backyard and almost forgotten. In 1852 it was rediscovered by J.A. Cogburn who presented it to Mercer University, in Macon, Georgia. It was described by Willet & Shepard (1854) who collected the above information and noted that the mass, as received by him, had been reduced to 60 pounds (27 kg). Shortly afterwards, about half of the mass was acquired by Shepard and eventually came with his collection to Amherst College. A significant part of the remaining mass appears to have been acquired by J.L. Smith who cut and distributed it widely. In 1876 he announced that Putnam County was among those irons which he would exchange in sizes from several hundred grams and downward (Smith 1876b: 5).

Since it was so well distributed, it was described or briefly mentioned on numerous occasions in the nineteenth century. The relevant literature is quoted by Wülfing (1897), Cohen (1905) and Farrington (1915). Cohen (1905: 342) described a specimen and presented a new analysis, and Brezina & Cohen (1886-1906: plate 22) gave five photomacrographs. Merrill (1916a: plate 31) also reproduced a photomacrograph, and Henderson & Furcron (1957) reviewed the case, presenting an improved photomacrograph. Jaeger & Lipschutz (1967b) noted the hatched ε-structure and estimated that it was due to shock pressures of 400-750 k bar. Bunch & Keil (1971) reported the chromite inclusions to be almost stoichiometric $FeCr_2O_4$ with very minor contents of MnO, V_2O_3, Al_2O_3, TiO_2, MgO and ZnO, these oxides totaling about 0.85 weight percent.

Bauer (1963) found ^3He and ^4He concentrations similar to Bristol and estimated the cosmic ray exposure age to be 340 million years. Voshage (1967) found a $^{40}K/^{41}K$ cosmic age of 410±75 million years. Schultz & Hintenberger (1967) confirmed Bauer's helium determinations and added information on the argon and neon isotopes. Since the discovery site is unknown the coordinates given above are for Eatonton, the center of Putnam County.

COLLECTIONS

Amherst (10.9 kg), Washington (2,735 g), Harvard (2,308 g), Tempe (1,387 g), Yale (372 g), Vienna (136 g), London (110 g), Göttingen (62 g), Calcutta (60 g), Stockholm (55 g), Chicago (53 g), Hamburg (45 g), New York (35 g), Leningrad (31 g), Tübingen (28 g), Dorpat (28 g), Dresden (27 g), Paris (26 g), Berlin (24 g), and minor pieces in numerous collections.

DESCRIPTION

According to Willet & Shepard (1854), the mass was shaped as "a rude, triangular pyramid, with its base and edges rounded, and its faces exposing many knobs and depressions." Examination of the larger preserved specimens in Amherst, Washington and Tempe reveals that some fissured parts are severely corroded and continue to corrode under exfoliation along Widmanstätten planes, while other more massive parts apparently are little altered. The fusion

PUTNAM COUNTY – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Wasson 1966	7.98								2.19	0.130	2.0	
Moore et al. 1969	8.12	0.34	0.04	140	115		160					

crust is lost and the surface is covered by terrestrial oxides 0.1-1 mm thick. It is, nevertheless, possible to identify 0.5-1 mm thick remnants of the heat-affected α_2 zone, so it is concluded that on the average only 2-3 mm of the surface is lost by terrestrial weathering. The loss of 5 kg estimated by Willet (ibid.) was probably mainly due to loss of edges and corners which could be separated by chiseling and only to a minor degree due to loss of oxide-scales.

Etched sections display a fine Widmanstätten structure of straight, long ($\frac{L}{W} \sim 40$) kamacite lamellae with a width of 0.28±0.04 mm. The kamacite is of the hatched, shock-hardened variety with a microhardness of 295±12. Towards the edge it decreases to 200 and in the remnants of the heat-affected α_2 zone it is 185±10 (hardness curve type I).

Taenite and plessite cover about 50% by area, as open-meshed net and comb plessite and as cellular plessite. A well developed field will exhibit a yellow taenite rim (HV 275) followed by a transition zone with martensite (HV 335±20). Further in, come duplex $\alpha + \gamma$ mixtures; the finer varieties are unresolvable with a 40x objective, while the coarser varieties exhibit 0.5-2 μ wide grains of taenite in a kamacite rich in subboundaries. The hardness ranges correspondingly from 325 to 295, but no plessitic texture is softer than the surrounding kamacite lamellae. This is a general observation, valid for both annealed and shock-hardened meteorites.

Schreibersite is absent under any form, in harmony with the chemically determined phosphorus value of 0.04%.

Troilite is present as scattered crystals, that occur with a frequency of about 15 per 100 cm^2. They are normally only 0.5-2 mm across and have hexagonal, rhombic or rounded outlines. The troilite is monocrystalline but exhibits a few lenticular twin lamellae from plastic deformation. Daubreelite is present as 1-100 μ wide lamellae oriented parallel to the hexagonal basis plane of the troilite.

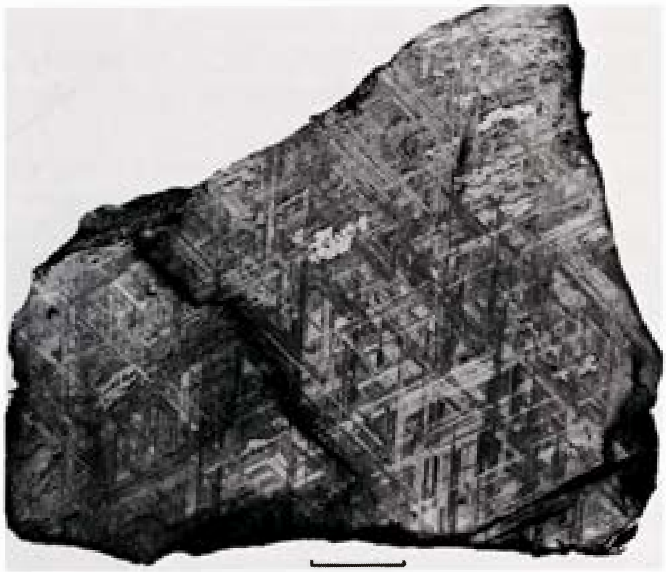

Figure 1410. Putnam County (U.S.N.M. no. 264). Fine octahedrite of group IVA. Cut almost parallel to $(111)_\gamma$ so that the fourth set of Widmanstätten lamellae appear as ragged plumes. Corroded fissures are also present. Deep-etched. Scale bar 20 mm. S.I. neg. M-5.

Daubreelite is further common in the metallic matrix as rounded blebs, 5-50 μ in diameter. Occasionally troilite and daubreelite form a regular intergrowth with less than 1 μ wide, alternating lamellae of the two sulfides.

Chromite is rather common as tiny, euhedric crystals which are usually associated with troilite and daubreelite. The chromite crystals are 0.2-1 mm in diameter.

The mass is penetrated by several cracks that follow the Widmanstätten structure. The larger of these are up to 1 mm wide and partially filled with corrosion products. It is probable that the cracks were already present when the meteorite landed, thus facilitating the terrestrial corrosion. The attack has selectively converted the alpha phase of the plessite fields, and troilite is partly transformed to pentlandite. However, a centimeter below the surface the corrosion is insignificant except along the cracks.

Putnam County is a shock-hardened fine octahedrite. Except for the pronounced ϵ-structure, it is related to Gibeon, Para de Minas, La Grange and San Francisco Mountains, and it is a typical member of the phosphorus-poor end of group IVA.

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

327 g weathered endpiece (no. 51, 5.5 x 5 x 2.5 cm)
2,294 g slice (no. 264, 14 x 10 x 2.5 cm)
22 g part slice (no. 3010, 27 x 27 x 3 mm)
92 g weathered, octahedral fragments (nos. 1118 and 3009)

Quairading. See Youndegin No. 9

Quartz Mountain, Nevada, U.S.A.

Approximately 37°12'N, 116°42'W; 1600 m

Medium octahedrite, Om. Bandwidth 1.10±0.20 mm. ϵ-structure. HV 310±15.

Probably group IIIA. About 7.9% Ni, and 0.12% P, judging from the structure.

HISTORY

A mass of 4,832 g was found in 1935 by John T. Waldis five miles southeast of Quartz Mountain, in Nye County. The find was made on the Manitouac mining property by miners while they were removing surface material preparatory to driving a tunnel. The meteorite lay upon bedrock under about two feet of surface detritus. The meteorite was acquired by the University of Nevada, where Gianella (1936) presented a preliminary description and gave a photograph of the exterior. Leonard (1944) examined a section and classified the meteorite as a coarse octahedrite, a practice which has been followed by Hey (1966: 397). Nininger & Nininger (1950: 88) correctly listed it as a medium octahedrite.

COLLECTIONS

Mackay Museum, University of Nevada, Reno (about 4.5 kg main mass), Washington (57 g), London (17 g), Tempe (16 g). [The main mass was in 1973 transferred from Reno to Tempe].

ANALYSIS

No analyses have been published. From my observations I would expect it to have 7.9±0.2% Ni and 0.12±0.02% P with trace-element concentrations placing it in the chemical group IIIA.

DESCRIPTION

According to Gianella (1936), the mass is roughly conical and has the average dimensions 15 x 12 x 7 cm. One side is relatively flat and smooth while the opposite is convex and exhibits many regmaglypts, 15-20 mm in diameter. Gianella and particularly Leonard (1944) assumed that Quartz Mountain was badly weathered and a very old fall resembling Canyon Diablo specimens, but an examination of the sections in the U.S. National Museum and in Tempe does not support these assumptions. Although most of the fusion crust is now lost by weathering, traces may be found; and, also, the heat-affected α_2 zone is present under considerable parts of the surface. It is estimated that, on the average, only 1-2 mm is lost by terrestrial weathering, so the exterior gives a rather true picture of the ablation-sculptured surface.

Etched sections display a medium Widmanstätten structure of slightly undulatory, long ($\frac{L}{W} \sim 20$) kamacite lamellae with a width of 1.10±0.20 mm. The kamacite has subboundaries decorated with 1-2 μ rhabdites. It is, by a shock wave, estimated to be above 200 k bar, converted to a shock-hardened, cross-hatched ϵ-structure which shows different shadings according to the orientation of the sectioned α-lamellae. The hardness is 310±15, decreasing in the near-surface zone to 210±10 for the α_2 tranformation product (hardness curve type I).

Taenite and plessite cover 20-30% by area in the form of rather degenerated comb and net plessite fields and in the form of isolated taenite ribbons. The larger taenite ribbons have a tarnished rim zone (HV 340±25) followed by a light-etching martensitic transition zone (HV 425±25). The interior may be decomposed to unresolvable, black taenite (HV 380±20) or to easily resolvable, duplex $\alpha + \gamma$ structures with 1-2 μ wide taenite grains (HV 330±30). The fully decomposed interiors are of approximately the same hardness as the surrounding kamacite lamellae.

Schreibersite occurs as 10-50 μ wide grain boundary veinlets and as irregular 5-50 μ blebs inside the plessite fields. A few small rhabdites are present locally.

Troilite occurs as scattered bodies, 0.2-1 mm in diameter. Daubreelite constitutes about 10 volume percent. A conspicuous fissure in the U.S. National Museum specimen almost cuts the specimen in two. It is 3 cm deep and up to 1 mm wide. It may be a section through the 7 cm long fissure, noted by Gianella (1936) as having almost split the meteorite. Now, this fissure was evidently previously partly filled with troilite a part of which is still preserved. The troilite is monocrystalline with undulatory extinction, or it is micromelted and solidified to 1-5 μ grains, or it is brecciated and loosely filling this fissure and several other fissures extending from the main fissure. Terrestrial corrosion has cemented the troilite fragments together. The metallic matrix within 1 mm on both sides of the fissure is severely kneaded and distorted. Moreover, complex pockets of fine-grained, fused metal occur scattered through most of the fissure. The melts are dendritic-cellular, and the cell size is 1-2 μ; the hardness is 450±20.

Perhaps the fissure formed early during the atmospheric deceleration, proceeding along a brittle Reichenbach lamella of troilite. The ablation-melted metal from the surface was of sufficiently low viscosity to penetrate through the whole crack and even fill in 10-25 μ narrow side fissures. On the other hand, the fissure may well be of a much more ancient origin, dating back to the ϵ-forming shock event. In that case, the curious metallic melts which appear to be distorted and kneaded into the matrix, were formed by shock-wave attenuation and local point melting of some metal and some troilite, while other parts were severely brecciated.

Whatever the origin, when the meteorite first landed the crack was there, readily accessible for terrestrial corrosion.

Quartz Mountain is a shocked, medium octahedrite which is related to Dexter, Bagdad, Merceditas and Trenton and probably will turn out to be a member of group IIIA.

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

57 g slice (no. 1225, 6 x 4 x 0.4 cm)

Queensland. See Gladstone (iron)

Quesa, Valencia, Spain

Approximately 39°0'N, 0°40'W

Medium octahedrite, Om. Bandwidth 0.7±0.2 mm.

Perhaps a member of group IID, judging from the structure.

HISTORY

A mass of 10.67 kg was observed to fall in 1898 near Quesa, in the neighborhood of Enguera, a town 60 km south-southwest of Valencia. Brief notes were published by Berwerth (1903: 4, 6) and by Cohen (1905: 304). At a later date Berwerth (1909) gave an elaborate description and six photographs of the exterior and of etched sections.

According to him and to Faura y Sans (1922: 49) who drew attention to some original Spanish publications on the subject, the meteorite fell at 8:45 p.m. on August 1st, 1898, "about an hour from Quesa." Several shepherds near the impact site saw a white trail of smoke and heard something similar to thunder or artillery fire from a northerly direction. The inhabitants of Quesa saw a flash of light which was followed by two almost simultaneous detonations; somewhat later they heard a brief noise as of an approaching storm. Bosca, a local resident who was watching from a farmhouse in Cabanal, saw a fireball moving across the sky in a somewhat curving path and gave the direction as from northwest to southeast. He visited the place of impact a week later and reported that the meteorite had been recovered from a 40 cm deep hole around which the soil was scattered for half a meter. Bosca had a feeling that another fragment had landed farther north, but he was unable to trace it.

The meteorite was purchased by the mineral dealer J. Böhm in Vienna, in 1900, and there it was divided to produce an 8,995 g main mass, a 1,000 g endpiece and a 375 g full section. Thus 300 g were lost in cutting and grinding. Before 1903 all samples were acquired for the Vienna collection through a donation by J. Weinberger.

Quesa is another example of a well-documented iron meteorite fall of which we unfortunately know almost nothing, not even the precise circumstances of fall or the precise analysis.

COLLECTIONS

Vienna (10.37 kg), Madrid (8 g), Chicago (1 g), Berlin (1 g).

ANALYSES

Several analyses have been performed by Spanish and German analysts, but they all appear to be insufficient. The best available is probably the one by Fahrenhorst (Cohen 1905): 10.75% Ni, 1.07% Co, 0.19% P, 0.04% Cu.

DESCRIPTION

Quesa is a wedge-shaped mass which weighs 10.67 kg and measures 17 x 16 x 9.5 cm in three perpendicular directions. Berwerth, in his elaborate description, suggested that the exterior of the body was bounded by four octahedral faces (111) and by a fifth, somewhat larger trapezohedral face (112). The last one should have formed the posterior face during the atmospheric flight, but the argument in favor of this is not convincing. Among other things, Berwerth found the thinnest part of the heat-affected zone under the supposed posterior face which is contrary to normal experience.

The meteorite shows only few and indistinct regmaglypts, 1-3 cm across. It was, however, in describing this somewhat atypical meteorite that Berwerth (1909) introduced the expression "regmaglypts" to cover any cavity or depression present on the meteorite surface before it landed on Earth. For a generation another expression "piezoglypt" (from Greek: $\pi \iota \epsilon \zeta \omega$ to press or push; $\gamma \lambda \upsilon \varphi \omega$ to cut or engrave) had been in general use. It had been introduced by Daubrée to indicate his experimentally supported belief that the cavities were produced by the erosive action of turbulent compression-heated air masses that passed the meteorite in its fall (see, e.g., Meunier 1884: 456).

Story-Maskelyne (1876) on the other hand, maintained that all depressions were formed by spalling during the atmospheric flight. Counter to this hypothesis, it may be said, among other things, that the majority of iron meteorite falls do not produce a large number of small fragments in addition to the major mass such as would be expected from the gradual degradation of the surface.

Berwerth proposed that the large fracture faces which resulted when parent meteoritic bodies disintegrated outside – or at an early stage in the atmosphere – were not plane but were covered with numerous fracture pits (Greek: $\rho \eta \gamma \mu \alpha$ fissure, fracture), and these pits became modified to regmaglypts during the flight. In later publications (e.g., Berwerth 1910), the case was further examined. The hypothesis is, however, not well-founded. The decisive objection is that the diameter of the regmaglypts is proportional to the diameter of the residual mass. The fact will be quite clear from an examination of the descriptions in the present handbook; the regmaglypts (on the front face) are usually one tenth the size of the residual mass. Such consonance would not be easy to explain on the basis of an early uneven fracture face.

Daubrée's view appears to be well-founded. The degradation of the surface occurs by ablation-heating, melting, vaporization, and in the last stages also by oxidative burning. Fragmentation and selective melting of troilite do also occur but are not responsible for the usual regmaglypts. Nevertheless, it is Berwerth's *word* "regmaglypt," that has won general acceptance in favor of piezoglypt.

Quesa is covered with a 0.5 mm thick black fusion crust of oxides, under which there is a fusion crust of dendritic metallic melts. Small grooves, resembling chisel marks, indicate where schreibersite lamellae were preferentially ablated away. Numerous narrow fissures are present in the oxidic fusion crust. They mainly follow the Widmanstätten directions of the underlying metal, and they appear to be associated with the phosphide-rich parts of the matrix. They may be perceived as fissures developed in a cold and brittle oxide crust, developed when the heat-affected exterior zone of metal transformed from the γ to the α_2 state, subject to volume increase during the latter part of the flight.

Only a deep-etched section, cut almost parallel to an octahedral plane, could be cursorily examined during a brief visit to Vienna. While the three (111) directions form equilateral triangles, the fourth forms 2-3 mm wide lamellae of kamacite with irregular borders. The kamacite lamellae are straight and long ($\frac{L}{W} \sim 15$) and have a width of 0.7±0.2 mm. At one end of the slice the near-surface lamellae are distorted. The deformation is of a nature that suggests a tensile fracture with some necking. It thus lends some support to the theory that another fragment was dislodged in mid-air and fell further north.

Taenite and plessite cover about 50% by area; on the deep-etched section normal comb and net plessite and duplex dark-etching fields could be distinguished.

Schreibersite occurs as 1-2 mm cuneiform skeleton crystals, surrounded by 1 mm wide rims of swathing kamacite. It is also present as up to 100 μ wide, discontinuous grain boundary veinlets.

The limited access to material unfortunately makes Quesa a rather uninvestigated and, consequently, unknown meteorite. From the few observations I have compiled here, it appears that it is a somewhat anomalous medium octahedrite which may be related to, e.g., Carbo and Elbogen. It is recommended that it be subjected to thorough examination and that modern analytical work be appended.

Quillagua. See North Chile (Quillagua)

Quinn Canyon, Nevada, U.S.A.

Approximately 38°10′N, 115°45′W; 1,800 m

Medium octahedrite, Om. Bandwidth 1.10±0.15 mm. Neumann bands. HV 180±15.

Group IIIA. 8.40% Ni, about 0.22% P, 20.9 ppm Ga, 41.5 ppm Ge, 0.58 ppm Ir.

Synonym Tonopah, see page 1004.

HISTORY

A mass of about 1,450 kg was discovered in August 1908 by a prospector looking for borax in the Quinn Canyon range, in Nye County. The mass was only partly embedded in the soil of a low hill of andesite and, resembling a large turtle, had the domed upper surface projecting above the ground. In 1909 the mass was hauled on a freight wagon with six horses the 90 miles to Tonapah, supervised by W.P. Jenney who also reported the details and circumstances of the finding (1909). He believed that the meteorite was the surviving nucleus of a violent fireball, observed and described in February 1894. This appears to be out of the question, however, since the corrosion indicates a higher terrestrial age than 14 years. In 1909 the whole mass was purchased by the Field Museum in Chicago and was described in detail by Farrington (1910a) who gave three photomacrographs of the exterior and two of small, etched sections. He concluded correctly that it was a medium octahedrite. This was disputed by Leonard (1944) with the result that it is now erroneously classified as a coarse octahedrite by Horback & Olsen (1965) and Hey (1966).

COLLECTIONS

Chicago (1,450 kg main mass), New York (13 g), Washington (11 g).

DESCRIPTION

The mass is shaped as an elongated low cone or shield, 110 cm long, 90 cm wide and 50 cm high. A visual inspection clearly reveals the "soil line" above which no significant weathering has occurred. The "soil line" has left about 30 cm of the thickness exposed to the atmosphere, and the regmaglypts here are well-preserved. They show a tendency to radiate away from the apex of the cone and are generally 4-7 cm in diameter. There is a large bowl-shaped depression in one place, 24 x 17 cm in aperture and 11 cm deep. Fusion crusts are present in numerous places. Where the corrosion is most progressive it has developed the Widmanstätten pattern as a delicate grid on the surface.

Below the "soil line" the morphology is radically different. Here, corrosion has modified the regmaglypts and produced numerous pits, 5-15 mm in diameter, with ragged edges. Locally, heavy caliche and ocher deposits are to be found under which the original surface may be preserved in a better way. On the average, several millimeters have been lost from the lower part of the meteorite by corrosion, while next to nothing has been lost from the top side.

A number of holes of almost cylindrical shape, 5-20 mm in diameter and up to 50 mm deep occur scattered irregularly over the surface. These cavities were undoubtedly produced by ablation of troilite nodules.

The specimen in the U.S. National Museum is a small fragment of 11 g, removed from the main mass with a chisel

Figure 1411. Quinn Canyon (Chicago). Close-up of a portion with well-preserved fusion crust, regmaglypts and cylindrical cavities from ablated troilite. Scale bar 2 cm. S.I. neg. M-71B.

QUINN CANYON – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Scott et al. 1973	8.40								20.9	41.5	0.58	