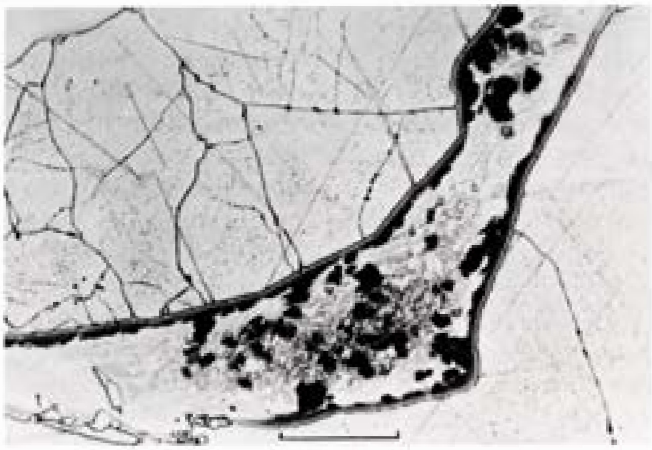

Figure 2007. Yenberrie (U.S.N.M. no. 607). Taenite with cloudy edges and martensitic interior in which cloudy patches occasionally occur. Part of the explanation may be sought in the taenite lamella being parallel to the plane of section. Etched. Scale bar 200 μ. See also Figures 109 and 119.

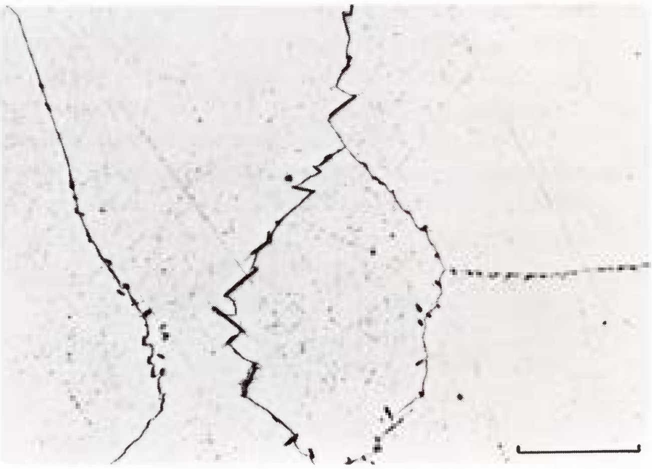

Figure 2008. Yenberrie (U.S.N.M. no. 607). The grain and subgrain boundaries of the kamacite are pinned by numerous fine precipitates, mainly of phosphides. Etched. Scale bar 200 μ.

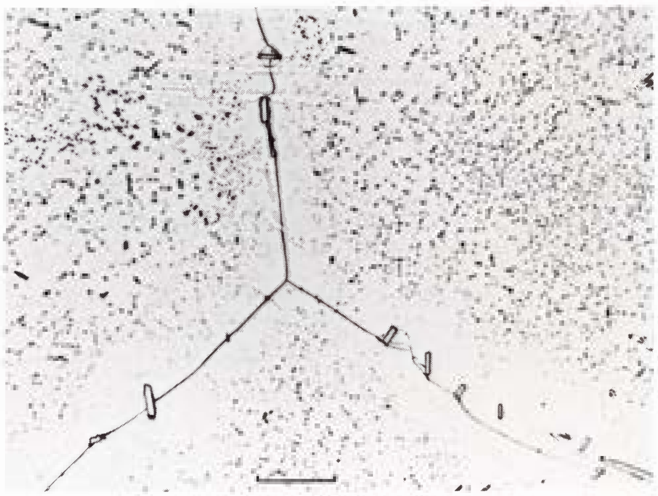

Figure 2009. Yenberrie (U.S.N.M. no. 607). Three subboundaries with angular rhabdite precipitates. The adjacent kamacite is P- and Ni-depleted and free of precipitates. Etched. Scale bar 50 μ.

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

3.54 kg on three slices (no. 607)
290 g part slice (no. 1626)

York (Iron), Nebraska, U.S.A.

Approximately 40°52'N, 97°35'W; 500 m

Medium octahedrite, Om. Bandwidth 1.00±0.15 mm. ϵ-structure. HV 305±15.

Probably group IIIA. About 7.7% Ni and 0.12% P.

HISTORY

A mass of 835 g was found in 1878 on the farm of Robert M. Lytle, near York in York County. The mass was plowed up from a depth of 20 cm in virgin, black loamy prairie soil. It was in the finder's possession until 1895 when it was acquired by Barbour (1898) who described it and gave figures of the exterior and of etched slices.

COLLECTIONS

New York (701 g), Washington (30 g).

ANALYSES

Kunz reported (in Barbour 1898) 7.38% Ni and 0.74% Co. The sum appears correct, but the present author would expect that some of the nickel has been included with the cobalt. The meteorite is estimated to have the following composition: 7.7±0.2% Ni, 0.50% Co, 0.12±0.02% P, with trace elements placing it in the chemical group IIIA.

DESCRIPTION

The mass, of which the major part is in New York, has the average dimensions of 8.5 x 7.5 x 4 cm. At one end there is a cut and polished face 5.5 x 4 cm in size. It is somewhat weathered, but since the heat-altered α_2 zone is still preserved as a 0.5-1.5 mm thick rim zone, at most 1-2 mm has been lost by corrosion. In places even a little of the fusion crust is preserved, albeit in a weathered form. The exterior morphology is surprisingly angular for such a small monolith. Other small meteorites with individual flight paths, as e.g., Freda, Föllinge and Avče, have smoothly rounded shapes, representing the surviving nuclei of larger meteorites. York, however, has a convex, rather smooth side and an opposite side covered with coarse regmaglypts, 1.5-2.5 cm across and 1 cm deep. The shape suggests that it is only a minor fragment of a larger mass which was never found. Perhaps it belonged with the 13.2 kg Lancaster County mass, reported by Barbour (1903), but now lost.

Etched sections display a medium Widmanstätten structure with straight, long ($\frac{L}{W} \sim 30$) lamellae with a width of 1.00±0.15 mm. There is little contrast between the plessite fields and the kamacite lamellae, since the fields are very open-meshed, kamacite-rich, and all kamacite has been converted by shock to the crosshatched ϵ-type. The hardness is 305±15; it drops in the α_2 rim zone to 205±10 (hardness curve type I). The α_2 grains are of the very fine-grained type, 5-15 μ across, arising from shock-hardened ε-structures.

Taenite and plessite cover about 35% by area, mostly as comb and net plessite. The taenite rims are tarnished, and the larger taenite wedges have martensitic or dark-etching, duplex interiors.

Schreibersite occurs as 10-50 μ wide grain-boundary precipitates and as 5-40 μ blebs inside the plessite. Rhabdites, 2-5 μ across, are common in some lamellae.

The chromium nitride, carlsbergite, is very common as 20 x 1 μ oriented platelets. They are unaltered in the heat alteration zone. Troilite was not present in the available sections, but daubreelite blebs, 30-100 μ across, occur in the kamacite lamellae and have served as nucleation centers for 10-20 μ thick schreibersite rims.

The mass is shocked and plastically deformed. All the larger phosphides are severely brecciated and individual segments are shear-displaced 1-10 μ in successive steps. Across the sections there are two parallel 0.5 mm wide shear zones, along each of which the macrostructure is displaced about 1 mm. The hardness of the cold-worked kamacite phase rises to 330±10 within these zones. There are numerous fissures, mainly following those of the Widmanstätten planes which are phosphide-filled. The fissures are probably preterrestrial, dating back to a cosmic collision. In one place the α_2 zone abruptly stops at a fissure running subparallel a little below the surface, proving that the fissure – by preventing a smooth heat penetration in the atmosphere – was of an early date. Of course, the fissures are now partially filled with terrestrial corrosion products.

York is a shock-hardened medium octahedrite which is closely related to San Angelo, Augusta County, Russel Gulch and other irons of group IIIA.

Specimen in the U.S. National Museum in Washington:
30 g polished part slice (no. 1354, 5 x 3 x 0.3 cm)

Youanmi, Western Australia

29°30'S, 118°45'E

Medium octahedrite, Om. Bandwidth 1.10±0.15 mm.

Group IIIA. 7.85% Ni, 0.15% P, about 0.5% S, 21 ppm Ga, 37 ppm Ge, 2.6 ppm Ir.

HISTORY

A mass of 118.5 kg was found in 1917 in the uninhabited granite country about 80 km south of Youanmi, at a place corresponding to the coordinates given above (Simpson 1938: 165). McCall & de Laeter (1965: 55) however, gave the discovery site as 80 km *north* of Youanmi; it is not clear whether their statement is based on additional information or is a simple misprint.

Simpson (loc. cit.) and McCall & de Laeter (loc. cit.) described the material as a medium octahedrite and provided photographs of the exterior and of etched slices. Cleverly & Thomas (1969) compared Youanmi and Yarri and found them different.

COLLECTIONS

Perth (main mass), Geological Survey of Western Australia, Perth (920 g).

DESCRIPTION

According to Simpson (1938) the mass measures 48 x 46 x 15 cm and weighs 118.5 kg. In at least two places on the surface there are deep cylindrical cavities, about 3 cm across, indicating where troilite nodules wholly or partly burned out during the atmospheric flight. Regmaglypts, 3-6 cm across, occur over most of the surface as well developed shallow, partly subparallel grooves. The mass is entire, except for two one-kilogram slices removed for examination.

The etched section displays a medium Widmanstätten structure of straight, long ($\frac{L}{W} \sim 15$) kamacite lamellae with a width of 1.10±0.15 mm. Taenite and plessite cover about 30% by area, mostly as comb and net plessite. Schreibersite is not present as large crystals but is common as 20-80 μ wide grain boundary veinlets. It also covers the troilite nodule as a discontinuous 0.2 mm wide rim zone. The troilite itself, a 16 x 20 mm nodule, could not be examined in detail on the deep-etched section.

According to Cleverly & Thomas (1969), the kamacite shows flecking, but exactly what is meant by this is not clear. They found a kamacite hardness of 212±8 and a taenite hardness of 240±11. Apparently the meteorite is annealed, either in space or artificially, most probably the first.

The fusion crust is preserved in several places, albeit in a slightly weathered state. The heat-affected α_2 zone is visible as a 2-3 mm wide rim; below the troughs of the regmaglypts the width decreases to about 1 mm, but below

YOUANMI – SELECTED CHEMICAL ANALYSES

References	percentage Ni	Co	P	ppm C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Wasson 1971, pers. comm.	7.85								21.0	37.4	2.6	
De Laeter 1972									20.5			

In an otherwise somewhat inadequate analysis, Simpson (1938) found 0.15% P and estimated the sulfur content to be about 0.5%.

the crests and protruding knobs the width may increase to 10 mm.

Youanmi is a very well-preserved octahedrite of group IIIA, which is closely related to Cape York, Casas Grandes, Cumpas, and Rowton.

Youndegin, Western Australia

Approximately 32°S, 118°E; 300 m

Coarse octahedrite, Og. Bandwidth 2.3±0.5 mm. Neumann bands. HV 176±18.

Group I. 6.74% Ni, 0.48% Co, 0.25% P, 0.64% C, 0.43% S, 89 ppm Ga, 339 ppm Ge, 2.0 ppm Ir.

HISTORY

Four masses of 11.7, 10.9, 7.9 and 2.7 kg, respectively, were found by Alfred Eaton, a mounted police constable, when he was on duty in the subdistrict of Youndegin in 1884. The locality was about 1 km northwest of Penkarring (Pikaring) Rock in a country described as granitic with dikes of quartz and schistose rocks with a superficial covering of sandstone. The four fragments, Nos. 1-4 in the table, were lying separately on the surface, three of them close together, and the fourth about 5 m away. Broken and severely oxidized pieces were discovered scattered around the irons. It appears that all the fragments originally belonged to one mass which had disintegrated by weathering (Fletcher 1887c).

Some years later, two much larger specimens, Nos. 5-6 in the table, were discovered by L. Knoop 10 miles north of Corrigin, and about eight miles southeast of Pikaring Rock. These were purchased in 1892 by the London mineral collector, Gregory, who briefly described them and gave a photograph of No. 5 (Gregory 1892). This mass was later acquired by Ward (Ward 1904a: XI and 28) and went with his collection to Chicago. Number 6 was purchased by the Vienna Museum (Brezina 1896: 232).

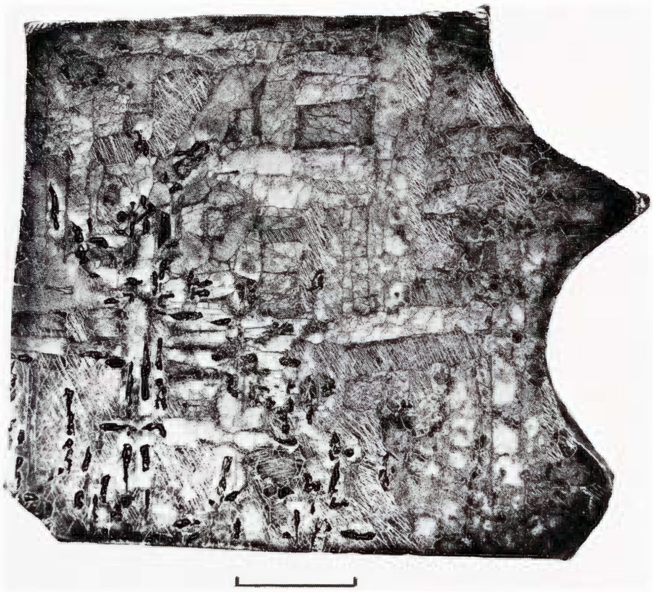

Figure 2010. Youndegin (U.S.N.M.). A coarse octahedrite of group I. Cohenite crystals (black) in lower left part. Note that Neumann bands and subboundaries are visible under this low magnification. Deep-etched. Scale bar 10 mm.

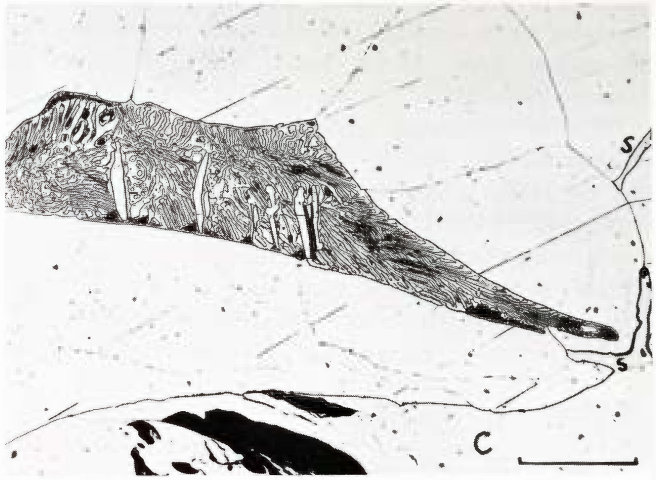

Figure 2011. Youndegin (U.S.N.M.). Cohenite (C) with schreibersite (S) at a grain boundary. Pearlitic plessite field above. Etched. Scale bar 200 μ. (Perry 1944: plate 44.)

A small mass of 4.1 kg (No. 7) was found on Finkelstein's farm about four miles northeast of Pikaring Rock in 1929, and additional specimens, totaling 13.6 kg, (No. 8), were found by L. Knoop and others; these were distributed among private collectors. One piece was made into a horseshoe and hung for many years in a blacksmith's shop at York, about 30 miles west-northwest of the finding place (Simpson 1938).

The largest mass of all, No. 9 of 2,626 kg, was found by E.C. Johnston, Sr., slightly buried on a gravel ridge, about 10 miles south-southwest of Pikaring Rock. It was donated to the Western Australian Museum in 1954 but had allegedly already been found in 1903, having been associated with a fireball observed in 1897 (Glauert 1954). This mass has not yet been cut and examined and has preliminarily been listed as a separate meteorite, Quairading, by McCall and de Laeter (1965: 49 and plate 1) and Hey (1966: 397). There is, however, little doubt that it belongs to the Youndegin shower.

Other fragments have been discovered on various occasions, some of them acquiring separate names (Nos. 10-13). These fragments of Youndegin have required separate treatment, so the description and discussion will be found at the end of the Youndegin description.

Youndegin is thus an impressive shower comprising of at least 13 different fragments with a total weight of more than 3.8 tons. Maps in Simpson (1938) and McCall & de Laeter (1965: 57) illustrate the approximate extent of the shower. Apparently, it covers at least 25 x 15 km, but the distribution is not systematic, either because only a fraction of the total number of specimens has been discovered, or because the already reported localities are known with too little precision.

Fletcher (1887c; 1899) described in detail the first four specimens, and made an important contribution in his minute description of the new mineral cliftonite. He concluded that this could not be a pseudomorph after pyrite, as had been maintained by Haidinger (see Magura), but was more likely a new allotropic form of carbon, distinct from diamond and graphite. Brezina (1896: 286) gave a description of the metallic structure and added a photomacrograph, and Farrington (1903: plate 37) gave a macrograph of a large etched section. Simpson (1938) showed other sections, while Perry (1944) presented the first photomicrographs of pearlitic plessite. Owen & Burns (1939) examined the kamacite by X-ray methods and found a lattice parameter of 2,8627 Å. Recent X-ray examinations by Jaeger & Lipschutz (1967b) indicated that the kamacite was only slightly altered by shock. McCall & de Laeter (1965: plates 11 and 13) presented photographs of the etched sections to be found in the Western Australian Museum.

With the advent of the electron microprobe, Youndegin was examined in detail by Short & Andersen (1965) and by Reed (1965a; 1965b; 1969). Reed found the kamacite to contain 6.4-6.8% Ni and 0.11% P in solid solution. The schreibersite crystals ranged from 25 to 42% Ni.

The content of noble gases, particularly $^3He/^4He$ was determined by Hintenberger et al. (1967a).

COLLECTIONS

Perth (2,626 kg No. 9, and 10.5 kg), Vienna (909 kg No. 6 and 900 g), Chicago (141 kg No. 5, and 5.5 kg), Sydney (69 kg No. 10), London (9.82 kg No. 1, 2.7 kg No. 4, and 815 g), Melbourne (10.9 kg No. 2), Washington (5.7 kg), New York (3.2 kg), Helsinki (919 g), Copenhagen (857 g), Harvard (623 g), Tempe (560 g), Tübingen (354 g), Paris (342 g), Dublin (261 g), Bally (233 g), Utrecht (200 g), Prague (188 g), Ann Arbor (180 g), Strasbourg (143 g), Canberra (135 g), Yale (124 g), Rome (103 g),

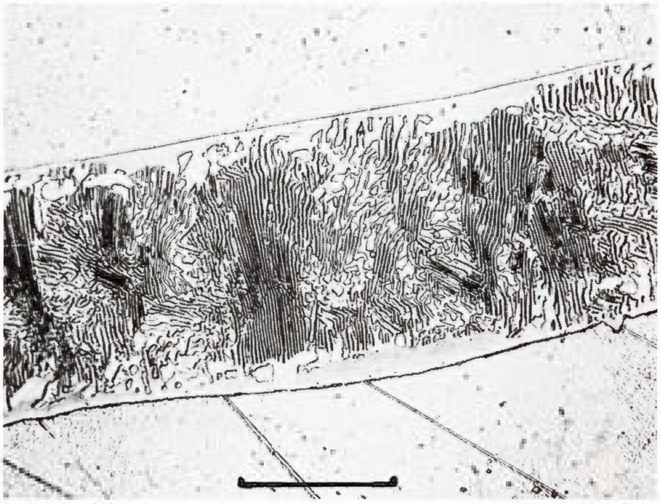

Figure 2012. Youndegin (U.S.N.M.). Pearlitic plessite with cloudy taenite edges. Etched. Scale bar 50 μ. (Perry 1944: plate 45.) See also Figure 157.

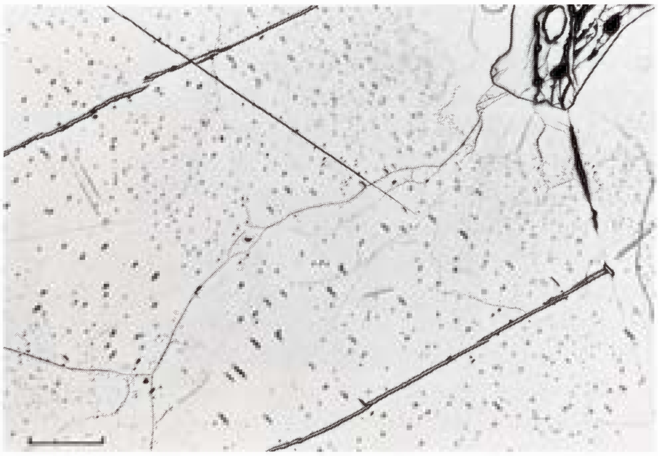

Figure 2013. Youndegin (Copenhagen). Cohenite in upper right corner with a grain boundary proceeding towards lower right corner. Subboundaries and prismatic rhabdites. The three prominent streaks are an unusual mineral; see following pictures. Etched. Scale bar 50 μ.

YOUNDEGIN – SELECTED CHEMICAL ANALYSES

As usual, the sampling problem with the coarse group I octahedrites is quite difficult. When the sample size is only of the order of 1-5 g, the risk of having a specimen which is nonrepresentative is significant. It appears that Wasson's analysis was performed upon kamacite without taenite; therefore the nickel value is low and the germanium value is high. The other analyses apparently contained both kamacite and taenite (plessite). See also the analyses p. 147.

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Fletcher 1887c	6.46	0.55	0.24	+			+					
Bowley in Simpson 1916	7.01	0.93	0.30	1500			200					
Lovering et al. 1957	6.92	0.49				2.5	155		88	322		
Smales et al. 1967					10.3	14.2	119	36	88	312		
Moore et al. 1969	6.95	0.46	0.21	50	300		150					
Wasson 1970a	6.38								90.8	383	2.0	
Crocket 1972											1.9	11.5
De Laeter 1972a									90.6			
Rosman 1972								42		342		

Leningrad (90 g), Calcutta (85 g), Hamburg (78 g), Berlin (76 g). There are also specimens in numerous other public and in some private collections.

DESCRIPTION

According to Gregory (1892) the two large masses Nos. 5 and 6 measured in their dimensions 57 x 51 x 33 cm and 125 x 67 x 50 cm, respectively. The largest mass, No. 9, is not described, but a good photograph of the exterior has been reproduced by McCall & de Laeter (1965: plate 1). Common to all masses, large or small, is the weathered exterior. No fusion crust and no heat-affected α_2 zones can be detected, and even the regmaglypts are severely modified by corrosion. Numerous cavities, frequently undercut, occur on the surfaces, e.g., 4 cm in diameter and 10 cm deep, or 5 cm in diameter and 4 cm deep. Some of the cavities, when present near an edge, may penetrate the mass as irregular, cylindrical holes. Many specimens show concave shallow cavities, separated by narrow sharp edges, indicating a severe corrosive attack. On the whole, the Youndegin specimens are considerably weathered, resembling in many respects the Canyon Diablo irons. On the other hand, on some specimens as yet uncut, (e.g., No. 9, Quairading) it appears to me that the top side is only slightly attacked and still displays regmaglypts and holes from troilite that burned out in the atmosphere. As mentioned on page 393 it is also possible to identify a few large Canyon Diablo irons with very modest corrosive attack; the exposed surfaces survived better than those that were buried.

Etched sections display a coarse Widmanstätten structure of straight but irregular ($\frac{L}{W} \sim$ 5-10) kamacite lamellae with a width of 2.3±0.5 mm. The smaller bandwidths are associated with cohenite-rich regions. Local grain growth

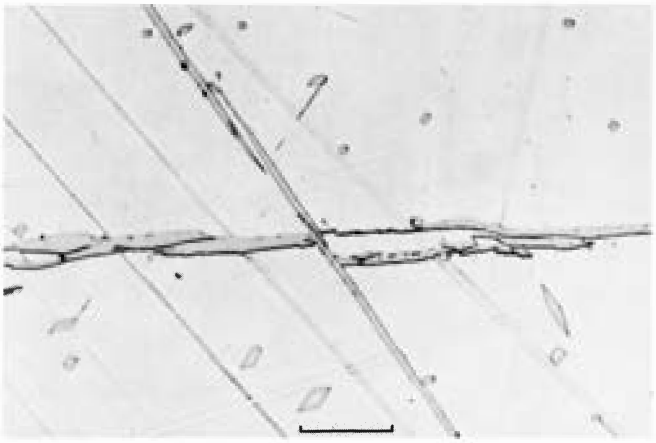

Figure 2014. Youndegin. Detail of Figure 2013 showing the intersections of the X-mineral. Rhabdites are also visible. Etched. Scale bar 100 μ.

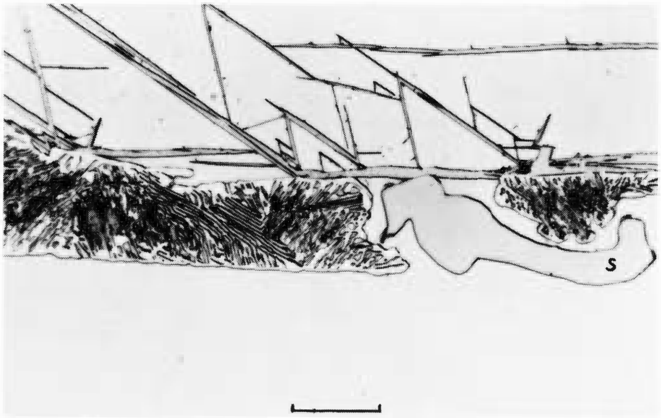

Figure 2015. Youndegin (Copenhagen). Pearlitic plessite and a schreibersite crystal (S). Several acicular platelets of the X-mineral are clustered above them. This is a very typical mode of occurrence. Etched. Scale bar 40 μ.

Table of Youndegin Individuals

No.	Name	Mass kg	Mass pounds	Year found	Approx. Coordinates °S	Approx. Coordinates °E	Present location
1	Youndegin I	11.7 kg	25¾	1884	32°2′	117°35′	London, Brit. Mus.
2	Youndegin II	10.9	24	1884	"	"	Melbourne, Natl. Mus.
3	Youndegin III	7.9	17½	1884	"	"	Perth, West. Austr. Mus.
4	Youndegin IV	2.72	6	1884	"	"	London, Brit. Mus.
5	Youndegin V	173.5	382½	1891	32°10′	118°50′	Chicago Field Mus. Part distributed by Ward.
6	Youndegin VI	927	2,044	1892	"	"	Vienna, Naturhist. Mus.
7	Youndegin VII	4.1	9	1929	32°3′	118°46′	Perth, Govt. Chem. Labs.
8	Youndegin	~ 14 on several masses		1891-1929	unknown		Private collections
9	Quairading	2,626	5,789	1903	32°10′	117°42′	Perth, West. Austr. Mus.
10	Mount Stirling I	92.0	202	1892	32°6′	117°55′	Sydney, Austr. Mus.
11	Mount Stirling II	0.42	–	unknown	32°6′	117°55′	Sydney, Austr. Mus.
12	Mooranoppin I	1.6	3½	1893	(31°45′	117°45′)	Distributed through Ward
13	Mooranoppin II	0.82	1¾	~ 1893	(31°45′	117°45′)	Perth, West. Austr. Mus.

has, to a certain extent, created large ferrite crystals, up to 10 x 20 mm in cross section. The ferrite is rich in Neumann bands and shows a hardness of 176±18. At certain spots near the surface, the hardness increases to 225±15, but this can be shown to be due to artificial cold working with a hammer. The ferrite displays numerous subboundaries decorated with less than 1 μ phosphide precipitates.

Taenite and plessite cover 1-5% of the available sections. The fields are small and may be developed with acicular, spheroidized (10-20 μ γ-islands) or pearlitic interiors. The hardness of the finer, pearlitic variety ($\sim$ 1 μ wide γ-lamellae) is 250±15; of the coarser variety ($\sim$ 2 μ wide γ-lamellae) 225±15. A few large comb plessite fields occur locally. Rhabdites, 1-5 μ wide, are sometimes situated inside the fields and may even be found in the massive taenite. Also some late haxonite precipitates may occasionally be identified inside the pearlitic and spheroidized plessite fields.

Schreibersite is common as up to 1 mm wide rims around troilite-graphite inclusions and as skeleton crystals that attain sizes of (10-20) x (1-2) mm. Vogel (1964) has reported an exceptionally large schreibersite lamella in a slice in the Vienna Museum: about 40 cm long and 1-2 cm wide and enveloped in an irregular rim of swathing kamacite. Schreibersite also occurs as 20-80 μ wide veinlets in the α - α and the α - γ grain boundaries. Rhabdites occur in profusion as well developed tetragonal prisms, 5-25 μ across and up to 1 mm long. The larger schreibersite crystals have nucleated rims of cohenite and of swathing kamacite, which have grown irregularly to thicknesses of 2-5 mm.

Troilite occurs as scattered inclusions, ranging from 1 to 50 x 20 mm in size. A representative section of 204 cm^2 was by planimetry found to contain 394 mm^2 of troilite, corresponding to approximately 0.43 weight percent S. The troilite is monocrystalline and often contains numerous parallel, 1-20 μ wide daubreelite lamellae. In a few places the troilite is distorted and shows undulatory extinction. It is typical for Youndegin that the troilite nodules are often intergrown with significant amounts of graphite; the complex aggregates may contain anything from 0 to 100% graphite. (The figure for troilite quoted above has been corrected for the graphite-content). The graphite may be segregated into one lump or may be distributed as angular or crescent-shaped blebs in one or more positions within the nodule. Silicates are apparently absent, although they would be expected to be present in a meteorite of group I related to Canyon Diablo and Campo del Cielo. Fuchs & Olsen (1965) identified chlorapatite in the graphite of a Mount Stirling fragment (page 1357).

Cliftonite occurs as well developed large crystal aggregates, 100-600 μ across. In exceptional cases they attain 1 mm size. They are situated in the immediate surroundings of troilite, either in kamacite or overgrown with later precipitates of schreibersite and cohenite. When near the surface or near corroded fissures, the kamacite in contact with cliftonite is invariably severely corroded; the conditions are apparently comparable to the corrosion (graphitization) of gray cast iron.

Cohenite is common as rounded crystals, elongated in the direction of the Widmanstätten lamellae and attaining sizes of 5 x 1 x 0.5 mm. They are monocrystalline and have hardnesses of 1100±50. Cohenite also forms 0.2-0.5 mm thick rims upon schreibersite. Most cohenite is brecciated and the fissures are frequently filled with corrosion products from terrestrial attack. No cohenite has been decomposed to graphite and ferrite. The distribution of cohenite is rather uneven. Some sections show no cohenite at all, while others, e.g., 10 x 10 cm^2 in size, may be very rich in them. It appears that such sections which contain significant troilite-graphite nodules, are low in cohenite and

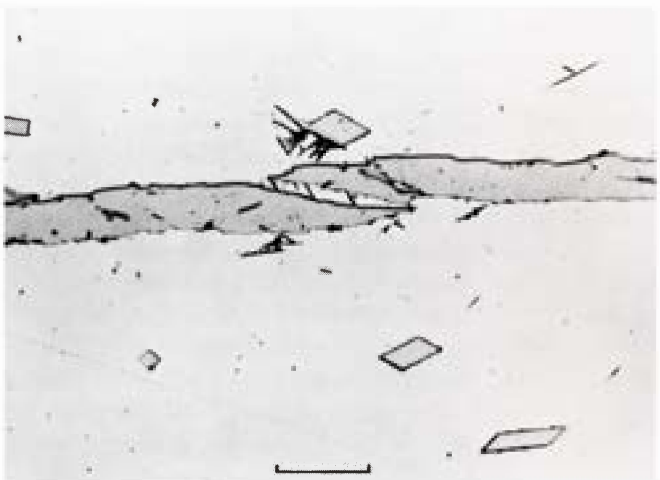

Figure 2016. Youndegin (Copenhagen). Detail of the acicular X-mineral. It is apparently a very late precipitate since it is attached to fully developed rhabdite and schreibersite crystals. Etched. Scale bar 40 μ.

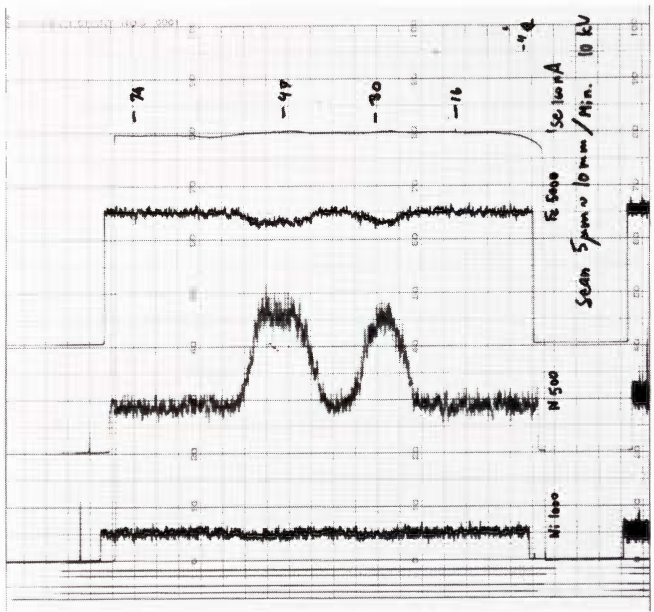

Figure 2017. Youndegin (Copenhagen). X-ray microprobe traces across two adjacent branches of the X-mineral, similar to Figure 2016. The preliminary examination indicates that it is a new mineral, probably the iron nitride Fe_4N.

vice versa. If this is true – but rather insufficient material was at hand – it might indicate that the carbon was initially more or less uniformly distributed through the bulk of the meteorite. In some places the carbon would then have had a chance at high temperature (> 1000° C) to be drained into the troilite melt residue; while in other places, where this opportunity did not exist, it remained in solid solution until it precipitated as cohenite at much lower temperatures. The cliftonite may represent an intermediate stage: precipitation from solid solution in the swathing kamacite immediately around troilite.

In an attempt to estimate the bulk carbon content of Youndegin, a representative slice of 204 cm^2 was planimetered. Graphite (in troilite and as cliftonite) accounted for 332 mm^2, corresponding to 0.47% C. Cohenite, present as rims around schreibersite (142 mm^2) and as individual rounded crystals (350 mm^2), accounted for 492 mm^2, corresponding to 0.16% C. Microscopic inclusions and carbon present in solid solution may be estimated to contribute less than 0.01%, since Moore & Lewis (1968), on a metallic fraction free of visible inclusions, found only 0.005%. The bulk carbon content arrived at is thus 0.64%, which should be a fair figure for the normal Youndegin slices.

Some sections, mostly those containing troilite with schreibersite-cohenite rims, show appreciable amounts of a new mineral. It is anisotropic and occurs in the kamacite as straight, bayonet-like hard precipitates, which attain sizes of 5000 x 20 μ in cross section, Figures 2013-2014, but more often occurs as shorter, spiky platelets, 1000 x 10 μ in size. It is frequently precipitated upon or near taenite and schreibersite and seems to be a very late precipitate. When in clusters, it looks very much like martensite needles in steel, Figures 2015-2016. The impression is that it has precipitated upon slightly deformed shear planes and other lattice defects in the kamacite.

Under the electron microprobe only Fe, Ni and N were found; Cr, Cu and P were not present. While the examination is at present only in the initial stages, it appears, however, that the mineral is an anisotropic iron nitride, possibly Fe_4N, with a few percent of nickel in substitutional positions. The mineral may easily be overlooked; close examination of other group I and IIB irons will probably disclose additional occurrences.

Youndegin is a coarse octahedrite of group I which is closely related to, e.g., Canyon Diablo, Yardymly, Yenberrie, Campo del Cielo and Seeläsgen. As discussed below, both Mount Stirling and Mooranoppin are fragments of the Youndegin shower, but for one's advantage, Mooranoppin specimens, particularly, should be kept separately, because they have been artificially reheated.

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

1,498 g slice (no. 678, 16 x 15 x 1.2 cm)
3,300 g slice (no. 822)
78 g part slice (no. 1752, 6 x 6 x 0.6 cm)
102 g part slice (no. 3156)
748 g part slice (no. 3157)
10 g part slice (no. 3386)

Youndegin (Mooranoppin), Western Australia

Approximately 31°45'S, 117°45'E; 300 m

Coarse octahedrite, Og. Bandwidth 2.3±0.6 mm. Neumann bands and α_2.

Group I. 6.91% Ni, 0.50% Co.

No. 1 is an artificially reheated fragment of the Youndegin shower.

HISTORY

A mass of 1.6 kg (3½ lbs.) was found about 1893 by an aborigine somewhere south of Mooranoppin Farm, near Kellerberrin, County Lansdowne. It was acquired by Ward in 1896, who sliced and briefly described it (1898). Simpson (1938: 170) reexamined the structure and gave a photomicrograph. He concluded that Mooranoppin was part of the Youndegin shower, and he also reported a second mass of 820 g, from the Mooranoppin farm. This was probably found at the same time as No. I, and is now in the Western Australian Museum (McCall & de Laeter 1965: 39). Reed (1969) found 6.5% Ni and 690 ppm P in solid solution in the kamacite on No. I.

COLLECTIONS

No. II: Perth (748 g), No. I: London (244 g), New York (175 g), Chicago (171 g), Perth (163 g), Washington (149 g), Vienna (65 g), Sydney (54 g), Vatican (42 g), Berlin (38 g), Stockholm (20 g), Bonn (12 g), Tübingen (7 g), Yale (4 g).

DESCRIPTION

According to Ward (1898) No. I was an oblong bar, 10 cm in length, 8 cm wide and 4 cm thick. No. II was an angular rhomboid mass of 820 g (Simpson 1938). Only specimens from No. I have been examined in this study. They evidently come from a weathered mass where the fusion crust and the heat-affected rim zones are lost. Selective corrosion has converted the alpha phase of the plessite fields and around phosphides to limonite, but only near the surface. On the other hand, there are many indications of a secondary artificial reheating, as discussed below.

Etched sections reveal a coarse Widmanstätten structure of straight, bulky ($\frac{L}{W} \sim 10$) kamacite lamellae, ranging

YOUNDEGIN (MOORANOPPIN) – SELECTED CHEMICAL ANALYSES

Reference	percentage Ni	Co	P	ppm C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Lovering et al. 1957	6.91	0.50				<1	175		79	396		

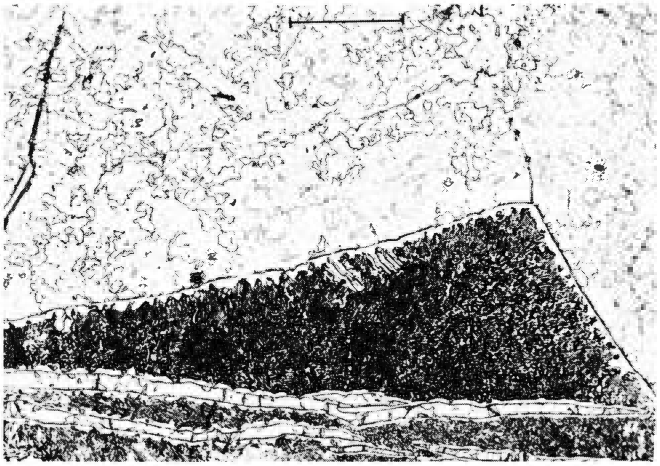

Figure 2018. Youndegin. The Mooranoppin fragment No. 1 (U.S.N.M. no. 1609). This sample has been artificially reheated. The kamacite is converted to unequilibrated α_2 and the plessite fields are diffuse. Etched. Scale bar 100 μ.

from about 1.6 mm in width near cohenite to about 2.8 mm in inclusion-free parts. The kamacite has subboundaries decorated with 1-2 μ rhabdites, and displays numerous Neumann bands. Taenite and plessite cover 2-5% by area, partly as comb plessite, partly as pearlitic and spheroidized fields that are often in contact with cohenite crystals.

Schreibersite occurs as 5 x 1 mm H- and L-shaped skeleton crystals which are surrounded by 0.3 mm thick rims of cohenite. Schreibersite is further common as 30-100 μ wide grain boundary precipitates. Rhabdites, 1-10 μ across, are common, particularly in the cohenite-poor parts.

Cohenite is present as typical rounded skeleton crystals, 3 x 0.5 mm in size, centrally in the kamacite. They are, as usual, concentrated in some parts of the sections and absent in others. Troilite and graphite were observed by Ward (1898), when he cut the mass in many parallel slices but were not seen in this study.

So far, Mooranoppin I – and probably No. II as well – are structurally identical to Youndegin, as suggested by Simpson (1938). The chemical analyses are also identical, within analytical errors, so the Mooranoppin irons are undoubtedly fragments from the northern part of the Youndegin strewnfield.

The structure of Mooranoppin No. I does, however, indicate a secondary reheating, absent in Youndegin material. The kamacite is converted to serrated α_2 units, particularly at one end. The rhabdites are almost dissolved, and the cohenite is rimmed by 10 μ black-etching bainite plus 50 μ light-etching martensite. The plessite and taenite areas are somewhat diffuse. Since these observations might indicate that some Youndegin fragments had been severely reheated by a violent impact and breakup, the structure was minutely examined. It turned out that the reheating was artificial, although no mention of this occurs in the recorded literature. The proof lies in the fact that Mooranoppin first corroded, then was reheated briefly, apparently to about 900° C at one end. The opposite end evidently only reached a somewhat lower temperature, since some Neumann bands are preserved there. Common to all sections available are the following facts: the terrestrial corrosion products have reacted with the phosphides and created creamcolored 2 μ wide reaction rims; high temperature intercrystalline attack is visible along the already corroded fissures; finally, the bainitic rim zones around cohenite were developed after the meteorite had corroded significantly.

Mooranoppin (No. I) is thus an artificially reheated fragment of the Youndegin shower.

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

72 g slice (no. 415, 5 x 3 x 0.6 cm)
51 g slice (no. 1609, 6 x 3.5 x 0.4 cm)

Youndegin (Mount Stirling), Western Australia

Approximately 32°6'S, 117°55'E; 300 m

Coarse octahedrite, Og. Bandwidth 2.3±0.6 mm. Neumann bands. HV 185±10.

Group I. 6.90% Ni, 0.50% Co, 0.19% P, 89 ppm Ga, 341 ppm Ge.

Mount Stirling is a part of the Youndegin shower.

HISTORY

Two masses of 92 kg (203 lbs) and 420 g (14¾ ozs) were found by aborigines in 1892 about 40 km southeast of Mount Stirling (Cooksey 1897: 58, 131). Ward must have borrowed the large specimen on his trip to Australia in 1896 in order to cut it. About 20 kg was sold or exchanged in large and small sections during the next generation from Ward's Establishment, while the main mass was returned to Sydney. Ward gave two photomacrographs (1904a: plate 1; Price List No. 237, 1921: figure 3). Simpson (1938) discussed the structure and location and concluded that Mount Stirling was a fragment of the Youndegin shower.

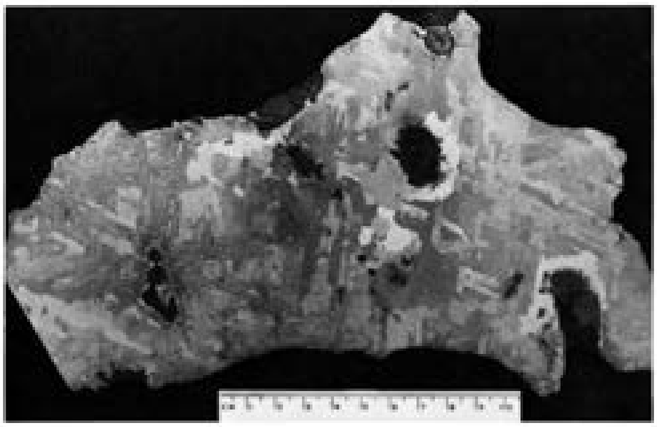

Figure 2019. Youndegin. The Mount Stirling fragment (Tempe no. 191a). Coarse octahedrite of group I with troilite-graphite inclusions. Deep-etched. Scale in centimeters. (Courtesy C.B. Moore.)

Hodge-Smith (1939: plate 2) gave a photograph of the exterior, while McCall & de Laeter (1965: plate 11) presented a photograph of a macroetched slice. Thode et al. (1961) examined the sulfur isotopes. Fuchs & Olsen (1965) identified chlorapatite as up to 0.5 mm clear, euhedral crystals in the graphite parts of a troilite nodule.

COLLECTIONS

Sydney (67.2 kg main mass and 1.9 kg slices), London (1,888 g), New York (1,464 g), Tempe (1,227 g), Chicago (1,000 g), Copenhagen (851 g), Perth (767 g), Berlin (471 g), Vienna (450 g), Washington (383 g), Prague (268 g), Stockholm (261 g), Yale (249 g), Budapest (216 g), Leningrad (206 g), Harvard (186 g), Amherst (110 g), Warsaw (83 g), Vatican (57 g), Bally (54 g), Ottawa (28 g), Paris (12 g).

DESCRIPTION

The large mass has the approximate overall dimensions 40 x 40 x 15 cm. In places it is deeply indented and elsewhere covered with shallow, sharp-edged pits, 4-8 cm across. Terrestrial oxides form a crust, 0.1-1.5 mm thick. Fusion crust and heat-affected rim zones are not present.

Etched sections display a typical coarse Widmanstätten structure, with numerous troilite, graphite, cohenite and schreibersite inclusions. The kamacite lamellae are straight, bulky ($\frac{L}{W} \sim 10$) and have a width of 2.3±0.6 mm, but local grain growth has, in addition, created almost equiaxial alpha grains, 5-15 mm in size. The kamacite has numerous subboundaries decorated with 0.5-2 μ rhabdites, and Neumann bands are ubiquitous. The microhardness (100 g Vickers) is 185±10. Taenite and plessite cover 2-5% by area, with comb plessite and acicular plessite being the most abundant varieties. Pearlitic plessite is also common, and attains rather coarse forms with about 1-2 μ wide taenite lamellae. Spheroidized plessite with 1-10 μ wide taenite spherules may be found locally, mostly associated with cohenite, pearlite, and some haxonite.

Schreibersite occurs as up to 20 x 5 x 1 mm skeleton crystals often resembling bayonets. It is also common as 20-100 μ grain boundary precipitates and as 10-50 μ irregular blebs inside the comb plessite. Rhabdites are common as 1-25 μ sharp prisms, and a fine cloud of <0.5 μ precipitates in many alpha grains is probably also rhabdites.

Troilite occurs associated with graphite in 5-20 mm irregular nodules. Even a 5 x 2 x 2 cm nodule was seen. The relative proportion of troilite to graphite varies from 1:100 to 4:1, while pure troilite is apparently rare. The nodules are normally enveloped in 1 mm schreibersite plus 0.5 mm cohenite, but the shape and number of rims vary considerably.

Cohenite is present as 0.3-0.5 mm wide rims encircling most of the nodules and some of the schreibersite skeleton crystals. It is not evenly distributed but occurs concentrated in, e.g., one-half of a 20 x 10 cm section, while the other half is cohenite-free. The typical cohenite crystals appear as clusters of rounded, club-shaped bodies, 3 x 0.5 mm in size, each oriented along a taenite-plessite field. The cohenite is monocrystalline and not decomposed to graphite. Small inclusions of 10-100 μ schreibersite and of kamacite and taenite are common in the cohenite.

Mount Stirling closely resembles unshocked Canyon Diablo specimens and Youndegin. Simpson (1938) showed that the location where Mount Stirling was found was only about 25 km east of Pikaring Rock where several of the Youndegin masses were found. Since the detailed structure

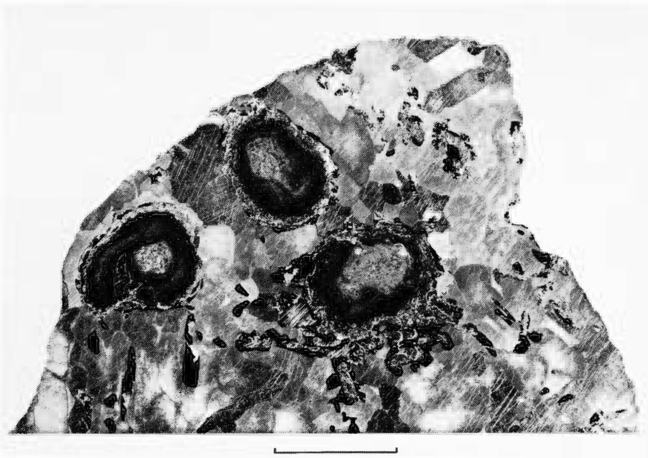

Figure 2020. Youndegin. The Mount Stirling fragment (Chicago no. 1004). Troilite-graphite nodules with rims of schreibersite (gray) and cohenite (black). Scattered cohenite crystals in the kamacite lamellae. Deep-etched. Scale bar 10 mm. S.I. neg. 1505.

MOUNT STIRLING – SELECTED CHEMICAL ANALYSES

Bowley's sample evidently contained appreciable amounts of cohenite judging from the high carbon value. His high cobalt value must be in error. Wasson (1970a) reported a Mount Sterling (sic.) specimen which showed significant differences in composition from those examined here. I believe that such Mount Stirling material has been mislabeled Nocoleche specimens. See also the analyses reported under Youndegin and Mooranoppin.

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Bowley in Simpson 1916	6.72	0.81	0.17	2400	600							
Lovering et al. 1957	6.93	0.55				7.2	225		63	409		
Moore et al. 1969	7.04	0.45	0.20	475	50		145					
De Laeter 1972a									88.6			
Rosman 1972	6.81							90		341		

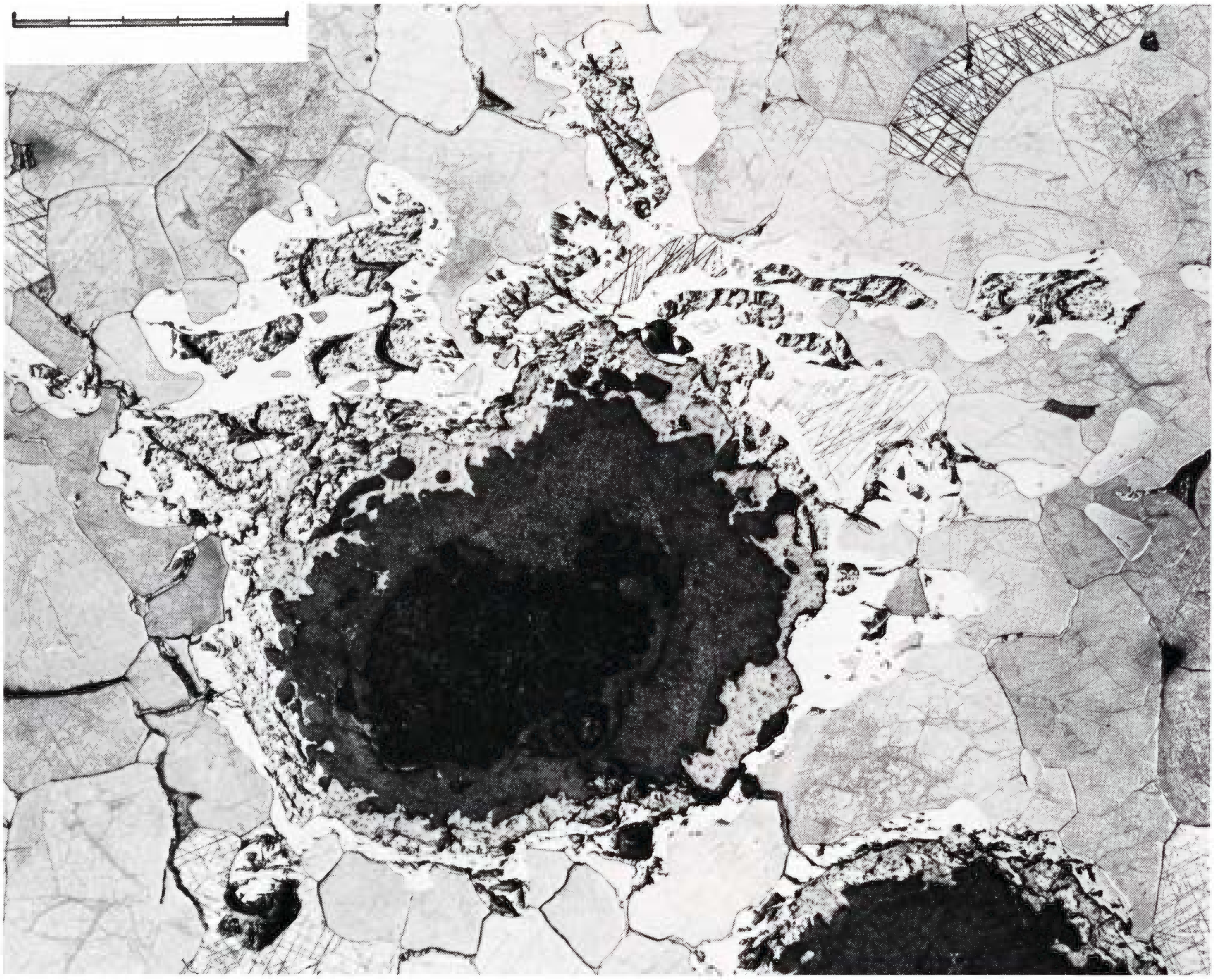

Figure 2021. Youndegin. Detail of Figure 2020. In center a graphite-rich nucleus with a few silicate and chlorapatite crystals. Further out fine-grained troilite-graphite mixtures. Then more graphite and an irregular troilite rim (T). Then follow schreibersite (rough, gray) and cohenite (white). Subboundaries and Neumann bands in the kamacite. Deep-etched. Scale bar 5 mm. S.I. neg. 1504.

and the state of corrosion of all the specimens are the same, it is safe to conclude that the various masses belong to the same shower.

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

272 g corner piece (no. 526, 10 x 3.5 x 2.5 cm)
110 g part slice (no. 2942, 8 x 7 x 0.4 cm)

Ysleta, Texas, U.S.A.

Approximately 31°40'N, 106°10'W

Anomalous. Polycrystalline with plessitic matrix. Neumann bands. HV 219±10.

Anomalous. 7.66% Ni, less than 0.05% P, 0.14 ppm Ga, 0.13 ppm Ge, 7.0 ppm Ir.

HISTORY

A mass of 140.7 kg was found some time before 1914 near Ysleta, El Paso County. Mr. Arthur Curtiss James purchased it from Mr. Lazard Cahn in 1914 and presented it to the American Museum of Natural History (MacNaughton 1926; Reeds 1937; Wiik & Mason 1965). The iron has never been examined. The analysis presented by Wiik & Mason (1965) and the structural determination (a fine octahedrite with 8.00% Ni and 0.45% Co) were unfortunately made on mislabeled material. This was discovered

YSLETA – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Schaudy et al. 1972	7.66								0.143	0.125	7.0	

during the present examination. Several large iron meteorites are in the collection of the American Museum and, because of superficial weathering, the painted identification numbers had fallen off. So a Gibeon mass was for a long time mistaken for the Ysleta mass, until I reidentified the masses during a brief visit in 1969. The classification by Reeds (1937) and the examination by Wiik & Mason were based upon Gibeon material.

COLLECTIONS

New York (140.43 kg main mass and 86 g endpiece), Washington (19 g).

DESCRIPTION

The mass weighs 140 kg and is irregularly pear-shaped with the maximum dimensions 50 x 45 x 30 cm. One side is flat and covered by a number of shallow, sharp-edged pits, generally 2-4 cm in diameter and 0.5 cm deep. They were probably formed by terrestrial weathering. The opposite side of the mass is rather smoothly rounded. Along one edge the two sides meet along a keel, 40 cm long, 25 cm high and only 6-7 cm thick. Where the keel is thinnest, a small quantity of material has been removed by chiseling. In other places, chisel and hacksaw marks from various unsuccessful attempts to divide the meteorite are to be seen. An inspection of the surface and of etched sections failed to reveal any fusion crust or heat-affected α_2 zones, so at least 3 mm has, on the average, been lost by corrosion.

The etched sections show that Ysleta is of the ataxite type. The metal shows no obvious macrostructure, and nonmetallic inclusions are few or absent. A close examination of a total of 30 cm^2 – all that was available – disclosed that Ysleta is composed of many parent austenite grains, each 1-2 cm in diameter. In this respect it resembles N'Goureyma. Ysleta's grain boundaries are, however, very delicate and only visible as 10-50 μ wide kamacite veins in which a few very small sulfide inclusions occur. When the high temperature austenite phase started its transformation to kamacite, nucleation began on the grain boundaries. The ferrite here grew to a maximum width of 50 μ, and saw-toothed oriented ferrite proceeded locally another 20-500 μ into the austenite interior.

The bulk of the austenite grains later transformed to micron-sized duplex mixtures of α and γ. At low magnifications some "schlieren" or "flames" may be detected; these are millimeter-sized regions within which the orientation of the microscopic precipitates of α and γ is uniform. The crystallographical relationship is, however, not entirely clear. To a certain degree of accuracy all the matrix may be termed plessite, although few other meteorites display a similar type. The kamacite phase is uniformly oriented over a few millimenters, but it is subdivided into cells, each of which is 2-10 μ across. The taenite forms somewhat diffuse, irregular, vermicular bodies, typically 0.5-5 μ wide and spaced with an average distance of 5 μ. The taenite is not spheroidized and is apparently far from equilibrium. The microhardness, averaging over numerous $\alpha + \gamma$ units, is

Figure 2022. Ysleta (New York no. 271). An anomalous meteorite of ataxite appearance. At high temperature it was composed of centimeter-sized taenite crystals. Three grains meet here near center. Grain boundaries G-G are narrow kamacite veins. Etched. Scale bar 2 mm.

Figure 2023. Ysleta. Detail of Figure 2022 where the three grains meet. The matrix is a fine-grained duplex mixture of α- and γ-particles. The variegated shading is caused by different population densities of α and γ. Etched. Scale bar 200 μ.

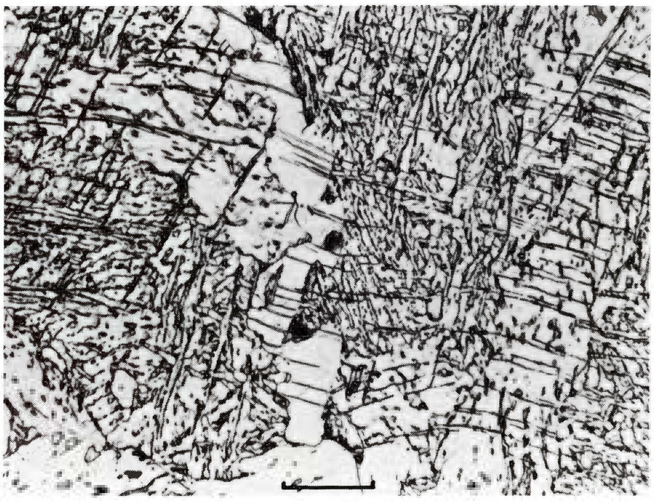

Figure 2024. Ysleta (New York no. 271). In the kamacite phase there are several Neumann bands. They are significantly distorted by some late event, possibly chiseling. Etched. Scale bar 100 μ.

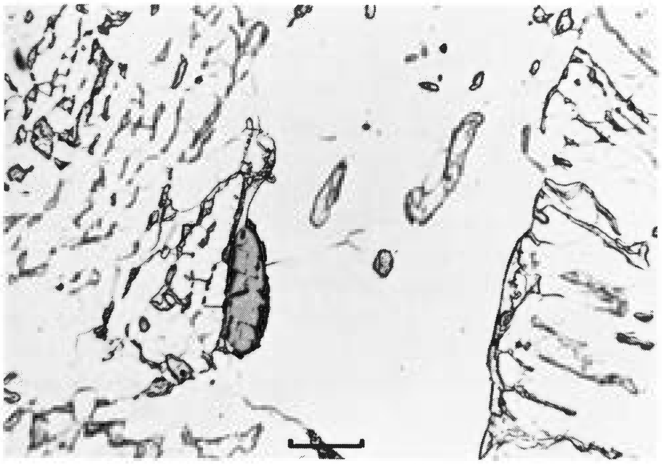

Figure 2025. Ysleta (New York no. 271). Nonmetallic inclusions are rare in Ysleta. Here, in a grain boundary, is a small brecciated crystal, probably daubreelite. Etched. Scale bar 20 μ.

219±10, except where chiseling has cold-worked the material to a high hardness of 270-290.

The kamacite phase is rich in Neumann bands, many of which are twisted and faulted. It appears that the Neumann bands are genuinely preterrestrial, but a final conclusion could not be reached because the only specimens available had been chiseled. Several deep fissures and violently cold-worked material to a depth of at least 3 mm bear witness to the artificial alteration of the material. No reheating was detected, however.

Schreibersite, cohenite, graphite and silicates were not present. The only inclusions seen were very small, blue subangular grains, 5-20 μ across, in the austenite grain boundaries. They probably consist of daubreelite or some other sulfide. The bulk phosphorus content is apparently below 0.05%.

Iron meteorites with 7.6% Ni and a low phosphorus content normally display very large parent austenite grains and well developed Widmanstätten structures. According to the relative cooling rates, the structures may be coarse (e.g., Bischtübe), medium (e.g., Henbury) or fine (e.g., Gibeon). The small austenite grain size of Ysleta indicates that only a limited time for grain growth at high temperature (1000° C) was available. The fine-grained plessitic matrix suggests a cooling rate (around 600-500° C) several orders of magnitude larger than that of Gibeon and other normal octahedrites. Both observations would indicate that Ysleta came from a parent body of smaller dimensions than other irons, or perhaps from an isolated "raisin" at a smaller depth on the parent body than other irons.

Ysleta is chemically and structurally an anomalous iron. No relatives are known; N'Goureyma and Nordheim have certain structures in common with it, without being chemically related.

Specimen in the U.S. National Museum in Washington:
19 g chiseled slice (no. 1357, 3 x 3 x 0.3 cm)

Yudoma, Khabarovsk Region, USSR
60°0'N, 140°48'E

A mass of 7.4 kg was found in 1946 and transferred to the Geological Museum in Yakutsk (Krinov 1947; Meteoritical Bulletin, No. 6, 1957; Krinov 1962). The structure was described, with a sketch, as that of a fine octahedrite (Zavaritskij & Kvasha 1952: 70), and Bergman (1955) reported 8.0% Ni.

A brief examination of a deep-etched sample in Moscow (No. 274, 2.8 g) indicates that Yudoma is a fine octahedrite with a bandwidth of 0.32±0.05 mm. Taenite and plessite cover about 40% by area, the plessite forming a variety of fields which apparently are similar to those of Gibeon and other irons of group IVA. Schreibersite is only present in minor amounts as blebs in the grain boundaries. It may cautiously be concluded that Yudoma is a fine octahedrite of group IVA which may turn out to be related to Muonionalusta and Seneca Township.

Zacatecas (1792), Zacatecas, Mexico
22°48'N, 102°33'W; about 2000 m

Anomalous. Polycrystalline, troilite-rich iron with indistinct Widmanstätten structure. HV 177±13.

Anomalous. 5.95% Ni, 0.49% Co, 0.6% P, about 0.5% S, 84 ppm Ga, 307 ppm Ge, 2.2 ppm Ir.

HISTORY

Only one mass is known, the original weight of which has been given from 2000 libras (Gazeta de Mexico, 1792) to 24 Zentner (1200 kg, Burkart 1856: 293). The former value of about 1000 kg appears to be the more reliable because it was obtained by an actual weighing. The mass was probably found during silver prospecting shortly after the conquistadores arrived in the region about 1520. As to its origin, there is only the belief that it was found by one of the first colonists when working the Quebradilla mine. This was situated on the western outskirts of the city of Zacatecas and is known to have been worked immediately after the conquest by the Spaniards (Burkart 1856: 288; Fletcher 1890a: 162). The coordinates given above are, therefore, for the city of Zacatecas.

The mass was brought to scientific attention by Sonneschmid (1804: 192) who saw it "exhibited" in the

Figure 2026. Zacatecas (1792). The main mass as exhibited in Tacuba No. 5, Old School of Engineering, Mexico City. The parallel drill holes indicate how a – roughly – 200 kg endpiece was removed by Burkart in the 1830s. White ruler is 15 cm long.