Near the inclusions the matrix is pearlitic in the best sense of the word: the slightly undulating, 1 μ wide on the average, subparallel γ-lamellae cover large areas and give the etched surface a macroscopically visible mother-of-pearl sheen. The pearlitic packets closely resemble pearlite in steel, except that they are coarser and, of course, consist of ferrite and austenite and not of ferrite and cementite. In addition, vermicular 5-20 μ wide bodies of schreibersite substitute regularly for taenite. The bulk hardness of the pearlite is 200±7; the individual taenite lamellae are 265±20, while the individual kamacite lamellae are 170±10. The lamellar packets occupy several square centimeters of rather uniform orientation, different from the Widmanstätten orientation. In places the lamella width of the pearlite changes abruptly, such as from 2.5 μ to 0.7 μ in one place for a full period of which the taenite constitutes about 33%. Such changes in steel are known to reflect a drastic difference in growth temperatures. Dayton provides a good chance to study the pearlite formation and morphology in meteorites as compared to that in steel and other alloys.

It is hardly a coincidence that the pearlitic structures are associated with the schreibersite inclusions. The analysis by Moore et al. (1969) shows an unusually high C-value, and it may well be that the carbon in some way is responsible for the pearlitic development, for example, by becoming concentrated in the immediate surroundings of the schreibersite, which upon growing would have rejected the carbon. The mechanism is not at all clear, and it is not known whether an intermediate phase of cohenite was present. In any case, the normal Widmanstätten structure and the pearlitic patches developed competitively at about the same temperatures, judging from the intriguing interlocking and sequence of structures, probably with the pearlite formation being a horsehead in advance. The carbon is now mostly in solid solution in the taenite lamellae which develop a tarnished, spotty appearance upon etching.

Schreibersite occurs as millimeter- to centimeter-sized skeleton crystals, enveloped in 0.1-1 mm swathing kamacite which displays a few Neumann bands. Schreibersite is further common as 20-50 μ angular crystals centrally in the Widmanstätten lamellae and as 5-20 μ vermicular bodies substituting for taenite in the pearlitic areas.

Troilite is not abundant but was observed as 1-5 mm nodules associated with the large schreibersite-phosphate aggregates. The troilite is monocrystalline with a few lenticular deformation twins.

When the meteorite was first cut in 1952, the saw hit a large cavity, 50 x 45 x 40 mm, of a kind which probably never has been reported in a meteorite. The cavity, which is more than 20 mm below the surface, is lined with 0.4 mm schreibersite and with a hard, black, unidentified mineral. The cavity was filled by a loose grain aggregate which, upon cutting, got mixed with water and carborundum and was only partially saved by being scraped out with a wooden spatula (E.P. Henderson, personal communication). An examination of the mixture is still pending, but it appears that crystalline graphite makes up a significant portion.

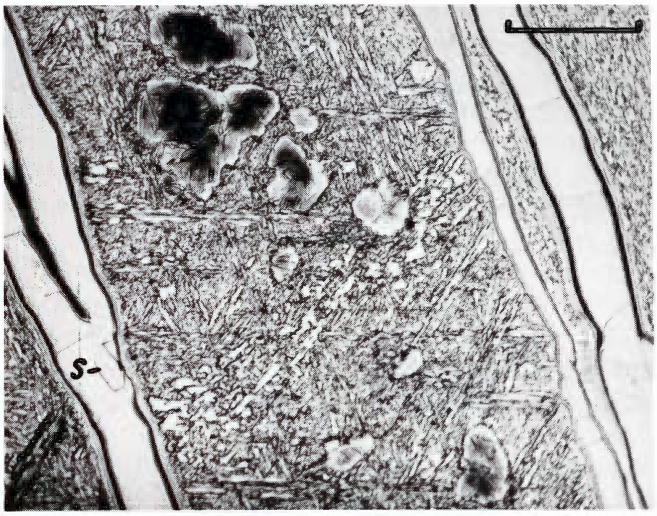

Figure 690. Dayton (Tempe no. 653.1). Detail of a martensitic field with platelets parallel to the bulk Widmanstätten structure. A schreibersite crystal (S). Etched. Scale bar 100 μ.

Dayton is structurally and chemically an unusual meteorite. In many respects it is identical to Tazewell, Wedderburn and Föllinge. In particular, the resemblance to Tazewell is remarkable except that Tazewell shows no pearlitic patches and no phosphates in the examined sections.

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

22 kg main mass (no. 1506, 24 x 20 x 13 cm)
1.8 kg slices (no. 1506, typically 13 x 8 x 0.5 cm)
660 g slices (no. 1592; 379 g and 281 g endpiece: 9 x 9 x 1 cm)

Deelfontein, Cape Province, South Africa
30°59′S, 23°47′E

Coarse octahedrite, Og. Bandwidth 1.75±0.25 mm. Neumann bands. HV 205±12.

Group I. 7.01% Ni, 0.41% Co, 0.16% P, 83 ppm Ga, 306 ppm Ge, 1.4 ppm Ir.

DEELFONTEIN – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Comerford et al. 1968	6.90	0.40										
M.I.T. in above	7.01	0.42	0.16									
Wasson, 1970a	7.11								83.1	306	1.4	

HISTORY

A mass of 28 kg was found about 1932 on a farm in Deelfontein. It was in possession of C.J. de Jager until 1967, when it was acquired by the Geological Survey of South Africa as a result of a public meteorite recovery program, supported by the Smithsonian Astrophysical Observatory (Comerford et al. 1968). The meteorite, which reportedly was a fragment of a larger, unrecovered mass, was described in the same paper and compared to other South African iron meteorites, but was found unrelated to them. Fireman & De Felice (1968) measured the noble gases and found a cosmic ray exposure age of 400±40 million years, while the terrestrial age was estimated to be greater than 1,400 years. Mc Corkell et al. (1968) found, on measuring the ^{36}Cl activity, measurements that the "larger mass" from which Deelfontein is supposed to have come probably does not exist. The recovered mass is complete in itself, otherwise the ^{36}Cl activity should have been lower.

COLLECTIONS

Main mass in Museum of the Geological Survey of South Africa, Pretoria; 105 g in Washington.

DESCRIPTION

The irregular, pitted mass has the approximate dimensions 20 x 20 x 17 cm. Cavities, 2-5 cm wide, are distributed over the surface as seen in figures 1a and 1b of Comerford et al. (1968). The surface is corroded with up to 5 mm thick, laminated, terrestrial oxides; and fusion crust and heat-affected α_2 zones are apparently not preserved. The large, cylindrical pits appear to be the result of burning out of troilite in the atmosphere.

Etched sections display a coarse Widmanstätten structure of bulky, short ($\frac{L}{W} \sim 10$) kamacite lamellae with a width of 1.75±0.25 mm. The narrower bands have central inclusions of 3 x 0.5 mm cohenite lamellae, associated with taenite ribbons, while the broader bands usually are inclusion-free. Neumann bands are common, often distorted slightly by a late plastic deformation. The hardness is 205±12, registering the slight deformations.

Plessite and taenite occur in small amounts (~5% by area), often in direct contact with the cohenite. The interior of the plessite is transformed to one or another of the three structures, which are typical of the carbon-rich group I octahedrites: (i) martensite of a considerable microhardness (HV 425±50), (ii) pearlite which ranges in hardness from 240 for the coarse varieties (1-2 μ wide taenite lamellae) to 310 for the poorly resolvable varieties (<0.3 μ wide taenite lamellae), or (iii) spheroidized plessite fields with 2-20 μ thick taenite globules, the fields being of the same hardness as the adjacent kamacite. The tarnished rim zones are probably submicroscopic duplex taenite with a significant amount of carbon in solid solution (HV 380±25).

The most characteristic feature of Deelfontein is the cohenite inclusions, which, according to Comerford et al.

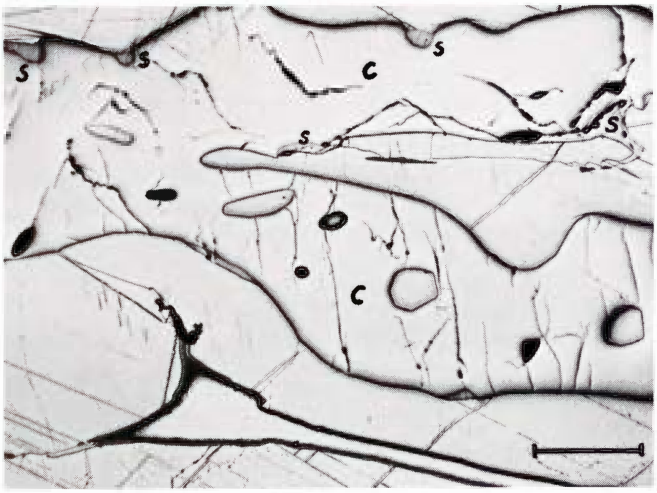

Figure 692. Deelfontein (U.S.N.M. no. 3275). A branching cohenite crystal (C) with inclusions of taenite (black), kamacite (gray) and schreibersite (S). Etched. Scale bar 400 μ.

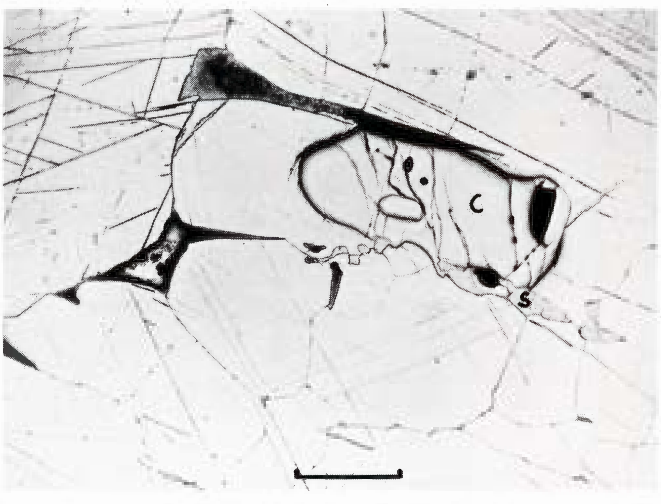

Figure 691. Deelfontein (U.S.N.M. no. 3275). A cohenite crystal (C) attached to pearlitic plessite above (black) and fissured schreibersite (S) below. The kamacite subboundaries have many phosphide precipitates. Etched. Scale bar 400 μ.

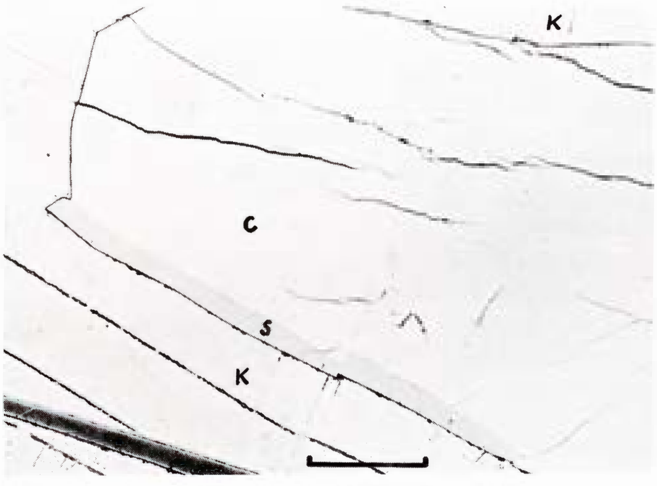

Figure 693. Deelfontein (U.S.N.M. no. 3275). Cohenite (C) with a schreibersite rim (S) in kamacite (K). A late shear-deformation has displaced the schreibersite and fissured the cohenite. Etched. Scale bar 100 μ.

(1968), constituted 13% of a 25 cm^2 polished surface. This corresponds roughly to 1% carbon by weight, assuming that the investigated slice is representative of the whole mass, and taking into account the carbon which is present as graphite and in solid solution in the taenite. The cohenite is developed as 100-500 μ polycrystalline rim zones around troilite-graphite nodules and around schreibersite crystals and also as 3 x 0.5 mm or smaller, lobed crystals conforming to the Widmanstätten pattern. Most of the cohenite show the normal, diagnostic features: well rounded outlines, high relief and 10-100 μ windows of kamacite, taenite and schreibersite. In many places (see, e.g., Comerford et al. 1968: figure 3) the cohenite is severely corroded along cracks; decomposition to graphite veinlets does not appear to have occurred. The hardness is 1050±30.

The cohenite-rich patches are, as usual, close to troilite-graphite nodules. Two nodules were observed, 7 and 9 mm in diameter. They are complex, e.g., with graphite concentrated in an exterior ring, 100-300 μ wide. Cliftonite crystals, 50-150 μ in diameter, occur in the cohenite rim zones and in the kamacite. Cliftonite also merges with fine-grained graphite of a unidirectional texture, different from the symmetrically built cliftonite. The troilite has been shock melted and now is a 1-5 μ polycrystalline aggregate in which original daubreelite is dispersed as rounded fragments of the same size. Furthermore, the troilite has been injected into 2-15 μ wide fissures in the surrounding cohenite; terrestrial corrosion has, unfortunately, obscured the precise details. The troilite shows creamy veinlets of pentlandite, due to corrosion.

Schreibersite is present as scattered 3 x 2 mm skeleton crystals and as 10-50 μ wide grain boundary precipitates. Rhabdites, 2-10 μ, are common. The phosphides are brecciated and frequently sheared and displaced 2-25 μ.

Deelfontein is a coarse, inclusion-rich octahedrite which is structurally similar to Vaalbult, Bogou, Odessa and many other group I irons. Cohenite and troilite are dominant in the investigated sections, but further sectioning may

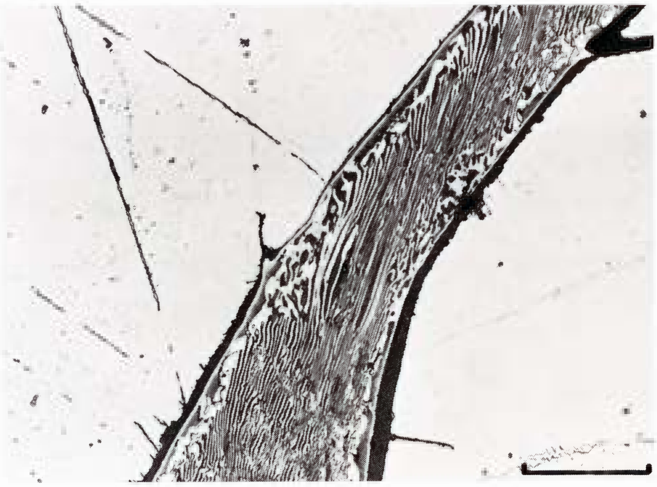

Figure 694. Deelfontein (U.S.N.M. no. 3275). Near-surface section with terrestrial corrosion. The cloudy taenite is tarnished, the α-lamellae of the pearlite are converted to limonite, and the α-γ grain boundaries are severely attacked. Etched. Scale bar 100 μ.

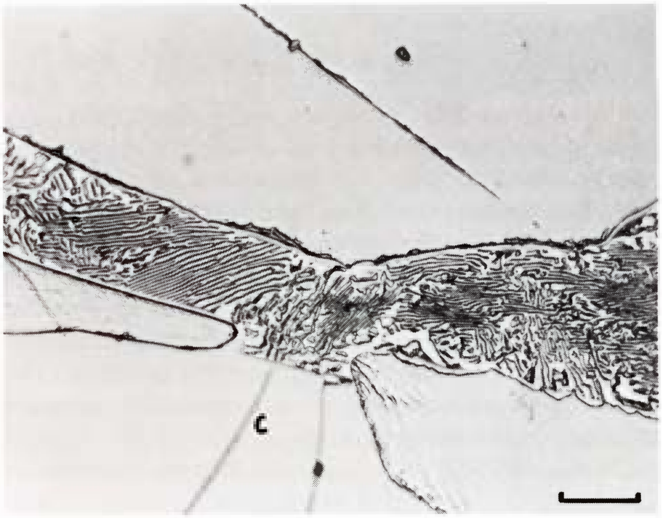

Figure 696. Deelfontein (U.S.N.M. no. 3275). Cohenite (C) in contact with pearlitic plessite. Kamacite with a Neumann band above. Etched. Scale bar 20 μ.

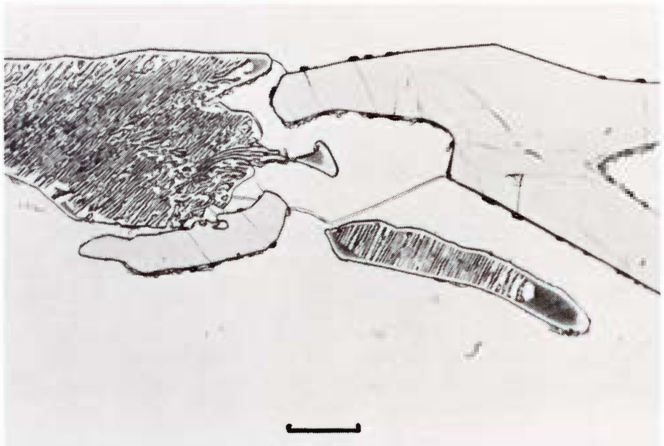

Figure 695. Deelfontein (U.S.N.M. no. 3275). A high-angle grain boundary in kamacite with two schreibersite crystals and two pearlitic plessite fields. Etched. Scale bar 20 μ.

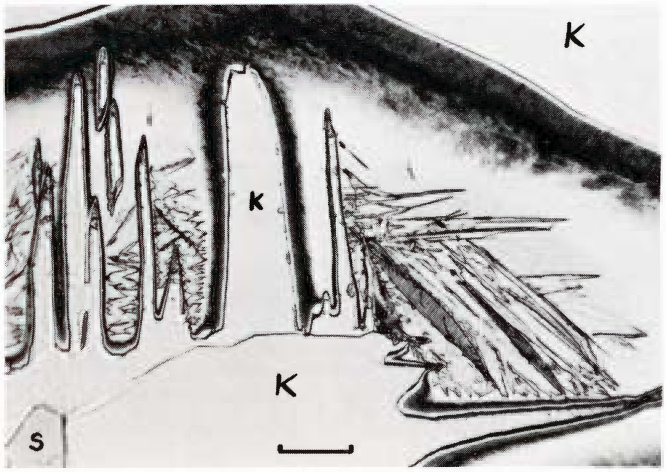

Figure 697. Deelfontein (U.S.N.M. no. 3275). Martensitic plessite field, typical of group I coarse octahedrites. Cloudy taenite (submicroscopic $\alpha + \gamma$ mixture) and acicular martensite in retained austenite (white). Kamacite (K), schreibersite (S). Etched. Scale bar 20 μ.

disclose rather inclusion-poor material. Significant deformation has hardened the kamacite, displaced the brittle minerals, and shock melted the troilite. It cannot be ruled out that Deelfontein and Vaalbult are two specimens of the same mass.

Specimen in the U.S. National Museum in Washington:
105 g part slice (no. 3275, 9 x 4 x 0.5 cm)

Deep Springs, North Carolina, U.S.A.

About 36°30'N, 79°40'W

Nickel-rich ataxite, D. Duplex $\alpha + \gamma$ with a few 2-10 μ wide spindles. HV 238±10.

Anomalous. 13.4% Ni, 0.65% Co, 0.03% P, 0.41 ppm Ga, 0.11 ppm Ge, 10 ppm Ir.

Said to have fallen in 1846 but obviously a find of considerable terrestrial age.

HISTORY

A mass of 11.5 kg was reported to have fallen in 1846 near the old "Mansion House," on Deep Springs Farm in Rockingham County. It was dug out of a 4- to 5-foot hole, was regarded for a while as a curiosity and eventually forgotten until 1889 when it was presented to the State Museum in Raleigh. It was described by Venable (1890b), who found a high nickel value (11.7%). He also noted that the surface was chlorine-rich, while drillings taken 2 cm below the surface were chlorine-free.

About 1900 H.A. Ward acquired the mass and cut and distributed it widely. Cohen (1900b: 353; 1905: 112) described and analyzed the iron; he confirmed Venable's observation on the chlorine distribution and found as much as 0.99% Cl in 4.7 g near-surface material, while the interior had only 0.02% Cl. Berwerth (1918) thought that Deep Springs had been reheated artificially, but he probably misinterpreted the corroded α-matrix. Owen & Burns (1939) determined the lattice parameters of the α- and γ-phases. Perry (1944) gave three photomicrographs that, among other things, showed so much terrestrial corrosion that an observed fall was out of the question.

Bauer (1960; 1963) reported very high ^3He and ^4He concentrations and estimated the cosmic ray exposure age to be 1550 million years, a value which was confirmed by Signer & Nier (1962). Voshage (1967) found the still higher value of 2250±70 million years, the highest age of any meteorite so far recorded. McCorkell et al. (1968) estimated the terrestrial age to be about 300,000 years. Fireman & Goebel (1970) found less than 0.2 dpm/kg of the radioactive nuclide ^{39}Ar (half life 270 years) and concluded that the terrestrial age was above 2,000 years.

COLLECTIONS

Raleigh (5,444 g), New York (733 g), Tempe (450 g), Chicago (430 g), Washington (312 g), Berlin (306 g), Amherst (290 g), London (170 g), Budapest (128 g), Harvard (103 g), Ottawa (75 g), Helsinki (75 g), Ann Arbor (46 g), Vatican (36 g), Vienna (7 g).

DESCRIPTION

The rhomboid flattened mass has the overall dimensions 27 x 21 x 4 cm and weighs 11.5 kg. It is heavily corroded and covered with 0.1-2 mm thick limonitic crusts, as plainly observed on the preserved half mass in Raleigh. It has lost all original regmaglypts and fusion crusts. On etched sections it is further seen that the heat-affected zone

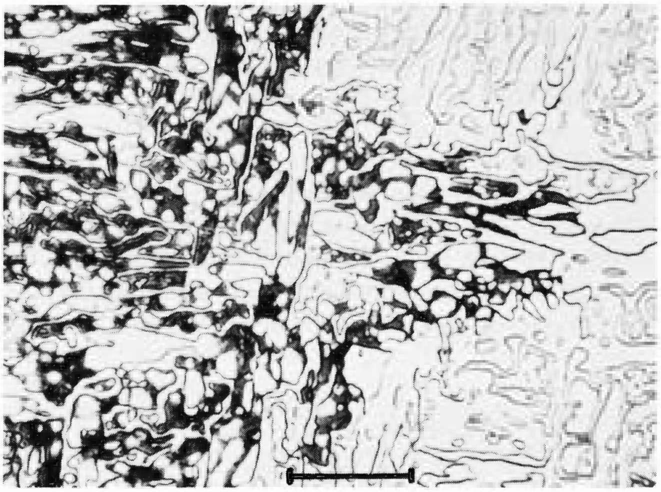

Figure 698. Deep Springs (U.S.N.M. no. 470). Terrestrial corrosion has selectively converted part of the α-phase to limonite (black), leaving the lamellar γ-phase intact. Etched. Scale bar 20 μ. (Perry 1944: plate 68.)

DEEP SPRINGS – SELECTED CHEMICAL ANALYSES

References	percentage Ni	Co	P	ppm C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Fahrenhorst in Cohen 1900b	13.44	0.70	0.06	200	0	300	300					
Lovering et al. 1957		0.68				182	205		<1	<1		
Wasson 1967a	13.2								0.41	0.11	9.4	
Smales et al. 1967						185	7.8			0.20		
Cobb 1967	13.4	0.59					15		<4		12	
Moore et al. 1969	13.72	0.62	0.01	110	135		65					

Deep Springs is evidently one of the better analyzed iron meteorites.

is corroded away. The corrosion invades the iron in characteristic shallow concentric arcs, as is also observed on, e.g., Chinga, Kokomo and Cape of Good Hope. It is evidently an attack which is conditioned by the very fine duplex structure; the α-phase is selectively transformed to limonitic products long before the γ-phase. Chlorine, no doubt, plays an important role and is present on a high level, as shown by Venable (1890b) and Cohen (1900b); it is, however, chlorine from the ground water and not chlorine from any cosmic lawrencite that is responsible. Lawrencite is not present here and, most likely, not in any other iron meteorite.

Etched sections appear homogeneous to the naked eye. Scattered troilite nodules, 0.5-5 mm in diameter, are the only visible inclusions and occur with about one per 10 cm^2. At higher magnification the metal is seen to be composed of a fine-grained $\alpha + \gamma$ mixture with scattered α-spindles. The spindles are typically 100 x 10 μ and occur with a frequency of about one per mm^2. Some of them contain 1-10 μ schreibersite nuclei or tiny aggregates of schreibersite, daubreelite and troilite. Neumann bands were not observed, but the largest continuous kamacite area was only 300 x 20 μ, so perhaps the bands just do not develop in these small volumes. The matrix is an oriented intergrowth of α and γ on the micron scale that has been termed a paraeutectoid by Perry (1944). The microhardness (100 g Vickers) of the duplex matrix is 238±10; individual α- and γ-particles were not measured.

Schreibersite inclusions are very rare. Occasionally a 1-10 μ particle may be identified, either as the nucleus of some α-spindles or as an integrating part of the paraeutectoid. The rarity is in agreement with the low bulk phosphorus values reported in wet chemical analyses.

The troilite nodules, which usually have discontinuous swathing kamacite rims, are monocrystalline particles with a few lenticular deformation twins. They are veined by 1-5 μ wide creamy pentlandite from terrestrial corrosion. Daubreelite is present as 1-50 μ wide bands parallel to the (0001) plane of the parent troilite crystal. An unusual 2 mm inclusion apparently originally consisted of troilite with daubreelite and unidentified pyroxenes and oxides. Now it, in addition, contains terrestrial oxides.

Deep Springs is a nickel-rich ataxite which in its structure is almost indistinguishable from Cape of Good Hope, Iquique, Kokomo and other nickel-rich ataxites of Group IVB. It is, however, slightly different by having less nickel and phosphorus than the others and by the absence of the conspicuous parallel banding visible on other group IVB irons. Deep Springs is terrestrially old, a fact which in convincingly demonstrated both by its corroded appearance and by the low concentration of short-lived radioisotopes of cosmic origin.

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

274 g part slice (no. 470, 9 x 3.5 x 1.3 cm)
17 g part slice (no. 2741, 3 x 2 x 0.4 cm)
18 g part slice (no. 413, 3 x 1.8 x 0.3 cm). Mislabeled Lick Creek!
3.7 g part slice (no. 998, 3 x 1 x 0.1 cm). Mislabeled Lime Creek!

Figure 699. Deep Springs (Tempe no. 357.1). A long kamacite platelet in a fine-grained ataxitic matrix. Etched. Scale bar 100 μ.

Figure 700. Deep Springs (Tempe no. 357.1). Widmanstätten directions in the ataxitic matrix. Etched. Scale bar 20 μ.

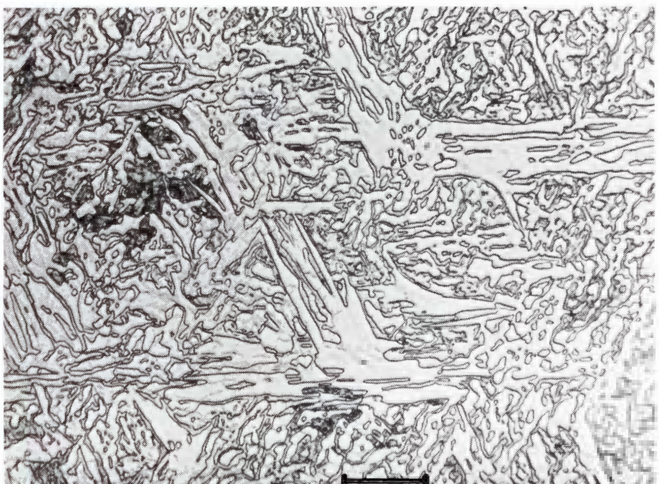

Figure 701. Deep Springs (Tempe no. 357.1). Another view of the matrix. Subboundaries are visible in the kamacite and imperfect transformation is apparent in the taenite blebs to the left. Etched. Scale bar 20 μ.

Figure 702. Deep Springs (Tempe no. 357.1). Small troilite lens with several parallel daubreelite lamellae (D). Shock-deformation has caused the troilite to form lenticular twins (gray, black). Etched. Slightly crossed polars. Scale bar 20 µ.

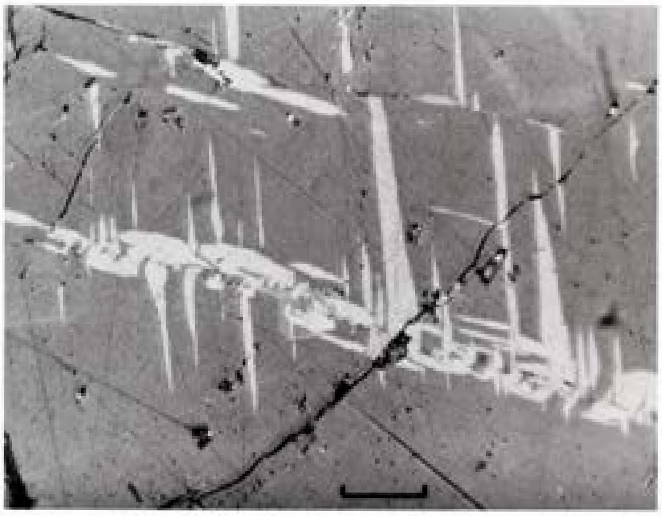

Figure 703. Deep Springs (Tempe no. 357.1). Multiple twinning in another, large troilite nodule. Slightly crossed polars. Scale bar 20 µ.

Dehesa, Santiago, Chile

Approximately 33°20'S, 70°40'W

Nickel-rich ataxite, D ? Only one individual mass of 280 g. Group unknown. Composition unknown.

HISTORY

This meteorite is virtually unknown, and its origin and place of discovery are obscure due to a mix-up of labels with material from the Copiapo fall.

In the accession papers of the Musée d'Histoire Naturelle, in Paris, the two numbers, 378 and 379, concern the acquisition of meteorites sent in January 1867 from Professor Domeyko, Santiago, Chile, to Daubrée in Paris. The original entries in the protocol have, however, later been changed in a confusing way, apparently by Daubrée himself. The brief descriptions published by Daubrée (1868a: 571; part II, no. 379; part III, no. 378) do not help to solve the problems regarding the original sizes and localities of discovery.

A reexamination of the specimens in Paris and a comparison with the entries in the protocol suggest that the material labeled No. 379 comprised one large sample of about 1,305 kg and one small one of 80 g (not 800 g as stated by Daubrée 1868a: 571). These samples are typical Copiapo specimens with angular silicates, and they have been further treated under that entry.

The material labeled No. 378 comprised one entire mass of 280 (or 282) grams. It is not clear from the French data from where this mass derived. However, Domeyko (1879: 134), who had originally sent the material to Daubrée, stated that the mass was supposed to have been found in "the cordillera de la Dehesa" in a not more specified locality. Perhaps the place of discovery is La Dehesa, situated 18 km north-northeast of Santiago (Fletcher 1889: 256). The 280 g individual mass appears to be the entire known Dehesa meteorite material.

Unfortunately, existing descriptions are very inadequate due to the fine-grained structures and to the confusion with Copiapo. Meunier (1893a: 237) assumed the structure to be similar to Smithland, Cape of Good Hope and Babb's Mill (Troost's Iron). Brezina (1896: 294) included the iron with his extremely heterogeneous Chesterville group, comprising, e.g., Salt River, Bingera and Linville. Cohen (1905: 116) reviewed the history and described a 2.4 g sample in Vienna. Berwerth (1917; 1918) reexamined the Vienna specimen and classified it as a finest octahedrite, a classification which later has been accepted by Prior (1923a) and Hey (1966: 131). However, it can be seen from the photomicrograph presented by Berwerth (1918) that this classification is inadequate.

COLLECTIONS

Again, there is some confusion here. The Paris catalogs listed in all their editions up to 1919 (Guide, edited by A. Labat) a 280 g specimen, labeled "Chili, unknown locality, found 1866." This is the original type specimen No. 378 examined by Daubrée. During a brief visit to Paris in May 1972 the mass was found to have been reduced to 221 g. Perhaps the 60 g endpiece is now in Bordeaux. A 235 g specimen (no. 388.1 in Tempe) labeled Chile by Nininger & Nininger (1950: 44) and listed by Hey (1966: 131) under Dehesa, is not Dehesa, but could be identified by the author as a slice of the Maria Elena meteorite. Finally, the following three small fragments may or may not represent authentic material: Vatican (10 g), Vienna (2 g), London (2 g).

ANALYSES

Domeyko (1879: 134) reported 14.2% Ni, while Dittler (in Berwerth, 1917) found 11.97% Ni, 0.56% Co and 0.01% P. None of the analyses appear particularly reliable, and a modern full analysis is strongly recommended.

DESCRIPTION

The specimen in Paris (no. 378) weighs at present 221 g; it is obvious that it represents the main mass of an individual meteorite that was never much larger. An original weight of 280-282 g is quite reasonable, and agrees with the original statements by Daubrée and Domeyko, but conflicts with the information in Hey (1966: 131).

Dehesa has the form of a flattened irregular pyramid, with a base of 5 x 5 cm and a height of 2 cm. It displays several imperfect regmaglypts, 5-10 mm in diameter. The original fusion crusts have been lost or modified due to handling and, possibly, some artificial reheating or severe attack with mineral acids.

A single cut has produced a surface of 4 x 2.5 cm; this is imperfectly polished and etched and does not allow any structural observations. All that can be said at present is that Dehesa is neither a hexahedrite – and thus not a member of the North Chilean hexahedrites – nor an octahedrite. Silicates are absent, so Dehesa is also different from Copiapo.

A modern reexamination of adequately prepared sections will probably reveal Dehesa to be an independent nickel-rich ataxite, thus adding another small nickel-rich iron to the already large number mentioned in Table 21.

Delegate, Wellesley County, New South Wales
37°0'S, 149°2'E

Medium octahedrite, Om. Bandwidth 0.85±0.15 mm. ϵ-structure. HV 310±15.

Group IIIB. Anomalous. 9.36% Ni, 0.57% Co, 0.5% P, 20 ppm Ga, 42 ppm Ge, 1.6 ppm Ir.

HISTORY

A mass of 27.6 kg was found about 1904 on the surface near a gully on the southeast side of Sawpit Creek, four miles north-northeast in a direct line from the village of Delegate. The coordinates of the place of find are approximately those given above. In 1916 the meteorite was secured for the Geological Museum in Sydney, and it was analyzed by Mingaye (1916), who also gave two photographs of the exterior and a photomacrograph. Hodge-Smith (1939: plate 4) reproduced one of the photographs. Lovering & Parry (1962) examined the thermomagnetic properties. El Goresy (1965) described the inclusions, and Ramdohr (1963a, b; 1966) found chalcopyrite, chalcopyrrhotite, valleriite and pentlandite associated with the troilite in small amounts. Jaeger & Lipschutz (1967b) observed shock structures in the kamacite, corresponding to a peak pressure of 400-750 k bar. Schultz & Hintenberger (1967) determined the content of noble gases, and Voshage (1967) found a cosmic ray exposure age of 775±60 million years.

COLLECTIONS

Sydney (17.9 kg, 6.2 kg, 1 kg), Chicago (359 g), Washington (202 g), Moscow (187 g), London (181 g), New York (130 g), Copenhagen (75 g), Tempe (39 g).

DESCRIPTION

The meteorite's shape has been compared to a boomerang. It is a flat, irregularly curved mass with the overall dimensions 45 x 15 x 7 cm. It is pitted from severe terrestrial corrosion, and all fusion crust and heat-affected α_2 zone are gone. Corrosion penetrates into the mass along grain boundaries, and 10-100 μ wide oxide veinlets are common. Some exfoliation along the Widmanstätten lamellae occurs locally. The troilite displays creamcolored pentlandite rims and cracks, also due to corrosion.

Etched sections show a Widmanstätten structure of somewhat irregular, medium ($\frac{L}{W} \sim 15$) kamacite lamellae 0.85±0.15 mm wide. The kamacite has numerous subboundaries, decorated with <1 μ precipitates, presumably phosphides. The kamacite is shock-transformed to a hatched structure intermediate between a structure of pure Neumann bands and one of dense hatching. The shock-hardened structure has a hardness of 310±15. There appears to be a slight hardness drop near the surface to 250±10, which indicates that 4-6 mm of the surface has been lost by exposure to terrestrial weathering (hardness curve type I, where only the right leg is preserved).

Plessite occupies about 40% by area. While comb plessite is present, the dominant forms are duplex, fine-grained $\alpha+\gamma$ fields and martensitic fields where the martensite plates repeat the bulk (111) pattern. Schreibersite is common as 1-10 μ vermicular bodies, normally a little larger than the associated taenite blebs in the duplex $\alpha + \gamma$ fields.

Schreibersite also occurs as Brezina lamellae, typically 20 x 6 x 1 mm, with 1-2 mm swathing kamacite. Several of the larger schreibersite bodies have small inclusions (heterogeneous nuclei) of 50-100 μ phosphates (?) and sulfides. The schreibersite is brecciated but monocrystalline. In one case an original 100 μ phosphate (?) nodule apparently was shock altered to glass, and 5-10 μ wide veinlets of glass and schreibersite fragments radiate from the flattened inclusion through the schreibersite. Schreibersite is further common

DELEGATE – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Mingaye 1916	9.25	0.55	0.28	160	0		80					15
Lovering et al. 1957	9.34	0.58				<5	102		19	48		
Scott et al. 1973	9.5								20.3	41.7	1.6	

as 30-100 μ wide grain boundary precipitates and as 1-10 μ blebs in the duplex $\alpha + \gamma$ fields. Rhabdites, 1-2 μ in cross section, are rather common in the matrix. Point counting of the larger phosphide inclusions on 36 cm^2 led to an estimate of 0.25% P; if we add the analytical value of 0.28% P from inclusion-free material, we get about 0.5% P as an estimate for the bulk phosphorus content.

Troilite is present in minor amounts, mostly as 50-100 μ inclusions in the phosphides, but also as lenticular or spindle-shaped bodies, e.g., 4 x 0.1 mm. It is monocrystalline with oriented, lenticular deformation twins. Locally a 15 mm troilite nodule with 1 mm schreibersite rim zones will be found. In such a nodule Ramdohr (1963; 1966) identified 5-15 μ wide, oriented intergrowths of chalcopyrrhotite, chalcopyrite and pentlandite. Daubreelite, chromite, graphite, cohenite and other meteoritic minerals were not observed.

Delegate is a weathered, shock-hardened, medium octahedrite which resembles Treysa and Ilinskaya Stanitza closely. It is further related to many other group IIIB meteorites, particularly Grant. Its high iridium content, however, makes it somewhat anomalous.

Specimen in the U.S. National Museum in Washington:
202 g part slice (no. 484, 9 x 6 x 0.5 cm)

Dellys, Algeria

Approximately 36°55'N, 3°55'E

Medium octahedrite, Om.
Group unknown. Analysis unknown.

HISTORY

An iron meteorite, supposedly originating from Dellys, in the province of Algeria, was briefly mentioned by Daubrée (1866), but without any details. Buchner (1869: 602) noted that Daubrée had received 76 g in Paris. Brezina (1885: 209; 1896: 268, 272) stated, on the basis of a 9 g sample in Vienna, that Dellys was a medium octahedrite, and he compared it to Elbogen, Hraschina, Asheville and Bear Creek. Meunier (1884: 133), on the other hand, made quite self-contradictory observations, comparing Dellys to Burlington, Nedagolla and Mejillones, meteorites which have virtually nothing in common.

COLLECTIONS

Paris (72 g), Vienna (9 g), Calcutta (4 g). Wülfing (1897: 100) listed these same fragments which are all that are known to have existed, except for a 2 g specimen, now apparently lost.

ANALYSIS

No analytical work has been reported.

DESCRIPTION

The main mass of 71.6 g in Paris (no. 325) is an octahedral rough fragment, measuring 33 x 30 x 17 mm. During an early examination, it has been severely attacked by nitric acid, but only a minor amount of cutting has taken place.

The sample in Vienna shows Dellys to be a medium octahedrite, possibly with a bandwidth of 1.0±0.2 mm. The kamacite is, apparently due to shock, converted to a hatched ε-structure of high hardness. Schreibersite occurs sparingly.

The fragmentary nature of Dellys suggests that it is not an independent meteorite. It occurs to me that the overall structure, the date and locality of discovery associate it with Tamentit, the first inadequate reports of which were circulated in the 1860s. A modern metallographic examination and/or an analysis would probably settle the problem quite easily.

If Dellys turns out to have a different analysis from that of Tamentit, we must admit that we know nothing of the original size or whereabouts of the main mass of Dellys.

Del Parque. See Imilac (in the Supplement)

Del Rio, Texas, U.S.A.

29°22'N, 100°58'W; 300 m

Polycrystalline nickel-rich ataxite, D. Bandwidth 70±20 μ.
Deformed ε-structure. HV 270±15.
Anomalous. 12.1% Ni, 0.55% Co, 0.11% P, 9.2 ppm Ga, 99 ppm Ge, 18 ppm Ir.

HISTORY

A mass of 3,346 g was found by a Mr. Mueller in 1965, approximately four and one-half miles west of Del Rio on the ranch of E.R. Daughtrey. The site of the find which was

DEL RIO – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
King & Henderson 1969	12.85	0.55	0.11	400	<100	200	300					
Wasson 1973, pers. comm.	11.34								9.2	99	18	

about 1.8 km north of the Rio Grande River, in Val Verde County, was searched and five additional small fragments (117, 65, 37, 24, and 7 g; totaling 250 g) were recovered. In a preliminary description, King & Henderson (1969) described the material and showed that Del Rio was an independent meteorite, different from previously known ataxites from Texas (Monahans and Nordheim).

COLLECTIONS

Main mass apparently still in private possession. Two small polished sections on loan in Washington.

DESCRIPTION

The mass is composed of at least three coarse grains in different orientations, each of them apparently a precursor austenite grain, that have independently developed a Widmanstätten pattern during the primary cooling.

Etched sections disclose an ataxite structure, where kamacite lamellae in a Widmanstätten array occur in varying sizes and concentrations. The prominent lamellae are slightly distorted and long ($\frac{L}{W} \sim 30$), with a bandwidth of 70±20 μ; and they frequently occur in parallel bundles of 6-10 lamellae. The kamacite is severely deformed and displays indistinct ϵ-structure and lenticular deformation bands. The microhardness is correspondingly high, 270±15.

The bulk of the sections is plessitic. The plessite is usually an easily resolvable duplex $\alpha + \gamma$ matrix, wherein deformation textures are also visible. The ratio of α to γ is about 5:1, and the γ-particles are 0.5-3 μ wide, or larger. The larger γ-particles, however, have an interior which is decomposed to unresolvable duplex $\alpha + \gamma$ mixtures, with γ-grains less than 0.4 μ across. The microhardness (100 g) of the duplex $\alpha + \gamma$ matrix is 270±15, virtually identical to that of the lamellae.

Schreibersite occurs as 1-20 μ subangular bodies, of the same general size as the γ-particles, and substituting for these in the plessite. A few 1-4 μ rhabdites are present in the larger kamacite lamellae.

Troilite occurs in the kamacite lamellae as lenticular or irregular inclusions, 50-300 μ across. Typical inclusions contain 10-20% daubreelite in the form of parallel 1-20 μ wide bars. The troilite is monocrystalline but shows multiple twinning from plastic deformation.

A small graphite inclusion was reported by King & Henderson (1969).

The meteorite is weathered and irregularly covered with limonitic crusts, up to 2 mm thick. The near-surface α-phase is selectively oxidized, but otherwise the corrosive attack seems to be superficial. While no fusion crust and no heat-affected α_2 zones were detected, hardness tracks perpendicular to the present surface showed a significant drop from interior values of 270 to values of 180 just below the oxidation zone. This indicates that, on the average, only 2-3 mm has been lost to weathering (hardness curve type I, where the left leg is lost by corrosion).

Del Rio is a shock-hardened meteorite which presents a transition case from the finest octahedrites, Off, to the ataxites, D. It is particularly interesting because it clearly exhibits a hatched, shock-hardened ϵ-structure on the 12% Ni bulk level; most previous reports on ϵ concern octahedrites and related meteorites on a lower bulk Ni level. In its trace element composition Del Rio will probably be found to be anomalous.

Denton County, Texas, U.S.A.

33°14'N, 97°8'W

Medium octahedrite, Om. Bandwidth 1.15±0.15 mm. Artificial α_2 structure. HV 200±25.

Group IIIA. 8.2% Ni, about 0.50% Co, 0.2% P, 19.7 ppm Ga, 42.7 ppm Ge, 0.28 ppm Ir.

The whole mass was heated to about 1000° C by a blacksmith, and many specimens were, in addition, forged or hammered.

HISTORY

A mass of about 40 pounds was found in 1856 in Denton County, but all details of the locality and circumstances were already lost when Shumard (1860) first described it. The iron had been taken to the blacksmith in Mc Kinney, Collin County, who divided it and forged cane heads and various implements from it. Shumard secured, however, the remainder, about 5.6 kg, for the Texas State Cabinet in Austin.

The iron was analyzed by Riddell (Shumard 1860) and by Madelung (1862, quoted by Farrington 1915), but only recently a modern analysis was performed (Scott et al. 1973). Berwerth (1914: 1080) correctly referred Denton County to his group of metabolites, i.e., irons with artificially altered structures. About 1900 Ward acquired a large fragment (1 kg ?) which he subdivided and sold to collectors. In 1904 he still had 692 g in his own collection. This specimen is apparently not in Chicago today as are most of his other specimens. The material in Austin has disappeared long ago, according to a note in the Smithsonian Institution.

COLLECTIONS

Vienna (203 g), London (122 g), Yale (66 g), Harvard (49 g), Dorpat = Tartu (45 g), Chicago (44 g), Göttingen (26 g), Tübingen (17 g), New York (13 g). Less than 10 g is in each of the following collections: Amherst, Berlin,

DENTON COUNTY – SELECTED CHEMICAL ANALYSES

	percentage			ppm							
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Scott et al. 1973	8.21								19.7	42.7	0.28	

Budapest, Calcutta, Copenhagen, Paris, Stockholm and Washington.

DESCRIPTION

The 5.6 kg fragment which was saved by Shumard (1860) appears to have formed the middle portion of an elongated mass, but dimensions have not been given.

The small specimens in collections today are more or less hammered fragments. The Harvard, Vienna and Washington specimens show definite overfoldings and flat, hammered portions. In several locations the fragments are fissured along Widmanstätten planes due to the beating by the blacksmith and the presence of numerous low-melting phosphides in these grain boundaries.

Etched sections display a medium Widmanstätten structure of long ($\frac{L}{W} \sim 20$) kamacite lamellae with a width of 1.15±0.15 mm. Open-meshed comb plessite occupies 20-30% by area. Schreibersite is common as 20-50 μ wide grain boundary precipitates. Rhabdites, 1-2 μ, are also fairly common. The bulk phosphorus content may be estimated to be 0.20%.

The forging has transformed all structural elements. The kamacite is now an aggregate of serrated α_2 grains, 10-50 μ across, and the rhabdites herein are almost resorbed. The taenite has diffuse borders and sends sharp, protruding thorns into the kamacite. The plessite interiors show various degrees of resorption, while the larger schreibersite crystals are enveloped in 1-5 μ wide cream-colored rims of taenite. On exposed edges the schreibersite is melted. Along the surface and along some of the cracks an incipient high temperature oxidation attack is pronounced in the grain boundaries of the high-temperature austenite phase. A fine-grained lacework of reaction products between terrestrial corrosion products, which were already present in the meteorite when it was reheated, and the various meteoritic phases is seen in many places. Several kamacite lamellae and comb plessite fields are heavily distorted by plastic deformation. The microhardness of the α_2 structure is 200±25.

From the above data it may be concluded that the whole mass was heated by the blacksmith to about 950-1000° C, in order to cut it, and that he subsequently forged various items from it. The material "saved" by Shumard had thus already been maltreated.

Denton County was originally a normal medium octahedrite related to, e.g., Dexter, Kayakent, Briggsdale, Trenton and Gundaring and belongs to group IIIA.

Specimen in the U.S. National Museum in Washington:
8 g part slice (no. 1013, 3 x 2 x 0.3 mm)

Deport, Texas, U.S.A.

33°32′N, 95°18′W; 150 m

Coarse octahedrite, Og. Bandwidth 1.30±0.20 mm. Neumann bands. HV 220±15.

Group I. 8.16% Ni, 0.47% Co, 0.12% P, 69 ppm Ga, 255 ppm Ge, 2.2 ppm Ir.

HISTORY

According to information in the Smithsonian Institution, Department of Mineral Sciences, three samples of 2.8, 1.3 and 0.9 kg were found in 1926, one mile east of Deport. Deport is in Lamar County, but the masses were found just over the border in Red River County. At least 23 more masses totaling an additional 10 kg were found later. An undivided fragment of 5.8 kg (no. 827) was acquired by the U.S. National Museum in 1928 from Mr. Archie Staton. The first description was by Palache and Gonyer (1932) who presented a photograph and an analysis of the three samples in Harvard. No information appears to have been preserved as to the original distribution and depth of specimens, but the author believes that Deport was a small shower where individual fragments weighed from about 200 g to about 6 kg. The total weight of recorded specimens is about 15 kg, but it is not unlikely that this only constitutes a minor fraction of the original fall.

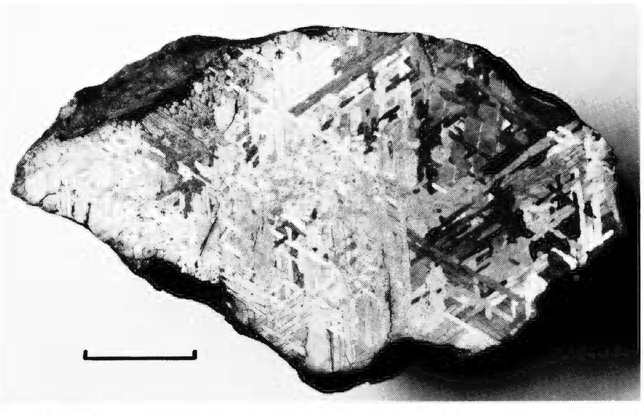

Figure 704. Deport (U.S.N.M. no. 827). Half mass of 3.8 kg. In its structure and chemical composition this meteorite is closely related to Toluca. Deep-etched. Scale bar 3 cm. S.I. neg. 41,412A.

DEPORT – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Palache & Gonyer 1932	7.97	0.41	0.12									
Goldberg et al. 1951	8.40	0.53							61.8			
Wasson 1970a	8.11								69.9	255	2.2	

COLLECTIONS

Washington (4,455 g), Harvard (3,875 g), Austin, University of Texas (1,100 g), London (1,048 g), Ann Arbor (952 g), New York (409 g), Los Angeles (363 g), Chicago (315 g), Tempe (204 g), Albuquerque (63 g).

DESCRIPTION

The largest preserved individual is a lenticular mass with the dimensions 17 x 10 x 9 cm and a weight of 5.8 kg (U.S.N.M. no. 827). It is corroded and shows several shallow pits, 2-3 cm in diameter. Oxide crusts, 1-4 mm thick occur locally. A typical small individual of 350 g measures 6 x 5 x 3 cm and is sculptured with pits and small cavities. While some of the sculpturing is due to terrestrial corrosion, the main part is original regmaglypts from the flight through the atmosphere. The evidence for this is the 0.2-0.5 mm wide remnants of heat-affected α_2 zones that are still to be found on both large and small specimens. On some of the samples the fracture surfaces from the atmospheric disruption may be identified although they were damaged by terrestrial corrosion. The recovered masses are, therefore, fragments from a larger mass that split in the atmosphere and produced a shower.

Etched sections display a Widmanstätten structure which is a borderline case between medium and coarse octahedrites. Since the microstructure unambiguously shows that Deport is closely related to the coarse octahedrites like Toluca, but unrelated to the medium octahedrites like, e.g., Briggsdale, it is decided here to refer Deport to the coarse octahedrites. The kamacite lamellae are rather short ($\frac{L}{W} \sim 10$) with a width of 1.30±0.20 mm. Neumann bands are common. Subgrain boundaries decorated with 1-10 μ phosphides exist in profusion in the ferrite phase. The kamacite has a hardness of 220±15 which indicates that it is somewhat cold worked and not as well annealed as in most other group I irons. It is, however, possible that the cold working is very late and was caused by the shearing and disruption in the atmosphere when the shower was produced. Plessite covers about 10% by area, either as comb plessite or as pearlitic plessite. The individual 10-20 μ wide taenite ribbons of the comb plessite are frequently decomposed to pearlitic structures, of which the taenite lamellae are about 0.5 μ wide.

Schreibersite occurs as scattered skeleton crystals, e.g., 10 x 2 mm and 12 x 0.5 mm. They are monocrystalline, but brecciated, and the larger ones are sheathed in 300-500 μ wide rims of cohenite. Schreibersite is further common as 20-50 μ grain boundary precipitates and as 1-25 μ vermicular or angular bodies in the various plessite fields. Rhabdites are ubiquitous, normally as 5-20 μ thick, tetragonal prisms.

Cohenite occurs as rims around schreibersite and as individual, monocrystalline, rounded units, 2 x 0.5 mm, centrally in some kamacite lamellae. The normal "windows" of 10-100 μ kamacite, taenite and schreibersite are present, but the cohenite has not started to decompose to graphite. Haxonite is locally present as 5-20 μ vermicular bodies in the pearlitic plessite normally associated with schreibersite.

Troilite occurs as scattered nodules up to 10 mm in diameter with the usual – for group I – rims of schreibersite and cohenite. Locally a little graphite is observed, e.g., as 2 mm nodules in contact with troilite and enveloped by schreibersite and cohenite. Rims of swathing kamacite, of 1-3 mm, are found around the troilite aggregates and around the larger schreibersite-cohenite crystals.

Deport is a coarse, carbon-rich octahedrite closely related particularly to Toluca and Leeds. As shown by the analyses of Wasson, it also corresponds well, chemically, to these in all respects and forms a natural member of group I.

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

3,850 g half mass (no. 827, 17 x 10 x 6 cm)
310 g half mass (no. 2267, 5 x 4 x 3 cm)
295 g entire mass (no. 2742, 6 x 4 x 3 cm)

Dermbach, East Germany

An extremely interesting new nickel-rich ataxite find, now in Berlin (G. Hoppe, personal communication. It appears to be the next-highest in nickel content after Oktibbeha County. Preliminary results: 42.1% Ni, 4.7 ppm Ga, 0.2 ppm Ge, 0.03 ppm Ir (Wasson 1973, personal communication).

Descubridora. See Charcas (Descubridora)

Dexter, Texas, U.S.A.

33°49'N, 96°58'W; 250 m

Medium octahedrite, Om. Bandwidth 1.10±0.15 mm. ε-structure. HV 300±25.

Group IIIA. 7.67% Ni, about 0.12% P, 20.5 ppm Ga, 40.9 ppm Ge, 1.2 ppm Ir.

HISTORY

A small mass of 1,724 g was found near Dexter, Cooke County, in 1889. It was privately owned until 1930 when the American Museum of Natural History in New York acquired the entire mass from M.E. Oxley of Trousdale, Oklahoma (Reeds, 1937: 556). Uhlig (1954) used Dexter as one example in discussing the metallography of iron meteorites and presented Knoop hardness measurements

DEXTER – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Scott et al. 1973	7.67								20.5	40.9	1.2	

and photomicrographs. Feller-Kniepmeier & Uhlig (1961) gave additional photomicrographs and microprobe analyses across several phases.

COLLECTIONS

New York (1,276 g), Washington (212 g), London (79 g).

DESCRIPTION

The specimen in the U.S. National Museum is a slab cut from one side of the main mass in New York. It is weathered and no trace of fusion crust or heat-affected α_2 zone is preserved. Corrosion penetrates somewhat along grain boundaries and along schreibersite veins into the mass, and the kamacite in the plessite fields near the surface is selectively corroded. Evidently Dexter is an old fall, reckoned in the thousands of years, and can have no connection whatsoever with a meteor seen in 1888, as believed by Reeds (1937).

The etched section shows Dexter to be a medium octahedrite with straight, long ($\frac{L}{W} \sim 25$) kamacite bands with a width of 1.15±0.15 mm. Since the few sections that have been cut were taken nearly parallel to a cubic plane of the original austenite crystal, the two sets of kamacite lamellae cut each other under 90° and display a deceivingly large width of about 1.4 mm. Hey (1966: 134) gives the lamella width as 1.6 mm which may reflect an approximate determination upon a small specimen oriented as discussed.

All kamacite is transformed to a contrast-rich, hatched ϵ-structure, indicative of shock pressures above 130 k bar. The numerous subboundaries in the kamacite are decorated with well defined 1-5 μ rhabdites, and locally it is seen that the boundaries have moved a few micron since the precipitation took place. The shock-hardened structure has a hardness of 300±25.

Plessite occupies about 25% by area, partly as open-meshed, comb plessite, partly as martensitic (HV 400±25) and fine-grained, duplex $\alpha + \gamma$ (HV 335±30) fields. The 5-10 μ wide taenite ribbons become brownish to grayish tarnished upon etching, indicative of a certain amount of carbon in solid solution (HV 335±15).

Schreibersite occurs as 20-50 μ wide grain boundary precipitates and as 2-10 μ thick vermicular bodies inside the comb plessite. A trifle of 1 μ rhabdites are present in the kamacite lamellae. The phosphorus content may be estimated to be 0.12±0.02%.

Troilite is distributed as 1-2 mm nodules without or with very minor schreibersite rims. Occasionally, minute lamellar troilite bodies, e.g., 2 x 0.1 mm, are seen.

Dexter appears to be related to such irons as Bagdad, Billings, Denton County, Canyon City and Boxhole, all of group IIIA with about 8% Ni, small amounts of phosphides and ϵ-structure.

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

212 g slice, endpiece (no. 1358, 9 x 7 x 0.5 cm)

Dimitrovgrad, Serbia, Jugoslavia

43°2′27″N, 22°51′50″E

Medium octahedrite, Om. Bandwidth 1.05±0.15 mm. ϵ-structure. HV 300±25.

Group IIIA. 7.64% Ni, about 0.12% P, 20.3 ppm Ga, 40.2 ppm Ge, 3.0 ppm Ir.

HISTORY

A mass of 100 kg was recognized during field work in 1956 by the geologist, Todor Spasov. The mass had been found by a farmer in 1947 on the surface of a compact Jurassic limestone which was being used as a construction material in the neighborhood. Within a few meters distance two additional fragments of 50 and 100 g had been recovered. The place is 5.5 km east-northeast of the village of Dimitrovgrad, close to the Bulgarian border. Spasov described and analyzed the iron (1960) and presented a map and several photomicrographs. A summary of the examination with map, photographs of the exterior and photomicrographs was given by Ramović (1965).

COLLECTIONS

Belgrade, Natural History Museum of Serbia (99.7 kg; 45 g), Washington (219 g), London (12 g), Sarajevo (8 g).

DESCRIPTION

The rounded, weathered mass has, according to Spasov (1960), the average dimensions 37 x 32 x 23 cm and a weight of 100 kg. The specimen in the U.S. National Museum is a part of the surface, chiseled and hammered free of the main mass, and, therefore, with superficial distortion of the Widmanstätten structure. All fusion crust and heat-affected α_2 zone are lost due to terrestrial corrosion, and corrosion also penetrates deep into the mass along octahedral planes as 10-100 μ wide oxide veinlets. Some exfoliation occurs along these weakened planes.

Etched sections display a medium Widmanstätten structure with little contrast and subdued oriented sheen. This is due partly to the small amount of grain boundary precipitates, partly to the almost resorbed plessite and in part to the ϵ-matrix. The lamellae are straight, long ($\frac{L}{W} \sim 20$) and 1.05±0.15 mm wide. The numerous subboundaries of the kamacite are profusely decorated with

DIMITROVGRAD – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Scott et al. 1973	7.64								20.3	40.2	3.0	

1-5 μ rhabdites so that the boundaries resemble barbed wire. The shock-hardened matrix shows a mixture of hatched-ε and Neumann bands, corresponding to shock pressures above 130 k bar. The hardness varies considerably from place to place, even within the same section of a few square centimeters. Most values cluster about 300, but a maximum of 380 in a heavy shear zone and a minimum of 260 in a little distorted region were registered.

Plessite covers 25-30% by area, mostly as open-meshed comb plessite that is being resorbed. The taenite rims around the fields are normally discontinuous. The larger taenite wedges may have martensitic-bainitic interiors (HV 385±30). By etching, most of the taenite becomes tinted in brownish-grayish tones, indicating a certain amount of carbon in solid solution (HV 335±20).

Schreibersite occurs sparingly as 20-40 μ wide, brecciated grain boundary veinlets and as 2-20 μ vermicular substitutes for taenite in the plessite fields. Rhabdites are numerous, particularly as 2-5 μ prisms in the kamacite lamellae, but also as somewhat smaller bodies in the interior of the comb plessite fields. The bulk phosphorus content is estimated to be 0.12±0.02%.

Troilite is present as discrete 5-10 mm nodules which display discontinuous schreibersite rims. The troilite is shock melted and has dissolved a small part of the adjacent metal, whereby fine-grained, metal-sulfide eutectics are created at the periphery of the nodule. The remainder is a polycrystalline mixture of 2-5 μ grains in which angular fragments of unmelted daubreelite are dispersed.

The hard phase of oriented 20 x 2 x 0.5 μ platelets, reported in Schwetz and others, was also found here, well dispersed in all parts of the α-phase. It was identified as the chromium nitride, carlsbergite.

Dimitrovgrad is a shocked, medium octahedrite related to Dexter, Canyon City and other group IIIA meteorites.

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

13 g fragment (no. 1785, 2 x 1.5 x 1 cm)
206 g surface knob (no. 2251, 6 x 4 x 2 cm)

Dorofeevka, Kokchetav Oblast, Kazakh SSR
53°20′N, 70°4′E

Plessitic octahedrite, Opl. Spindle width 90±30 μ. No Neumann bands. HV 187±8.

Anomalous. 11.42% Ni, 0.67% Co, 0.10% P, 9.1 ppm Ga, 124 ppm Ge, 23 ppm Ir.

HISTORY

A mass of 12.68 kg was acquired by the expedition led by L.A. Kulik which was sent to Siberia in 1921 by the Russian Academy of Science (Chirvinsky 1923). The meteorite had been plowed up two versts (i.e., 2 km) from the village of Dorofeevka in 1910; it was transferred to the nearby village of Chutjye where a blacksmith cut off pieces in order to "analyze" it. It was later purchased for 10 to 15 Rubles by Sergeev who gave the eminent specimen to Kulik (Kulik 1922: mapsketch and two figures). The whole mass came to Moscow and was described by Zavaritskij & Kvasha (1952: 64) who presented two photographs of the exterior and two sketches of etched sections. Additional observations and two photomicrographs were given by Zavaritskij (1954). Krinov (1947: 19-20) gave a photograph of the exterior and (1960a: 365) briefly discussed the structure as shown in an attached photomicrograph. Trofimov (1950) examined the $^{12}C-^{13}C$ ratios in the meteorite. The meteorite has been classified as a hexahedrite (Krinov 1947; Prior

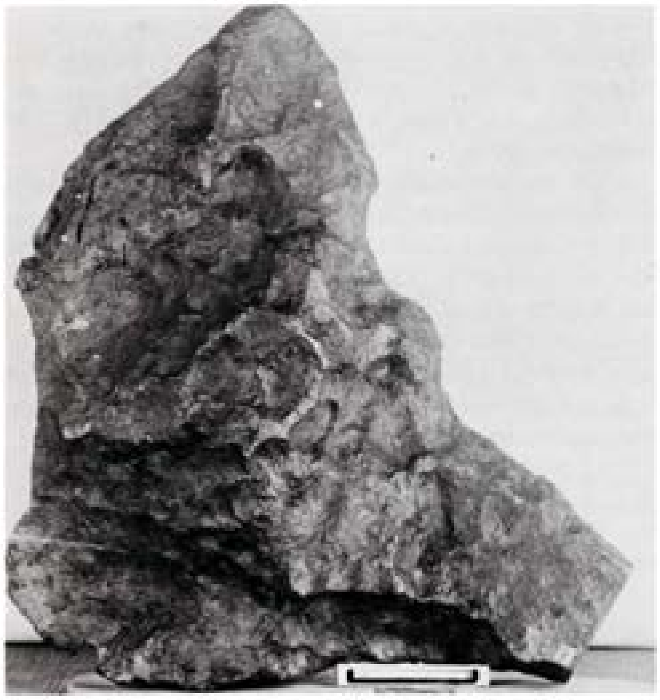

Figure 705. Dorofeevka (Moscow). The main mass of 12.7 kg. Regmaglypts, although weathered, are indistinctly visible. Scale bar 5 cm. (Courtesy E.L. Krinov.)

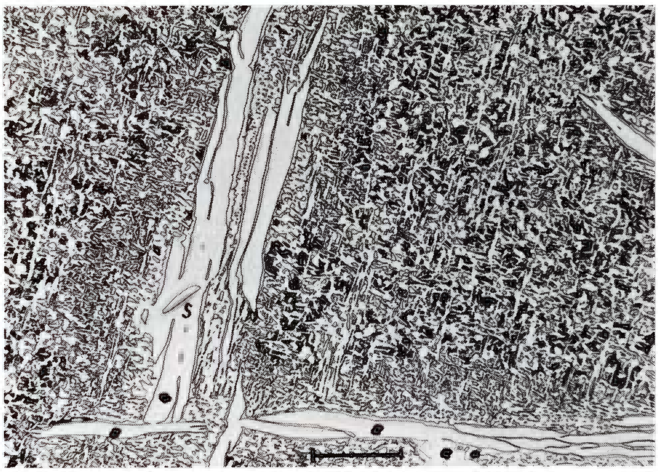

Figure 706. Dorofeevka (Moscow no. 652). Kamacite spindles in a duplex plessitic matrix. Schreibersite (S). Five microhardness indentations (black) have been partially removed by repolishing. Etched. Scale bar 400 μ.

1953), as a medium to fine octahedrite (Zavaritskij & Kvasha 1952; Krinov 1960a) and as a nickel-rich ataxite (Zavaritskij 1954). The present author would prefer to classify it as a plessitic octahedrite.

COLLECTIONS

The entire mass of 12,375 g is in Moscow; only small protruding knobs have been detached for examination and analysis (Kvasha 1962: 137).

DESCRIPTION

The mass is an irregular, flat triangular slab with the maximum dimensions 27 x 18 x 9 cm in three perpendicular directions. Part of the surface is weathered and roughened to a typical corrosion relief. However, one of the flat surfaces does exhibit remnants of shallow regmaglypts, 1.5-2.5 cm across.

The sample examined here is a 13 g endpiece (no. 652), kindly loaned to me by Dr. Kvasha, Akademija Nauk, Moscow. Its surface is slightly hammered, probably by the finder or by the blacksmith mentioned above. No fusion crust and no heat-affected α_2 zone could be detected, and there was no hardness gradient from the interior towards the surface, except for irregularities which could be explained by the artificial cold working. Corrosion penetrates along the grain boundaries and has selectively dissolved the α-phase of the plessite, locally to a depth of 1 mm. Oxide shale covers most of the surface. It is estimated that at least 4 mm has been lost by terrestrial corrosion from this part of the meteorite. It appears, however, that the loss is only of the order of 1 mm on other parts of the meteorite where regmaglypts are visible.

The etched section exhibits a coarse plessitic structure in which scattered kamacite spindles are exsolved in a Widmanstätten pattern. The kamacite spindles are pointed and subdivided in cells by low angle boundaries. The individual spindles are 90±30 μ wide and 0.5-1 mm long; they are, however, often clustered in tight bundles of 2-10 units and may then be easily detected with the naked eye. Such clusters occur with a frequency of about 10 per cm^2. The kamacite is devoid of Neumann bands, except near the hammered surface, and has a hardness of 187±8.

The plessite covers 95% of the available sections as a rather coarse-grained mesh of kamacite and taenite. The kamacite forms 5-25 μ wide channels, partly arranged in the Widmanstätten directions, or it forms irregular patches subdivided in 10-20 μ wide cells. The taenite, on the other hand, forms isolated concave areas, 1-35 μ wide; whenever the width increases above about 3 μ the interior is decomposed to indistinctly resolvable $\alpha + \gamma$. The taenite islands vary in hardness, according to the actual nickel content and microstructure, from 250 to 280. The plessitic matrix as a whole exhibits a hardness of 225±15.

Schreibersite is not present as large crystals but is very common as particles of the same general size as taenite (1-35 μ) thus forming an integral part of the plessitic.

Figure 707. Dorofeevka (Moscow no. 652). Duplex matrix with micro-Widmanstätten structure. Around the schreibersite particle (right) there is swathing kamacite and much retained taenite. Etched. Scale bar 200 μ.

Figure 708. Dorofeevka (Moscow no. 652). Kamacite spindles in Widmanstätten directions. A single schreibersite crystal (S). Etched. Scale bar 100 μ.

DOROFEEVKA – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Trofimov 1950				230								
Dyakonova & Charitonova 1960	11.57	0.67	0.10				400					
Wasson 1970, pers. comm.	11.26								9.10	124	23	

matrix. The largest particle observed was 200 x 30 μ, and, around this, a kamacite spindle had formed. The smaller schreibersite particles are, on the other hand, often in close contact with, or even surrounded by, taenite.

Troilite was not observed. A few 1-5 μ blue particles occur in the plessite, often overgrown with schreibersite; these appear to be iron chromium sulfides. No carbides, nitrides, silicates nor graphite were detected.

The rare absence of Neumann bands, the general morphology of kamacite and taenite, and the rather low hardnesses of kamacite and taenite, suggest that Dorofeevka has not been exposed to violent shock events in cosmos.

Dorofeevka is an anomalous iron meteorite which may best be described as a plessitic octahedrite – plessitic because the plessite forms the major part of the structure; octahedrite because the octahedral pattern is clearly revealed by visual inspection of an etched hand specimen. The classification nickel-rich ataxite is unfortunate because ataxites proper appear structureless to the naked eye. Dorofeevka has some similarities to Bacubirito and the resolved chemical group IIC, exemplified by, e.g., Perryville and Wiley. However, Dorofeevka resembles the plessitic octahedrite Monahans, discovered in Texas in 1938, still more.

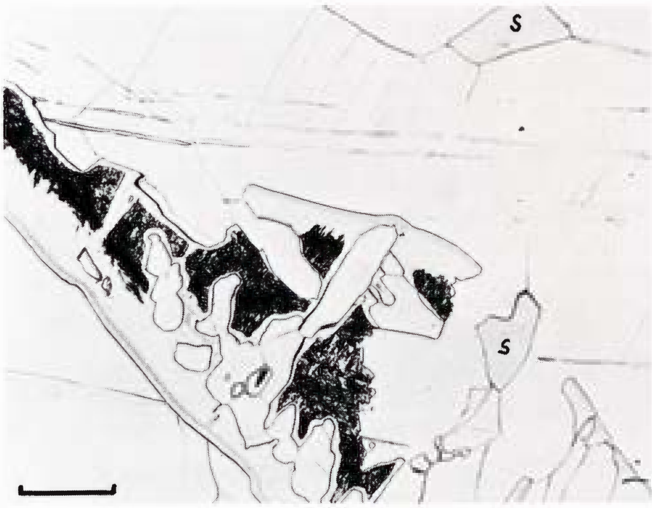

Figure 709. Dorofeevka (Moscow no. 652). Kamacite with Neumann bands and schreibersite particles (S). Plessite with dark unresolvable parts. Etched. Scale bar 40 μ.

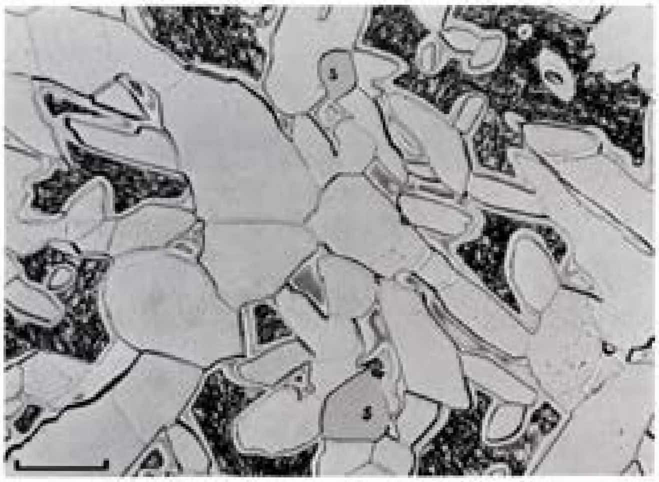

Figure 710. Dorofeevka (Moscow no. 652). Dark, unresolvable plessite fields with cloudy taenite rims. Two schreibersite crystals (S) in contact with cloudy taenite particles. Etched. Oil immersion. Scale bar 20 μ.

Dorrigo, New South Wales
30°17'S, 152°40'E

Plessitic octahedrite, Opl. Spindle width 0.15±0.05 mm.

Probably anomalous. Estimated composition: 11±2% Ni and 0.25±0.05% P.

Severely weathered.

HISTORY

A mass of about 10 kg (?) was found before 1948 by J.A. McGuire in the town of Dorrigo which is situated 40 km inland from Coffs Harbour, New South Wales. It was found among weathered basalt boulders, and was intended as rubble for a road, when it was recognized as something extraordinary. Due to its considerably corroded state it was easily split with a hammer. The 16 pound (7.2 kg) main mass and some fragments were acquired by the Australian Museum, Sydney, and briefly described with a figure of the exterior by Chalmers (1948). He particularly emphasized the alarming rate of corrosion that started after the meteorite arrived at the museum which was why the decision was made to preserve it in a sealed glass container filled with silica gel. The reason for the corrosion was believed to be the presence of the cosmic mineral lawrencite, but this can be ruled out, as noted on page 113.

COLLECTIONS

Sydney (8.5 kg), Washington (fragments).

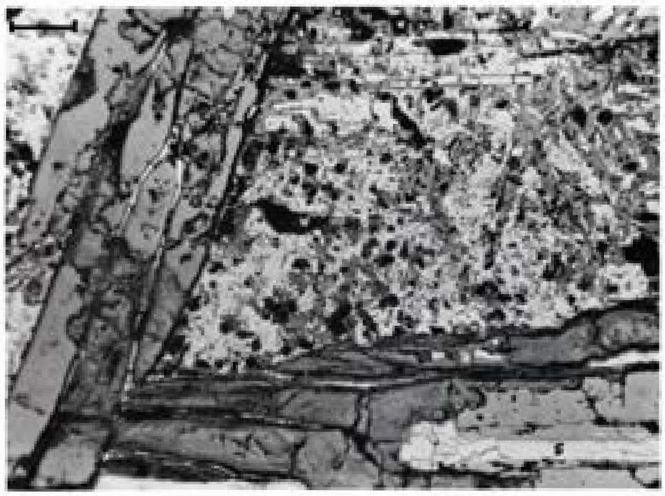

Figure 711. Dorrigo (U.S.N.M.). Low magnification of this corroded fragment suggests that the meteorite was originally a plessitic octahedrite, somewhat resembling Dorofeevka (Figures 705-710). A large schreibersite crystal (S) is rather well preserved in the limonitic kamacite lamella below right. Polished. Scale bar 200 μ.

ANALYSIS

The material is unanalyzed mainly due to its severe degree of corrosion. From the present structural examination, it is estimated that the (uncorroded) meteorite contained 11±2% Ni and 0.25±0.05% P, with trace elements that would refer it to an anomalous position in the classification system.

DESCRIPTION

The small fragment in the Smithsonian Institution exhibits a severe degree of weathering. The main mass is crumbling along Widmanstätten directions so that octahedral and irregular, angular fragments easily spall off. No fusion crust and no heat-affected zones could be detected; several centimeters of the exterior seem to have been lost. The chloride content was acquired from circulating ground water during long terrestrial exposure.

Sections reveal only little unaltered metal. The original structure seems to have been that of a plessitic, or a finest, octahedrite of a rare type. The kamacite forms spindles or lamellae that are generally 0.15±0.05 mm wide and are up to 10 mm long. Several spindles are usually aggregated in a bundle which irregularly tapers off at the ends. The kamacite is subdivided in cells by subboundaries.

The plessitic matrix between the primary spindles constitutes 60-70% by area. Dense, duplex areas alternate with more open plessite in which pointed, 10-50 μ wide α-spindles are common. Martensitic transition zones are also occasionally apparent.

Schreibersite is common as angular laths that reach a maximum size of 1.5 x 0.06 mm. They are enveloped in swathing kamacite, usually 10-50 μ wide. Schreibersite is further present as 5-20 μ particles within the plessitic areas. Rhabdites were not detected.

Troilite, graphite, carbides and silicates were not observed.

The corrosion has proceeded along α - α, α - γ and α-phosphide boundaries almost everywhere and possibly to the center of the mass. The examined surface fragments (specific gravity 3.5 g/cm^3) were almost entirely converted to limonite. In particular, the kamacite phase was transformed and also the dense, duplex plessite areas. The largest area of continuous uncorroded α-phase measured only 100 x 40 μ. The phosphides and the high-nickel taenite ribbons and borders were best preserved, and it is mainly because of these that we are able to examine the fossil structure and come to conclusions regarding its original state.

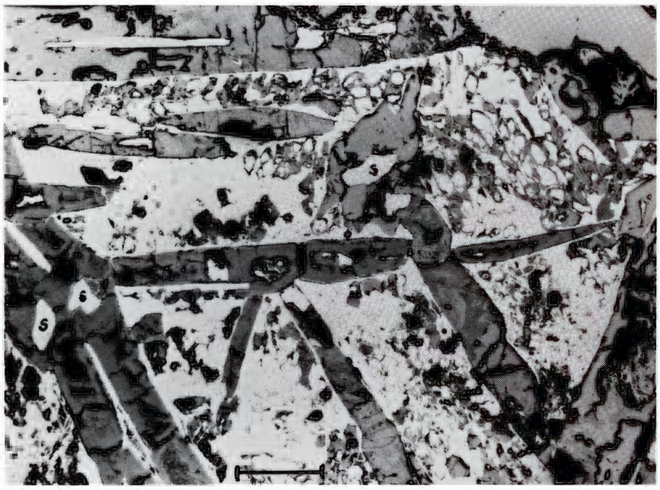

Figure 712. Dorrigo (U.S.N.M.). Almost all kamacite has been converted to limonite (black) by corrosion. The white area is a slightly altered plessite field. Schreibersite (S). Polished. Scale bar 200 μ.

Figure 713. Dorrigo (U.S.N.M.). A plessite field severely attacked by terrestrial corrosion. The exterior, 2 μ thick, high-nickel taenite rim has become detached, but survives for a long time in this state. Polished. Scale bar 100 μ.

A comparison with the other plessitic octahedrites of New South Wales, Corowa and Cowra, showed that the three masses are significantly different in structure and cannot be paired falls.

Dorrigo is a plessitic, or finest, octahedrite of a rare type. It appears to fall outside group IIC which contains plessitic octahedrites exclusively. In its structure it slightly resembles Prambanan, Bacubirito, Dorofeevka and Victoria West. If it should be possible to perform a trace element analysis (Ga, Ge, Ir) on the weathered material, it will probably show Dorrigo to be an anomalous meteorite.

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

Polished section and corroded fragment (3 x 1.5 x 1 cm)

Dowerin, Western Australia
31°12′S, 117°4′E

Many small fragments were found before 1932 near Dowerin, but, except for a brief note by Simpson (1938: 158) nothing is known of this material. The total weight is unknown but is apparently not more than 1 kg (?). The locality is somewhat northeast of the Youndegin shower, and a possible relationship with this material should be checked.