the reheated material originates from the village smiths in Caille, or perhaps represent experimental fragments from the Paris laboratory. It is at least known that Daubrée and Meunier for many years experimented with heating, forging, dissolving and synthesizing meteorites; see, e.g., Daubrée 1868c: 31; Meunier 1884: 39, 321.

Summing up then, La Caille fell a long time ago and probably split in a few fragments of which the largest 625 kg mass was acquired by the Paris Museum in 1828. From Paris two types of material were distributed. Most specimens represented artificially reheated material, but a few, notably No. 1060 in Washington, represented undamaged material. Since undamaged material is available at all, it appears that the main mass has not suffered significant reheating; and it is urged that the mass be cut again in order to furnish authentic, undamaged material. La Caille is structurally anomalous by its shock-reheated, granulated structure and by its content of parallel belemnite-shaped troilite nodules. It is also chemically anomalous by its Ga-Ge-Ir combination.

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

80 g slice (no. 1060, 6 x 3 x 0.8 cm, Shepard Collection no. 4)
24 g slice (no. 2869, 4 x 4 x 0.2 cm). Reheated artificially.

La Grange, Kentucky, U.S.A.

38°24′N, 85°23′W; 250 m

Fine octahedrite, Of. Bandwidth 0.27±0.05 mm. Complex ϵ-structure. HV 270±20.

Group IVA. 7.65% Ni, 0.41% Co, 0.03% P, 2.1 ppm Ga, 0.12 ppm Ge, 2.3 ppm Ir.

HISTORY

A mass of 112 pounds (51 kg) was found in 1860 by William Daring, near La Grange, in Oldham County. It was acquired by J.L. Smith who cut and distributed one third of it and gave a brief description with an analysis (1861). Cohen (1905) reviewed the literature and gave a new description. Brezina & Cohen (1886-1906: plate 20) presented three photomacrographs and grouped, inappropriately, La Grange with Russell Gulch, a medium octahedrite of group IIIA. Voshage (1967) found too low a potassium concentration to establish a cosmic ray exposure age by his ^{40}K/^{41}K method.

COLLECTIONS

Amherst (35.5 kg block and 500 g slice), Washington (2,160 g), Berlin (1,013 g), Tempe (912 g), Calcutta (503 g), Vienna (442 g), Paris (368 g), Göttingen (368 g), Bonn (222 g), Chicago (218 g), London (202 g), Harvard (193 g), Stockholm (136 g), Los Angeles (60 g), New York (56 g), Strasbourg (52 g), Tübingen (48 g), Yale (46 g), Leningrad (31 g), Rome (24 g), Vatican (23 g), Ottawa (21 g), Oslo (8 g).

DESCRIPTION

The extreme dimensions of the elongated, flattened mass were, according to Smith (1861), 50 x 27 x 16 cm. The present mass is cut at both ends, weighs 35.5 kg and measures 27 x 25 x 15 cm. It is turtle-shaped and rather smooth, with 0.1-2 mm thick oxide crusts from terrestrial weathering. In places the Widmanstätten structure may be suspected from the regularly oriented ridges in the weathered crust. No fusion crust and no heat-affected α_2 zone are preserved.

Etched sections display a rather dull, indistinct Widmanstätten structure, that in places is quite distorted. The lamellae are long ($\frac{L}{W} \sim 30$) and very narrow, 0.27±0.05 mm. The cold-worked kamacite may perhaps best be described as a contrastless mixture of Neumann

Figure 1037. La Grange (Amherst). The main mass of 35.5 kg. It has been cut at both ends to provide slices for exchange. Ruler in centimeters. See also Figure 779.

LA GRANGE – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	**Ni**	**Co**	**P**	**C**	**S**	**Cr**	**Cu**	**Zn**	**Ga**	**Ge**	**Ir**	**Pt**
Smith 1861	7.81	0.25	0.05									
Bürger in Cohen 1905	7.61	0.62	0.03		200	200	100					
Goldberg et al. 1951	7.71								2.11			
Moore et al. 1969	7.71	0.41	0.03	370	105		165					
Schaudy et al. 1972	7.40								2.07	0.115	2.3	

La Grange is one of the better analyzed meteorites.

bands, hatched ε-structure and lenticular deformation bands. The particular structure appears to be the result of considerable cold deformation, with compression and shearing. This view is corroborated by the observation that enveloping taenite and plessite fields show minute faulting and displacement, always in the same direction. The hardness of the kamacite is 270±20.

Plessite covers about 40% by area, partly as open-meshed comb and net plessite, partly as cellular plessite, the particular IVA type mentioned under Chinautla. Duplex, poorly resolvable $\alpha + \gamma$ fields and wedges of taenite, of which the interior is developed as martensite parallel to the bulk Widmanstätten directions, are also common. As mentioned above, the linear elements are locally heavily folded, and there is a tendency for the individual small α and γ units to be oriented parallel to the shearing forces.

Phosphides were not observed and are probably not present at all, in harmony with the analytical data.

Troilite is present as scattered 0.5-5 mm rhombic and lenticular inclusions. They occur with a frequency of about one per 10 cm^2 and normally contain 5-20% daubreelite by area. Daubreelite, or perhaps brezinaite, is also common as individual 10-100 μ angular blebs in the alpha matrix. A 50 μ unit was composed of parallel, but folded, stacks of 0.5-2 μ wide troilite plus daubreelite lamellae. The troilite nodules have been melted along the phase boundaries against metal and daubreelite; in the melt are included 100-300 μ passive, unmelted blocks of troilite that only show some lenticular deformation bands. The troilite melts have been injected into the fragmented daubreelite crystals as 1-10 μ wide veinlets. Such troilite is now a fine aggregate of 1-3 μ anisotropic units with only little metal. The whole appearance is that of a very rapid, partial melting, probably due to shock, whereby the melt neither was hot enough nor had sufficient time to dissolve the metal and daubreelite. It was only able to penetrate and envelop the shattered crystals. Terrestrial corrosion has converted part of the troilite to pentlandite.

A very interesting feature is the presence of the fine fissures that zigzag across the etched sections and of which many attain lengths of several centimeters with a width of 10-100 μ. They are mutually subparallel and almost parallel to the exterior, flattened surfaces. They appear locally in connection with troilite nodules, and they are themselves filled with a fine-grained troilite aggregate with dispersed 2-10 μ daubreelite fragments. They evidently represent a partial fissuring of the mass, whereby point-melted mobile troilite melts became injected together with fragments of shattered daubreelite.

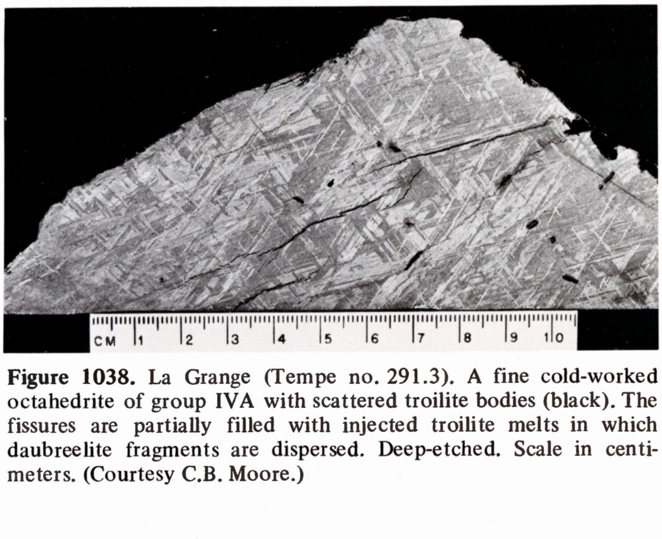

Figure 1038. La Grange (Tempe no. 291.3). A fine cold-worked octahedrite of group IVA with scattered troilite bodies (black). The fissures are partially filled with injected troilite melts in which daubreelite fragments are dispersed. Deep-etched. Scale in centimeters. (Courtesy C.B. Moore.)

La Grange is a fine octahedrite with a structure that is modified by heavy cold-working and injection of troilite melts in fissures. It is closely related to Huizopa, Obernkirchen, Charlotte, Wood's Mountain and other group IVA meteorites.

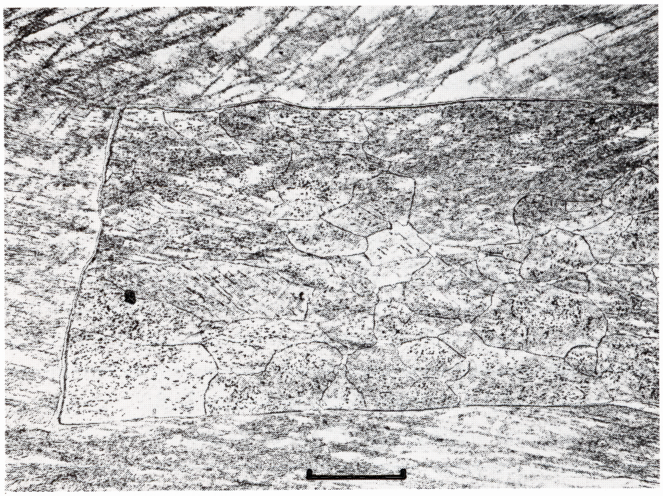

Figure 1039. La Grange (U.S.N.M. no. 55). An open-meshed cellular plessite field occupies most of the picture. The kamacite displays an indistinct mixture of Neumann bands, shock-hatched ε-structure and lenticular deformation bands. Etched. Scale bar 200 μ. (Perry 1950: volume 6.)

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

172 g part slice (no. 55, 4.5 x 4 x 1.1 cm)
975 g corner (no. 1061, 8 x 5.5 x 5 cm)
984 g endpiece (no. 1061, 11 x 6 x 5.5 cm)
28 g part slice (no. 2870, 3 specimens)

Laguna Manantiales, Santa Cruz, Argentina
48°35'S, 67°25'W

A mass of 92 kg was found in 1945 and retained by the finder except for very minor pieces of which 2.5 g is in the British Museum (Hey 1966: 258).

Lake Murray, Oklahoma, U.S.A.
34°6'N, 97°5'W; 250 m

Coarsest octahedrite, Ogg. Large, irregular kamacite grains; locally 5-12 mm bandwidth. HV 160±5.

Group IIB. 6.3% Ni, about 0.5% P, 53.9 ppm Ga, 141 ppm Ge, 0.02 ppm Ir.

HISTORY

A weathered mass of about 270 kg was found, exposed in a gully, before 1930 on the farm of J.C. Dodson, Carter County. It was recognized as a meteorite in 1952 by A.A. Graffham, the director of the museum in the newly created Lake Murray State Park of which Dodson's farm had become a part. Graffham (1953; 1964) noted that the mass was embedded in the cretaceous Antlers sandstone, and the undisturbed nature of the overlying 30 cm of sand suggested that the meteorite had fallen into the sand during deposition. The presence of an extremely thick rust crust supported this observation; Graffham, and Leiper (1966), reported that nearly 1,000 pounds of oxidized shale was found in the immediate vicinity of the mass itself. The meteorite was excavated and shipped to Albuquerque where it was preliminarily described with photographs of the exterior by La Paz (1953a). In one of the photographs some of the scattered shale is visible around the main mass in situ. The difficult cutting operation was described by La Paz (1953b). Henderson (1965) briefly mentioned the iron and presented a photomacrograph, demonstrating the mixed structure of Widmanstätten lamellae and granular parts.

COLLECTIONS

Albuquerque (half mass of about 125 kg and 20 kg slices), Tempe (about 1 kg), Washington (80 g), Tucker Tower Museum, Lake Murray State Park (half mass).

DESCRIPTION

After the weathered mass had been freed of most of its oxide coating it measured about 60 x 40 x 23 cm. The shales were laminated and exceeded a thickness of 10 cm over a considerable part of the surface (La Paz 1953a). La Paz assumed that the numerous, scattered oxide shales, on and in the ground, were the result of the impact of many smaller masses of the same fall, but it is more likely that there was only one mass which, upon long terrestrial exposure, disintegrated partially whereupon the debris was scattered slowly by water, snow and wind around the main mass. A conservative estimate of the weight of the meteorite before weathering is 500 kg.

Etched sections display both Widmanstätten areas and granular areas. The Widmanstätten structure is composed of straight, irregular ($\frac{L}{W} \sim 6$) kamacite lamellae with a width of 5-12 mm. The granular areas apparently compose 90% of the known sections. Each grain is developed as a shell of swathing kamacite around a troilite-schreibersite inclusion. The troilite nodules range in size from 5-30 mm, and the resulting kamacite grains easily attain sizes of 5-10 cm across. Nevertheless, as the orientation of the residual Widmanstätten areas shows, the original mass must at one time have been a single austenite crystal.

Taenite occurs very sparsely as 5-50 μ thick ribbons, either in grain boundaries or wholly within kamacite grains, that have pushed the grain boundaries across previous lamella boundaries. Plessite is present as rare, open-meshed fields in the Widmanstätten areas. The taenite is apparently well annealed, since it is broken up into partially spheroidized blebs, somewhat resembling the taenite of Maria Elena and Seneca Falls.

The kamacite previously had numerous Neumann bands, but they have now almost all disappeared, leaving, however, distinct double rows of 1 μ phosphides. The subgrain boundaries are decorated by <1 μ phosphides, except in the 0.2-1 mm wide zones around the larger schreibersite inclusions where the matrix is phosphorus-depleted. The subgrains are frequently arranged in subparallel, elongated units which indicates that their formation was conditioned by the Neumann bands. The hardness of the kamacite is generally 160±5, but locally it increases to 190 or decreases to 145, possibly due to changes in the concentration of phosphorus and nickel in solid solution.

Troilite is common as 5-30 mm nodules which are enveloped by rosette-like growths of 1-10 mm thick schreibersite crystals (HV 915±25). Similar developments are found in Ainsworth and Santa Luzia, and their formation may be explained in the same way. Schreibersite further occurs as 20-200 μ thick grain boundary precipitates. The schreibersite is frequently decorated along its edges by tiny taenite blebs; these are spheroidized and 1-2 μ across. It appears that they were formed by a short-time annealing

Figure 1040. Lake Murray (Albuquerque). The etched end section shows large troilite nodules associated with rosette-shaped schreibersite crystals, all enveloped in wide rims of swathing kamacite. Further out, an extremely coarse Widmanstätten structure. Deep-etched. Scale bar 25 mm.

LAKE MURRAY – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Wasson 1969	6.3								53.9	141	0.018	

from the schreibersite which rejected surplus nickel. The rhabdites are 2-10 μ thick, and rounded, presumably due to the same annealing. In addition, the matrix is loaded by $<2\ \mu$ rhabdites. The bulk phosphorus content of the meteorite is estimated to be 0.5%. Along the edge of some of the larger schreibersite crystals there occur 50 to 200 μ wide rims of cohenite. It appears, however, that all cohenite is decomposed to graphite and granular kamacite due to late cosmic reheating.

Some black, fragmented minerals were noted in the troilite, but they were not identified. No polished section of a troilite nodule was available, but from the other structural details, it is expected that the troilite is shock-melted and composed of fine-grained iron-sulfide eutectics.

Lake Murray is closely related to Ainsworth, Sikhote Alin, São Julião and Santa Luzia. It appears to have suffered significant reheating, possibly in connection with a shock event. Its state of weathering indicates that it is of high terrestrial age.

Specimen in the U.S. National Museum in Washington:
80 g part slice (no. 1768, 5 x 3 x 0.7 cm)

Lancaster County, Nebraska, U.S.A.

According to Barbour (1903), a mass of 13 kg was received by the Nebraska Geological Survey in 1903. The material was perhaps an octahedrite, but it is unexamined, and the present repository is not known.

Landor, Western Australia

About 25°40'S, 117°E

Several masses, totaling 20 pounds, were found about 1931 near the head of Wooramel River on the Landor sheep station. The main mass was retained by the finder, but fragments were described by Simpson (1938: 161). An additional note is found in McCall & De Laeter (1965: 37). The material appears to be a fine octahedrite.

Lanton, Missouri, U.S.A.

36°32'N, 91°48'W; 250 m

Medium octahedrite, Om. Bandwidth 1.05±0.15 mm. ϵ-structure. HV 285±20.

Group IIIA. 8.30% Ni, 0.18% P, 20.6 ppm Ga, 39.3 ppm Ge, 3.5 ppm Ir.

HISTORY

Four weathered fragments totaling 13.78 kg, were found in 1932 by R.A. Newcomb on his farm 0.5 mile northwest of Lanton, in Howell County. The individual fragments of 8.93, 2.73, 0.76 and 1.36 kg were found close together on the surface. Cullison & Muilenburg (1934), who described the find with two photomicrographs, argue convincingly that only one mass fell, but that terrestrial oxidation, plus plowing of the land, separated the fragments 1-2 meters. The 2.73 kg fragment was heated in the blacksmith's forge at Lanton, but most of this material appears to have been retained by the smith.

The meteorite is erroneously listed as a fine octahedrite by Hey (1966: 263).

COLLECTIONS

Missouri Bureau of Geology and Mines, Rolla (8.93 kg), Washington (543 g), Tempe (80 g), London (16 g).

DESCRIPTION

The half-kilogram fragment in the U.S. National Museum is externally badly weathered. The oxidized crust crumbles away along octahedral planes, and the fragment is itself detached from a larger mass along weathered, octahedral planes. The corrosion apparently continues, even under the dry air conditions of the museum; it is believed that a significant amount of terrestrial chlorides is present in the crust and in the oxidized grain boundaries.

Etched sections display a beautiful, medium Widmanstätten structure of straight ($\frac{L}{W} \sim 25$) kamacite lamellae with a width of 1.05±0.15 mm. The oriented sheen has a silky appearance, due to the shock-hardened ϵ-structure which is present in all kamacite, indicating peak pressures above 130 k bar (HV 285±20). Subgrain boundaries, decorated with 1 μ rhabdites, are common. Plessite covers about one third by area, essentially as comb and net plessite. The framing taenite becomes stained in brownish-bluish colors upon etching, indicating carbon in solid solution. The plessite fields often incorporate wedges and rhombs, the interiors of which show various degrees of transformation to martensite, oriented parallel to the octahedral structure, or to fine-grained, poorly resolvable, duplex $\alpha + \gamma$ mixtures. Normally, a martensitic zone is

LANTON – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	**Ni**	**Co**	**P**	**C**	**S**	**Cr**	**Cu**	**Zn**	**Ga**	**Ge**	**Ir**	**Pt**
Cullison & Muilenburg 1934	8.33	0.61	0.18									
Scott et al. 1973	8.28								20.6	39.3	3.5	

It appears that cobalt is about 25% too high.

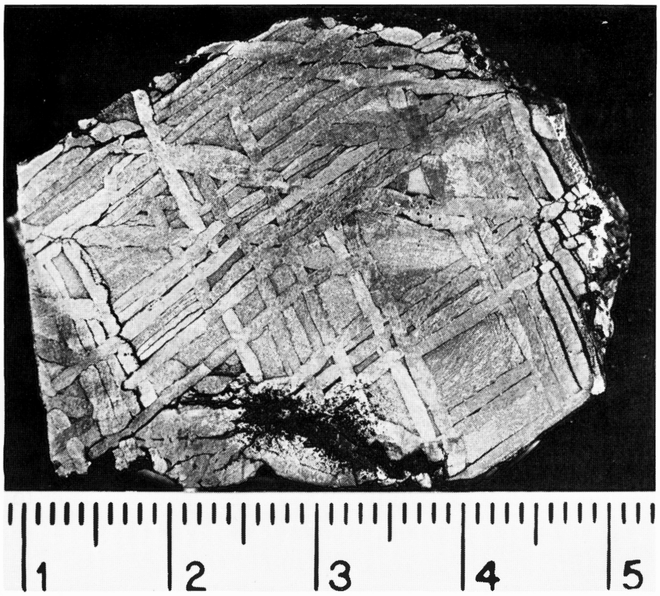

Figure 1041. Lanton (Tempe no. 308.1). A medium octahedrite attacked by terrestrial corrosion along the Widmanstätten lamella boundaries. Deep-etched. Scale in centimeters. (Courtesy C.B. Moore.)

intercalated between the taenite frame and the duplex interior.

Schreibersite occurs as 25-50 μ wide grain boundary precipitates, and as irregular 5-20 μ blebs inside the coarser plessite fields, substituting for taenite of its own size. The schreibersite is monocrystalline but heavily brecciated due to shock. The cracks are filled with terrestrial corrosion products.

Troilite or other meteoritic minerals were not observed in the sections available.

Lanton is a shock-hardened, medium octahedrite, structurally similar to Bagdad, Dimitrovgrad, Iron Creek and Merceditas. It also resembles Norfork, which fell 50 km southwest of Lanton in 1918. The state of weathering, the hardness and the ϵ-structure of Lanton exclude, however, that it could be some overlooked fragment of the Norfork fall. Lanton belongs chemically to group IIIA.

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

506 g fragment (no. 876, 5 x 5 x 3.5 cm)
37 g part slice (no. 1602, 3 x 3 x 0.5 cm)

La Porte, Indiana, U.S.A.

Approximately 41°35′N, 86°44′W

Medium octahedrite, Om. Bandwidth 1.05±0.15 mm. ϵ-structure. HV 230±10.

Group IIIA. 7.88% Ni, about 0.18% P, 22 ppm Ga, 43 ppm Ge, 1.4 ppm Ir.

HISTORY

A mass of 14.56 kg was found about 1900 by a farmer near Chicago, possibly in La Porte County. It was acquired by W.N. Rumely who operated a farm supply store in La Porte, and after his death in 1937 it was donated to the Field Museum in Chicago (Annual Report of the Field Museum of Natural History for 1937, Volume 11: 212; Roy & Wyant 1950b). It had been drilled in two places, but that it should have been found in four fragments, as stated by Hey (1966: 263), is probably a printer's error, going back to the list of A.D. Nininger (1940), where La Porte appears right after Lanton. Lanton was found in four fragments. La Porte was described by Roy & Wyant (1950b) who presented photographs of the exterior and several photomacrographs. Since the exact locality of find probably never will be known, the coordinates given above are those of the town La Porte.

COLLECTIONS

Chicago (10.0 kg main mass and 1,580 g slices), Washington (1,490 g), Tempe (48 g), London (43 g).

DESCRIPTION

The irregular, angular mass weighed 14.56 kg (32 pounds) when received by the Field Museum, but the dimensions were not given in the paper by Roy & Wyant (1950b), and the scale under their Figure 59 appears to be incorrect, since it would correspond to a considerably larger mass. The endpiece, of 1.5 kg, in the U.S. National Museum shows that La Porte is a weathered mass, covered with 0.5-2 mm thick, terrestrial oxides. All traces of fusion crust are corroded away, and no heat-affected rim zones are found on the sections. Corrosion penetrates many centimeters into the mass, particularly along phosphides and grain boundaries. The irregular, shallow depressions upon the surface are 2-6 cm across and may reflect atmospheric sculpturing, but their shape is now modified significantly by corrosion. In the crust are numerous, 0.5-1 mm wide, patches of a dark green mineral, which cannot be ferrous chloride, as believed by Roy & Wyant, but may be one of several green minerals produced by weathering as, e.g., nickel serpentine or cassidyite.

Etched sections display a medium Widmanstätten structure of straight, long ($\frac{L}{W} \sim 25$) kamacite lamellae with a width of 1.05±0.15 mm. The kamacite is of the hatched ϵ-form, associated with peak pressures above 130 k bar. The hardness is only 230±10, indicating some annealing after the shock-hardening. Plessite covers about 35% by area, mostly in form of open-meshed, comb and net plessite. The

LA PORTE – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Scott et al. 1973	7.88								21.5	43.1	1.4	

fields may attain rather large sizes, as, e.g., 8 x 6 mm. The more nickel-rich fields are converted to fine-grained, duplex $\alpha + \gamma$ structures, often unresolvable with a 45x objective (HV 300±15). Between the interior duplex structures and the framing homogeneous taenite (HV 390±30) there appear martensitic zones, probably reflecting a fixed, intermediate nickel content (HV 410±30). The taenite etches in bluish and brownish tones, probably indicating a certain amount of carbon in solid solution.

Schreibersite is common as 25-50 μ wide grain boundary precipitates, and as 5-50 μ irregular blebs inside the various plessite fields. The finer the duplex $\alpha + \gamma$ development, the finer the associated schreibersite. A small amount of 1-2 μ thick rhabdites is present in the kamacite but obscured by the ϵ-hatching. The bulk phosphorus content is estimated to be 0.15-0.20%.

Troilite occurs as scattered nodules and elongated bodies, e.g., 3 x 2, 2 x 1 and 10 x 0.5 mm in cross section.

La Porte is a medium octahedrite with annealed shock structures. It is related to Trenton, Canton and Lanton, and belongs to group IIIA. It is not a paired fall with Plymouth which apparently was found not too far away. It is also different in several details from Trenton, a shower which occurred north of Chicago.

Specimen in the U.S. National Museum in Washington:
1,490 g endpiece (no. 1479, 12 x 10 x 3 cm)

La Primitiva, Tarapaca, Chile

19°52′S, 69°54′W

Schreibersite-rich hexahedrite. ϵ-structure, and shock-melted troilite. HV 280±25.

Anomalous. Bulk composition: 5.8% Ni, 1.7% P, 0.2% S, 32 ppm Ga, 39 ppm Ge, 0.04 ppm Ir.

HISTORY

At least four different masses, totaling about 13 kg, were found in the years 1888-1911 in the desert of Atacama, about 65 km from the coast towns of Pisagua and Iquique. A fifth mass of 9 kg was reportedly found in 1907 on a mountain of the Sierra Gorda, 350 km further south, and appears to be a transported fragment (Hey 1966: 264). A sixth mass of 5.4 kg was in March 1973 discovered by the author in the La Plata Museum, mislabeled Tarapaca. The old label read "Siderit. Tarapaca, Chile. Descubierto en 1889. Peso 5,400 g", but the unique structure of an exposed cut surface clearly identified the mass as a fragment of La Primitiva. The 5.4 kg mass has previously only been very inadequately described by Radice (1959). See also Tamarugal (Tarapaca).

La Primitiva was first seen by Ward, who on his Chilean journey in 1889 acquired (only!) a 28 g fragment from a 3 kg mass which had been found near the nitrate works at La Primitiva, Salitra. Part of this mass, or perhaps a different one, was apparently acquired early by Brezina who owned 1.2 kg (Wülfing 1897: 284) and was able to give the first description, accompanied by a photomacrograph (Brezina 1896: 297). Cohen (1897d: 122; 1905: 72) described and analyzed Brezina's material.

In 1904, 1906 and 1911 the British Museum purchased three masses of 4,065 g, 1,480 g and 4,341 g, respectively. The first had been picked out from between the jaws of one of the crushers of the Angela Nitrate Co. Ltd., at the Oficina Angela, and all of them had been found close to the works. Prior (1914) described them with photomacrographs and an analysis and concluded that they were nickel-poor ataxites from the same parent mass as La Primitiva. The distance between the localities is about 19 km, according to Prior, who also gave their coordinates. The coordinates quoted here are the average of Prior's coordinates, indicating the "midpoint" of the line of showering. Berwerth (1914: 1078) believed that the material had been artificially reheated; this is probably only true of a very minor part. The specimens I have seen in various collections appear to be undamaged, except for mechanical damage, as particularly well demonstrated by the 4,065 g mass which was chewed by the jaw crusher (see, e.g., Prior 1914: plate 6, figure 1). Owen & Burns (1939) determined the α-parameter by X-ray diffraction, and Perry (1944: plate 10) gave two photomicrographs showing the hatched ϵ-matrix. Buchwald (1966: 30), Axon (1968a: 222) and

LA PRIMITIVA – SELECTED CHEMICAL ANALYSES

Sjöström's analysis was performed on material free of large schreibersite inclusions. Reed (1969) examined the kamacite with the probe and found 5.1% Ni and 0.18% P. It appears that this phosphorus concentration is too high for a solid solution and reflects the presence of a large number of small rhabdites, more or less unresolvable with the probe technique. Moss (quoted by Reed 1969) isolated a large schreibersite inclusion and found 11.4% Ni, 0.25% Co, 71.8% Fe, 15.6% P.

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Sjöström in Cohen 1897d	4.72	0.71	0.18	300	200		tr.					
Moss in Hey 1966	5.1	0.55				1	98		34	40		
Smales et al. 1967						<5	94	<1	30	38		
Crocket 1972											0.034	2.1
Scott et al. 1973	4.9								33.3	37.3	0.039	

Axon et al. (1968: 589) have recently discussed the structures briefly.

COLLECTIONS

London (the main masses of the finds in 1904, 1906, 1911 and 1907, totaling 17 kg, and 196 g of La Primitiva), La Plata (5.4 kg), Harvard (978 g), Ann Arbor (480 g), New York (174 g), Bally (109 g), Washington (93 g), Bonn (47 g), Berlin (32 g), Chicago (30 g), Vienna (23 g), Sarajevo (20 g), St. Louis (20 g), Prague (12 g), Copenhagen (2 g).

DESCRIPTION

The largest mass, of 9 kg, now weighs 6.53 kg (Brit. Mus. no. 1927, 77). It was a complete individual mass covered by distinct regmaglypts, 15-20 mm across and 5-10 mm deep. Sections display abundant rosette schreibersite and a 2 mm wide heat-affected α_2 zone. In one place a 20 mm troilite nodule is partly burned out in the atmosphere.

The 4,065 g mass (Brit. Mus. no. 86831) is also a complete individual mass, measuring 12 x 9 x 9 cm. It has never been cut and examined but is believed to belong to the other masses.

The small masses are of irregular shape with jagged pieces of iron projecting in many directions. This is, as observed by Prior (1914), essentially due to the fact that the iron is honeycombed by schreibersite, and was easily split into numerous fragments in the atmosphere. The individual masses are slightly corroded and partly covered with adhering, whitish caliche, the raw material for the sodium nitrate production. On U.S. National Museum No. 741, a 7 x 7 mm fusion pit in a massive schreibersite crystal indicates that not all the fusion crust has weathered away, and also other sections have preserved 0.1-2 mm wide heat-affected zones of α_2, which stand in marked contrast to the interior acicular structure. The hardness of the α_2 zone is 190±15; it increases rapidly to 280±25 which is the hardness of the unaffected interior (hardness curve type I).

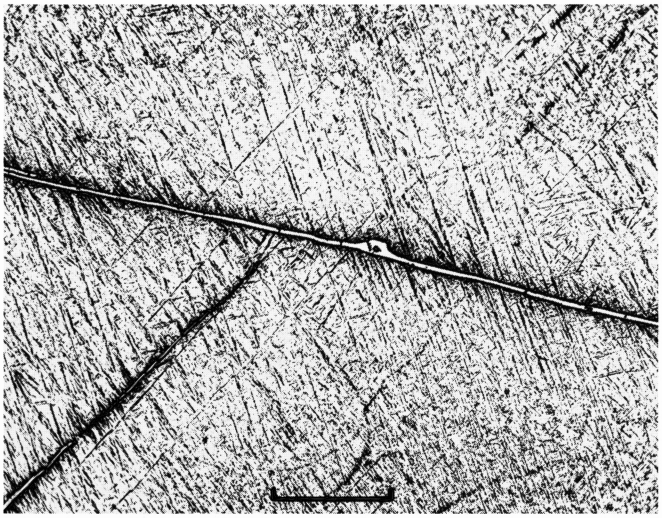

Figure 1042. La Primitiva (U.S.N.M. no. 741). Shock-hatched kamacite and sheared schreibersite lamella. Etched. Scale bar 200 μ. (Perry 1950: volume 3.)

Etched sections are remarkable by their high proportion of schreibersite. It occurs as 0.4-2 mm wide, winding ribbons, as 30 x 10 x 10 mm solid masses, and as rosettes of varying widths around central 10-20 mm large troilite nodules. The morphology resembles that of Bellsbank, Tombigbee, Lake Murray, São Julião and a few other meteorites. The amount of schreibersite in different individuals of La Primitiva ranges from about 5% to about 25% by area. Point counting of five arbitrary sections, totaling 110 cm^2 showed 12.1 cm^2 schreibersite, or 11 x 0.138 = 1.52% P as large inclusions. If we add 0.18% P, present as rhabdites and in solid solution in the matrix between the large inclusions, we find that the total phosphorus content of La Primitiva is about 1.7%.

With 11% schreibersite present, we have about 88% kamacite, allowing for about 1% troilite. Since the schreibersite has about 11.4% Ni (Moss 1969) and the kamacite about 5.1% Ni (Reed 1969), the bulk composition of La Primitiva may be calculated to be about 5.8% Ni and 1.7% P, a result which is useful when considering its cooling history below.

The kamacite is of the hatched, shock-hardened ε-type, associated with peak pressures above 130 k bar. The hardness is 280±25 but decreases in the Ni- and P-depleted zones near the schreibersite hieroglyphs to 230±10. In the kamacite there is a very high concentration of tiny rhabdites, generally less than 1 μ in diameter. Rhabdites in the 5-100 μ range, so common in other low-nickel irons, do occur, but not abundantly. A few, 2-10 μ thick rhabdites are present on the, not too common, subgrain boundaries. High angle boundaries, partially filled with schreibersite veinlets, apparently separate adjacent areas of high schreibersite concentrations, but the observations are uncertain due to the fragmental character of the masses.

The schreibersite is monocrystalline (HV 850±20) but severely fractured and locally displaced in discrete steps, 10-100 μ relative to each other. The adjacent kamacite displays deformation bands and distorted ε-structures but no recrystallization; this is a distinction from Tombigbee.

Troilite occurs as 1-2 cm nodules, surrounded at some distance by rosette-schreibersite. Troilite is also present as scattered spherules, ranging from 50 μ to 5 mm in diameter. These may form series of islands around the larger nodules but inside the rosette-schreibersite. Some troilite occurs completely enclosed by the schreibersite as spherules, 10 μ to 2 mm in diameter. All troilite is shock-melted and resolidified to fine-grained aggregates. The troilite which was in contact with metal dissolved a small part of the kamacite, which was again rejected during the eutectic, rapid solidification to aggregates of 0.5-2 μ grains. Troilite, which was fully enclosed in the schreibersite, resolidified to pure sulfide aggregates of 5-10 μ grains. Both types contain schreibersite fragments, shattered and dispersed in the melt during the shock event. The acicular ε-structure is present right to the edge of the shock-melted inclusions. Daubreelite and chromite were not observed, in harmony with the low bulk chromium content reported by Moss (1966) and

Smales et al. (1967). Graphite was reported by Cohen (1897d; 1905), but this could not be confirmed and appears to be a misinterpretation. A small quantity of bluish-gray, weakly birefringent phosphates is present as 0.1-1.5 mm inclusions in the troilite. Like the schreibersite, they were usually shattered and dispersed through the troilite melts during the shock event.

La Primitiva's bulk composition is about 5.8% Ni, 1.7% P, 0.2% S, the remainder being mainly iron. With this composition it appears that, after an initial cooling period from higher temperatures, the meteorite, at about 1000° C, was still just inside the ($\alpha + \gamma$ + liquid) field but close to the α-corner; compare the ternary diagrams Figures 2-4 in Buchwald (1966). It seems that the last part of La Primitiva to solidify was composed of irregular, phosphorus-enriched cells, several centimeters in diameter, centered about the troilite melts, and squeezed between large, primary α-crystals, the contours of which are difficult to see now because the sections are too small. The last liquid must have solidified around 950° C, but the schreibersite continued to grow by solid state precipitation upon the already existing rosettes and ribbons. The kamacite adjacent to the schreibersite crystals was depleted to a low-nickel (2-2.5%) and low-phosphorus (0.1%) level in the process. At 700° or 650° C the diffusion of nickel and phosphorus was insufficient to enlarge these schreibersite bodies which had reached 11% Ni; continued cooling led to phosphide precipitation at grain and subgrain boundaries and to exsolution of very fine-grained rhabdites in the matrix. It appears that the cooling rate below 650° C was relatively high, since intermediate-sized rhabdites are rather rare. Or perhaps sufficient nuclei were just not available.

At a late cosmic event the mass was subjected to shocks which hardened the matrix and melted the troilite, while the schreibersite was fractured and somewhat faulted.

Structurally, La Primitiva resembles Bellsbank and Tombigbee somewhat. Its trace-element concentration also is in the same range as these meteorites, but La Primitiva is still rather unique.

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

69 g endpiece (no. 741, 5.5 x 2.5 x 1.5 cm, from the 1906 mass)
24 g part slice (no. 2876, 3.3 x 3.5 x 0.2 cm, from Brezina's mass)

Lasher Creek, New York, U.S.A.

About 42°50'N, 74°30'W

A mass of 639 g was found in 1948 at Lasher Creek, Montgomery County, five miles east-southeast of Canajoharie (Hey 1966: 264). No particulars are available.

Las Salinas, Antofagasta, Chile

About 23°S, 69°30'W

A mass of 3,515 g was found in 1905 by E. Rühle, who sold it to the Dresden collection. According to the finder, the meteorite had been discovered in a saltpeter mine, situated near the Antofagasta-Calama railroad, 144 km from Antofagasta. A cut and etched section indicated that it was a medium octahedrite, so it may well be paired with one of the other known North Chilean octahedrites. It was, however, provisionally listed as the independent meteorite, Las Salinas (Schreiter 1912: 61, 71). The meteorite is undescribed and not listed in any catalog other than Schreiter's. It is recommended that it be subjected to a full metallographical and chemical examination, and that it be compared to Baquedano, Joel's Iron, Sierra Sandon and Tamarugal, medium octahedrites from Antofagasta with which it might be related. The reported place of discovery is, in fact, rather close to Baquedano, suggesting that the two masses belong together.

Las Vegas, Nevada, U.S.A.

Approximately 36°25'N, 114°45'W

Coarse octahedrite, Og. Bandwidth 1.9±0.4 mm. Shocked, α_2 matrix.

Group I, judging from the structure. About 7.0% Ni, 0.5% Co, 0.25% P, and significant amounts of carbon and sulfur. Probably a transported Canyon Diablo mass.

HISTORY

A mass of 3,045 g was purchased in May 1939 by the U.S. National Museum from Cliff Whitmore of Las Vegas. It was said to have been found in 1930 by J.P. King in a wash about four miles east of the Comstock Service Station on highway 91, about 30 miles northeast of Las Vegas. It was also said that the mass had been heated at one corner with a torch in an attempt to divide it. It was briefly mentioned by Perry (Contributions of The Meteoritical Society, 1947: Volume 4:84), who classified it as a coarse octahedrite.

COLLECTIONS

Washington (2,826 g), Ann Arbor (111 g).

ANALYSES

The material has not been analyzed.

DESCRIPTION

The meteorite, as received in Washington, was complete, except for a few gram-sized fragments that had been removed from one end. The overall dimensions of the angular mass are 12 x 8 x 8 cm. The surface is covered with terrestrial oxides, but in two places there are vesicular, slag-like cakes, 5-10 mm across, which appear to confirm the late artificial reheating. Some chisel and hammer marks are also present, but the mass has only been beaten superficially, not forged, and the general appearance of the exterior is not that of an artificially reheated mass. No fusion crust and no heat-affected α_2 zone could be distinguished.

An etched section displays an indistinct, coarse Widmanstätten structure similar to that known from shock-heated Canyon Diablo specimens. The kamacite lamellae are bulky and short ($\frac{L}{W} \sim 10$) and have a width of 1.9±0.4 mm. The kamacite is granulated α_2, indicating a late heating into the austenite field and subsequent "rapid" cooling, rapid relatively to the original cooling rate of the mass. Taenite and plessite cover 2-5% by area, both in form of comb and acicular plessite. Near the cohenite crystals the plessite is pearlitic, with $< 1 \mu$ wide taenite lamellae, or spheroidized, with 5-10 μ taenite spherules. All taenite and plessite is somewhat blurred due to short-range diffusion, that must have occurred when the late $\alpha \rightarrow \gamma \rightarrow \alpha_2$ transformation took place.

Schreibersite is common as 10 x 2 or 5 x 1 mm skeleton crystals, as 10-100 μ wide grain boundary precipitates, and as partially destroyed 0.1-1 mm rim zones around the troilite inclusions. The schreibersite is recrystallized to an aggregate of 20-50 μ units, which is rarely seen except in shock-heated Canyon Diablo specimens. Rhabdites are very common as 5-15 μ prisms; they have reaction haloes and thorns protruding into the α_2 matrix, again indicating significant reheating of short duration.

Troilite is present as 5-15 mm vesicular nodules in the sections and on the surface. It turns out that the slag-like cakes on the surface are, in fact, weathered troilite nodules of a special morphology. They are shock melted and have injected 1-30 mm long veins of melted material into the surrounding matrix. The cohenite and graphite, associated with the troilite, have melted and solidified to ledeburitic spherules, 10-100 μ in diameter, which became dispersed in the sulfide melt. The associated schreibersite only melted partially, but the unmelted fragments recrystallized. By terrestrial weathering the curious assemblages have developed into vesicular cakes of an unusual appearance.

Cohenite is confined to about 20% of the sectioned area, where it is developed as rounded, branched crystals inside the kamacite lamellae. Its size ranges from 2 x 0.5 mm to 10 x 0.8 mm; and windows of kamacite, taenite and schreibersite, 100 x 500 μ, are common. Both the cohenite and the schreibersite are recrystallized, in patches, to 5-50 μ grains. A former rim zone, 40 μ wide, around the cohenite of bainite-martensite is decomposed to ferrite-cementite in a finely granulated texture.

In an attempt to verify the loose oral report of an artificial reheating, a thorough search for high temperature intercrystalline oxidation products and for reaction zones between the meteoritic minerals and the corrosion products was instigated, however, in vain. If reheating by man has taken place at all it must have been to low temperatures ($< 600°$ C), for short times and very locally. The structure, as described above, is in all essentials a genuine one.

The only known meteorite with a similar structure is Canyon Diablo and then only the most intensely shocked specimens. But Meteor Crater is 375 km east-southeast of the locality of the Las Vegas meteorite! If the report of the locality is true, we have, then, a fragment hurled an almost incredible distance from the crater, or we have an independent meteorite which was severely shocked by some cosmic event and happened to have the same structure as Canyon Diablo. On the other hand, the information of the early history is no better than it leaves room for an interpretation of Las Vegas as a transported specimen of Canyon Diablo.

Las Vegas is structurally indistinguishable from Canyon Diablo specimens of the shock-heated type. Its composition is about 7.0% Ni and 0.2% P with significant amounts of carbon. It is a normal member of the group I irons.

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

2,680 g	main mass (no. 1329, 12 x 7.5 x 6.5 cm)
146 g	slice (no. 1329, 11 x 4 x 1 cm)

Laurens County, South Carolina, U.S.A.

Approximately 34°40'N, 82°10'W, 150 m

Fine octahedrite, Of. Bandwidth 0.30±0.05 mm. Neumann bands. HV 186±8.

Anomalous. 13.1% Ni, about 0.3% P, 10.5 ppm Ga, 22.4 ppm Ge, 7.9 ppm Ir.

HISTORY

A mass of about 2.1 kg was found in 1857 in the northwestern corner of Laurens County. The approximate coordinates are those given above, while those in Hey (1966: 265) must be a printer's error. The mass was deposited in Laurens Court House and exhibited in New Orleans in 1884-85 before it was acquired by Hidden (1886a, b) who described it with three photomacrographs. He noted that the mass was composed of two austenite crystals which were in twin position, probably the first observation of this kind. Most of his other structural observations are, however, disputable. Brezina (1886) acquired the whole mass for the Vienna collection and described it briefly (1896: 234, 269). Cohen (1905: 262) gave a full description, and Brezina & Cohen (Atlas 1886-1906: plate 24) presented three photomacrographs.

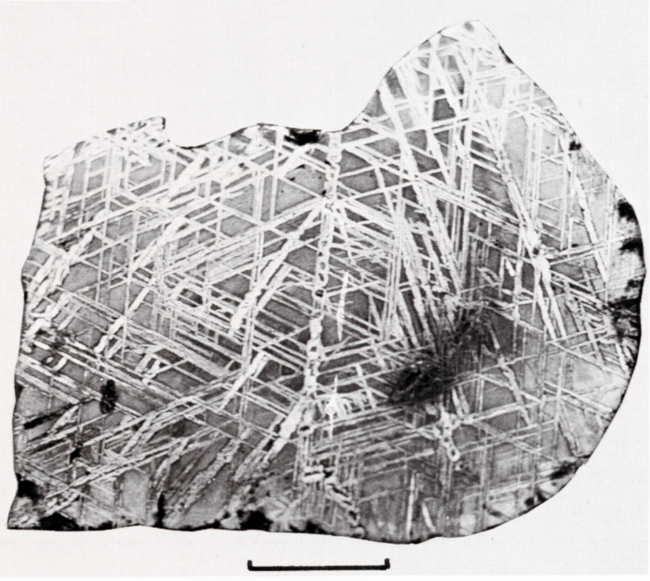

Figure 1043. Laurens County (Vienna no. D 21866). A 1 mm thick slice with a $(111)_\gamma$ twin boundary vertically through the picture. One Widmanstätten direction is common to the left and right twin. Slightly altered fusion crust and heat-affected α_2 zone to the right. Deep-etched. Scale bar 20 mm.

Himmelbauer (1909) thoroughly discussed the twin relationship and based his method of orienting sections through octahedrites upon studies of Laurens County and Gibeon. Hey (1942) reexamined the data and confirmed the observations. Perry (1944) gave a metallographical description with eight photomicrographs. Axon & Faulkner (1967) included Laurens County in their discussion of the possible modes of twin formation in three meteorites and gave a photomacrograph.

COLLECTIONS

Vienna (1,537 g), Chicago (81 g), Budapest (81 g), London (61 g), New York (40 g), Prague (40 g), Paris (39 g), Washington (12 g).

DESCRIPTION

The overall dimensions of the mass are approximately 9 x 8 x 7 cm. It has been described as having a cuboidal form with a smooth, cone-shaped face at one end. It is weathered and covered with a thin crust of terrestrial oxides; but, in slight depressions, the somewhat altered fusion crust, consisting of, e.g., a 60 μ metallic layer plus a 100 μ magnetite layer, is still preserved. In sections, the heat-affected α_2 zone is found to range from 1 to 4 mm, depending on the angle of section with the surface and the local amount of weathering. Micromelted phosphides are present in the exterior part of the α_2 zone. The microhardness of the α_2 zone is 200±10. It decreases to a minimum of 155 in the recovered transition zone, and then it increases to interior values of 186±8 (hardness curve type II).

It appears that Laurens County was an oriented fall. It must be of some terrestrial age, since selective corrosion has converted the alpha phase of the duplex plessite fields to "limonite," and has penetrated a considerable distance along the schreibersite and troilite inclusions. Locally, at the surface of one end is heavy plastic necking which indicates that the mass split in the atmosphere; the other fragment has apparently never been recovered.

Etched sections display a beautiful Widmanstätten pattern of straight, long ($\frac{L}{W} \sim 20$) kamacite lamellae with a width of 0.30±0.05 mm. Neumann bands are present in limited amounts in most lamellae. The hardness is 186±8. Plessite occupies about 60% by area, mostly as duplex $\alpha + \gamma$ fields and as martensitic fields. The duplex fields (HV 250±25) are densely loaded with ragged taenite bodies, 1-10 μ across; intercalated with the kamacite and taenite

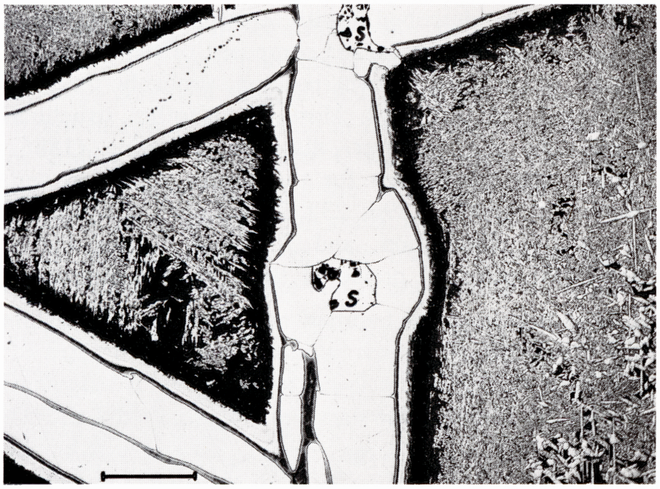

Figure 1044. Laurens County (U.S.N.M. no. 535). Prominent plessite fields, the triangular one showing cloudy taenite rims, tempered martensitic transition zones and untempered martensitic interiors. Schreibersite (S). Etched. Scale bar 400 μ. (Perry 1950: volume 3.)

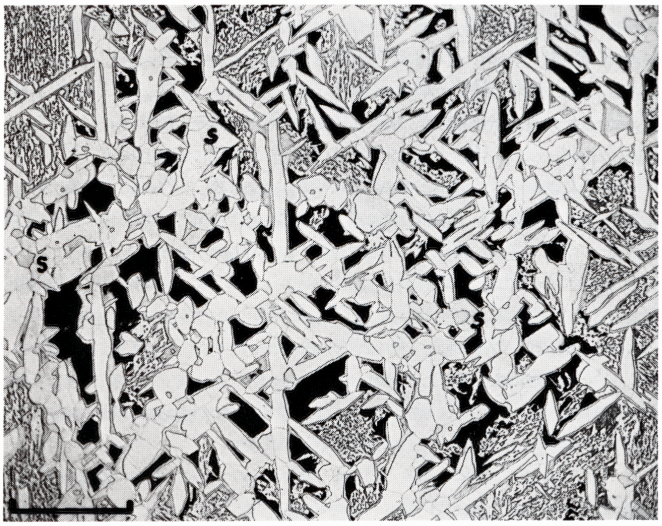

Figure 1045. Laurens County (U.S.N.M. no. 535). Part of a plessite field similar to the one on the right in Figure 1044. Acicular kamacite spindles repeat the bulk Widmanstätten pattern. Numerous schreibersite crystals (S), only three are indicated. Etched. Scale bar 200 μ. (Perry 1944: plate 15.)

LAURENS COUNTY – SELECTED CHEMICAL ANALYSES

The cobalt appears high, and the phosphorus value is probably too low. Hidden (1886a) believed that he saw solid lawrencite in one of his sections, and his observation is quoted (Mason 1962a: 60) as one of the few, good reports on this mineral. Hidden was, however, in error since what he reported was probably one of the corroded intergrowths of troilite and schreibersite characteristic for Laurens County.

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Mackintosh in Hidden 1886a	13.34	0.87	0.16									
Wasson & Schaudy 1971	12.95								10.5	22.4	7.9	

are many schreibersite bodies of comparable dimensions. A particular variety is rich in acicular kamacite, about 5-20 μ wide, and such fields resemble the matrix of Arltunga and Butler. The martensitic variety (HV 405±40) displays platelets parallel to the octahedral structure. Martensite is further common as a zone, squeezed between the framing taenite and the duplex interior of many fields. The taenite on the 30% nickel level (HV 350±25) is unusual in its etching charactristics and displays numerous zigzag fissures, but the reason for its peculiar structure is not clear. Can it be carbon or phosphorus in solid solution?

Most specimens in collections (e.g., Vienna, London, Prague) are parallel sections through the mass, cut perpendicular to the octahedral twin plane (111), the traces of which may be followed on the weathered surface of the mass. Each section displays two individual crystals, with three Widmanstätten directions almost in mirror position and the fourth parallel to the twin plane. The twin plane is also the plane of intergrowth and is remarkable by its development as a 1-2 mm wide kamacite zone with numerous 1-2 mm long and 0.5 mm wide schreibersite-troilite intergrowths. In those parts of the twin plane which were poor in inclusions, the austenite has transformed to ferrite of 0.5 mm bandwith. In other words, the wide ferrite zones of the twin boundary are mainly swathing kamacite nucleated upon the inclusions before the Widmanstätten transformation took place. The reason that the twin plane may be traced upon the exterior is probably that the inclusions ablation-melted preferentially in the atmosphere and left a series of shallow grooves.

Schreibersite occurs as 1-2 mm irregular blebs and as 50-250 μ wide bodies, centrally, in some kamacite lamellae. It is monocrystalline but slightly brecciated. It is further present as 5-25 μ wide grain boundary precipitates and as 1-10 μ substitutes for taenite in the plessite interiors.

Cohenite has been reported by Brezina (1896: 269), but its occurrence could not be confirmed.

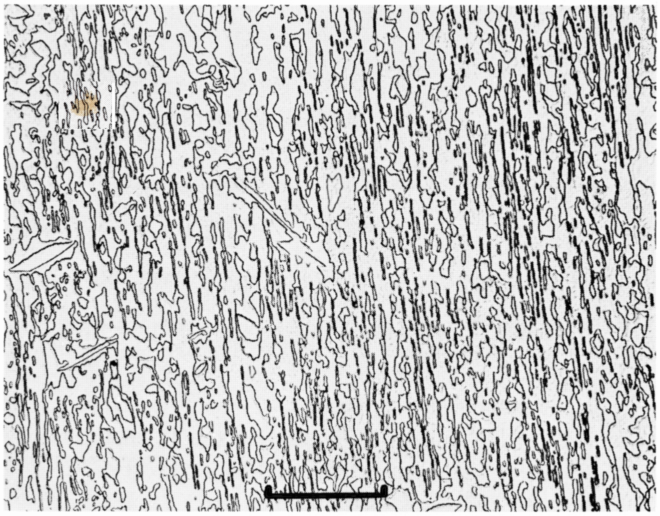

Figure 1046. Laurens County (U.S.N.M. no. 535). Duplex plessite within another field. The α - γ mixture shows pronounced orientation, compare, e.g., Kokomo Figure 1013. Etched. Scale bar 40 μ. (Perry 1944: plate 16.)

Troilite is present as 0.5-1 mm nodules enveloped in 0.1 mm schreibersite and 0.2-0.4 mm swathing kamacite. It was, unfortunately, not present in any of the microsections prepared.

Laurens County is an anomalous iron which resembles Carlton somewhat but is different in, among other things, its lower phosphorus content and the trace-element concentrations.

Specimen in the U.S. National Museum in Washington:
12 g part slice (no. 535, 3 x 1.5 x 0.2 cm)

Lazarev, Humboldt Mountains, Antarctica

71°57′S, 11°30′E; 3,000 m

Probably a pallasite. Probably polycrystalline taenite. Bandwidth 0.8±0.2 mm. Neumann bands.

Group unknown. Above 10% Ni, 0.23% P.

HISTORY

Two fragments of about 8 kg and 2 kg were found in January 1961 on a southern spur of the Humboldt Mountains, behind the Antarctic Princess Astrid Coast (Meteoritical Bulletin, No. 20, 1961). The material was described, with figures of the exterior and of an etched section, by Ravich & Revnov (1963) who had found the meteorites during the 6th Soviet Antarctic Expedition. When geological mapping of a gneiss-diorite terrace situated only 30-40 m from a fringe of the glacial sheet was carried out, the meteorites had been discovered among debris that covered the terrace as a 10-20 cm thick sheet. They were lying 6-8 cm from each other, in 2-3 cm deep depressions in the sandy gravel. They were named after one of the Expedition's bases, Lazarev, situated 230 km north of the actual site of discovery. The discoverers classified Lazarev as a coarse octahedrite, but the information given below proves this to be unsatisfactory.

COLLECTIONS

Leningrad (the larger mass), Moscow (the smaller mass).

ANALYSES

Ravich & Revnov (1963) reported 10.05% Ni, 0.67% Co, 0.23% P and 0.02% Cu. They also identified small olivine grains.

DESCRIPTION

The following is based on notes taken during a brief examination of the two masses in Russia. The largest mass, which may weigh between 6 and 7 kg and thus somewhat less than originally reported, measures 15 x 13 x 10 cm in three perpendicular directions. The other mass, of 2 kg, measures 10 x 8 x 6 cm. Both are significantly weathered, displaying a distinct Widmanstätten grid on large parts of the surfaces. Fusion crusts and heat-affected α_2 zones are apparently lost due to weathering.

The largest mass displays an unusual fissure with slightly slanting walls, being 7 cm deep, 8 cm long and 6-8 cm wide. The fissures are developed along prominent parallel octahedral planes; locally, metallic bridges still connect the two sides of the fissure but are visibly strained by plastic deformation. The origin of the fissures is uncertain, but the most likely explanation involves the action of alternative frost and thaw. It appears that an early fine fissure, so common in meteorites, has been filled with water by capillary action. In each successive winter the freezing water expanded the crack slightly and slowly wedged the meteorite open. The smaller fragment, found only a few centimeters away, may be a fragment separated entirely by the same mechanism. This fragment also displays octahedral fissures, however, on a minor scale. It appears less likely that the large fissure formed during the atmospheric flight, because (i) the atmospheric sculpture has in all other places disappeared long since, due to corrosion; (ii) the two fragments were found side by side and seem to be bordered by octahedral cleavage faces that may be roughly fitted together; (iii) the morphology of the fissures and the bridges across it suggest a slow process rather than a violent atmospheric breakup.

Etched sections display a medium Widmanstätten pattern of short, somewhat bulky ($\frac{L}{W} \sim 10$) kamacite lamellae with a width of 0.8±0.2 mm. The bandwidth of 1.5-2 mm reported by Ravich & Renvov (1963) was apparently based on measurement of non-characteristic lamellae, perhaps those with significant schreibersite inclusions. The kamacite is rich in subboundaries and Neumann bands.

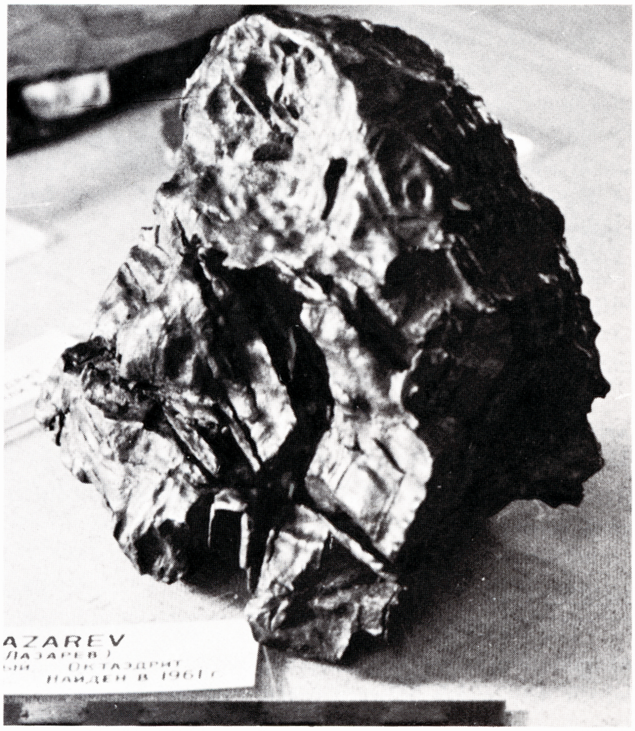

Figure 1047. Lazarev (Moscow). The 2 kg mass in Moscow. The weathered meteorite displays a distinct Widmanstätten grid on part of the surface. Octahedral fissures are present. Ruler divided in cm.

Taenite and plessite cover 10-15% by area. Comb and net plessite are common, and dense dark-etching duplex $\alpha + \gamma$ fields also occur. The plessite fields are slightly different from those of normal octahedrites and resemble those of pallasites, such as Glorieta Mountain and Brenham.

Schreibersite is common as subangular crystals up to 1 x 0.5 mm in size; as 0.1-0.3 mm blebs, centrally, in some kamacite lamellae; and as minute bodies associated with plessite. Rhabdites, 1-10 μ in size, are common in many kamacite lamellae. An 8 mm troilite nodule with a few 0.1 mm grains of olivine was noted in the Leningrad sample but could not be further examined.

From the very preliminary description above, it appears that Lazarev is not a coarse octahedrite as believed by Ravich & Revnov (1963). It occurs to me that a bandwidth of 0.8 mm, associated with above 10% nickel, and troilite with scattered olivine grains, strongly suggest that Lazarev is the metal-rich fragment of a pallasite related to Brenham, Glorieta Mountain and similar pallasites. From an examination of the weathered surface of the smaller Lazarev mass, I assume that the material is, moreover, polycrystalline, being composed – like many pallasites – of several inch-sized precursor taenite crystals.

I suggest that Lazarev be reexamined and reanalyzed with this supposition in mind. A determination of the specific gravity for the two masses might indicate which one is the most promising to investigate for larger olivine concentrations.

Lebedinnyi, Amur, Siberia

According to Hey (1966: 266) a mass of 410 grams was found in 1925 at 55°57'N, 125°24'E near the head of the Zeya River, a tributary of the Amur. The mass, which possibly was an octahedrite, was in the collection of N.N. Padurov of Leningrad, but was lost before it could be examined.

Leeds, Quebec, Canada

46°18'N, 71°20'W; 300 m

Coarse octahedrite, Og. Bandwidth 1.30±0.15 mm. Neumann bands. HV 210±25.

Group I. 8.04% Ni, about 0.25% P, 67.1 ppm Ga, 241 ppm Ge, 2.1 ppm Ir.

HISTORY

A mass of 1,445 g, listed as "magnetite from Leeds, Quebec" in the mineral collection of the Laval University, was identified as a meteorite by Nininger (1933c: 167; Nininger & Nininger 1950: 112 and plate 5). Perry (1944) presented two photomicrographs typical of the pearlitic and spherulitic plessite fields of Leeds, but otherwise the meteorite appears to be undescribed.

COLLECTIONS

Tempe (597 g), London (194 g), Chicago (80 g), Harvard (77 g), Ottawa (59 g), Washington (20 g), Ann Arbor (13 g).

DESCRIPTION

The approximate dimensions of the angular mass were 12 x 7 x 4 cm. An examination of the specimens in Tempe and Washington shows that both the fusion crust and the heat-affected α_2 zone have been lost by weathering. Selective corrosion has especially attacked the ferrite adjacent to rhabdites and schreibersite and the ferrite of the fine plessite fields. The troilite contains several pentlandite veins.

Etched sections show that Leeds is a border case between medium and coarse octahedrites. The bandwidth of the straight ($\frac{L}{W} \sim 15$) kamacite lamellae is 1.30±0.15 mm, but since the meteorite has many structural features in common with the coarse octahedrites, and few with the medium, Leeds is best classified as a coarse octahedrite. The kamacite has subboundaries decorated with 1-5 μ phosphides, and it has well-developed Neumann bands. The microhardness is 210±20.

Taenite and plessite cover 15-25% by area, the comb plessite areas sometimes attaining dimensions of 8 x 8 mm. Such large comb plessite fields are then subdivided into cells, each having the taenite combs aligned along one of the major Widmanstätten directions. Pearlitic plessite is very common; the individual taenite lamellae of the pearlite are 0.5-2 μ wide. Sometimes a pearlitic rim envelopes a spheroidized interior where the taenite spherules are 5-25 μ across.

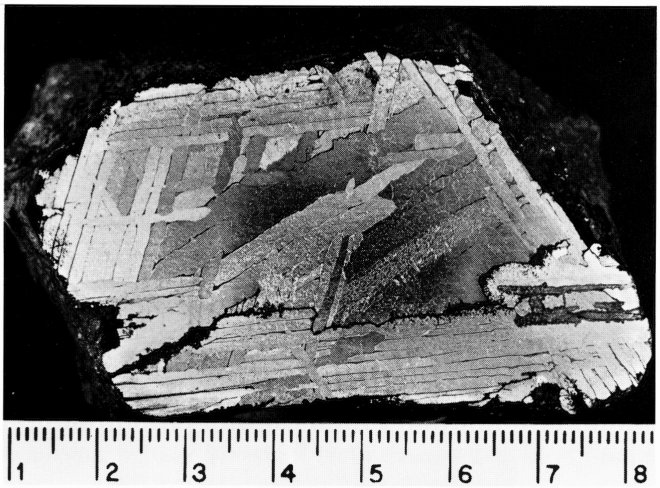

Figure 1048. Leeds (Tempe no. 69a). A meteorite which, in its bandwidth, is intermediate between the coarse and the medium octahedrites. Structurally, it closely resembles Toluca. To the right, a schreibersite skeleton crystal with cohenite rim. Deep-etched. Scale in centimeters. (Courtesy C.B. Moore.)

Schreibersite occurs as 10-15 mm long and 1-2 mm wide H- and L-shaped skeleton crystals. They are monocrystalline but brecciated. They normally have a 100-200 μ wide cohenite rim which also is brecciated but free of graphite precipitates. Schreibersite is further common as 20-150 μ wide grain boundary precipitates and as 5-50 μ wide blebs inside the plessite fields. Rhabdites, 5-15 μ across, are common. The bulk phosphorus content is estimated to be 0.25%.

Troilite-graphite-silicate nodules occur as scattered bodies, 2-4 mm in diameter. They have served as nuclei for precipitation of continuous rims of 1 mm schreibersite plus 0.1-0.2 mm cohenite. The troilite is monocrystalline and has about 5% by area of daubreelite in the form of parallel, 1-10 μ wide lamellae. The graphite is normally composed of numerous, unordered sheaves, but a local 50-150 μ cliftonite crystal may be found, either in the schreibersite or in the kamacite. The silicates, which were not examined in thin section, consist of subhedral, 50-200 μ crystals, probably mainly olivine and pyroxenes, mixed with graphite and troilite.

Both the schreibersite-cohenite crystals and the complex troilite nodules are enveloped in 2-3 mm wide rims of swathing kamacite which nucleated and grew before the Widmanstätten structure formed. Late ferritic grain growth has further pushed some of the rim boundaries outwards.

Leeds is a typical, inclusion-rich octahedrite, closely related to, e.g., Bischtübe, Deport, Toluca and Balfour Downs. Chemically, it is a typical group I member.

Specimen in the U.S. National Museum in Washington:
20 g slice (no. 4837, 3 x 3 x 0.5 cm)

Lefroy, Tasmania

According to Hey (1966: 267), a minute piece of iron of about 0.2 grams was found in alluvial drift 27 miles northwest of Launcestown. It is now preserved in the Queen Victoria Museum in Launcestown. It is recommended that the sample and its history be reexamined in order to verify the meteoritic nature of the surprisingly small mass. The smallest individual iron meteorites recognized so far weigh 200 grams or more, as may be seen from Table 21.

Lenarto, Slovakia, Czechoslovakia

49°20′N, 21°1′E; 900 m

Medium octahedrite, Om. Bandwidth 1.15±0.20 mm. ε-structure. HV 215±10.

LEEDS – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	**Ni**	**Co**	**P**	**C**	**S**	**Cr**	**Cu**	**Zn**	**Ga**	**Ge**	**Ir**	**Pt**
Goldberg et al. 1951	8.08								75.7			
Wasson 1970a	7.99								67.1	241	2.1	

Group IIIA. 8.78% Ni, 0.53% Co, 0.3% P, 21.7 ppm Ga, 43.5 ppm Ge, 0.33 ppm Ir.

HISTORY

A mass of about 108 kg was found in 1814 by Ruthenian peasants "on one of the highest summits of the Carpathians" (Tehel 1815). According to Sennowitz (1815), the mass was found on a forest-covered slope by a shepherd and his friend who were collecting wood on a small cart. The finders believed the mass to be valuable on account of the silvery luster of the fracture, so they transported it to their village of Lénarco. They decided to melt it and cast a church bell from it, but, fortunately, the proprietor of the land, József Kapy, found out, purchased the mass and donated it to the Museum of Natural History in Budapest in 1815 (Tehel 1815; Chladni 1819; Tokody & Dudich 1951). The locality of find appears to be poorly known and various coordinates have been given in the literature. Chladni (1819: 329) says "three hours from Bartfeld," the present Bardejov, and Brezina (1896: 352) adds "west of" Bartfeld. The coordinates given, 49°18'N, 21°41'E, are, however, not at all in harmony with this statement. An examination of old, detailed maps shows Lenarto or Lénarco to be a tiny Carpathian village, a collection of houses rather, about 16 km west of Bardejov and 2 km east of the present Polish-Czechoslovakian state line, which corresponds to the above given, new coordinates. "The high summits" of this area range from 750-1000 m, and they are mostly forest-covered, so this must be the place from which Lenarto was hauled in 1814.

It was the Lenarto iron, among others, which was first shown to be built by a surprisingly regular latticework of intersecting, finger-like lamellae, which was named the Widmanstätten structure in honor of its discoverer (Schreibers 1820: 77, plate 8). The term had already been used by Chladni (1819: 330 and elsewhere). Paneth (1960) and Smith (1962) have examined the historical setting of the scene. Partsch (1843: frontispiece and 161) discussed the specimens in Vienna and explained in detail how – in order to get a print made – he deep-etched a Lenarto slice, made a gypsum cast of the etched surface, and then used a type metal (Pb-Sn-Sb-alloy) in order to get a perfect printing block. Good analyses were presented by Wehrle (1835) and Boussingault (1872), while Reichenbach (1862a, b: 630 and other places) made various observations on the structure and, among other things, briefly noted that he had observed plates of iron sulfide, thin as pergament; these were later to carry his name: Reichenbach lamellae. Occluded gases, of which 85% were hydrogen, were examined by Graham (1867). Reed (1965a, b) examined the various phases with the microprobe, and a photomacrograph was given by Tuček (1966: plate 5).

COLLECTIONS

Budapest (73.6 kg main mass and 2.9 kg slices), Tübingen (3,288 g), Vienna (3,243 g), London (2,013 g), Chicago (677 g), Berlin (532 g), Bonn (382 g), Prague (357 g), Calcutta (304 g), Paris (297 g), Washington (208 g), Canberra (190 g), New York (173 g), Dresden (134 g), Yale (121 g), Harvard (119 g), Göttingen (117 g), Tempe (111 g), Ann Arbor (90 g), Leningrad (83 g), Rome (77 g) and smaller slices in numerous other collections. The difficult task of the early cutting took 29 days and was only accomplished when "English clock-spring-steel" saw-bands were taken into use (Sennowitz 1815).

DESCRIPTION

The mass is corroded. In many places the surface is disintegrating into octahedral fragments, due to preferential attack along the Widmanstätten planes. All fusion crust and heat-affected α_2 zone are long since removed by the corrosion, and limonitic veinlets penetrate some centimeters below the surface. The Reichenbach lamellae appear to be corroded in particular.

Etched sections display a medium octahedrite structure of somewhat swollen, irregular ($\frac{L}{W} \sim 15$) kamacite lamellae with a width of 1.15±0.20 mm. The numerous subgrain boundaries of the ferrite are decorated by 0.1-2 μ phosphides. The kamacite appears to be shocked above 130 k bar and displays the typical hatched ϵ-structure, in various shadings. Its hardness is, however, rather low, 215±10, suggesting significant annealing after the shock. Plessite occupies about 30% by area, in the form of comb and net plessite, and in the form of martensite that merges into duplex $\alpha + \gamma$ areas, closely resembling the ataxitic matrix of, e.g., Tlacotepec. The taenite that frames the plessite fields is frequently grayish tinted, particularly near veinlets of terrestrial corrosion products. A typical plessite field will have a tarnished yellow taenite rim (HV 350±15) with an indistinct grid. Then follows a martensitic transition zone (HV 395±15) and then a poorly resolvable, duplex $\alpha + \gamma$ mixture (HV 295±15). The central, easily resolvable $\alpha + \gamma$ mixtures have hardnesses only slightly higher than the adjacent kamacite lamellae.

Schreibersite is common as 3 x 0.5, or 2 x 0.3 mm monocrystalline skeleton crystals, sheathed in rims of 1-1.5 mm swathing kamacite. Schreibersite blebs, 0.2-0.6 mm in diameter, may also be found centrally in

LENARTO – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Moore et al. 1969	8.70	0.53	0.26	90	30							
Scott et al. 1973	8.85								21.7	43.5	0.33	

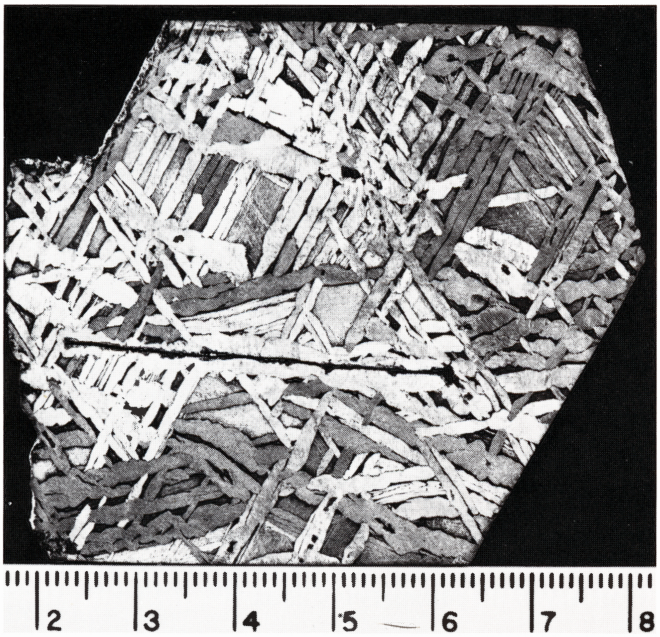

Figure 1049. Lenarto (Tempe no. 70a). A medium octahedrite which is transitional between group IIIA and IIIB. A horizontal Reichenbach lamella of troilite which is now shock-melted and corroded. Deep-etched. Scale in centimeters. (Courtesy C.B. Moore.)

some α-lamellae, but most of the smaller bodies are present as 40-80 μ wide veinlets in the grain boundaries. Some schreibersite occurs as 1-20 μ vermicular bodies inside the plessite fields where they substitute for taenite. Point counting indicated a bulk content for the meteorite of 0.3% P.

Troilite occurs sparsely as 5-25 mm irregular nodules with 0.6 mm rims of schreibersite. The troilite is more common in the form of Reichenbach lamellae that, typically, are 30 x 20 x 0.2 mm in size and occur with a frequency of one per 25 cm^2. The plates originally consisted of troilite upon which irregular "flags" and "sacks" of schreibersite later precipitated. Zones of swathing kamacite, 1 mm wide, developed around the plates before the Widmanstätten structure formed. The troilite of the plates later micromelted and solidified to 2-5 μ fine-grained eutectics of sulfide and iron in which angular fragments of the enclosing schreibersite became dispersed. Sulfide-eutectics, 2-10 μ wide, were injected into fissures in the remaining schreibersite. The morphology indicates that a shock event caused the troilite to melt, evidently because the troilite, due to its compressibility, was heated far above the surrounding metallic matrix. Unfortunately, it appears that the resulting fine-grained structures with finely dispersed iron are very prone to terrestrial oxidation, so in many specimens the Reichenbach lamellae are converted to limonitic pockets. Another reason for the corrosion along the Reichenbach lamellae are the numerous microfissures that follow them, providing easy access for terrestrial water.

Some few specimens have been cold hammered or even reheated artificially. Vienna No. J4919 is a small slab which, about 1840, was forged by Partsch to a 0.5 mm thick plate and then deep-etched to show the characteristic damask produced by the undulating taenite ribbons and the α_2 structure.

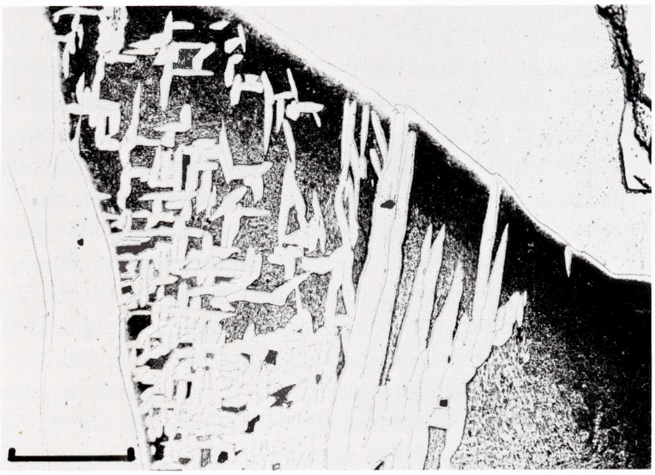

Figure 1050. Lenarto (U.S.N.M. no. 450). Acicular plessite field and the corroded end of a troilite-schreibersite Reichenbach lamella (above, right). Lightly etched. Scale bar 200 μ. (Perry 1950: volume 7.) See also Figure 23.

Graphite nodules have been reported by Reichenbach (1862b), but this could not be confirmed and is probably a misinterpretation of some corroded troilite nodules.

Lenarto is a shock-annealed medium octahedrite with ϵ-structure and several Reichenbach lamellae. It closely resembles El Capitan and, in a wider context, also Cleveland, Sierra Sandon, Drum Mountains and others. It is a transitional member of group IIIA - IIIB with about 0.3 ppm Ir, as shown by Wasson.

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

132 g part slice (no. 450, 6.5 x 5 x 0.5 cm)
17 g part slice (no. 1064, 5.5 x 2 x 0.2 cm)
40 g part slice (no. 2878, 4 x 2.5 x 0.5 cm)

Lexington County, South Carolina, U.S.A.

Approximately 33°57'N, 81°14'W

Coarse octahedrite, Og. Bandwidth 2.1±0.4 mm. Neumann bands. HV 176±9.

Group I. 6.69% Ni, about 0.2% P, 85 ppm Ga, 307 ppm Ge, 2.3 ppm Ir.

HISTORY

A mass of 4.8 kg (10.5 pounds) was found in 1880 upon farm land in Lexington County. Since the exact locality is unknown, the coordinates above are those of Lexington town. The mass was acquired by Professor C.U. Shepard who described it with an analysis (1881a) and correctly noted that it was related to Bohumilitz. Brezina (1896: 269) gave a brief description of the 58 g specimen in Vienna. Berwerth (1902: 15) mentioned an additional 369 g specimen in the Vienna Collection, but apparently we are here confronted with one of the frequent mislabelings of Lexington County.