
Ector County, Texas, U.S.A.

A mass of perhaps 25 kg, briefly mentioned by La Paz (1944: 302), was assumed to be an independent meteorite and labeled Ector County. I have examined a 75 g sample cut from the mass (Chicago no. 2388) and found it to be a typical Odessa specimen. Other samples in Chicago, each of about 0.5 kg weight (nos. 2329, 2330, 2331), were so weathered that they might be termed shale-balls, consisting of rather massive limonite with only minute amounts of uncorroded metal. The Odessa Crater with its numerous associated iron fragments, some of them thoroughly weathered, lies in Ector County, so it is confusing to retain Ector County as an individual iron meteorite. Consequently, it should be deleted, and all material so labeled transferred to Odessa.

Edmonton (Canada), Alberta, Canada

53°40'N, 113°25'W

Hexahedrite, H. Single crystal of ferrite, larger than 15 cm. Decorated Neumann bands. HV 125±5.

Group IIA. 5.37% Ni, about 0.2% P, 60.4 ppm Ga, 172 ppm Ge, 33 ppm Ir.

HISTORY

The mass of 7.34 kg was first recorded by A.D. Nininger (1940). According to a report in the Smithsonian Institution from Professor John A. Allan, Department of Geology, University of Alberta, Edmonton, the mass was plowed up 6-10 km north of Edmonton and 3-6 km east of the road to the Namao Airport. The location is in the east half of Township 54, Range 24, west of the fourth meridian, and the approximate coordinates are given above. The mass was apparently found in the early thirties and was in private possession until it was acquired by Professor Allan for the University of Alberta in 1938. Bauer (1963) found a very low amount of helium isotopes, lower than in any other of the 34 irons, examined by him.

COLLECTIONS

Main mass in University of Alberta, Edmonton. Washington (584 g).

DESCRIPTION

The mass has the average dimensions of 15 x 12 x 10 cm and is partly bordered on four sides by cubic cleavage planes so that the exterior appearance approximates a truncated box. It is covered with 0.1-1 mm adhering oxide scales, but an etched section discloses that a 1-1.5 mm continuous heat-affected α_2 zone is well-preserved. It is extremely interesting, then, that the exterior cube form as we see it now probably closely resembles the

shape that the mass had when circling in cosmos, except for the truncated, rounded portions which were ablation-sculptured during penetration of the atmosphere. In other words, it appears that Edmonton at an early time was dislodged from its "matrix" in the form of a boxlike, cubic cleavage fragment, which was only little modified during the atmospheric flight.

An etched section shows that Edmonton is a normal hexahedrite, a monocrystal with Neumann bands from rim to rim. In the heat-affected zone they are replaced by 50-200 μ serrated α_2 grains, in the outermost 0.2 mm of which may be found micromelted phosphides. It can be

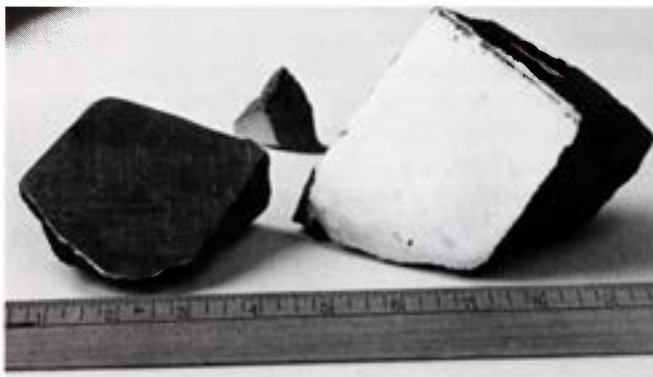


Figure 745. Edmonton (Canada). Main mass in University of Alberta, Edmonton. Note the box shape. Ruler in inches. (Courtesy P.M. Millman.)

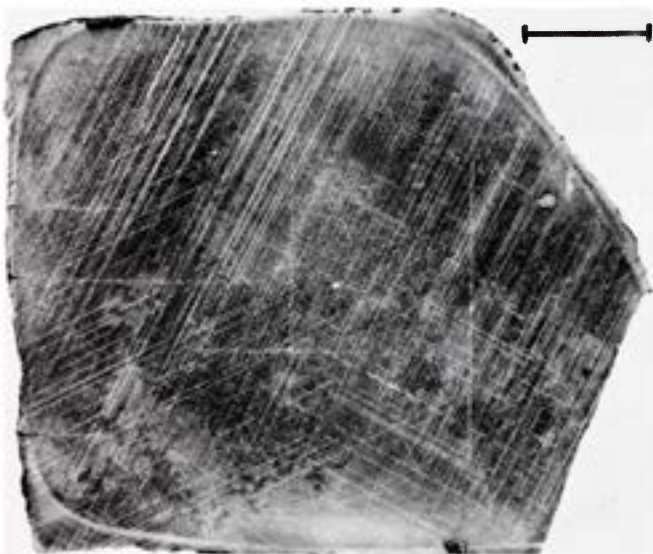


Figure 746. Edmonton (Canada) (U.S.N.M. no. 1634). The Neumann bands are parallel to $(211)_\alpha$ and indicate that the exterior faces are $(100)_\alpha$ cleavage faces. Some imperfect cleavage fissures run horizontally across the picture. The heat-affected α_2 zone is distinctly developed around the whole periphery. Deep-etched. Scale bar 2 cm. S.I. neg. 259.

EDMONTON (CANADA) – SELECTED CHEMICAL ANALYSES

Reference	percentage			C	S	Cr	Cu	ppm				
	Ni	Co	P					Zn	Ga	Ge	Ir	Pt
Wasson 1969	5.37								60.4	172	33	

concluded from this that the mass on the average has lost only a 0.5-1 mm thin skin by corrosion. The Neumann bands on this particular section follow six directions, divided in three sets which are mutually perpendicular; it can be shown that the only case where the traces of the (211) Neumann bands occur in this configuration is on a cube face of the kamacite; see for example Spencer (1951). The Neumann bands are discontinuous and partly resorbed due to some slight reheating, but recrystallization has not started. Some are decorated with 0.5-2 μ rhabdites. The microhardness of the kamacite is 125 \pm 5, but increases steeply to 175 \pm 20 in the heat-affected rim zone (hardness curve type III). Edmonton belongs to the softest meteorites ever recorded, and it must have been thoroughly annealed during its cosmic sojourn. A 5.4% Ni – 0.2% P alloy will only in its annealed state exhibit as low a hardness as 125; compare Buchwald 1966: figures 13-15.

In six different places of the section cubic cleavage planes parallel to the exterior surfaces stand in contrast because they are easily attacked by corrosion and are now filled with thin oxide veinlets. This characteristic is a diagnostic for the cube planes in hexahedrites and may help to orient any hexahedrite.

Schreibersite was not identified on 100 cm², but rhabdites in form of 5-20 μ thick, tetragonal prisms, are very common. Rhabdite plates, typically 10-20 μ thick and 0.5-2 mm large, are also common. They are monocrystalline and distorted only a little, if at all.

Troilite occurs as scattered 1-4 mm nodules that are composed of 5-10 μ grains due to shock melting. Locally, an aggregate of 200 μ daubreelite with tiny troilite and metal grains inside is seen. Two irregular, lobed grains 800 x 200 μ were suspected to be cohenite, but they disappeared during repolishing before the identification could be fully confirmed under the microprobe.

The general appearance of the etched section is mottled; bright and matte patches alternate in an irregular way. Under high magnification it is seen that the main reason for this is the varying concentration of small rhabdites.

Edmonton (Canada) is a typical hexahedrite which closely resembles Scottsville, as described by Buchwald (1967a: figures 53-57). It further resembles Bennett County, Bruno, and Angra dos Reis.

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

584 g slice (no. 1634, 10 x 8 x 0.9 cm)

Edmonton (Kentucky), Kentucky, U.S.A.

36°59'N; 85°34'W; 300 m

Polycrystalline, fine octahedrite, Of. Bandwidth 0.32 \pm 0.05 mm. Neumann bands. HV 230 \pm 15.

Group IIIC. 12.65% Ni, 0.70% Co, about 0.3% P, 24 ppm Ga, 34 ppm Ge, 0.55 ppm Ir.

HISTORY

A mass of 10.2 kg was plowed up in 1942 on the farm of Samp Johnson, about 7 km east of Edmonton, Metcalfe County. It was acquired by the U.S. National Museum in 1943 as a gift from Stuart H. Perry, and it was described with an analysis and photomicrographs by Henderson & Perry (1947). One end had been heated with a blowtorch by the finder in order to detach a specimen, but the metallographic examination showed that the damage to the mass was very local. By now about 10 slices, each 6-8 mm thick, have been cut from this end. Uhlig (1954) reproduced two of the photographs given by Henderson & Perry, while Mason (1962a: figure 54) and Wood (1968: figure 3) gave photomicrographs of two other slices to demonstrate the extremely well developed Widmanstätten structure. Agrell et al. (1963) found a nickel depletion in the kamacite close to the taenite interphase, and Reed (1965a,b) determined the composition of the kamacite, taenite and schreibersite. Short & Andersen (1965) also examined Edmonton with the electron microprobe.

COLLECTIONS

Washington (8,275 g), Moscow (300 g), Sydney (265 g), La Jolla, School of Engineering (257 g), Madrid (246 g), Harvard (165 g), Chicago (151 g).

EDMONTON (KENTUCKY) – SELECTED CHEMICAL ANALYSES

References	percentage			ppm								
	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Henderson & Perry 1947	12.57	0.79										
Goldberg et al. 1951	12.68	0.73							24.7			
Lovering et al. 1957		0.57				1.7	396		22	26		
Nichiporuk & Brown 1965											0.6	0.5
Wasson & Kimberlin 1967	12.7 \pm 0.3								25.4	34.6	0.55	

Analyses for phosphorus and carbon are needed.

DESCRIPTION

The mass has the approximate overall dimensions 24 x 11 x 8 cm, but it is more irregular and distorted in its shape than most irons; and this is not due to corrosion, since the heat-affected α_2 zone is preserved as a continuous rim. The shape resembles a piece of modern, nonfigurative art with knobs, noses and large, irregular indentations; no deep holes or cavities are present. There is no evidence on the surface or on the slices that Edmonton should have fragmented in the atmosphere. It rather represents another extreme in atmospheric sculpturing, widely different from the flat plates of Arlington and Angelica, and from the rather smooth cones or semi-spheres of Avče, Bogou and Bushman Land, but somewhat similar to Mesa Verde and Cruz del Aire.

Etched sections reveal a beautiful, fine Widmanstätten structure of straight, long ($\frac{l}{w} \sim 40$) kamacite lamellae with a width of 0.32 ± 0.05 mm. Since the slices were cut almost parallel to an octahedral plane of the parent austenite crystal, the fourth Widmanstätten direction is observed as 1-1.5 mm wide, irregular ribbons of kamacite with ragged taenite edges. This configuration often confuses the occasional observer. The kamacite shows numerous subgrain boundaries decorated with $0.5\text{-}2 \mu$ rhabdites, and Neumann bands are common. The α -phase has a hardness of 230 ± 15 , indicating slight cold-deformation.

Plessite occupies about 40% by area, mostly as dense, dark-etching fields. While comb plessite with unusually broad taenite ribbons do occur, most plessite is martensitic or of the almost unresolvable, duplex $\alpha + \gamma$ type (HV 290 ± 25). The dark-etching, acicular martensite (HV 425 ± 25) repeats the macroscopically visible Widmanstätten directions. Other, light-etching martensite fields show the acicular-platey martensite type associated with high ($\sim 25\%$) nickel content (HV 360 ± 20). The tarnished taenite rims and the (40μ) wide taenite ribbons have hardnesses of 360 ± 15 . Almost 10% of all plessite fields are characteristic by their carbide-taenite "roses." As discussed under Carlton, these are $100\text{-}200 \mu$ wide intimate

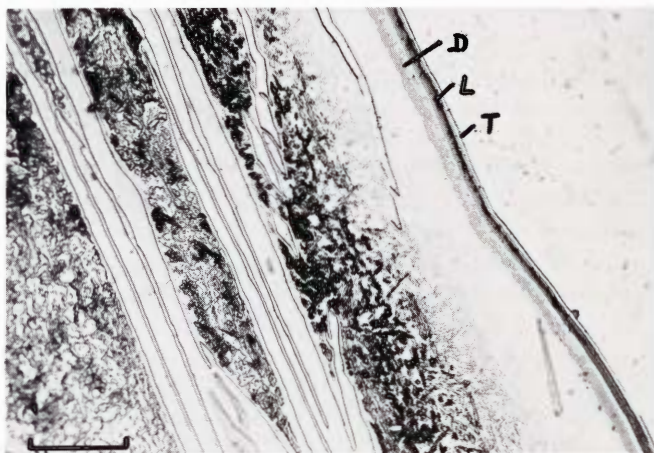


Figure 747. Edmonton (Kentucky). (U.S.N.M. no. 1413). Plessite field. Terrestrial limonite (L) has invaded the boundary between yellow, high-nickel taenite (T) and cloudy, decomposing taenite (D). Etched. Scale bar 40μ . See also Figure 180.

intergrowths of lobed cubic carbides and $1\text{-}5 \mu$ taenite grains. The "roses" do occasionally increase to a volume of $4 \times 4 \times 4$ mm resembling a cavernous sponge. They are particularly easy to identify upon a deep-etched section where they appear as shiny, white patches on a dark, plessitic background. Their immediate surroundings are spheroidized plessite with $2\text{-}10 \mu$ taenite spherules, or pearlitic plessite with $0.5\text{-}1 \mu$ wide taenite lamellae. The carbide roses have hardnesses ranging from 600 to 900, depending upon the amount of inclusions. The adjacent duplex plessite is much softer, about 260-300. The carbide is haxonite (Scott 1971).

The taenite is loaded with carbon in solid solution and etches gray to dark brown. In the heat-affected rim zone the carbon has diffused from the taenite to produce $25\text{-}50 \mu$ wide, light-etching bainite-martensite zones in the surrounding α_2 . The dark-etching taenite has simultaneously become replaced by a yellow, unmottled taenite.

Schreibersite occurs as scattered, large skeleton crystals, typically $15 \times 6 \times 2$ mm, surrounded by $0.6\text{-}1$ mm swathing kamacite. It is further common as 5×0.2 mm elongated crystals centrally in some kamacite lamellae, and as $10\text{-}40 \mu$ wide grain boundary precipitates. While large rhabdites were not seen, the ferritic matrix appears to be rich in microrhabdites less than 0.5μ across. The schreibersite is monocrystalline and little broken, except where incipient corrosion is penetrating near the surface. Based upon the frequency of large and small phosphide inclusions upon 225 cm^2 sections the bulk phosphorus content is estimated to be 0.3%, one third of this being in solid solution and in microrhabdites.

Troilite has only been observed as a few $3\text{-}20$ mm nodules with ragged 0.2 mm schreibersite rims.

Edmonton (Kentucky) is closely related to Carlton, Havana and Mungindi, structurally and chemically, as seen from the discussion above. It resembles Carlton in yet another respect. It is polycrystalline. At one end of one of the U.S. National Museum slices is a distinct grain boundary, separating a small $3 \times 1 \times 1$ cm individual from the

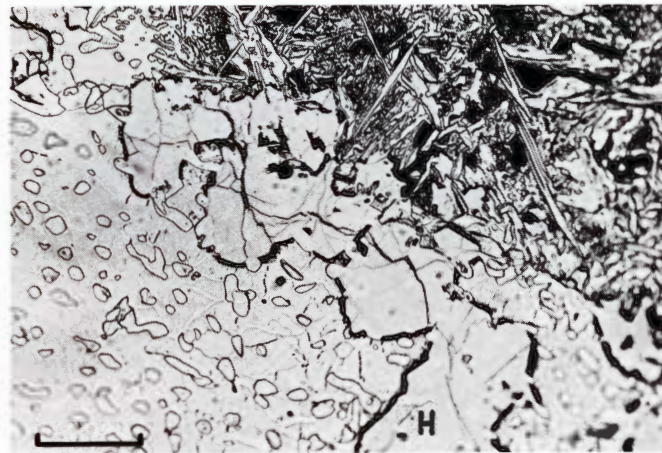


Figure 748. Edmonton (Kentucky) (U.S.N.M. no. 1413). Plessite field with haxonite (H). The haxonite has enveloped several spheroidized taenite particles during its growth in the kamacite. Etched. Scale bar 40μ . (From Henderson & Perry 1947.)

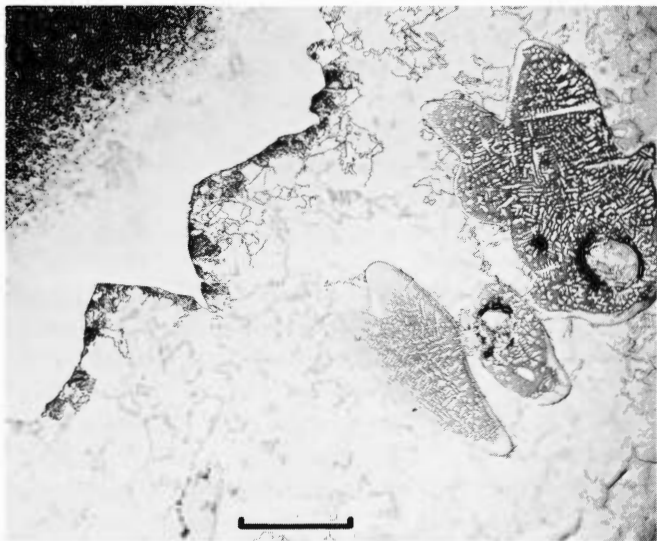


Figure 749. Edmonton (Kentucky) (U.S.N.M. no. 1413). Heat-affected zone A (page 53) with melted schreibersite crystals and unequilibrated α_2 structure. Etched. Scale bar 40 μ . (From Henderson & Perry 1947.)

main mass. The Widmanstätten direction-shift across the boundary shows that the two sides were originally independently oriented austenite individuals. What once was a troilite-schreibersite inclusion in the boundary is now severely corroded. As in Carlton, the morphology resembles Pitts.

The heat-affected zone of α_2 forms a 0.1-2 mm wide continuous rim around all slices examined. In the exterior 40-50% numerous phosphide melts are found. As mentioned above, the significant carbon content of the taenite gives rise to martensitic rim zones. The fusion crust itself is removed by corrosion. The hardness of the α_2 phase is rather high, 230 ± 20 ; it decreases to 190 ± 5 in the recovered transition zone and then increases to the interior hardness of 230 ± 15 (hardness curve type II).

Edmonton (Kentucky) is a fine octahedrite that bears no structural resemblance to the numerous fine octahedrites of the Gibeon-Chinaulta type. It is also much higher in nickel and phosphorus and has its closest relatives in Carlton and Mungindi, meteorites which recently have been grouped together in the resolved chemical group IIIC (Wasson & Schaudy 1971).

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

- 7,300 g main mass (no. 1413, 20 x 11 x 8 cm)
- 368 g slice (no. 1413, 15 x 6 x 0.7 cm)
- 236 g slice (no. 1413, 9 x 5 x 0.7 cm)
- 172 g slice (no. 1413, 9 x 5 x 0.5 cm)
- 162 smaller slices (no. 1413)

Ehrenberg. See Canyon Diablo (Ehrenberg)

Elberton. See Smithonia

Elbogen, Bohemia, Czechoslovakia

50° 11' N, 12° 45' E; 450 m

Medium octahedrite, Om. Bandwidth 0.75 ± 0.15 mm. α_2 matrix. HV 172 \pm 6.

Group IID. 10.25% Ni, 0.64% Co, about 0.3% P, 74 ppm Ga, 87 ppm Ge, 14 ppm Ir.

The whole mass has apparently been reheated to about 950° C in a medieval blast furnace.

HISTORY

A mass of 191 Pfund (probably Viennese, equal to 107 kg) and in the shape of a horsehead, was preserved for centuries in Elbogen before it was recognized as meteoritic by Professor K.A. Neumann of Prague (1812). He collected some important historical data, and Chladni (1819: 327) added some observations, but in essential respects our knowledge is limited by the fact that war and accidental fires have repeatedly destroyed the archives of Elbogen, the present day Loket, 10 km west-southwest of Karlovy Vary (Carlsbad). A summary of Neumann's information follows.

The population of Elbogen recalled several stories in connection with the iron. It was supposed to date back to a time when Elbogen Castle was the seat of the deputy of the Emperor (Burggraf); if this is correct, it must date back to about 1350-1430, since this was the only period when the castle was so used. On one occasion the hated Burggraf, upon summoning his serfs to service, was transformed to a piece of iron, or, as some thought, a bell-bronze. This piece of iron is the meteorite Elbogen which, since that time, has also been called "Der verwünschte Burggraf" or "The bewitched burgrave." The mass was preserved in the basement of the castle, and it was believed that if by some misfortune it was removed, it had the power to come back again. To disprove this tale, and to annoy the Bohemians, the French occupation army in 1742 threw the mass into the 22 klafter (=40 m) deep well of the castle. It remained here until 1776 when the well had dried out, making the mass comparatively easy to get hold of. It was then transferred to the town hall (Rathaus), in the basement of which Neumann found it among other antiquities. In a casual but important remark, Neumann stated that it was believed the mass could not be melted; attempts in the blast furnace (Hochofen) had at any rate been unsuccessful.

Various early analyses showed from 2.5% (Klaproth, about 1810) to 8.5% Ni (Berzelius 1834), sufficient to remove any doubt as to its meteoritic origin. Widmanstätten showed the octahedral structure to be present, and this is the first published mention of these etching figures (Neumann 1812). The first application of the term "Widmanstätten figures" was made a year later by Schweigger (1813) in a note based on information supplied by Neumann. Schreibers (1820: plate 9) published a "nature print," made using an expensive and time consuming technique. A finger-ring and two cubes of Elbogen material were cut and polished and used as a title-vignette

by Schreibers (1820:97). As pointed out by C.S. Smith (1962), the Widmanstätten structure of Elbogen was also observed and discussed by Laumont (1815) who had acquired material and some information from Schreibers. Chladni (1819: 329), in discussing the structure, mentions that he forged a small knife with a beautiful damask from Elbogen material. This knife, a scalpel 8.5 x 0.8 x 0.3 cm (5 g), is still preserved in the Berlin museum (Humboldt University).

The mass was divided in 1812; 140 or 150 Pfund came to Vienna, while the thinner "muzzle of the horse-head" weighing 40 Pfund remained in Elbogen (Schreibers 1813). This piece was further divided at a later date. Today the remaining sample in the Elbogen Rathaus only weighs 14.3 kg.

Elbogen was widely studied in the nineteenth century, particularly by Partsch (1843), Reichenbach (1858; 1859; 1862a) and Rose (1864a). A pamphlet to satisfy the curiosity of the Kurgäste in Carlsbad was also prepared (1834, unknown author: *Der verwünschte Burggraf von Elbogen. Ein Andenken an Elbogen für die T.T. Herren Carlsbader Brunnen-Gäste*. Book: 32 pp, printed by Gebrüder Franieck, Carlsbad). The tales of the meteorite aroused the interest of several authors and were, for example, incorporated in the novel "Knagsted" by Gustav Wied (Copenhagen 1902).

Leonhardt (1928: 167) presented X-ray pictures that showed diffuse Laue spots, different from the well defined Laue photographs of Youndegin and Braunau. Hoffman (1940) studied the uranium-radium equilibrium in Elbogen, while Tuček (1947) reviewed its history. Photographs of a model and of slices have been given by Tuček (1958: plate 9; 1966: plate 1). Paneth (1960) and C.S. Smith (1962) included Elbogen in two historical essays on the Widmanstätten structure. Based upon the structure of the specimen in Copenhagen, Buchwald suggested that Elbogen was artificially reheated (Buchwald & Munck 1965; Hey



Figure 750A. Elbogen (Humboldt University, Berlin). Above a piece which, after polishing, has been slightly heated so that the Widmanstätten pattern is developed in purple, blue and yellow colors (German Anlaufätzung, English heat-tinting). Below, a knife, 83 mm long, forged from Elbogen material. Both specimens originally in the possession of Chladni. (Courtesy Professor G. Hoppe.)

1966). Jaeger & Lipschutz (1967a) examined the schreibersite by X-ray diffraction and found that it had never been severely shocked; therefore, the observed recrystallization of the kamacite was attributed to a cosmic annealing without previous shocking. Voshage (1967) was unable to determine a cosmic ray exposure age due to the small amount of potassium in the specimen examined.

COLLECTIONS

Vienna (79 kg), Elbogen Rathaus (14.3 kg), Prague (6.6 kg and 168 g slice), Prague, Mineralogical Institute of German University (6.4 kg, according to Wülfing 1897), Budapest (455 g, lost?), Uppsala (287 g), Berlin (225 g), Harvard (169 g), Tübingen (152 g), Göttingen (130 g), London (108 g), Calcutta (100 g), Washington (94 g), Copenhagen (65 g), Rome (65 g), Paris (65 g), Chicago (60 g). It is further represented in a large number of collections by triangular or prismatic parallelepipeds of 10-100 g weight. Many of the specimens have been etched by heat-tinting.

DESCRIPTION

The mass has been compared to a horsehead in shape and size. According to the model in Prague, it has the approximate overall dimensions 50 x 30 x 20 cm, and is smoothly rounded. On one side there are several 5-9 cm wide and 2-4 cm deep grooves; the mass is covered by a crust of terrestrial oxides. On no section examined by the author was any kind of fusion crust or heat-affected rim zone preserved.

Etched sections display a medium-sized Widmanstätten structure with no oriented sheen. The lamellae are straight, long ($l \sim 20$) and have a width of 0.75 ± 0.15 mm. No Neumann bands are present. Plessite fields occupy about 30% by area.

Schreibersite occurs as scattered platy, skeleton crystals, typically 10 x 3 x 0.6 mm with a 1 mm rim of

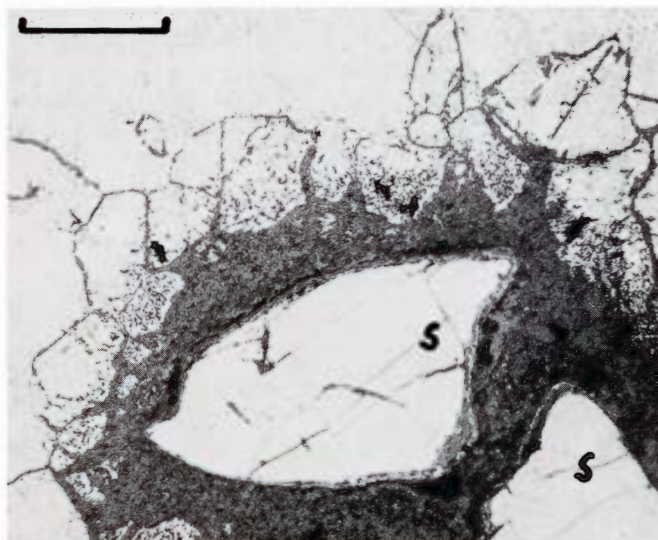


Figure 750B. Elbogen (Harvard no. 4B). Polycrystalline schreibersite crystals (S) enveloped in terrestrial corrosion products that have been altered by artificial reheating. Lightly etched. Scale bar 200 μ .

swathing kamacite, and as 10-60 μ grain boundary precipitates. In the interior of the comb plessite, 5-20 μ schreibersite blebs are common. Troilite occurs as 1-5 mm nodules, often associated with, or embedded in, the larger schreibersite crystals. A few 0.2-0.5 mm chromite crystals were found embedded in troilite and schreibersite. The bulk phosphorus content is estimated to be $0.30 \pm 0.05\%$.

This is about as much as can now safely be said about the primary structure. It appears that all the specimens investigated (Berlin, Copenhagen, Prague, Tübingen, Vienna, Harvard, Washington) have structures affected by at least one secondary reheating, which has given a unique microstructure to the Elbogen specimens.

The kamacite is polycrystalline after having been reheated to the austenite region, that is, above 800°C . It is composed of serrated 20-100 μ α_2 units which evidently were formed during a relatively slow cooling from this temperature. Numerous 0.5-2 μ precipitates in the α_2 matrix appear to be phosphides. In other samples they resemble isothermal taenite. The original taenite is partly resorbed and shows thorny ragged edges against the α_2 lamellae. There are only small differences between the α_2 , which formed from the original kamacite lamellae, and the α_2 which formed from previous taenite and plessite. The secondary reheating evidently provided sufficient time and temperature for nickel to diffuse over long distances. The kamacite lamellae have a hardness of 172 ± 6 , while the original taenite ribbons are still softer (~ 140), confirming the thorough annealing.

Schreibersite has recrystallized to 25-100 μ units, but has largely preserved the original shape, except for a 1-5 μ wide rim zone of taenite. The recrystallized units follow fracture lines through the schreibersite which clearly indicates that the fissuring (by some cosmic event) antedates the recrystallization. The schreibersite exhibits a hardness of 865 ± 30 . Near the schreibersite in the α_2 matrix are 10-50 μ crystalline spherules of graphite. They resemble the graphite spherules in Mejillones and were probably precipitated during annealing.

Original troilite with its schreibersite rim is decomposed to a fine-grained mixture of sulfides, phosphides and metal, and the sulfide frequently penetrates into the surrounding matrix for some hundred microns. The temperature, therefore, appears to have been just above the melting point of the complex, perhaps about 950°C . Since the schreibersite has not melted, the peak temperature can not have been much higher.

No heat-affected rim zone from atmospheric penetration could be identified. Nevertheless, the exterior shape of the mass certainly suggests a well-preserved fall. On some polished sections which contained the original surface, 25-100 μ grains of what might be iron ore in a partly reduced state, were firmly embedded in the meteorite's surface. Several samples contain minor amounts of terrestrial corrosion products, such as 50-200 μ wide limonite veins along schreibersite. The veins are partially decomposed by reheating and exhibit 2-20 μ wide cream-colored zones along the schreibersite. Some limonitic veins are decomposed to 100-1,000 μ wide zones where metal and oxides occur in an intricate lacework.

The facts are rather confusing, but I think that the following supposition accounts for most of the observations, and is supported by legends as related by Neumann (1812).

Elbogen was probably plowed up sometime around the year 1400 and soon became associated with the simultaneous death (killing?) of one of the hated burgraves. An attempt was later made to melt the mass by putting it in a primitive blast furnace, in which the temperature may have been about 950°C where the meteorite was situated. The atmosphere of the furnace was reducing, so there was only an insignificant loss by oxidation. The thorough soaking led to partial resorption of the taenite, precipitation of graphite spherulites, recrystallization of schreibersite, incipient melt-

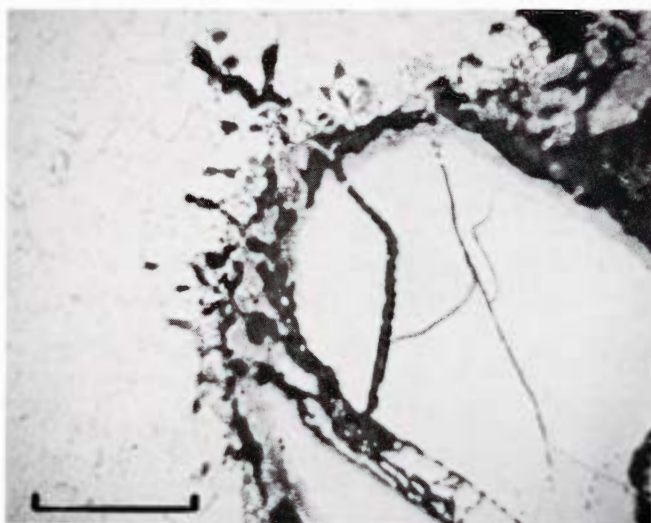


Figure 751. Elbogen (Harvard no. 4B). Detail of the altered interfaces schreibersite-limonite-kamacite. The lace-like reaction zone is typical for artificially reheated iron meteorites. Lightly etched. Scale bar 50 μ .

ELBOGEN - SELECTED CHEMICAL ANALYSES

References	percentage			C	S	Cr	Cu	ppm Zn	Ga	Ge	Ir	Pt
	Ni	Co	P									
Jarosewich 1969, pers. comm.	10.25	0.64	0.22									
Wasson 1970, pers. comm.	10.2 \pm 0.4								74.5	87.0	14	

exists in the immediate surface which is also corroded. It is not clear what proportion of the chlorine is terrestrial contamination, but since their specimen was one of the near-surface fragments chiseled off by the finder, and since, as shown in the following, El Burro is a weathered find that has lost much of its heat-affected α_2 zone, there has been ample time (thousands of years?) for chloride-bearing ground water to penetrate along the grain boundaries. Lawrencite was not observed, although sought for; neither was it observed in any of the other twelve irons they examined, of which four were falls. This may be taken as another evidence that lawrencite does not exist in iron meteorites.

COLLECTIONS

Washington (34.2 kg), Tempe (1.10 kg), London (700 g), New York (315 g), Kyancutta (174 g).

DESCRIPTION

The mass is an angular lump with rounded edges with the overall dimensions 23 x 21 x 17 cm. It is covered by 0.5-2 mm thick oxide scales from terrestrial corrosion, and several oxide-filled cracks along the partly phosphide-filled grain boundaries are visible upon the surface. About 2 kg fragments have been removed by the finder by chiseling along these weak, corroded planes of adhesion. Locally, small amounts of ochre-yellow caliche is adhering in pits. Since the heat-affected α_2 zone is only preserved locally as a 0.1-2 mm rim, the iron has lost at least 2 mm of its "skin" by corrosion and thereby all the details of flight sculpturing.

Etched sections show a vestigial Widmanstätten pattern of the very coarsest dimensions. In some areas 5-15 mm wide, parallel kamacite fingers ($\frac{l}{w} \sim 3$) with a trifle of taenite and plessite are seen. But most of the sections appear to be occupied by irregular, almost equiaxial kamacite grains, 1-5 cm in diameter. Where long-time corrosion has separated the individual grains it is better apprehended how the three-dimensional mass is composed

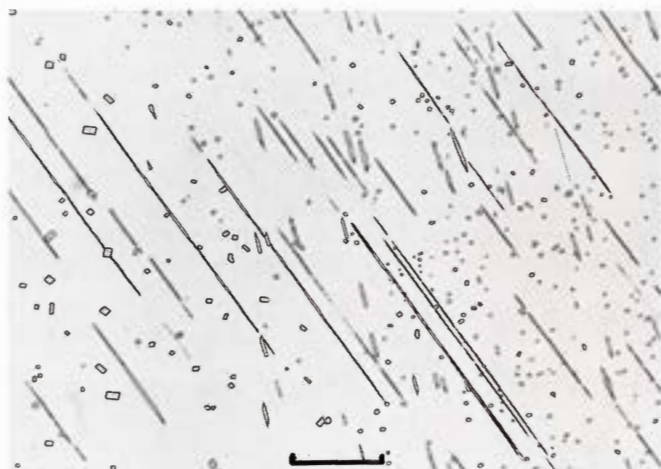


Figure 754. El Burro (Tempe no. 469.1x). Discontinuous Neumann bands and broken rhabdites. Etched. Scale bar 200 μ .

of interlocking Widmanstätten kamacite fingers, between which the interstices are filled by more equiaxial kamacite grains. The taenite and plessite occur with about one 0.5-1 mm² field per 10 cm², and it is interesting how these few remaining comb plessite fields have similar Widmanstätten orientations which proves that the mass was originally one single austenite individual. Late grain growth, after completion of the Widmanstätten transformation, has worked to eliminate almost all traces of the transformation itself. Neumann bands are common, and so are kamacite subboundaries, which are profusely decorated with 1-2 μ thick rhabdites. Some cubic cleavage planes are filled with corrosion products.

The microhardness of the kamacite is 205 \pm 15. It drops significantly towards the edge, reaches a minimum of 145 \pm 10 and then increases to 195 \pm 10 in the extreme rim zone where α_2 and micromelted rhabdites are present (hardness curve type II). The interior hardness indicates that the kamacite is somewhat cold-worked, while the drop

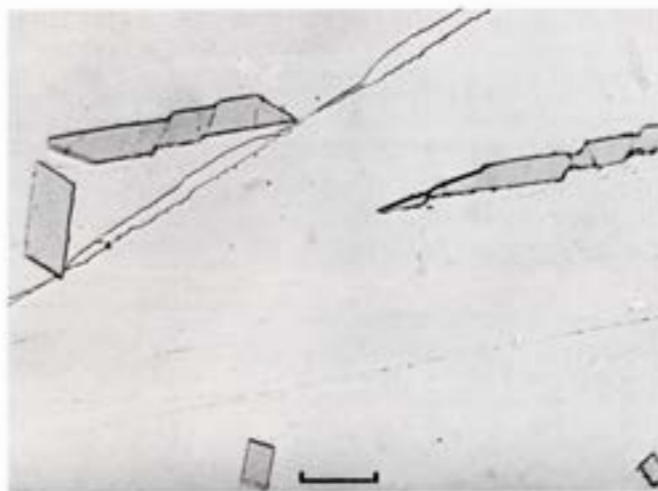


Figure 755. El Burro (Tempe no. 469.1x). Shear-displaced rhabdite prisms. Several more or less distinct Neumann bands. Etched. Scale bar 20 μ .

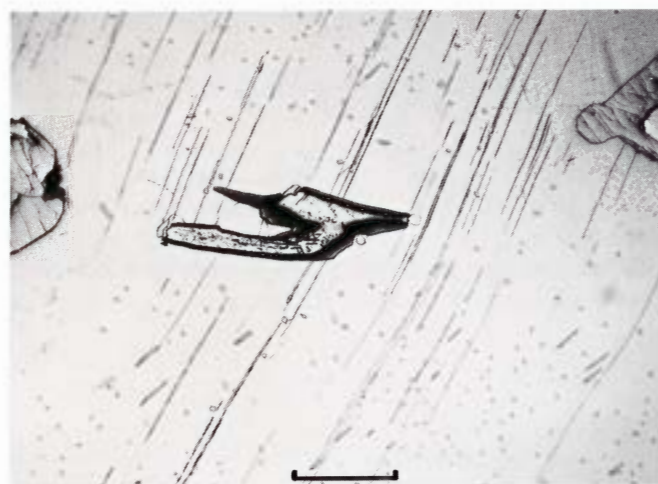


Figure 756. El Burro (Tempe no. 469.1x). Old grain boundary with a plessite field (center) and two schreibersite crystals. Deformed Neumann bands. Etched. Scale bar 400 μ .

to about 145 shows the effect of recovery or strain relieving during the brief reheating in atmospheric flight.

Schreibersite occurs as scattered skeleton crystals up to 10 x 10 x 5 mm in dimensions. The crystals are enveloped in 5-10 mm swathing kamacite. Most of the schreibersite is, however, present as winding 0.1-0.5 mm wide grain boundary veins. The schreibersite is monocrystalline, but brecciated and locally sheared, and displaced as much as 100 μ . Numerous deformation bands occur in the surrounding kamacite due to the local plastic flow. Rhabdites are numerous in form of sharp, faceted prisms 10-25 μ in cross section. Some are sheared and displaced their own thickness. Dense clouds of fine rhabdite precipitates, 0.5-2 μ across, are present in many grains.

Troilite is present as 5-10 mm nodules with thin schreibersite rims. In a few places a discontinuous outer rim of 10-20 μ cohenite may be observed. The troilite is monocrystalline with about 10% of 50-200 μ wide, parallel daubreelite lamellae and wedges. Due to plastic deformation the daubreelite lamellae are somewhat distorted, and the troilite displays lenticular deformation twins. The troilite is frequently heavily corroded.

El Burro is a coarsest octahedrite with few remnants of taenite and linear Widmanstätten elements. Structurally, it is closely related to Ainsworth and Sikhote-Alin, and, chemically, it is a natural member of group IIB, as shown by Wasson (1969). For a possible relationship with Iredell, see the description, page 685.

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

- 31.4 kg main mass (no. 1345, 23 x 18 x 17 cm)
- 2.15 kg slice (no. 1345, 17 x 13 x 2.1 cm)
- 406 g slice (no. 1345, 14 x 8 x 0.7 cm)
- 130 g slice (no. 1345, 6 x 4 x 1 cm)
- 94 g hammered fragments (no. 1345)

El Capitan, New Mexico, U.S.A.

Approximately 33°40'N, 105°15'W

Medium octahedrite, Om. Bandwidth 1.10±0.20 mm. ϵ -structure. HV 275±15.

Group IIB. 8.68% Ni, 0.48% Co, 0.43% P, 21.5 ppm Ga, 45.1 ppm Ge, 0.11 ppm Ir.

HISTORY

A mass of about 27.5 kg was found in 1893 by a Mexican shepherd, Julian Jesu, on the northern slope of the El Capitan mountain range north of Rio Bonito, Lincoln County. Through C.R. Biedermann a fragment of

67 g, chiseled off the main mass, reached the U.S. National Museum (no. 169) while the main mass and two other, larger, detached fragments were acquired by Ward's Establishment, and described by Howell (1895). Biedermann reported herein, and this has been quoted by Merrill (1916a) and Hey (1966), that the meteorite probably was associated with a fireball observed to fall in the El Capitan range in 1882; but this is out of the question since, as shown below, the heat-affected rim zone has been removed by corrosion, and this is a process that requires thousands of years. Howell gave two woodcuts of the exterior shape, while Ward (1904a: plate 1) and the Niningers (1950: plate 5) gave photomicrographs. Feller-Kniepmeier & Uhlig (1961) gave photomicrographs and determined with the microprobe the composition of the various metallic phases.

COLLECTIONS

New York (6,319 g), Washington (4,831 g), Chicago (2,226 g), London (956 g), Bally (661 g), Harvard (540 g), Tübingen (495 g), Berlin (307 g), Yale (252 g), Copenhagen (140 g), Tempe (110 g), Calcutta (86 g), Vatican (80 g), Strasbourg (76 g), Vienna (74 g).

DESCRIPTION

The mass had the overall dimensions of 25 x 22 x 13 cm and had an irregular, angular shape with numerous pits. The largest preserved specimen is the 3.9 kg endpiece (no. 209) in the U.S. National Museum. It shows, contrary to what Howell (1895) stated, that the meteorite is heavily corroded with 0.1-1 mm adhering oxide crusts. On sections no fusion crust or heat-affected α_2 zone are preserved, and

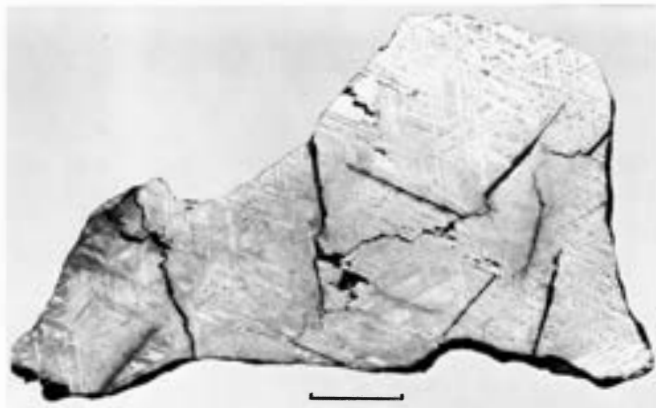


Figure 757. El Capitan (U.S.N.M. no. 209). Medium octahedrite of group IIB. Many Reichenbach lamellae along which terrestrial corrosion has progressed. Schreibersite is common as blebs along the center of the kamacite lamellae. Deep-etched. Scale bar 30 mm. S.I. neg. 36722A.

EL CAPITAN – SELECTED CHEMICAL ANALYSES

References	percentage			C	S	Cr	Cu	ppm				
	Ni	Co	P					Zn	Ga	Ge	Ir	Pt
Jarosewich 1968, pers. comm.	8.80	0.48	0.43									
Scott et al. 1973	8.56								21.5	45.1	0.11	

oxide-filled veins penetrate deep into the interior along Widmanstätten planes and particularly along the Reichenbach lamellae. The meteorite has, no doubt, been exposed to terrestrial weathering for thousands of years.

Etched sections display a well developed Widmanstätten structure of straight, long ($\frac{L}{W} \sim 20$) kamacite lamellae with a width of 1.10 ± 0.20 mm. The kamacite is of the densely hatched, contrast-rich type from shock in the 200-300 k bar range, and similar to that found in, e.g., Narraburra and Treysa. The Vickers hardness (100 g) of the shock-hardened ferrite is 275 ± 15 . The faintly visible sub-grain boundaries of the kamacite are decorated with $< 1\mu$ rhabdites. Plessite fields occupy about 40% by area, some as open-meshed, unspheroidized comb and net plessite, some as martensite with platelets that repeat the Widmanstätten directions, and some as duplex $\alpha + \gamma$ fields of varying fineness. The duplex plessite fields may resemble the plessite of Cape of Good Hope or Chinga, corresponding to an average nickel content of 16%.

Schreibersite is very common, mostly in the form of rather small, elongated bodies, centrally in the kamacite lamellae. They are 0.1-0.4 mm wide and up to several millimeters long. Occasionally, a 20 x 1 mm or 2 x 2 mm crystal enveloped in 1-1.5 mm swathing kamacite may be found. Very characteristic for El Capitan are the island-arcs of 10-25 μ wide schreibersite blebs that are situated in rows 10-25 μ outside the taenite and plessite fields. All schreibersite is monocrystalline but frequently heavily brecciated and faulted.

Troilite occurs as 10-25 mm nodules with rims of 0.1 mm schreibersite. It is also present as numerous, smaller blebs and as characteristic Reichenbach lamellae which in this meteorite may be exceptionally wide. A typical Reichenbach lamella in El Capitan is 50 x 15 x 0.2 mm, and the main part of it is troilite. The lamellae, or foils, occupy at least five directions of which one is parallel to a Widmanstätten trace. Since most of the lamellae are heavily corroded, it is difficult to assess their original structure. It appears, however, that they consisted of a central 0.1-0.3 mm wide troilite platelet upon which numerous, irregular schreibersite crystals precipitated. Some of the lamellae are shock melted and contain angular fragments of schreibersite, irregularly dispersed along the lamellae. The lamellae are sheathed in 0.1-1.5 mm swathing kamacite, and this often shows plastic deformation bands, indicating relative displacement of the two sides of the Reichenbach lamellae.

El Capitan is a medium octahedrite with relatively high phosphorus content and with numerous Reichenbach lamel-

lae. Structurally, it resembles Baquedano, Bartlett, Luis Lopez, and Caperr and, chemically, also the larger group of meteorites, transitional between group IIIA and IIIB, and exemplified by Cleveland and Drum Mountains.

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

3,948 g endpiece (no. 345, 20 x 10 x 4 cm)
756 g slice (no. 209, 21 x 8 x 0.5 cm)
67 g chiseled fragment (no. 169)
60 g part slice (no. 2754, 5 x 3 x 0.4 cm)

El Chanaralino. See Merceditas

Elga, Yakutsk Autonomous S.S.R., USSR

$64^{\circ}42'N, 141^{\circ}12'E$

A mass of 28.8 kg was discovered in 1959 by the chief geologist Y.N. Urusev, in the Indigirian mine, while washing auriferous gravel from a depth of 20 m. It was briefly mentioned in the Meteoritical Bulletin (No. 16, 1960, then analyzed by Dyakonova & Charitonova (1963). Vinogradov (1965: figure 15) gave a photomicrograph of an etched slice, displaying an unusual mixture of metal and silicate. Wasson (1970b) compared Elga to Colomera, Weekeroo Station and a few other anomalous irons with silicate inclusions. The main mass is in Moscow. The coordinates above are from Krinov (1962).

DESCRIPTION

Unfortunately no material was available for examination.

El Mataco. See Campo del Cielo

El Mocovi. See Campo del Cielo

El Qoseir, Red Sea Coast, Egypt

$26^{\circ}17'N, 34^{\circ}15'E$; near sea level

Nickel-rich ataxite, D.

Anomalous. 14.0% Ni, 0.70% Co, 0.16% P, 6.2 ppm Ga, 11.7 ppm Ge, 5.5 ppm Ir.

El Qoseir was not available for metallographic examination. The following are excerpts from the sparse literature on the meteorite.

HISTORY

According to Krinov (1945b) a mass of 2,405 g was picked up by a boatswain called Peter Churilov, in March

ELGA – SELECTED CHEMICAL ANALYSES

References	percentage			C	S	Cr	Cu	ppm				
	Ni	Co	P					Zn	Ga	Ge	Ir	Pt
Dyakonova & Charitonova 1963	8.38	0.64	0.47				100					
Wasson 1970b	7.98								24.1	71.8	4.1	

1921 when his ship visited the small town of El Qoseir, on the Egyptian coast of the Red Sea. When Churilov was boating along the shore, about 15 km south of El Qoseir, he entered a closed bay. Walking along the coast at this point, he found the said meteorite on an alabaster terrace. It was almost entirely exposed on the surface; it was well-preserved and was estimated to be a relatively recent fall. In 1925 it was purchased by Kulik for the USSR Academy of Sciences but was first mentioned in the scientific literature in 1945 by Krinov.

Krinov (1945b; 1947) gave a brief description and presented photographs of the exterior. The dimensions were 15 x 10 x 7 cm, and the somewhat irregular arched shape was estimated to be the result of stabilized passage through the atmosphere. Regmaglypts, 10-15 mm across, were well-preserved so only small losses by terrestrial weathering can have occurred.

Upon sectioning, Krinov found no Widmanstätten pattern, and, since the nickel content was high (15.17%), the meteorite was classified as a nickel-rich ataxite. The present name of the place of discovery is Qoseir, the coordinates of which are given above.

COLLECTIONS

Moscow (2,321 g main mass and 37 g slices).

El Simbolar, Cordoba, Argentina

Approximately 30°38'S, 64°53'W

A mass of 40 kg was found in 1938 and was described by Olsacher (1939). El Simbolar appears to be a coarse octahedrite of the resolved chemical group I, but since no material was available for examination, I have no comments, except that it should be checked to see whether El Simbolar might be a transported fragment from the Campo del Cielo shower field which is situated about 500 km northeast of El Simbolar.

El Taco. See Campo del Cielo

El Timbu, Santa Fe, Argentina

33°7'S, 60°58'W

A mass of about 500 kg was found in 1942 in the San Lorenzo Department, according to Hey (1966: 152). No particulars are available; the mass is in Buenos Aires.

EL QOSEIR – SELECTED CHEMICAL ANALYSES

The nickel values are high but not entirely in agreement. The Ni-Ga-Ge-Ir data indicate that El Qoseir is an

References	percentage			C	S	Cr	Cu	ppm				Pt
	Ni	Co	P					Zn	Ga	Ge	Ir	
Dyakonova & Charitonova 1963	14.85	0.70	0.16				300					
Wasson & Schaudy 1971	13.19								6.15	11.7	5.5	

El Toba. See Campo del Cielo

Elton, Texas, U.S.A.

Approximately 33°43'N, 100°49'W

A mass of 1.9 kg was found about 1936 near Elton, in Dickens County (A.D. Nininger 1939; Hey 1966: 152). The main mass is in Austin where Barnes (1939a: 588, 594) gave a preliminary description. Wasson (1970: personal communication) found 6.9±0.5% Ni, 46.3 ppm Ga, 165 ppm Ge and 0.053 ppm Ir, which data indicate that Elton is anomalous or slightly related to the resolved chemical group IIB. Unfortunately, no material was available for a metallographic examination in this study.

Emmitsburg, Maryland, U.S.A.

39°42'N, 77°20'W; 150 m

Medium octahedrite, Om. Bandwidth 1.00±0.15 mm. ϵ -structure. HV 270±15.

Group IIIA, judging from the structure, with about 7.7% Ni and 0.11% P.

HISTORY

Very little is known and very little is preserved of this iron. The meteorite has never been described from the beginning, and to make the confusion complete, it appears that the samples presently in collections come from two entirely different meteorites. Where and when the confusion started is almost impossible to unravel now, and hardly worth-while, since so little material is preserved. In the following, I shall give the history as far as it can be deducted from various sources, and the two kinds of material known to the author will be described.

According to Hey (1966: 152), a mass of about 1 pound (450 g) was found and passed into the possession of Dr. J.R. Chilton of New York, from whom the collector S.C.H. Bailey obtained specimens. The mass is recorded as having been found near Emmitsburg, Frederick County, in 1854; it was, however, not mentioned in print until Brezina (1885: 211) obtained and briefly described a 9 g specimen and based one of his early classificatory groups on it. Bailey also exchanged specimens with other museums, e.g., London (no. 56158, 6.5 g) and Harvard (no. 211, 10 g), about 1885. In 1897 he still had a 77 g specimen (Wülfing 1897), but when his collections was sold about 1900 this

anomalous iron, unrelated to, e.g., Deep Springs, Mount Magnet and Carlton, other irons with 13-15% Ni.

appears to have been divided, to end up eventually in various dealers' catalogs (Gregory 1901; Ward 1904a; Foote 1912).

COLLECTIONS

Chicago (41 g), New York (31 g), Harvard (10 g), Vienna (9 g), Washington (7 g), London (6.5 g), Göttingen (0.9 g). The listed samples are possibly not all from the same meteorite.

ANALYSES

No analytical work has been published.

DESCRIPTION

The shape and dimensions of the main mass are unreported. The following is based upon an examination of specimens in Chicago (Me 67, 28 g on two samples), (Washington no. 279, 7 g) and Vienna (9 g); these samples were found to be identical.

The Washington specimen no. 279 was listed in "Catalogue of the Collection of Meteorites of James R. Gregory of London," (1901: 19) and was purchased by the U.S. National Museum through the medium of H.A. Ward about 1902. On the label is an old number 84907. The specimen is a small slab, separated from a larger piece along the (corroded) Widmanstätten lamellae. Exterior surfaces are absent. The Chicago specimens (Me 67) are thin (0.2-0.3 cm) part slices, very similar to the Washington specimen.

Etched sections show a medium octahedrite structure of straight, long ($\bar{W} \sim 20$) kamacite lamellae with a width of 1.00 ± 0.15 mm. The matrix displays a contrast-rich, densely hatched ϵ -structure, indicating shock-pressures above 130 k bar. The microhardness is correspondingly high, 270 ± 15 . Taenite and plessite occupy about 30% by area, in the form of open-meshed comb and net plessite that are in the process of being resorbed. Some wedge-shaped fields have martensitic interiors.

Phosphide precipitates are relatively uncommon. Blebs, 20-50 μ wide, may be found in the grain boundaries, and 1-3 μ rhabdites occur in the grain interiors. It is estimated that the bulk phosphorus content is $0.11 \pm 0.02\%$.

Troilite occurs as lenticular nodules, e.g., 1.5 x 0.5 mm in size, and as bars, e.g., 7 x 0.5 mm. The smaller nodules are composed of alternating 5-10 μ wide lamellae of troilite and daubreelite, this mineral covering up to 50% by area of the nodule.

Carlsbergite is common in the kamacite as oriented platelets, measuring 20 x 0.5 μ . They also occur as irregular somewhat larger particles on the grain boundaries. The meteorite is corroded, particularly along the schreibersite-filled grain boundaries. The Chicago specimens have 0.1-1 mm thick crusts of terrestrial oxides; apparently the fusion crust and the heat-affected α_2 zones have been lost.

This material, which is here assumed to be the genuine Emmitsburg material, comes from a shock-hardened, unannealed medium octahedrite with ϵ -structure. It is related to

Mapleton, Red River and Canyon City, and probably contains $7.7 \pm 0.2\%$ Ni. It is a typical group IIIA iron, entirely different from the following material.

pseudo Emmitsburg. Specimen no. 1022 (2.6 g) in the U.S. National Museum is a small corroded fragment chiseled from a larger mass. It seems to be identical to a 2.8 g sample, mentioned as "Maryland, Emmitsburg" in Shepard's handwritten chronological list of his collection (Smithsonian Archives, 1884). It is a late addition by Shepard, squeezed in between two irons which were discovered in 1829 and 1839, indicating that he assumed the iron to have been discovered in this period. The sample is not mentioned in Shepard's printed list, with addenda, dated February 4, 1882, so he evidently acquired it about 1884.

The fusion crust and the heat-affected α_2 zone have been removed by terrestrial corrosion, and the near-surface duplex plessite fields display selective corrosion of the α -phase.

The etched section shows a coarse Widmanstätten structure of bulky, short ($\bar{W} \sim 10$) kamacite lamellae, 1.35 ± 0.20 mm wide. Neumann bands are common. The hardness is 220 ± 15 , indicating slight cold-deformation. Taenite and plessite occupy about 10% by area, partly as acicular plessite, partly as pearlitic and spheroidized fields, and partly as open-meshed comb plessite.

Schreibersite occurs as scattered 1-3 mm wide cuneiform or plate-shaped skeleton crystals with 1-2 mm wide rims of swathing kamacite. It is also common as 20-60 μ wide grain boundary precipitates and as 5-25 μ irregular particles inside comb plessite. The schreibersite is monocrystalline, but brecciated, partly due, however, to the artificial chiseling. Rhabdites are numerous in the form of 2-5 μ thick prismatic rods.

The macro- and microstructure indicate that this material is from an inclusion-rich coarse octahedrite, related to Toluca and Shrewsbury, and with about 8% Ni and 0.25% P. Shrewsbury was found in Maryland, but not until 1907, and its microstructure is thoroughly annealed as opposed to that of no. 1022. It appears more likely that Shepard's material is a mislabeled Toluca specimen, since it tallies very well in macro- and microstructure and in the degree of weathering. Moreover, Toluca samples are numerous and have little intrinsic value, while a Toluca sample sold/exchanged as Emmitsburg material would have considerable value.

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

- 7 g part slice (no. 279, 3 x 1 x 0.3 cm; from J.R. Gregory). Genuine.
- 2.6 g part slice (no. 1022, 3 x 1 x 0.1 cm; Shepard Collection). Probably a mislabeled Toluca specimen.
- 5.4 g part slice (no. 414. Either Shepard Collection no. 45, - see F.W. Clarke 1889: Supplement: 261; - or purchased from Howell about 1904). Not examined.

Emsland, Lower Saxony, Germany

53°6'N, 7°12'E

Medium octahedrite, Om. Bandwidth 0.90 ± 0.15 mm. Neumann bands. HV 210 ± 15 .

Anomalous. 9.40% Ni, 0.27% P, 2.9 ppm Ga, 35 ppm Ge, 2.9 ppm Ir.

HISTORY

A mass of 19 kg was found in 1940 near the village of Brahe on the moors west of the river Ems, only 500 m from the Dutch boundary. It was embedded in a layer of sand at a depth of 2 m and found by workers who were exploiting the turf as fuel. The meteorite was acquired by the Göttingen University and was described at length by Vogel (1943), who also reproduced photographs of the exterior and of etched sections. Vogel speculated that the mass might have fallen in 1901 or 1905 when large fireballs had been observed over Lower Saxony. His case, however, is unconvincing, or at least insufficiently discussed.

COLLECTIONS

Göttingen (18.2 kg), Copenhagen (82 g).

DESCRIPTION

The mass is irregularly angular with the approximate dimensions of 22 x 19 x 13 cm in three perpendicular

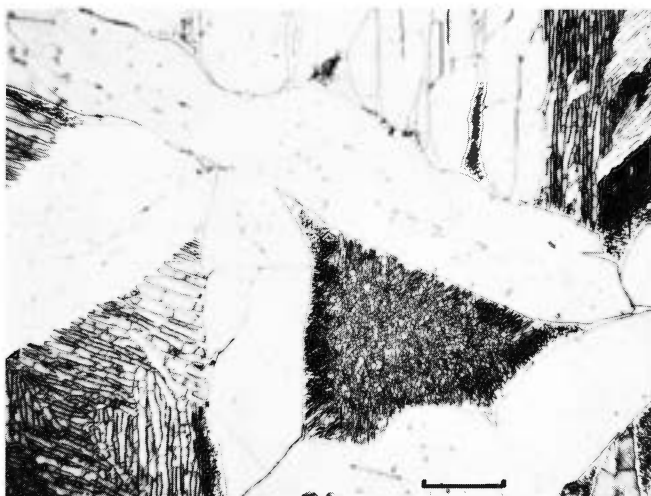


Figure 758. Emsland (Copenhagen no. 1973, 2081). Kamacite with Neumann bands and rhabdites. Various pleistite fields. Etched. Scale bar 500μ .

directions. Most of the surface is covered with well developed regmaglypts, 15-30 mm across and 5-10 mm deep, and meeting along smoothly rounded ridges. One surface, 17 x 14 cm in size, is almost plane and distinctly etched by the humic acids of the soil so that the Widmanstätten grid is clearly seen. In my opinion, an attack of this character cannot have developed during the 35 years between the supposed fall and the recovery. In all probability the fall took place well before 1900.

For the present study a 17 g sample ($4 \times 1 \times 0.5$ cm) was kindly loaned to me by Dr. J.T. Wasson before it was subjected to chemical analysis. Emsland is a medium octahedrite displaying straight, long ($l/w \sim 25$) kamacite lamellae with a width of 0.90 ± 0.15 mm. The kamacite shows Neumann bands. In several places the kamacite contains cubic cleavage fractures, and there are also some cracks along the schreibersite-filled grain boundaries. The fissures are now recemented by terrestrial corrosion products. Vogel (1943) assumed that the Neumann bands and the cracks formed when the meteorite impacted the ground. Considering the rather slow rate of fall of a 19 kg mass (say 300 m/sec) and the fact that the ground was boggy, it appears much more likely that both formed either as a result of a cosmic event or during the violent atmospheric deceleration. The hardness of the kamacite phase is 210 ± 15 .



Figure 759. Emsland (Copenhagen no. 1973, 2081). The cleavage cracks (C) follow $(100)_\alpha$ planes in the kamacite lamellae. Thin black lines indicate Neumann bands. Acicular pleistite fields and conspicuous rhabdites. Etched. Scale bar 200μ .

EMSLAND – SELECTED CHEMICAL ANALYSES

It is estimated that the old Ni-Co analysis is somewhat inferior, and it is consequently not used in calculating the average. It is anomalous that the Ga-Ge ratio is below 0.1 in

iron meteorites; there is, however, another iron with a similar analysis, Mbozi; the two masses are also rather similar in structural respects.

References	percentage			C	S	Cr	Cu	ppm				
	Ni	Co	P					Zn	Ga	Ge	Ir	Pt
Schultz in Vogel, 1943	8.71	0.78	0.27	500	70	120						
Scott et al. 1973	9.40							2.9	35	2.9		

Taenite and plessite cover about 40% by area, both as comb and net plessite, and as acicular and dark-etching optically unresolvable fields. It is noteworthy that the fields almost lack the normal heterogenous frame of taenite with transitional structures.

Schreibersite is common as elongated or slightly branching crystals, usually 2×0.5 or 1×0.3 mm in size and located centrally in the kamacite lamellae. It also occurs as $10\text{--}40 \mu$ wide grain boundary precipitates and as $2\text{--}25 \mu$ irregular blebs inside the plessite fields substituting for taenite of similar sizes. Rhabdites occur locally as $5\text{--}10 \mu$ angular tetrahedral prisms.

Troilite was not present in the section, but was reported by Vogel. He observed two hemispherical cavities, 8 and 6 mm in diameter, in the surface and proved that they were the seat of troilite nodules that burned out in the atmosphere.

In places the meteorite has preserved a fusion crust, composed of exterior oxidic layers (50μ thick) and interior laminated dendritic metal (up to 100μ thick). Under the fusion crusts, a $1.5\text{--}2.5$ mm wide heat-affected α_2 zone is well-preserved. Micromelted phosphides are present in the exterior half of this zone. The α_2 zone has a hardness of 210 ± 10 , and the recovered transition zone a hardness of 170 ± 5 (hardness curve type II).

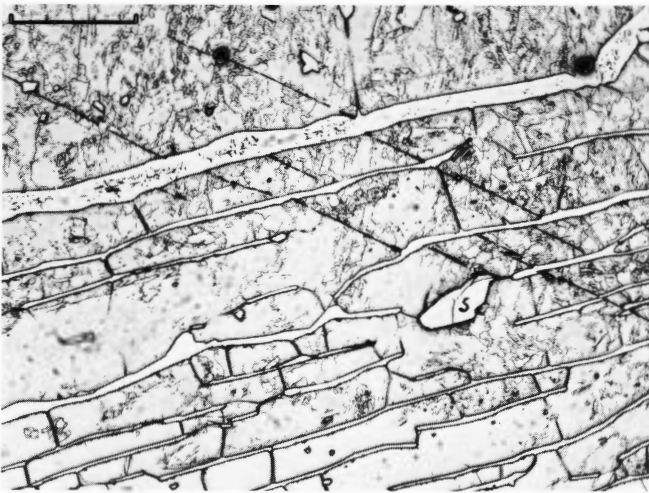


Figure 760. Emsland (Copenhagen no. 1973, 2081). Heat-affected zone above. In the exterior part the phosphides have been melted; they solidified rapidly, with gas holes (black). In the interior part the phosphides (S) are unaffected. Etched. Scale bar 200μ .

Emsland is a medium octahedrite which would be difficult to tell apart from medium octahedrites of group IIIA and B, if it were not for the anomalous concentration of trace elements. Emsland is, thus, more related to Mbosi, than to, e.g., Treysa, Grant and Joe Wright Mountain with the same approximate nickel contents. The phosphorus content of Emsland is, however, definitely lower and causes less schreibersite to be present than in Treysa, etc.

Espirito Santo. See Chupaderos, (Espiritu Santu)

Etosha. See the Supplement.

Fair Oaks. See Canyon Diablo (Fair Oaks)

Filomena. See North Chile

Floydada, Texas, U.S.A.

$33^{\circ}59'N, 101^{\circ}17'W$

A mass of 12.5 kg was found before 1912 in Floyd County but was first recognized as a meteorite by the Niningers (A.D. Ninger 1939: 212; Ninger & Ninger 1950: 52). It appears to be a medium octahedrite; but since no material was available for examination, I can add no comments. The Texas Observers Collection, Fort Worth has 12.5 kg (Barnes 1939a: 594), and 21 g is in Tempe.

Föllinge, Jämtland, Sweden

$63^{\circ}44'N, 14^{\circ}51'E$

Finest octahedrite, Off. Bandwidth $40 \pm 10 \mu$. α_2 matrix. HV 165 ± 10 .

Group IID. 18.1% Ni, 0.64% Co, 0.2% P, 4.0 ppm Ga, 3.2 ppm Ge 0.072 ppm Ir.

HISTORY

A small, almost complete individual of 400 g was found during plowing in 1932 at Föllinge, near Ottsjön, about 60 km north of Östersund. It was acquired by the Riksmuseum in Stockholm, where it was cut and analyzed

FÖLLINGE – SELECTED CHEMICAL ANALYSES

References	percentage			C	S	Cr	Cu	ppm				
	Ni	Co	P					Zn	Ga	Ge	Ir	Pt
Blix in Buchwald 1967a,b	18.05	1.1	0.13		800	500	500					
Buchwald 1967a,b	18.16	0.64	0.18		<60		430		2	1		
Wasson & Schaudy 1971	18.13								4.0	3.15	0.072	

The chromium value appears erroneously high.