Polished and etched sections show that the unusual macro- and microstructures are identical in every respect to sections through the Cedartown mass. There is no point in giving a full description of the fragments, since it is obvious that they derive from the Cedartown mass: (i) Aragon and Cedartown are both in Polk County, Georgia; (ii) Aragon and Cedartown were both reported as new meteorites in 1898; (iii) the unusual macro- and microstructures and, in addition, the state of corrosion are the same; (iv) the Aragon fragments are somewhat cold-worked; this occurred when they were separated (by hacksaw or chisel) from the Cedartown mass.

A tentative explanation for Aragon's listing as a separate meteorite could then be that the finder detached a sample from the main mass and submitted it to Chicago for identification and possible sale. In the meantime, the Georgia state geologist intervened and secured the main mass for Georgia, so that the sale did not materialize. The state geologist acquired some additional information and was able to give the exact locality as Cedartown. Since nothing was published about the main mass until 1946, and since no one previously has compared sections through the appropriate samples, both Aragon and Cedartown have persisted as individual meteorites in all catalogs and textbooks until now.

Central Missouri. See Ainsworth

Chambord, Quebec, Canada 48°26'N, 72°3'W

Medium octahedrite, Om. Bandwidth 0.95 \pm 0.15 mm. ϵ -structure. HV 310 \pm 20.

Group IIIA. 7.53% Ni, about 0.1% P, 18.4 ppm Ga, 35.0 ppm Ge, 10 ppm Ir.

HISTORY

A mass of about 6.6 kg was found in 1904 in a field about two miles from the village of Chambord, county of Lake St. John. A preliminary description was presented by Johnston (1906), who gave a set of coordinates which must be erroneous. Dawson (1963) reported the correct set, quoted above. The mass, which has apparently been only little subdivided, has not previously been the object for metallographic examinations.

COLLECTIONS

Ottawa (6,350 g main mass; 52 g slice), Chicago (18 g).

DESCRIPTION

According to Johnston (1906) the block was irregularly shaped, with a length of 19 cm, a thickness of 9 cm, and a width varying from 10 to 15.5 cm. Unfortunately, the surface was marred to a considerable extent by hammer and chisel marks made in an attempt to penetrate and split the iron. The surface was weathered and over a large area a natural etching was visible, in some places as coarse furrowings, and in others as minute ridges.

For the present study, the 18 g sample in Chicago (Me 921, 2 x 1.7 x 0.7 cm) was kindly loaned to me by Dr. E. Olsen. It is a medium octahedrite with slightly deformed, long ($\frac{1}{W} \sim 20$) kamacite lamellae with a width of 0.95±0.15 mm. There are numerous subboundaries in the kamacite, decorated with less than 1 μ phosphide particles and with 5 x 1 μ carlsbergite platelets. Due to a cosmic shock that postdated the formation of the primary structures, all kamacite has been converted to a hatched ϵ -variety of extensive contrast, and the taenite and the carlsbergite lamellae have been bent and distorted. The microhardness of the kamacite is high, 310±20, suggesting significant shock hardening.

Taenite and plessite cover about 35-40% by area, mostly as almost resorbed, degenerate comb and net plessite. The taenite lamellae are cloudy, stained in brown and yellow colors, and hard (HV 365±25), due to plastic deformation. The slightly wider parts of the lamellae are decomposed to indistinct duplex structures of α and γ (HV 310±20). Most common is an acicular plessite type where fine bayonet-like α -spindles, 1 μ wide, occur in an unresolvable matrix.

Schreibersite is rare, occurring only as scattered 2-5 μ wide grain boundary veinlets, and as occasional blebs of the same size inside the plessite fields. Rhabdites are abent. The bulk phosphorus content is estimated to be 0.10±0.02%.

Troilite was reported by Johnston as two small nodules about 13 mm in diameter. They were apparently monocrystalline with distinct cleavage planes.

Carlsbergite is common as $30 \times 1 \mu$ oriented platelets in the kamacite and as irregular precipitates on some grain boundaries. Daubreelite occurs as scattered particles in the kamacite, 5-30 μ across. Carbides, graphite and silicates are absent.

Chambord is sufficiently weathered to have lost the fusion crust and the heat-affected α_2 zone. On the section, no hardness gradient could be detected toward the surface so it appears that on the average more than 5 mm has been lost by corrosion. Corrosion also penetrates to a depth of

CHAMBORD – SELECTED CHEMICAL	ANALYSES
CIAMDORD - SELECTED CHEMICAL	ALLEDED

	p	ercentage	è					ppm				
Reference	Ni	Со	P	С	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Scott et al. 1973	7.53								18.4	35.0	10	

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1 cm into the mass along grain boundaries. No artificial reheating has occurred.

Chambord is a shock-hardened medium octahedrite of group IIIA, which is closely related to Russel Gulch, Norfolk, Kenton County and Santa Apolonia.

Chanaral. See Ilimaes (Chañaral)

Charata. See Campo del Cielo

Charcas, San Luis Potosi, Mexico Approximately 23°9'N, 101°10'W

Medium octahedrite, Om. Bandwidth 1.05 ± 0.15 mm. ϵ -structure, but artificially altered.

Group IIIA. 8.02% Ni, 0.48% Co, 0.12% P, 19.4 ppm Ga, 41.4 ppm Ge, 1.9 ppm Ir.

Many museum specimens have been reheated artificially to about 1000° C. Charcas is probably a paired fall with Descubridora.

HISTORY

A mass, later shown to weigh 780 kg, was reported by Sonneschmid (1804:288) as standing at the corner of the churchyard in Charcas, San Luis Potosi. It appears, however, that the mass had been transported there at an early time from its original finding place, Hacienda San José del Sitio, which was about 12 Leguas (\sim 50 km) distant in an unknown direction, and in which neighborhood several other masses had been found firmly embedded in a limestone-like rock. Burkart (1856:286) saw the mass at the northwestern corner of the church building and gave a sketch and the dimensions of the visible part of the block. While the French army was in Mexico under Emperor



Figure 560. Charcas (Tempe no. 356.1x). Medium octahedrite with a large and two smaller troilite nodules. Deep-etched. Scale bar in cm. (Courtesy C.B. Moore.)

Maximilian's brief government, the two meteorites, Charcas and La Caille, were acquired for France and sent to the Paris Museum by General Bazaine in 1866. Daubrée (1867a) described the masses shortly after that. Fletcher (1890a) discussed the locality of find but was unable to pinpoint it. He suggested, however, that Charcas and Descubridora were a paired fall and presented circumstantial evidence for their coming from the vicinity of Catorce, a small mining community 70 km north of Charcas, with the coordinates given above. Brezina (1896) described a section in Vienna and gave a photomacrograph, but he could not support Fletcher's suggestion as to the paired fall.

Wülfing's list of references (1897) included, besides the above mentioned principal sources, numerous papers in which Charcas is briefly mentioned. Berwerth (1905) concluded that his Vienna specimen was reheated artificially. Meunier (1914) mentioned that a large slab of 1,200 cm², 1 cm thick, had been cut successfully. Haro (1931) translated Fletcher's and Daubrée's papers and gave a photograph of the whole mass. Lovering & Parry (1962) analyzed Charcas thermomagnetically, while Agrell et al. (1963) briefly reported a normal M-curve across the $\alpha - \gamma$



Figure 560A. Charcas (Paris). The main mass weighed originally about 780 kg. Full slices have been removed from the top and from one side. The regmaglypts are weathered but still visible as 4-5 cm shallow depressions. Scale bar approximately 10 cm. (Photo courtesy Professor J. Fabriès.)

CHARCAS	- SELECTED	CHEMICAL	ANALYSES

	р	ercentage	e					ppm	-			
References	Ni	Co	Р	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Moore et al. 1969	8.17	0.48	0.12	110	20		155					
Scott et al. 1973	7.86								19.4	41.4	1.9	

Reed (1965b) found an inhomogeneous kamacite with 7.2-7.4% Ni.

phases by microprobe analyzing. El Goresy (1965) discussed the sulfide inclusions in which he found troilite, daubreelite and chromite in direct contact. Signer & Nier (1962) measured the rare gases and found the cosmic ray exposure age to be 600 ± 150 million years. The preatmospheric mass was estimated to be about 2,000 kg.

COLLECTIONS

Main mass, about 760 kg, in Paris. Chicago (5,230 g), London (1,050 g), Belgrade, Geology Faculty (943 g), Vienna (421 g), Tempe (408 g), Budapest (366 g), Göttingen (263 g), Stockholm (204 g), Bonn (193 g), Rome (192 g), Washington (182 g), Amherst (182 g), Tübingen (157 g), New York (148 g), Copenhagen (31 g), and numerous other collections.

DESCRIPTION

Charcas is an angular, prismatic mass with the overall dimensions of $100 \times 47 \times 37$ cm. The surface is corroded and shows numerous shallow pits, 4-5 cm wide; they are apparently the altered remnants of regmaglypts produced during atmospheric entry.

Etched sections show Widmanstätten structure with long ($\frac{L}{W} \sim 35$), somewhat bundled α -lamellae of an average width of 1.05±0.15 mm. The matrix appears to be converted to ϵ -structure due to shock. Comb plessite occupies about 40% by area.

Schreibersite occurs as $20-50 \mu$ wide grain boundary precipitates and as $5-10 \mu$ vermicular bodies in the comb plessite. Occasionally a $150 \times 50 \mu$ subangular schreibersite body is found. Rhabdites occur locally as $1-2 \mu$ tetragonal prisms.

Troilite is common as 5-15 mm nodules and as lenticular-rhombohedral bodies, typically 4 x 1 mm in size.



Figure 561. Charcas (U.S.N.M. no. 1355). Scanning X-ray pictures of a sample which was artificially reheated on some unknown occasion. Oxygen- and chlorine-containing limonite has reacted with the metallic matrix and created low-melting Fe-Ni-S-O eutectics in near-surface grain boundaries. Scale bar 100 μ .

The troilite is polycrystalline and displays parallel daubreelite lamellae and an occasional chromite crystal. Discontinuous schreibersite rims, 0.1 mm wide, surround the larger troilite nodules.

The above description appears to be true for the undamaged specimens, such as Tempe no. 3561x, London no. 1959.948, Tübingen 157 g and others.

A large number of museum specimens are, however, damaged. No Charcas material appears to have been distributed before 1867 when the mass came to Paris. It was cut there on several occasions, and since it appears that both unheated and heated specimens came into circulation, it may be concluded that the main mass is unheated, while one or perhaps more slices were reheated by Daubrée or Meunier in the late nineteenth century before the specimens were exchanged. The continuing interest of the French scientists in synthesizing and reheating meteorites is clear from the papers such as those by Daubrée (1868c:31) and Meunier (1884:39, 321).

The evidence for reheating, as seen in, for instance, U.S.N.M. no. 1355, may be presented in the following points. (i) The metallic matrix is converted to serrated 25-50 μ α_2 grains of the kind which normally is only present in the heat-affected rim zone. The hardness is irregular, ranging from 175 to 225, suggesting rather unequilibrated transformation products. (ii) The rhabdites and smaller schreibersite bodies are almost resorbed in the kamacite- α_2 . (iii) The larger schreibersite crystals are either melted and solidified into fine-grained eutectics with holes, or they are surrounded by $5-10 \mu$ wide, creamcolored reaction zones of the kind seen in, e.g., Rodeo. (iv) Pearlitic oxidation zones separate original corrosion oxides from the metallic matrix; these pearlitic intergrowths are probably high temperature reaction products between metal and "limonite." (v) The taenite borders are indistinct, with many "thorns" protruding into the surrounding lamellae from slight high temperature diffusion. Circumstantial evidence, therefore, indicates a reheating to 900 or 1000° C; individual specimens seem to be a little different.

Some Charcas specimens, e.g., Vienna no. A 770 and U.S.N.M. no. 146, furthermore show distorted Widmanstätten structures near the surface. Since the distortion penetrates to 1 or 2 cm depth, it is unlikely that it is due to hammering by man; rather, it is the remains of a ductile fracture from the moment the mass split in the atmosphere to produce a shower, or from some preatmospheric deformation.

Charcas is a medium octahedrite closely related to Thunda, Descubridora and Casas Grandes. There are structurally and chemically heavy indications that Charcas and Descubridora are, in fact, fragments of the same fall. However, the early removal from the original places of find and the artificial reheating make it difficult to reach a final conclusion; it would certainly be helpful to have the main mass in Paris cut in order to examine authentic material, which, expectedly, would be undamaged. Specimens in the U.S. National Museum in Washington:

66 g wedge-shaped block (no. 146, 4 x 1.7 x 1.2 cm; from Meunier 1889)

116 g part slice (no. 1355, 10.5 x 4 x 0.4 cm).

Charcas (Descubridora), San Luis Potosi, Mexico

Medium octahedrite, Om. Bandwidth 1.05 ± 0.15 mm. ϵ -structure, but artificially altered. HV 175 ± 15 .

Group IIIA. 7.89% Ni, 0.52% Co, 0.15% P, 20.1 ppm Ga, 39.9 ppm Ge, 2.2 ppm Ir.

The whole mass has been artificially reheated to $600-700^{\circ}$ C. It is probably a paired fall with Charcas.

HISTORY

Already before 1783 an oblong mass of about 576 kg was found on the slopes of the Descubridora Mountain about 70 km north of Charcas in the vicinity of Catorce (Zérega et al. 1872; Burkart 1874; Castillo 1889). It was probably accidentally discovered by miners who, since 1773, had successfully prospected for silver in the area. It was moved to the nearby Hacienda de Poblazon and was



Figure 562. Charcas. The two halves of the Descubridora specimen (Museum de Chopo, Mexico City). Six-lined inscriptions on the two surfaces commemorate the difficult cutting operations in 1871. The two halves do not fit together today, since a thick slab has been removed. At "a", an old fissure (matte streak) is filled with corrosion products. Below right an unlabeled and unidentified meteorite, probably a Toluca mass. Ruler measures 15 cm.

seen there by Berlandier in 1827, as shown by Fletcher (1890a:158). Later it was moved by a Mr. Aguilar to the amalgamation works in San Miguel de Catorce to be used as a base for the ore crushing stamp mills. According to the present label in the Mexican National Museum it was for some time used as an anvil during coin embossing in San Miguel de Catorce. But eventually, in 1871, it was presented to the Mexican Society of Geography and Statistics which had it cut in two almost equal halves. About 50 kg was further separated in order to have the iron distributed to collections and to have it thoroughly investigated. Tensile and compression tests were carried out, and heat treatments and forging experiments were undertaken. The blacksmith at Poblazon had, however, previously proven that it was possible to produce highly estimated hoes and chisels from the specimens he slowly dislodged under great difficulty (Zérega et al. 1872).

The division of the mass in Mexico City led to a heated dispute in which one group within the scientific society reproached another group, responsible for the cutting, on philosophical principles. Unfortunately, in a 20-page polemic few new data on the iron itself were added



Figure 563. Charcas. The opposite end of the Descubridora mass, "b", Figure 562. The oblique left surface once served as an anvil and many hundred square centimeters are flattened by hammering. The deep fissure is up to 2 cm wide and follows octahedral (111) γ planes. Many slices in collections, e.g., U.S.N.M. no. 469 and no. 675, come from this cut. Evidently the cutting took place by means of milling from two sides and, finally, by drilling 11 parallel one-half inch holes. Ruler measures 15 cm.

	р	ercentage	e					ppm				
References	Ni	Co	Р	С	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Lovering et al. 1957		0.56				75	148		13	49		
Smales et al. 1967						29	151	2.8	19.6	40		
Wasson & Kimberlin												
1967	7.70								20.5	39.7	2.3	
Moore et al. 1969	8.07	0.52	0.15	120	50	•	170					
Crocket 1972											2.1	13

(Camacho et al. 1873); a few rough sketches of the exterior shape were, however, included.

Another mass, of 41.7 kg, was found in 1885 by a miner near Catorce. It was described with woodcuts by Kunz (1887e) who drew attention to an early attempt at splitting the mass with a copper (?!) chisel, the remains of which were still firmly wedged in the fissure. The mass was bought for the Vienna Collection where it is still preserved, almost undivided (Kurat, personal communication).

Two or three other small masses appear to have been recovered at different times from the region (Fletcher 1890a). Further, it is almost certain that the 780 kg Charcas mass was originally found here.

Brezina (1896: 272-76, 345) found the structure similar to Charcas, Misteca, Rancho de la Pila and others; he gave two photomacrographs. Berwerth (1905) concluded that the fine-grained matrix indicated reheating by man. Nininger & Nininger (1950: plate 5) gave a photomacrograph. Reed (1965a, b; 1969) determined the composition of the kamacite, taenite and phosphides, both with respect to nickel and phosphorus. Jaeger & Lipschutz (1967b) and



Figure 564. Charcas. Descubridora (Tempe no. 39a). Severely distorted Widmanstätten structure of preatmospheric origin. Deepetched. Scale bar in cm. (Courtesy C.B. Moore.)



Figure 565. Charcas. Descubridora (Tempe no. 39a), Recrystallized kamacite and annealed dark plessite field. The schreibersite crystals (S) are unaffected. The recrystallization was caused by artificial reheating, Etched. Scale bar 100 μ .

Jain & Lipschutz (1968) concluded that Descubridora recrystallized by sustained heating in some preterrestrial collision. Voshage (1967) found by the 40 K/ 41 K method a cosmic ray exposure age of 510 ± 110 million years, while Hintenberger et al. (1967) determined the helium and neon isotopes, and found them in normal quantities. Axon (1969) discussed the severe plastic deformations in the metallic matrix.

COLLECTIONS

The two butt ends (about 500 kg) are in Museum de Chopo, Mexico City. A 1,632 g plate is in Institute of Geology, Mexico City. The 41.5 kg Catorce mass is in Vienna. Chicago (33 kg), Washington (6 kg), London (4.4 kg), Helsinki (2.4 kg), Harvard (1.3 kg), Prague (668 g), Tübingen (638 g), Tempe (293 g), Rome (245 g), Bonn (233 g), Yale (192 g), Copenhagen (168 g).



Figure 566. Charcas. Descubridora (Tempe no. 39a). Recrystallized kamacite and lacework reaction zones between kamacite and terrestrial limonite. Both effects caused by artificial reheating. Etched. Scale bar 30μ .



Figure 567. Charcas. Descubridora (Tempe no. 39a). Two schreibersite crystals (S) surrounded by terrestrial weathering products. Artificial reheating has created serrated reaction rims between schreibersite and limonite. Etched. Scale bar 30 μ .

DESCRIPTION

The 576 kg mass was an oblong, triangular prism with rounded edges. Its average dimensions were $90 \ge 40 \ge$ 35 cm, but it was divided in 1871 to produce two end specimens, each 40 cm high, while an intermediate section was removed for testing purposes. From one end, several parallel slices, each about $30 \ge 24 \ge 0.7$ cm, were cut, possibly by Ward about 1895, and distributed to collections (e.g., U.S.N.M. no. 469; no. 675; London; Vienna; Helsinki). At least 35 kg passed through Ward, and some slices were for sale still as late as 1940. The two endpieces in Mexico City have polished and etched, now tarnished, surfaces which carry identical inscriptions, six lines long, in Spanish. They were chiseled in to commemorate the cutting in 1871 but contain little significant information.

The two end masses, which are now in the abandoned, old Mexican National Museum, Museum de Chopo, display numerous shallow pits, probably from terrestrial corrosion. No visible fusion crust is preserved. One end has a 36 x 12 cm flat face, which evidently was produced by heavy pounding, probably while serving as an anvil or stamp mill base. Less conspicuous hammering is found in several other places. A large ragged fissure extends from the anvil end through most of the mass; its width is 20 mm at the surface but gradually tapers off to nothing as it follows the schreibersite-filled octahedral planes. The fissure contains thick laminated corrosion products which include a few specks of metal and phosphides. From the size and state of corrosion it must be concluded that the fissure was present when found and dates back to the atmospheric disruption. Similar large fissures from the same cause may be observed in, e.g., Bacubirito, Hoba, Monahans and numerous Sikhote-Alin specimens.

Etched sections display a medium Widmanstätten structure of long ($\frac{L}{W} \sim 35$) kamacite lamellae with a width of 1.05±0.15 mm.

Taenite and plessite occupy 30-40% by area, mostly as degenerated comb and net plessite fields. Schreibersite occurs as $20-50 \mu$ wide grain boundary precipitates and as 5-40 μ irregular blebs inside the plessite. The kamacite subboundaries are decorated with small phosphides, and some $1-2 \mu$ wide rhabdite prisms are present in the matrix.

Troilite is common as 0.5-10 mm nodules and rhombic inclusions. On numerous, old deep-etched sections the troilite is black and limonite- or silicate-like. Some workers have even reported them to consist of graphite, but this mineral is not present. Numerous oriented platelets, typically $10 \times 1 \mu$ in size occur in the kamacitic matrix; they are identical to the chromium-nitride, carlsbergite, reported in Cape York, Schwetz and others. (Buchwald & Scott 1971).

Now, the original cosmic structure is severely altered by artificial reheating and hammering. The kamacite lamallae have recrystallized to a rather uniform aggregate of grains, 5-40 μ across, which exhibit a hardness of 175±15. The original structure seems to have been a shock-hardened and annealed ϵ -structure, traces of which may still be discovered in "fossilized" form in corroded parts of the meteorite.

The taenite and plessite fields show a double set of grain boundaries, one set being ghost-lines indicating the previous location of the boundaries, which correspond to normal unaltered plessite. The taenite is brownly tarnished and shows modest thorns and warts, suggesting partial resorption at the reheating. In accordance with this is its low hardness of 205 ± 15 (measured on $40\,\mu$ wide taenite ribbons) which suggests artificial annealing.

The troilite is a recrystallized aggregate of $1-100 \mu$ grains. It appears that is is a late artificial recrystallization of a cosmically produced shock-melted troilite which had frayed edges against the metal and was subdivided into $1-10 \mu$ grains.

At the pointed end of the mass, severe distortions with bent and displaced kamacite lamellae occur. A section through this region reveals several narrow, subparallel shear zones with relative displacements ranging from 0,1-10 mm. A comparison with the main specimens in Mexico City shows that these deformations occur in positions which were not particularly exposed when the meteorite served as an anvil, so they must be of preterrestrial origin. The shear zones are now rather complex intergrowths of troilite, daubreelite, schreibersite and various terrestrial oxides. Locally a larger troilite bleb is present. It appears that a cosmic event produced the deformations and opened up minute fissures which became filled with troilite, daubreelite and schreibersite debris. Later, the cracks were easily attacked by terrestrial water, and the minerals were cemented together by limonitic oxides. Finally, on the artificial reheating, the limonite decomposed to a distinct two-phase mixture resembling the magnetite-wüstite of the fusion crust. Also, the schreibersite and the limonite reacted to form 1-5 μ wide creamcolored transition zones, and 10-50 μ wide, lace-like metal-oxide intergrowths formed abundantly.

Oxide-shales, which I removed from the large fissure in the main mass mentioned above, show the same minerals



Figure 568. Charcas. Descubridora (Tempe no. 39a). An original deformed troilite nodule has, on artificial reheating, recrystallized and, upon cooling, decomposed into narrow lamellae of alternating troilite and daubreelite. Etched. Crossed polars. Scale bar 30 μ .

and the same alterations which indicate that not only a few small specimens, but the whole mass, has been artificially reheated.

Descubridora thus has a very complex story, involving both cosmic and artificial deformation and reheating. It appears originally to have been a normal group IIIA iron with a bandwidth of 1.05 mm, similar to Cape York, Sacramento Mountains and Kyancutta. It was shocked and somewhat annealed whereby the ϵ -structure, the polycrystalline troilite and the severe local deformations were formed. It penetrated the atmosphere and produced a small shower of which the 4l kg Catorce and the 780 kg Charcas masses were fragments. The masses corroded significantly before they were recovered. They then had somewhat different fates among the various prospectors, engineers and scientists, and their present structures are therefore rather different. It appears that all of Descubridora was reheated to about 600 or 700° C, while a significant number of Charcas specimens were reheated as high as 1000° C. The Catorce specimen has never been well examined, so its structure is virtually unknown.

Specimens in the U.S. National Museum in Washington

58 g part slice (no. 78, 4 x 1,4 x 1,2 cm) 2.8 kg slice (no. 469, 30 x 24 x 0.7 cm) 3.0 kg slice (no. 675, 30 x 27 x 0.5 cm)	adjacent, parallel slices from Ward's workshops
25 g part slice (no. 1014, 2.5 x 2 x 0.4 cm)	ward 5 workshops
352 g part slice (no. 2743, 10 x 6 x 1.3 cm)	

Charlotte, Tennessee, U.S.A. 36°12'N, 87°22'W

Fine octahedrite, Of. Bandwidth 0.30 ± 0.05 mm. Neumann bands. HV 200 ± 15 .

Group IVA. 8.22% Ni, 0.40% Co, 0.055% P, 2.24 ppm Ga, 0.118 ppm Ge, 1.5 ppm Ir.

Most distributed material is rich in ablation-heated rim zone with $\alpha_{\rm 2}$ structure.

HISTORY

While the details of the falls of Hraschina, 1751, and of Braunau, 1847, are rather well known, the circumstances connected with the fall of Charlotte are poorly known. According to Troost, who obtained the main mass of 3.5 kg and described it (1845), the fall may have occurred in 1835, on the last of July or the first of August, between 2:00 and 3:00 p.m. A kidney-shaped mass of about 4 kg hit the ground obliquely (?) from the west and buried itself in the roots of a large oak. The usual light and sound phenomena accompanied the fall and frightened a man and horse plowing the cotton field for the last time that season. The smaller end of the mass was partly cut, partly broken off by a blacksmith and lost. The place of fall was "near"



Figure 569. Charlotte (Copenhagen no. 1876, 44). A fine octahedrite which was recovered immediately after its fall in 1835. Etched. Scale bar 3 mm.



Figure 570. Charlotte, Detail of Figure 569. Black taenite wedges and net plessite. All kamacite of this section was transformed to unequilibrated α_2 structures during atmospheric flight. Etched. Scale bar 500 μ .

CHARLOTTE – SELECTED CHEMIC	CAL ANALYSES
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	р	percentage						ppm	1.1			-
References	Ni	Co	Р	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Smith 1875	8.01	0.72					600					
Cobb 1967	8.19	0.38					136		< 10		1.45	
Moore et al. 1969	8.44	0.41	0.055	55	30		165					
Schaudy et al. 1972	8.04								2.24	0.118	1.5	

The values of Smith are good for their time but are not used in calculating the average composition here.

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Charlotte, county seat of Dickson County, which has the coordinates given above. Smith (1875) presented an analysis; having acquired the mass he distributed several slices. Cohen (1905) reviewed the literature and discussed the structure of two specimens in Vienna and Tübingen. He concluded correctly that specimens from the thin part of the meteorite were thoroughly reheated, while those from the more massive part were unheated, except for a 3 mm rim zone. Photomicrographs of the Vienna specimen were given by Brezina and Cohen (1886-1906: plates 17 and 18). Buchwald (Hey's Catalog 1966: 99) suggested that the whole mass might have been damaged in the cutting operation by the blacksmith, but as will be discussed here this is apparently not the case. Jaeger & Lipschutz (1967b) noted the "recrystallized" structure in a Harvard specimen. Vilcsek & Wänke (1963) and Chang & Wänke (1969) determined the cosmic ray exposure age to be 220±30 million years, while Voshage (1967) found 340±100 million years. Fisher (1967) included Charlotte in his discussion of the space erosion problem.

COLLECTIONS

Harvard (endpiece 1,965 g), Tempe (213 g), Washington (181 g), Vienna (166 g), Tübingen (110 g), London (77 g), New York (59 g) Göttingen (58 g), Copenhagen (41 g), Ottawa (18 g), Stockholm (13 g), and small slices in several other collections.

DESCRIPTION

As seen from the drawing by Troost (1845), the mass is comparable to a flattened pear with the maximum dimensions $20 \times 14 \times 5$ cm. While the more massive 2 kg front end is undivided in Harvard, all other specimens in collections come from the relatively thin rear half of the specimen where the thickness rapidly decreases below 5 cm. The normal magnetite fusion crust is apparently absent, most likely because some early possessor abraded it



Figure 571. Charlotte. Detail of Figure 569. Cellular plessite field inside the heat-affected α_2 zone. The oriented γ -platelets are still indistinctly seen. Etched. Scale bar 100 μ .

mechanically to obtain a smooth, metallic surface. If so, he failed to remove the metallic part of the fusion crust. This is preserved as a 10-300 μ thick, laminated, dendritic-cellular crust, intimately intergrown with the exterior unmelted part of the meteorite.

In one respect Charlotte is peculiar: many sections examined by the author consist almost entirely of reheated material, in which the α_2 structure of 20-100 μ serrated scalloped grains dominates. Most other meteorites have narrow α_2 rim zones of 2-4 mm width. Specimen no. 1876.44 in Copenhagen, a 53 x 35 x 4 mm slice, shows only α_2 , while the somewhat larger specimens no. 382.1 in Tempe and no. 577 in Washington, below a 4-15 mm thick α_2 zone, have interior parts of untransformed ferrite rich in Neumann bands. Some specimens, in addition, display wavy kamacite lamellae.

It appears to the writer that there are only two possibilities for these structures. The first is that Charlotte penetrated the atmosphere, stably oriented, with the blunt end as the leading edge, and possibly was slowly decelerated during a long oblique flight. Thereby, the rear part, especially, was thoroughly reheated and developed α_2 structure to a greater depth than normally met with. In this connection it is perhaps significant that the meteorite was still warm when it was picked up (Troost 1845), although the report may be biased by the observer's expectation and imagination.

The other possibility is that Charlotte originally had a perfectly normal 2-3 mm thick α_2 zone which was enlarged by the activity of the blacksmith. The absence of intercrystalline high temperature oxidation, normally present on artificially reheated meteorites, and the survival of an interior region with Neumann bands speak against this theory. A blacksmith, who intended to divide a meteorite by heat application, would, in fact, be rather superficial if he didn't soak the mass in the forge, thereby transforming *all* 4 kg to α_2 structure.



Figure 572. Charlotte (Tempe no. 382.1). Layered metallic fusion crust (above) and heat-affected α_2 zone. No phosphides are present. Etched. Scale bar 200 μ .

I will, therefore, conclude that Charlotte developed its anomalously wide α_2 zone in flight, particularly on the rear end; it is exactly from this end that all examined museum slices come. The blacksmith probably divided the mass with a cold chisel, thereby creating the bent and deformed kamacite lamellae seen on some specimens. The α_2 structure can, under no circumstances, be preatmospheric, and it should not be termed recrystallized since this term is reserved for structural changes taking place within the α -range, while the structure of Charlotte obviously was created by a short reheating into the γ -range with subsequent rapid cooling.

Etched sections display a fine Widmanstätten structure of bundled, long ($\sqrt[4]{w} \sim 30$) kamacite lamellae with a bandwidth of 0.30 ± 0.05 mm. The microhardness is 200 ± 15 . Plessite occupies about 50% by area. It is mainly developed as an open-meshed comb plessite, repeating the large scale Widmanstätten pattern, but poorly resolvable duplex fields of $\alpha + \gamma$ are also common. The cellular fields, described from, e.g., Chinautla, are also common. All kamacite is beset with Neumann bands unless it is situated in the 2-40 mm wide heated rim zone where it is transformed to α_2 . The taenite shows here thorny edges due to slight diffusion; and grain boundaries enriched in phosphorus show incipient melting. The microhardness of the reheated rim is 185 ± 15 .

Schreibersite and rhabdite are practically absent, in harmony with the analytical value of 0.055% P. Only very few scattered 2-5 μ schreibersite bodies, still partly enveloped by taenite, were observed. Troilite was only seen on a few, old, deep-etched sections as 0.5-2 mm lenticular bodies. Small bluish daubreelite bodies, 10-20 μ in diameter, were observed locally in the α -phase.

Charlotte is a normal fine octahedrite, closely related to such well known irons as Altonah, Muonionalusta and Gibeon. Its confusingly large amount of reheated α_2 structure is almost certainly due to deep heat penetration during oriented flight. A close examination of the main mass in Harvard would help to clarify the situation.

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

171 g part slice (no. 577, 8 x 5.5 x 0.5 cm) 8 g part slice (no. 550, 2 x 1 x 0.3 cm) 2.7 g part slice (no. 991, 2 x 1 x 0.2 cm)

Chebankol, Kemerovsk Oblast, RSFSR 53°40'N, 88°0'E

Coarse octahedrite, Og. Bandwidth 2.5 ± 0.5 mm. Distorted Neumann bands. HV 265 ± 25 .

Anomalous, or slightly related to IIIE. 8.92% Ni, 0.44% Co, 0.29% P, 21.8 ppm Ga, 52.5 ppm Ge, 0.11 ppm Ir.

HISTORY

A weathered mass of 124 kg and several oxidized fragments, totaling about 1 kg, were found in 1938 and were recognized as meteoritic by the engineer-geologist A.S. Muchina. In 1940 an additional individual of 3.8 kg was found in the same place. The meteorites were recovered during sorting of gold bearing alluvial deposits from a depth of 130 cm, which was in the ground water zone. The locality was close to the rivulet Chebankol, a tributary of the river Kondoma, about 350 km southeast of Tomsk. The material was transferred to the Committee of Meteorites in Moscow and was briefly described by Kulik (1941b) and Krinov (1947). In 1948 Krinov gave a thorough description with a map and photographs of the exterior and of etched slices. Additional structural information was supplied by Zavaritskij and Kvasha (1952) and by Yavnel et al. (1958) who studied the detailed phase composition with the electron microprobe. Krinov (1960a) mentioned the meteorite in several places and reproduced a couple of photographs. He mentioned Chebankol as an example of



Figure 573. Charlotte. Detail of Figure 572. Seven layers of metallic, dendritic fusion crust. Black spots are gasholes and iron oxide inclusions. Corrosion products are virtually absent. The rapidly cooled metalic melts transformed diffusionless to martensitic α_2 structures. Etched. Scale bar 30 μ .



Figure 574. Chebankol (Moscow). An unusual coarse octahedrite. The Widmanstätten lamellae are short and bulky, and the bandwidth is very large for the bulk nickel content of 8.9%, suggesting extremely slow cooling. Wasson (1971b) noted that the cooling rate of 0.3° C per million years is perhaps the lowest of any iron meteorite. Deep-etched. Scale bar 30 mm.

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lawrencite-rich material, but the evidence appears to be insufficient. Rather, the observed rust staining is the result of chloride penetration during a long terrestrial exposure in the ground water zone. Starik et al. (1960) determined the lead content and the amount of the various lead isotopes. The results were discussed in a larger context by Sobotovich (1964).

COLLECTIONS

Main mass (122.9 kg) and fragments (2.1 kg) in Moscow, Tallinn (162 g), Leningrad (about 100 g), Sydney (70 g), Washington (57 g).

DESCRIPTION

The main mass is turtle-shaped with the overall dimensions $60 \ge 45 \ge 12$ cm; it is supposed to represent an example of oriented fall, since one face is convex (front side) and the other is rather flat (Krinov 1948). It is heavily corroded with loosely adhering oxide scales, 3-5 mm thick. As the associated fragments clearly indicate, the mass has been exposed to disintegration for a long time. In some places the octahedral structure is seen as a grid on the weathered surface.

Etched sections display a beautiful, but unusual, Widmanstätten structure. The kamacite lamellae are bulky and short ($\frac{1}{W} \sim 10$) and have an average width of 2.5±0.5 mm. The marked rounding and irregular pinching of the individual lamellae are probably what first catch the eve, as an unusual development of the macrostructure, but the associated rather contrast-rich, triangular and rhombohedral plessite areas do also add to the characteristic appearance. The kamacite has numerous Neumann bands, but in addition a late cosmic deformation has produced considerable distortions and offsets of the primary structural elements. Locally a plessite area is displaced 1 mm, and sets of lenticular deformation bands are everywhere in the kamacite. The individual lenticular band is 10-20 μ wide and is decorated with a cloud of submicroscopic precipitates. The numerous subgrain boundaries of the kamacite are also decorated – but by somewhat larger, 2-10 μ wide, prisms and rods of rhabdites. The hardness is 265±25, rather high, in accordance with the cold-worked appearance of the kamacite.

Plessite covers about 25% by area, mostly in form of comb and net plessite, and as martensitic and acicular fields. The framing taenite is $10-20 \mu$ thick and usually etches grayish-blue, indicating a significant concentration of carbon in solid solution. The martensite plates and the

acicular fields repeat the Widmanstätten directions of the primary structure. The carbon content found by Trofimov (1950) is high, but the structure also does appear to be unusually rich in dissolved carbon, mainly in the taenite. No cohenite or graphite was observed. A typical plessite field will have a tarnished taenite rim (HV 450±20) followed by a light martensitic transition zone. Then follow brown-etching martensites (HV 400±30) and, finally, duplex poorly resolvable $\alpha + \gamma$ mixtures (HV 310±30).

Schreibersite occurs sparsely as 1 mm skeleton crystals with 2-3 mm wide rims of swathing kamacite, but it is far more common as 50-200 μ wide grain boundary precipitates. It further occurs as 5-50 μ irregular bodies in the plessite interiors. The schreibersite is monocrystalline but somewhat broken and locally faulted. Rhabdites are numerous as 1-5 μ wide prisms, often offset their own thickness by a late plastic deformation.

Troilite and other meteoritic minerals were not observed on the available section.

Long-term corrosion has removed the fusion crust and the heat-affected α_2 zone completely. Limonitic veinlets, 50-100 μ wide, penetrate many centimeters into the interior, and, near the surface, the α -phase of the plessite fields is selectively corroded. A delicate branched network of oxidic cracks in the α -phase resembles stress corrosion cracks in stainless steels. As mentioned above, Chebankol has, at a late time in its development, suffered severe plastic deformation, so it is only natural that a stress corrosion-like attack should develop during its supposedly long terrestrial exposure to ground water.

Chebankol is structurally unique, since no other iron on the 9% Ni level has a coarse Widmanstätten structure. Its significant carbon content contributes in yielding a range of microstructures otherwise mostly seen in group I irons, such as Toluca, but Chebankol does not really belong to group I. Its Ga, Ge, and Ir contents are slightly related to Rhine Villa, Coopertown and Kokstad.

Specimen in the U.S. National Museum in Washington: 57 g part slice (no. 1731, 5.5 x 3 x 0.5 cm)

Chesterville, South Carolina, U.S.A.
34°42′N, 81°13′W; 150 m

Originally a hexahedrite similar to Hex River, now altered by the blacksmith.

CHEBANKOL -	SELECTED	CHEMICAL	ANALYSES
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	perce	rcentage						ppm				
References	Ni	Co	Р	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Trofimov 1950				4300								-
Dyakonova &												
Charitonova 1960	9.03	0.44	0.29				300					
Scott et al. 1973	8.80					_			21.8	52.5	0.11	

Group IIA. 5.71% Ni, 0.57% Co, 0.30% P, 58.9 ppm Ga, 178 ppm Ge, 1.8 ppm Ir.

All specimens in collections display artificially altered structures.

HISTORY

A mass of about 16 1/2 kg was plowed up a few years before 1849 near Chesterville, Chester County. The finder took it "to the blacksmith, who at once proved it to be malleable. He cut several pieces from the mass, out of which he made horseshoes, nails and hinges for a gate." The unworked half of the mass and at least two pieces in a wrought condition came to Shepard and were exchanged with other collections (Shepard 1849). Chesterville was described by Rose (1864a: 69), Brezina (1885: 203, 219; 1896: 294) and Cohen (1897a: 46; 1899: 148; 1905: 62), but it never occurred to these authors that the structure might have been heavily influenced by the treatment given by the blacksmith. Wülfing (1897: 76) and Farrington (1915: 121) reviewed the literature. Berwerth (1914: 1078) was probably the only one who recognized the artificial structure and included the meteorite in a special subclass of metabolites. His results were, however, never acknowledged, for later descriptions and conclusions by Vogel (1927; 1952), Perry (1944: 75), Heide (1957: figure 89), Marchese et al. (1966a) are all based upon the assumption that Chesterville has a genuine, cosmic structure. Recently I drew attention to the original information by Shepard and urged that whenever a meteorite showed signs of reheating, the source literature should be consulted in order to escape hasty conclusions (Buchwald 1965; 1967a: figure 1). Chesterville is the present city of Chester, which has the coordinates given above.

COLLECTIONS

London (2,144 g), Amherst (1,967 g), Yale (751 g), Vienna (681 g), Berlin (336 g), Tübingen (274 g), University of South Carolina, Columbia (185 g), Tempe (147 g), Chicago (144 g), Göttingen (115 g), Washington (103 g), Paris (88 g), Copenhagen (79 g), Budapest (64 g), Stockholm (63 g) and many other collections. A total of 7.6 kg could be located in the collections. Two large nails forged from Chesterville material are preserved at Amherst, see Figure 576.

DESCRIPTION

"Its original shape was similar to that of a common fresh water muscle (a species of Unio). Its surface was much indented" (Shepard 1849). A cast of the meteorite was previously in the Field Museum (Farrington 1895: 61). The surviving fragments have apparently lost their indented surfaces; instead they are commonly bounded by sets of more or less plane parallel surfaces. Typical, for instance, is the largest preserved single specimen, no. 24001 of the British Museum. It was bought from Shepard in August 1849 and at that time weighed 2,250 g. The box-shaped specimen is bounded by two 5 x 7 cm flat and parallel surfaces, and there are many small empty cracks and fissures. The same is generally true of the specimens in Amherst, Yale, Vienna, Tübingen, Copenhagen, Berlin and Tempe, except that the actual sizes of the flat surfaces and the empty cavities vary. Marks from chiseling and hammering may be seen on many specimens. No remnants of the crust from penetration of the atmosphere have been observed on any Chesterville specimen. On the contrary, a blistered and porous crust may be found locally, indicative of artificial reheating. On larger sections, such as no. A 464 of Vienna, traces of the original macrostructure may still be seen. Rhabdites, typically 2 x 0.2 mm, are arranged in long, parallel planes 5-10 mm distant, and irregularly scattered phosphide and sulphide inclusions are also seen. Unaltered meteorites with such a distribution of the phosphides are, e.g., Hex River, Calico Rock, Coahuila, Indian Valley and Mayodan, the last two probably being paired falls (Buchwald 1967a: 46).

Figure 575. Chesterville (Vienna no. A 464). An artificially reheated and slightly forged fragment The rhabdites are arranged in conspicuous sets of parallel planes, one direction being vertical, the other inclined at about 50° . Deep-etched. Scale bar 30 mm.

All phosphides and sulphides have been melted; that is, the temperature has been above about 1000° C. The original angular rhabdites dissolved upon melting a little of



Figure 576. Chesterville (Amherst). Two large nails forged from the Chesterville meteorite. There is also a 1.9 kg endpiece in Amherst which shows significant alterations due to artificial reheating. Ruler in centimeters.

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the surrounding matrix, thus assuming rounded outlines. The progressive diffusion of phosphorus away from the phosphide regions occurred particularly along the high temperature austenite grain boundaries. Upon etching, these become visible as thorn-like projections from the phosphides. Upon solidifying, primary austenite dendrites precipitated in the melt and lined the cavity, and the rest solidified in eutectic structures. Troilite modified the details of solidification when present. In near-surface parts the micromelts have sweated out leaving irregular cavities. Cohenite was originally present in minor amounts as narrow rims around schreibersite. Due to the heat treatment, it has been resorbed but left carbon-enriched iron-nickel grains which, upon cooling, transformed to bainitic-martensitic structures similar to those reported from Rasgata specimens of Santa Rosa (Buchwald & Wasson 1968).

The metallic matrix is composed of irregular serrated flakes of α_2 , typically 100 μ in diameter. This is the structure which may be expected when a hexahedrite is heated beyond about 800° C for a relatively short time and cooled in the air. It is also the structure normally found in the near-surface kamacitic parts of meteorites that still preserve their atmospheric penetration crust. In Chesterville, however, the structure is present everywhere in the sections.

In many specimens, as, for instance, Copenhagen no. 1862.485, there are wavy ghost-lines on the etched section,



Figure 577. Chesteville (Copenhagen no. 1872, 2804). At low magnification the schreibersite crystals and rhabdite platelets are distinctly seen. Spherical shrinkage cavities are common in the remelted phosphides. Etched. Scale bar 3 mm.

parallel to the flat surfaces. This indicates that the specimen has been hot-pressed or forged; ghost-lines have also been observed in Babb's Mill, Troost's Iron and interpreted in the same way (Buchwald 1967a: 25).

Summarizing, there are the following essential facts to be accounted for: no trace of penetration crust, parallel and



Figure 578. Chesterville. Detail of Figure 577 at A. The central phosphide crystal has melted entirely, partly dissolving the surrounding kamacite walls. Upon solidification fine dendrites precipitated in a eutectic matrix. Etched. Scale bar 200 μ .



Figure 579. Chesterville. Detail of Figure 577. The kamacite matrix now displays unequilibrated α_2 grains. The diffuse streaks indicate the former positions of rhabdites. They are now resorbed, but full homogenization has not occurred. Etched. Scale bar 200 μ .

	percentage							ppm				
References	Ni	Со	P	С	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Sjöström in Cohen 1905	5.66	0.74	0.34	200	300		200					
Moore & Lewis 1968	5.86	0.39	0.25				150					
Wasson 1970,												
pers. comm.	5.61								58.9	178	1.8	

CHESTERVILLE -	SELECTED	CHEMICAL	ANALYSES
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Figure 580. Chesterville. Detail of Figure 577. A branched rhabdite crystal and a rhabdite plate (right), which have both been melted. Granulated α_2 matrix. No small rhabdites in the nickel- and phosphorus-depleted zones adjacent to the large phosphides. Etched. Scale bar 300 μ .



Figure 581. Chesterville (Copenhagen no. 1862, 485). An original troilite-daubreelite nodule with rims of schreibersite and cohenite. Remelted and entirely altered by artificial reheating. Etched. Scale bar $300 \ \mu$.

flat surfaces, metallic matrix of rapidly transformed α_2 grains, micromelted inclusions with eutectic structures and empty near-surface cavities. The only possible conclusion is that Chesterville was thoroughly heat treated by the blacksmith (about 1848), who, in order to cut pieces for his work, probably heated all the meteorite and not only those parts that were later forged.

Another "Nickel-poor ataxite" is thus shown to be a product of man, a hexahedrite which was transformed by heat treating in the 1000° C range.

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

- 54 g part slice (no. 995, 32 x 32 x 6; Shepard Collection no. 43) 36 g part slice (no. 995, 40 x 20 x 6 mm; Shepard Collection no. 42)
- 12 g part slice (no. 2721, 32 x 20 x 2 mm)



Figure 582. Chesterville (Copenhagen no. 1872, 2804). Detail of an artificially remelted nodule. Sulfide (glossy gray), austenite dendrites, now α_2 (dotted gray), and Fe-Ni-C-P eutectic (dotted white). Etched. Scale bar 30 μ .

Chichimeguillas. See Mazapil

Chico Mountains, Texas, U.S.A. Approximately 29°N, 103°W

Hexahedrite, H. Completely shock-recrystallized to about 0.5 mm ferrite grains. HV 180 ± 10 .

Group IIA. 5.56% Ni, 0.33% P, 59 ppm Ga, 176 ppm Ge, 6.2 ppm Ir.

HISTORY

A 212 g fragment of a larger mass was sent to the Smithsonian Institution in 1915 where it was described with an analysis and a photomacrograph by Merrill (1922a). The finder, E.M. Flynn of Alpine, Texas, reported having found a large mass of about 2 tons in the Chico (correct=Chisos) Mountains in the southwestern part of Brewster County, of which the specimen in question was a detached fragment. Chisos Mountains are now a part of The Big Bend National Park. According to Barnes (1939a: 590), the big mass had been seen on two different occasions by Mr. R.W. Miller, supervisor of a survey sponsored by the Bureau of Economic Geology. The location was believed to be Juniper Canyon, about 80 miles south of Alpine. Barnes suggested that relocation might be difficult because the meteorite could have become covered by talus. Up to this date, no mention of the reappearance of the mass has been made in the reports from personnel or visitors of the National Park.

COLLECTIONS

Washington (172 g), New York (1.7 g).

DESCRIPTION

The fragment in the U.S. National Museum measures 6.5 x 3 x 2.5 cm and constitutes a triangular wedge, evidently broken from some larger mass. The original surface is smooth and slightly corroded. Locally, the fusion crust, consisting of a few layers of rapidly solidified metal, is preserved as a 100 μ thick deposit. The fused metal is dendritic-cellular with about 2 μ wide cells. Under the fusion crust is a 2-3 mm wide zone of serrated α_2 grains, 25-50 μ in size. The specimen is slightly weathered with some oxides present in grain and subgrain boundaries to a depth of less than 1 mm. The mass from which the fragment was detached is, thus, in a good state of preservation – or was in 1915.

Etched sections display a polycrystalline aggregate of equiaxial ferrite grains 0.2-1 mm in diameter. Each large grain is subdivided in numerous 20-100 μ subgrains which are only slightly tilted with respect to each other. Fine phosphide precipitates, which hardly deserve the designation schreibersite or rhabdite, are evenly distributed upon the grain boundaries as 1-5 μ thick wedges and flags. Still finer precipitates are located on the subgrain boundaries and in the grain interiors. Neumann bands are absent. The microhardness is 180±10.

What were originally massive schreibersite crystals, each about 1 x 0.5 mm, are now complex, polycrystalline aggregates of 5-10 μ thick phosphide-austenite blebs in networks of 30-50 μ ferrite grains. The somewhat diffuse areas are visible to the naked eye because of their deviating etching characteristics. The so-called sensitized loops are very common. These apparently consist of an unequilibrated metal phase, 5-15 μ across, surrounded by narrow lobes of phosphides. Upon weathering the components are among the first to corrode, and during preparation of polished sections they easily dissolve, disappear and leave angular cavities, occurring with a frequency of 400 per mm². They may represent shock-altered rhabdites.

A 9 x 5 mm nonmetallic nodule, with scalloped edges towards the metal, turned out to be a complex, polycrystalline aggregate of 1-3 μ troilite and daubreelite grains (20% by area) embedded in a fine-grained eutectic network of metal and phosphide. The metallic part of the aggregate is partly converted to violet-blue oxides by terrestrial corrosion.

Several spherical graphite nodules, about 30μ in diameter, are present in the ferrite phase.

The structures are best explained by assuming that a normal hexahedrite, like Coahuila, was severely shocked in

Cosmos and recrystallized during the accompanying relaxation temperature rise. The combination of pressure, temperature and time was sufficient to completely melt, not only the troilite as commonly is the case, but also the sheathing schreibersite and dissolve or melt the numerous schreibersite and rhabdite inclusions scattered through the hexahedrite. The metallic matrix recrystallized completely from numerous nuclei without passing into the γ or ϵ region of the P-T diagram, and generated the polycrystalline aggregate of equiaxial ferrite grains. The phosphides reprecipitated upon available grain boundaries, and a small part precipitated upon subgrain boundaries and dislocations in the grain interior. The small amount of carbon precipitated as graphitic sheaves, forming rather perfect spherulites.

Chico Mountains is an interesting meteorite, and it is a pity that the (somewhat?) larger main mass was never secured. Chico Mountains is, however, rather similar to Wathena, Forsyth County, Holland's Store, Kopjes Vlei, Mejillones and other so-called nickel-poor ataxites, and does in itself not display any completely new and anomalous feature which can not be studied in one or another of these irons. Chico Mountains closely resembles Pima County. Since both are fragments from an allegedly larger mass located in southwestern United States or in Mexico, and since both apparently became known about 1915, there is a remote possibility that they are parts separated (artificially) from the same, not yet identified, main mass. They are definitely different from the Coahuila specimens which came from the same general region.

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

155 g endpiece (no. 513, 6.5 x 3 x 2.5 cm)

17 g shavings

Chihuahua City, Chihuahua, Mexico Approximately 28°40'N, 106°6'W

Polycrystalline iron with cohenite. Recrystallized. HV 185±10. Anomalous. 6.87% Ni, 0.45% Co, 0.39% P, 0.25% S, 0.15% C, 52 ppm Ga, 212 ppm Ge, 0.11 ppm Ir.

HISTORY

This interesting meteorite was first described by Nininger (1931b). While visiting the National Observatory in Mexico City he saw an 11 kg endpiece cut from some larger mass. Realizing that it represented an unrecorded fall, completely different from the Toluca irons with which it

	percentage							ppm					
References	Ni	Co	Р	С	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt	
Whitfield in				1.1.1									
Merrill 1922a	5.62	0.43	0.33	80	120		160						
Wasson 1971,													
pers. comm.	5.50		_						59.3	176	6.2		

CHICO MOUNTAINS - SELECTED CHEMICAL ANALYSES

was exhibited, he set about tracing its source. This led to the recovery of the main mass of 43 kg which was in the possession of Sr. Mauro Moya in Chihuahua City. The



Figure 583. Chihuahua City (Tempe no. 27ax). The 16 kg endpiece in Tempe. It is only indistinctly seen in the picture that the meteorite is a polycrystalline aggregate of centimeter-sized precursor taenite grains. Dark minerals are troilite and schreibersite. Etched. (Courtesy C.B. Moore.)



Figure 584. Chihuahua City (Copenhagen no. 1968, 337). A former taenite grain boundary with schreibersite (S), kamacite (K) and cohenite roses (C) on both sides. Etched. Scale bar 200 μ .

original monolith was thus a mass of about 54 kg, but the place of find could not be established. The coordinates given above are those of Chihuahua City (Nininger & Nininger 1950: 107; and personal communication).

COLLECTIONS

London (18.1 kg, half of endpiece), Tempe (16.0 kg, other half of endpiece), Mexico City, National Observatory (about 8 kg), Harvard (2,037 g), Chicago (1,994 g), Canberra (650 g), Washington (363 g), Copenhagen (55 g). It has not been possible to trace the whereabouts of the following, authentic slices listed for sale by Ward's Establishment 1931: 20 g, 30.5 g, 63.8 g, 942 g, 1,238 g and 1,391 g. The 19 kg mass listed in Hey (1966: 104) as being in Chihuahua City, Chamber of Mines, could not be verified. If such a mass exists, it is probably not Chihuahua City, because the authentic specimens listed above add up to what was found originally when allowing for some loss by cutting, analyzing, etc.

DESCRIPTION

In the Arizona State University Collection at Tempe is a 16.1 kg mass which is the left half of the mass figured by Nininger & Nininger (1950: plate 7). Its dimensions are



Figure 585. Chihuahua City (Copenhagen no. 1968, 337). Detail of cohenite rose, showing the Widmanstätten intergrowth of cohenite (C), taenite (T), black taenite (P), kamacite (K) and schreibersite (S). Compare Figure 141. Etched. Scale bar 100 μ .

percentage							ppm				
Ni	Co	Р	С	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
6.96	0.40	0.42	500	650	230	1400					
6.95											9.6*
6.91	0.49							46			
6.68								52.7	212	0.11	
6.86	0.44	0.35	150								
	P Ni 6.96 6.95 6.91 6.68 6.86	percentage Ni Co 6.96 0.40 6.95 0.49 6.68 0.44	percentage Ni Co P 6.96 0.40 0.42 6.95 0.49 0.49 6.68 0.44 0.35	percentage P C Ni Co P C 6.96 0.40 0.42 500 6.95 - - - 6.91 0.49 - - 6.68 - - -	percentage P C S Ni Co P C S 6.96 0.40 0.42 500 650 6.95 - - - - 6.91 0.49 - - - 6.68 - - - -	percentage C S Cr 6.96 0.40 0.42 500 650 230 6.95 - - - - - - 6.91 0.49 -	percentage C S Cr Cu 6.96 0.40 0.42 500 650 230 1400 6.95 -	percentage ppm Ni Co P C S Cr Cu Zn 6.96 0.40 0.42 500 650 230 1400 - 6.95 -	percentage C S Cr Cu Zn Ga 6.96 0.40 0.42 500 650 230 1400	percentage ppm Ni Co P C S Cr Cu Zn Ga Ge 6.96 0.40 0.42 500 650 230 1400	percentage ppm Ni Co P C S Cr Cu Zn Ga Ge Ir 6.96 0.40 0.42 500 650 230 1400

CHIHUAHUA CITY – SELECTED CHEMICAL ANALYSES

*Includes all platinum metals.

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 $21 \times 15 \times 12$ cm, and it is covered with very shallow regmaglypts, 1-10 cm in diameter. The edges are somewhat hammered, and a hacksaw scar bears witness of an unsuccessful attempt to divide the mass; but, apart from this, the specimen was not maltreated by man. Cylindrical, parallel holes 5-25 mm in diameter that penetrate up to 6 mm into the interior are a peculiar manifestation. A trivial amount of fusion crust may be seen in the outer part of the holes so they are, no doubt, due to the former presence of parallel troilite rods that partly melted away during the atmospheric passage.

Etched surfaces display a polycrystalline aggregate of almost equiaxial grains, each about 3 cm^2 in size. For example, a total of 120 grains varying between 1 x 1 and 5 x 3 cm are on 350 cm^2 . Each grain was a separate austenite crystal at high temperature, and many grains unambiguously show traces of austenite twinning. The reason that these features may still be seen with the naked eye is twofold, one being that each grain and twin part of a grain developed its own Widmanstätten structure, the other, that a considerable number of precipitating phosphides and carbides segregated in the austenite grain boundaries upon cooling.

The Widmanstätten structure is, however, no longer visible, and it is not possible to assign a well defined α -width to the meteorite. On the contrary, all of the metallic matrix is recrystallized, resulting in very irregular, lobed ferrite grains, each 10-100 μ in diameter. Only a limited grain growth took place after recrystallization so the maximum ferritic grain size is about 500 μ . After the recrystallization a shock wave produced Neumann bands that are present in some places in profuse amounts. The hardness of the kamacite is 185±10.

Sulphides are present as parallel rods, 5-25 mm in diameter and at least 6 cm long. They often taper slightly at the ends and thereby approach a belemnitic shape. They do not respect the old austenite grain boundaries but often cut through several grains, apparently obeying no crystallographic laws. They are enveloped in discontinuous



Figure 586. Chihuahua City (Copenhagen no. 1968, 337). Recrystallized kamacite with a new generation of Neumann bands. Spheroidized phosphide particles (S). Etched. Scale bar 100μ .

0.1-0.2 mm wide schreibersite rims. Irregular troilite bodies of 1-5 mm size are found sprinkled through the mass. The troilite is recrystallized to an aggregate of grains 5-25 μ in diameter. One troilite rod, 3 mm in diameter, was found to be brecciated with only minor recrystallization.

Schreibersite is present in large amounts, partly disseminated as 1-10 μ subangular bodies in the recrystallized ferrite grains and their boundaries, partly as larger veinlets, e.g., 10 x 0.3 mm in the former austenite grain boundaries. The immediate surroundings of the schreibersite in the former austenite grain boundaries are precipitation-free ferrite, but then irregular palmate bodies of cohenite follow on both sides. This double row of inclusions along the grain boundaries is typical for Chihuahua City and unique, as already stated by Nininger (1931b).

The cohenite bodies are not homogeneous. Each crystallographic unit of 0.5-1 mm diameter is an intricately



Figure 587. Chihuahua City (Copenhagen no. 1968, 337). Recrystallized kamacite with Neumann bands and spheroidized phosphide crystals. Etched. Scale bar 30 μ .



Figure 588. Chihuahua City (Copenhagen no. 1968, 337). Altered troilite nodule with mosaic structure. Two schreibersite crystals at either end. Spheroidized rhabdites in the adjacent kamacite. Slightly crossed polars. Scale bar 100 μ .

branched island which incorporates inclusions of taenite lamellae, plessite fields and schreibersite blebs. The whitish taenite lamellae trace a micro Widmanstätten pattern which can be followed from unit to unit and is uniformly oriented within each original austenite crystal. A few cohenite units of this type are also found in the interior of the grains. Considering the frequency with which cohenite occurs, the carbon analyses reported appear to be low; 0.15% C would be more consistent with the observed structure. The hardness of the cohenite aggregates is 1000±100, varying with the local abundance of inclusions.

Rhabdites are present locally as euhedric 10-30 μ crystals on the twin boundaries of former austenite individuals.

The zone from atmospheric friction heating is preserved in some places as a 1-2 mm wide belt of serrated α_2 grains. It has a hardness of 200±10. In the inner part of the zone (~ 1000° C) the cohenite is partially decomposed. Carbon has diffused into the immediate surroundings and, thereby, created 10-20 μ wide brown-etching zones of martensitic-bainitic structures. These attain hardnesses of 550±50. In the outer part the temperature was sufficiently high to create pools of molten schreibersite and of molten carbon-rich metal, that solidified to ledeburitic-austenitic dendritic structures, of which part of the austenite, upon further rapid cooling, was transformed into beautiful martensite plates. The hardness is variable but around 850. Similar structures are found in, e.g., Arispe, Hammond, Morrill and Santa Rosa; see Buchwald & Wasson (1968:16). It is important to note that a rim zone is preserved because it proves better than anything else that the unique structures in Chihuahua City are not due to artificial reheating but are preatmospheric. Corrosion is superficial. It has removed most of the α_2 -zone but is otherwise of no consequence on this meteorite.

Chihuahua City is structurally and chemically related to Santa Rosa but deviates in some details, especially in the absence of the crystalline graphite ("cliftonite") of Santa Rosa. Both irons contain pencil-sized, parallel troilite rods as do also Bendegó and Cape York; and the explanation advanced there may also be valid for Chihuahua City.

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

363 g slice (no. 853, 12 x 8 x 0.5 cm); see Nininger (1931b: figure 2)

Chilkoot, Alaska, U.S.A. Approximately 59°20'N, 135°30'W

Medium octahedrite, Om. Bandwidth 1.00±0.15 mm. Heavily deformed, HV 220±15.

Group IIIA. 7.83% Ni, 0.12% P, 20.0 ppm Ga, 39.3 ppm Ge, 1.8 ppm Ir.

HISTORY

A mass of about 43 kg was purchased by the State Mining Bureau of California in 1881 from Chief "Donawack" or "Silver Eye," who said that it had been seen to fall by the father of one of the oldest Indians of the tribe, about one hundred years before. The locality is given as Chilkoot Inlet, Portage Bay, which has the coordinates given above (Hanks 1882: 307; Farrington 1915: 122).

COLLECTIONS

Division of Mines, San Francisco (main mass, according to Linsley 1934), Washington (5,523 g), Harvard (155 g), Chicago (62 g), London (39 g), New York (26 g), Tempe (16 g).



Figure 589. Chilkoot (U.S.N.M. no. 756). The matte appearance is due to cold-worked and annealed kamacite which is rich in ultrafine precipitates. Comb plessite above. Etched. Scale bar 400 μ .

CHILKOOT – SELECTED CHEMICAL ANALYSES

An old analysis on the label of the specimen on exhibit in San Francisco (see Farrington 1915: 122) states 7.11% Ni, 0.12% Co, 0.12% P. While the first two values are low, the phosphorus determination appears good.

	pe					ppm						
References	Ni	Со	Р	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Goldberg et al. 1951	7.89								18			
Scott et al. 1973	7.77								20.0	39.3	1.8	

458 Chilkoot

DESCRIPTION

The endpiece in Washington (no. 1368) shows that the mass was violently sculptured during atmospheric flight. Smooth, rounded parts interchange with grooved parts, one of which is a shallow bowl 10 cm wide and 2 cm deep, subdivided in several centimeter-sized pits. Locally, especially in protected grooves, the warty, striated magnetite crust may still be seen, but most of it has been worn away, probably by human handling.

The etched section shows that the mass has been heavily plastically deformed preatmospherically. The deformed Widmanstätten pattern appears to indicate a mainly compressive action with some shearing that opened up a few fissures along grain boundaries. These became partially filled with ablation melts during the atmospheric passage. The laminated crust consists of numerous thin, dendritic metallic layers that locally attain a thickness of 2 mm. The fissures may have 0.2 mm thick fillings of dendritic metal with a little sulphide and phosphide. It is noteworthy that the meteorite has circled in Cosmos with numerous fissures and cracks that were available for filling with metalic melts of low viscosity when passing through the atmosphere.

The fusion crust is dendritic with well developed columnar growth perpendicular to the unmelted substrate; the hardness is 360 ± 30 . Under the fusion crust is a 2-2.5 mm thick α_2 -zone with hardnesses of 215 ± 25 . Then follows a recovered transition zone which attains a minimum hardness of 165 ± 5 , and finally, at a depth of about 8 mm, comes the unaffected interior.

The Widmanstätten structure has α -lamellae 1.00±0.15 mm wide, with a length-width ratio of about 25. The lamellae undulate and are locally faulted, and so are the comb plessite fields. The taenite ribbons and the taenite of the plessite fields are partly resorbed; the interior of the larger taenite wedges is a duplex, poorly resolvable $\alpha + \gamma$ structure ("black taenite"). The kamacite lamellae show a confusing conglomerate of faulted and bent Neumann

bands and of sliplines and deformation zones which subdivide the ferrite in rhombic cells. At high magnification it appears that the deformed ferrite is decomposing to $\alpha + \gamma$, precipitating submicroscopic grains of γ along the sliplines, which is the reason for the general etching picture. In the 2 mm heated rim zone along the surface this impression is reinforced since the fine γ -grains become visible here as 0.5μ rounded nodules lining up along the deformation zones. The observation is in harmony with the known fact that a metastable, slightly supersaturated phase (kamacite) may decompose by deformation plus reheating, normally by precipitating small particles of the other phase (here, γ -particles rich in nickel). The hardness is 220±15, corresponding to deformed and partially annealed kamacite.

Schreibersite occurs as $20-50 \mu$ wide veinlets in the grain boundaries. They are brecciated and often displaced 50 μ , but they are monocrystalline. Their low frequency is in harmony with the analytical value of 0.12% P.



Figure 591. Chilkoot (U.S.N.M. no. 756). Annealed taenite-plessite field. The taenite is deformed – note its interface with kamacitete – and numerous, almost submicroscopic, α -beads have been precipitated in it. Etched. Oil immersion. Scale bar 10 μ .



Figure 590. Chilkoot (U.S.N.M. no. 756). Heat-affected α_2 zone (above) and unaffected interior (below). Taenite lamellae (white) and several angular schreibersite crystals (grayish). Etched. Scale bar 200 μ .



Figure 592. Chilkoot (U.S.N.M. no. 756). Annealed taenite lamella (white) with indistinct grid of α -beads. Annealed kamacite (gray) with two severely distorted carlsbergite platelets, the upper one associated with rhabdites. Etched. Oil immersion. Scale bar 20 μ .

Troilite occurs as scattered 1-2 mm nodules, locally with minor amounts of daubreelite. On a well polished slice tiny, hard, oriented platelets of chromium-nitrides may be seen in the kamacite. They are typically $10 \times 2 \times 0.5 \mu$ in size and identical to the oriented carlsbergite precipitates noted in Cape York, Schwetz and others.

Chilkoot is structurally and chemically related to such irons as Boxhole and Henbury, but its heavy plastic deformation is preterrestrial. It is well preserved and may well have been observed to fall, as claimed, by the Indians.



Figure 593. Chilkoot (U.S.N.M. no. 756). The kamacite was apparently shock hardened and afterwards exposed to some annealing whereby less than 0.5μ taenite particles were able to precipitate copiously. Etched, Scale bar 10μ .

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

64 g slice (no. 756, 6.5 x 6 x 0.2 cm) 5,435 g endpiece (no. 1363, 29 x 16 x 6 cm) 22 g slice (no. 1584, 4.5 x 2.5 x 0.3 cm)

Chinautla, Guatemala Approximately 14 1/2°N, 90 1/2°W

Fine octahedrite, Of. Bandwidth 0.35 ± 0.05 mm. Neumann bands, deformed. HV 260 ± 20 .

Group IVA. 9.44% Ni, 0.42% Co, 0.17% P, 2.13 ppm Ga, 0.14 ppm Ge, 0.12ppm Ir.

HISTORY

Little is known of the origin of this iron. It was briefly described as Guatemala by Meunier (1902) who had obtained an 81 g slice from Mr. Guerin in Guatemala. Guerin reported that a 5.72 kg mass had been found in 1901 in the vicinity of Guatemala City. The name Chinautla appears to have been first used by Ward's Establishment, who presumably cut and, between 1910 and 1930, distributed the meteorite. In Ward's Price List No. 237 (July 1921) a piece was listed for sale as "Chinautla, 15 km from Guatemala City." An old label in the U.S. National Museum, which followed a specimen cut by Ward's, states that about 1.5 kg was lost in cutting. This is in harmony with the fact that most specimens in collections today are thin slices of 2-5 mm thickness, weighing between 50 and 200 g.

Nininger & Nininger (1950: plate 5) gave a photomacrograph which showed the typical slice of Chinautla, and Buchwald (1966: figures 39 and 40) presented two photomicrographs. The meteorite was included in the thermomagnetic study of Lovering & Parry (1962), and in the age determination work of Voshage (1967).

COLLECTIONS

London (corner piece, 972 g, plus 356 g slices), Budapest (204 g), Washington (162 g), Paris (133 g), Chicago (127 g), Oslo (106 g), Harvard (95 g), New York (95 g), Stockholm (86 g), Prague (83 g), Copenhagen (67 g), Tempe (48 g).



Figure 594. Chinautla (Tempe no. 272a). The size and shape are typical for many Chinautla samples in collections. Deep-etched. Scale in centimeters. (Courtesy C.B. Moore.)



Figure 595. Chinautla (Copenhagen no. 1913, 199). Fine octahedrite with bundles of kamacite lamellae and with various types of plessite fields, characteristic of group IVA. Etched. Scale bar 3 mm.

460 Chinautla

DESCRIPTION

The 5.7 kg mass must have been weathered considerably, judging from the slices which often show exfoliation along the exterior Widmanstätten lamellae due to grain boundary attack. The atmospheric flight crust has disappeared and so has the α_2 zone; therefore, at least some millimeters have been removed by weathering.

The Widmanstätten structure is well developed with a bandwidth of 0.35 ± 0.05 mm. The lamellae are long



Figure 596. Chinautla. Detail of Figure 595. Cellular plessite (left) and comb plessite (right). Numerous small schreibersite crystals (dark, vermicular) both in grain boundaries and inside the fields. Etched. Scale bar 300 μ .



Figure 597. Chinautla. Detail of Figure 595. Cellular plessite field with continuous taenite frame and martensitic transition zones. Etched. Scale bar 100 μ .

 $(\bigcup_{W} \sim 50)$ and they undulate slightly, as do the Neumann bands, due to some plastic, cosmic deformation. The Vickers hardness (100 g) of the ferrite phase is 260±20 and thus reflects the deformation hardening. Plessite occupies 30-40% by area and is developed as comb plessite, repeating the Widmanstätten directions, or as poorly resolvable duplex structures of $\alpha + \gamma$ ("black taenite"). Further, especially well developed in Chinautla is the cellular plessite. This consists typically of a 3 x 1 mm rhombic



Figure 598. Chinautla. Detail of Figure 595. A view of another cellular plessite field with distinctly oriented taenite particles. Etched. Scale bar 100 μ . See also Figure 125.



Figure 599. Chinautla. Detail of Figure 595. An open-meshed net plessite field. The kamacite displays fine grain boundaries with angular-vermicular taenite particles (white). Scattered, hard schreibersite particles in relief (gray). Etched. Scale bar 100μ .

	percentage							ppm				
References	Ni	Co	Р	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Easton in Hey 1966	9.30											
Smales et al. 1967						30	119	< 1	2.17	0.17		
Moore et al. 1969	9.48	0.42	0.17	205	10							
Schaudy et al. 1972	9.54								2.08	0.112	0.12	
Crocket 1972											0.12	3.6

CHINAUTLA - SELECTED CHEMICAL ANALYSES

field, framed by a continuous taenite ribbon. The interior is divided into unequal cells, 100-500 μ in diameter. Each cell is decomposed as a unit to a fine-grained oriented structure of 1 μ thick, parallel γ -plates and rods in a matrix of α . Each cell is differently oriented from its neighbor, as witnessed by Neumann bands and precipitates. The cellular plessite appears to be typical for group IVA meteorites and is rare in other meteorites. Angular schreibersite inclusions, 1-10 μ in diameter, may or may not be present, dependent on the overall phosphorus content of the meteorite. It is first clearly visible when the overall phosphorus content increases above 0.10%.

Chinautla has 0.16% P, and schreibersite is common in the plessite and as $10-50 \mu$ wide grain boundary precipitates. It is brecciated but monocrystalline. The subgrain boundaries of the ferrite are clearly indicated, essentially because of about 0.5μ thick precipitates. Locally the



Figure 600. Chinautla (Copenhagen no. 1913, 199). Dark-etching finger plessite field with a clear (or cloudy) taenite rim. Repetition of the bulk Widmanstätten directions. Etched, Scale bar 100μ .



Figure 601. Chinautla. Detail of the upper left corner of Figure 600. The finger plessite pattern is due to the presence of a large number of oriented fine γ -particles along α_2 block boundaries. Etched. Scale bar 20 μ .

ferrite phase etches in a way that suggests that it is supersaturated and has precipitated considerable quantities of submicroscopic particles (phosphides?).

Troilite occurs as a rare accessory mineral, 0.2-0.5 mm in diameter. One small euhedric chromite crystal (15 μ) was observed associated with schreibersite.

Chinautla is a typical fine octahedrite, but it has more nickel and more schreibersite than most irons of its class.

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

85 g part slice (no. 742, 6.5 x 6.5 x 0.3 cm) 77 g part slice (no. 2722, 6.5 x 6.5 x 0.3 cm)

Chinga, Tuva Autonomous Oblast, RSFSR 51°3.5'N, 94°24.5'E

Ataxite, with deformed schlieren bands locally. A few $10\,\mu$ wide $\alpha\text{-spindles},\,HV\,300\pm6.$

Group IVB. 16.58% Ni, 0.55% Co, 0.05% P, 0.18 ppm Ga, 0.08 ppm Ge, 3.6 ppm Ir.

HISTORY

About 30 fragments of individual weights from 85 g to 20.5 kg, and totaling about 80 kg, were found scattered along the Chinge stream in 1912. The canyon-forming creek runs into Urgailyk. This empites in Elegest, which again is a tributary to Yenisey from the high mountains of Tannu Ola (Krinov 1947; 1960a). The material had already been examined by Backlund & Khlopin (1915), who, however, believed that it was of terrestrial origin. Pehrman (1923) reexamined it and, assuming that he had identified fusion crust and regmaglypts, concluded that it was, in fact, meteoritic. While the conclusion was correct, the premises concerning the preserved fusion crust are certainly errone-



Figure 602. Chinga (Moscow no. 527). An entire mass of 1,670 g. A deep fissure has almost divided the mass into two smaller ones. Scale bar 5 cm. (Courtesy E.L. Krinov.)