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 μ wide grain boundary precipitates. It is brecciated but monocrystalline. The subgrain boundaries of the ferrite are clearly indicated, essentially because of about 0.5 μ thick precipitates. Locally the ferrite phase etches in a way that suggests that it is supersaturated and has precipitated considerable quantities of submicroscopic particles (phosphides?).

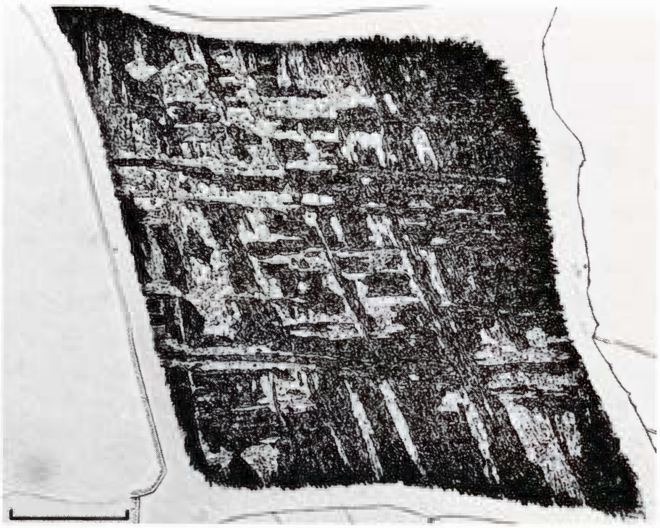

Figure 600. Chinautla (Copenhagen no. 1913, 199). Dark-etching finger plessite field with a clear (or cloudy) taenite rim. Repetition of the bulk Widmanstätten directions. Etched. Scale bar 100 μ.

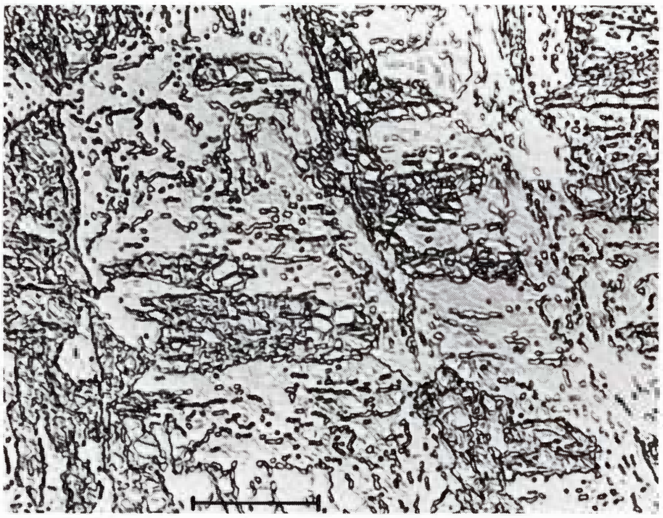

Figure 601. Chinautla. Detail of the upper left corner of Figure 600. The finger plessite pattern is due to the presence of a large number of oriented fine γ-particles along α_2 block boundaries. Etched. Scale bar 20 μ.

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 μ wide α-spindles. HV 300±6.

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-

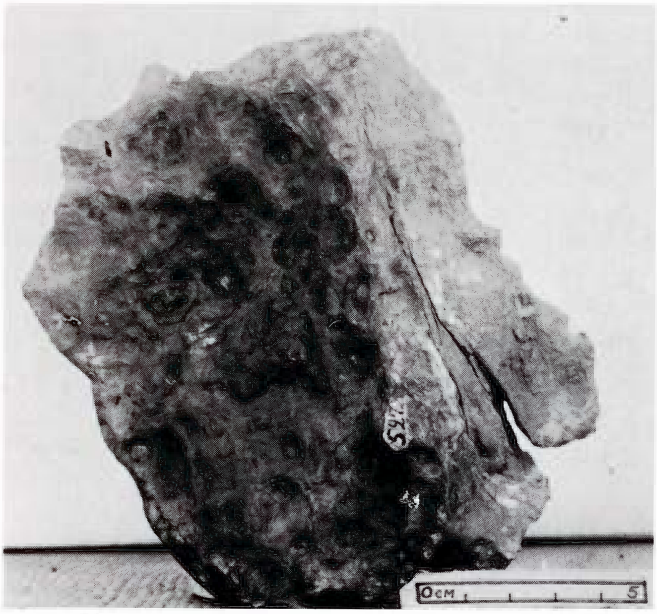

Figure 602. Chinga (Moscow no. 527). An entire mass of 1,670 g. A deep fissure has almost divided the mass into two smaller ones. Scale bar 5 cm. (Courtesy E.L. Krinov.)

ous. In the years 1910-1950, when the creeks of this area were exploited for gold, "native iron" was found on several occasions; thus, in 1948, a 7.5 kg fragment was discovered by the prospector-geologist A.L. Dodin. In another case, in 1929, S. Ivanov found a cluster of at least 20 individuals. Some were forged into spikes and nails, others reached museums in Moscow, Kyzyl, Irkutsk, Alma-Ata and Minusinsk (Vronskij & Zotkin 1968). Krinov (1947; macrophotograph of a specimen) suggested that since the majority of the fragments had a flattened, somewhat curved form, often with sharp torn edges, the original mass could have been a crater-producing meteorite like Henbury. The crater was thought to have disappeared through erosion or simply to have passed unnoticed, since, in 1912, little attention was paid to crater-producing meteorites. Field work was carried out in 1963 (Vronskij & Zotkin 1968) in order to test the crater theory. The authors found neither craters nor impact holes, in spite of a thorough search through the difficult, taiga-covered, steep terrain. Two lakes and several depressions in the vicinity were shown to be natural erosional phenomena not associated with the impact. The exact locality of recovered specimens was identified (map), and they concluded that the fall had been a small shower and that erosion had eliminated all traces of impact, since the fall probably was of considerable terrestrial age. A determination of this age would be interesting.

Chinga has been examined by Zavaritskij & Kvasha (1952) and cosmic age determinations have been performed by Starik et al. (1960), Bauer (1963) and Sobotovich (1964).

COLLECTIONS

Moscow (16 fragments totaling 54 kg), Leningrad University, Geology Department (15.6 kg), Åbo (2 kg), Washington (1.5 kg), Tempe (315 g), London (154 g), Sydney (109 g), Yale (72 g), Perth (43 g).

DESCRIPTION

All specimens in collections are flattened, somewhat lenticular fragments, the largest being no. 515 in Moscow (20.4 kg), 25 x 20 x 8 cm. The U.S. National Museum no. 3453 is typical of the many smaller fragments: (1,042 g) and 11.5 x 8 x 2.5 cm in size. Its top and underside meet along sharp edges, and it is covered with 1-2 mm thick terrestrial oxides. No regmaglypts or atmospheric sculpturing are preserved. On the contrary, it is highly probable that most of the present exterior form of the fragments are due to long-term weathering and erosion in the stream bed of Chinga. Due to the extreme homogeneity of the metal, with very few sulfide and no phosphide inclusions and with no high angle grain boundaries, the corrosion has progressed in an unusual way, creating achate-like, rhythmically zoned oxide deposits. Similar attacks can be seen on Cape of Good Hope, Deep Springs and Kokomo which are meteorites related to Chinga. Some specimens, such as Moscow no. 527, display deep fissures along which the corrosive attack may concentrate; the voluminous oxides then slowly wedge the mass wide open and eventually split it in two. Changing frost and thaw may likewise have been active in splitting originally larger masses into several fragments.

The U.S. National Museum no. 3451 displays a 0.2 mm fissure that penetrates to a depth of 5 cm. A 3 x 2 mm troilite nodule situated in the fracture zone shows conclu-

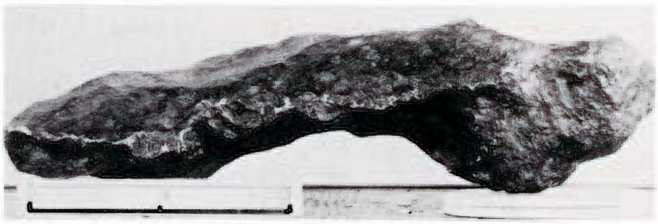

Figure 603. Chinga (Moscow). Another flattened 2-3 kg mass. Scale bar 10 cm. (Courtesy E.L. Krinov.)

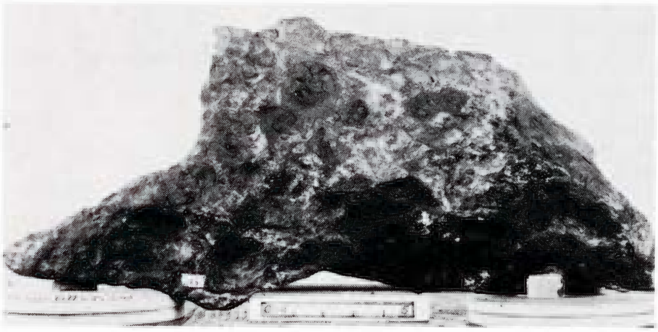

Figure 604. Chinga (Moscow no. 523). This angular, flattened mass weighs 3,075 g. (Courtesy E.L. Krinov.)

CHINGA – SELECTED CHEMICAL ANALYSES

The high-carbon content reported by Trofimov always appeared questionable, and was not confirmed by Lewis & Moore (1971). Moore (in Mason 1971: 128) reported 400 ppm Si, which appears to be an anomalously high silicon content for a group IVB iron.

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Backlund & Khlopin 1915	16.71	0.40										
Trofimov 1950				2600								
Dyakonova 1958a	16.56											
Lewis & Moore 1971	16.66	0.55	0.05	40								
Schaudy et al. 1972	16.38								0.181	0.082	3.6	

sively that the two sides of the fissure have been sheared and rotated with respect to each other, the troilite itself being sheared and displaced some 3 mm. The otherwise straight schlieren bands are likewise displaced and curved conspicuously. Other signs of heavy plastic deformation are also present. The intense plastic deformation is probably due to a remote violent event, perhaps in connection with the detachment of the meteorite from its parent body.

Etched sections show the schlieren bands characteristic of so many group IVB ataxites. They are – on undeformed specimens – straight and parallel, 1-10 mm wide and taper out in irregular ways. There are generally only two "sets," one having high, the other low reflectivity, but they are of the same chemical composition. Also the microhardness is the same, 300±6. At high magnification there is an indication that the only difference is a somewhat different orientation of the submicroscopic duplex $\alpha + \gamma$ structure, corresponding perhaps to decomposition of parallel millimeter-wide bands in twin position. A better defined orientation difference between dark and light bands will be described for Tlacotepec which has measurable α-and γ-units.

The matrix is a poorly resolvable mixture of α-and γ-units, which very much resembles the structures produced in laboratory experiments by Buchwald (1966). Working with a 15% nickel alloy that was quenched from a homogeneous austenite range, Buchwald was able to show how the supersaturated α_2 phase slowly decomposed to a duplex, fine-grained $\alpha + \gamma$ structure when reheated for weeks at 350°, 450° or 550° C. Figure 9 in that paper duplicates almost exactly the structure of Chinga, but it is important to note that this structure far from represents an equilibrium structure; a few more weeks at 550° C is sufficient to make the $\alpha + \gamma$ structure clearly resolvable. While Figure 9 corresponds to Chinga, Figure 11 corresponds to some of the other group IVB meteorites as Hoba

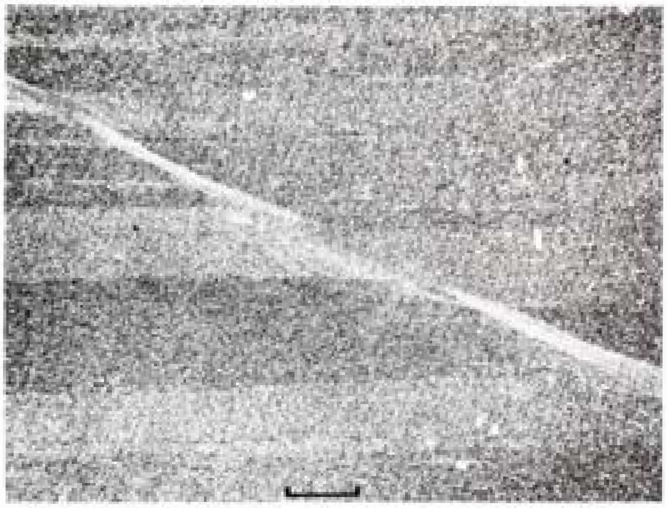

Figure 605. Chinga (U.S.N.M. no. 1426; cut from Moscow no. 537). Ataxitic structure at low magnification. A significant shear zone extends diagonally across the picture. See also Figure 207. Etched. Scale bar 500 μ.

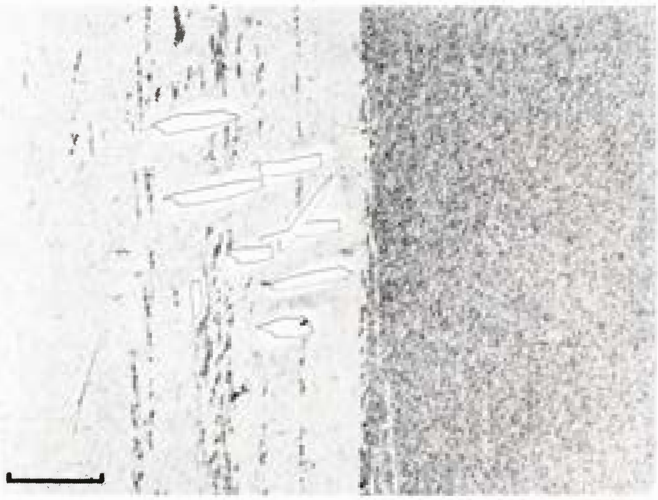

Figure 606. Chinga. Detail of Figure 605. Adjacent Schlieren bands with oriented sheen. A cluster of fine kamacite spindles. Etched. Scale bar 200 μ.

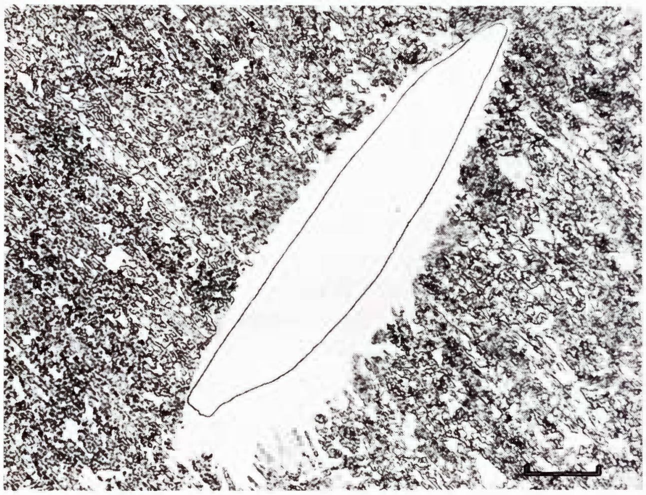

Figure 607. Chinga. Detail of Figure 605. A kamacite spindle with its enveloping undecomposed, high-nickel taenite rim. Etched. Oil immersion. Scale bar 10 μ.

Figure 608. Chinga. Detail of Figure 605. The matrix appears to be an imperfectly annealed duplex $\alpha + \gamma$ structure, with mostly submicroscopic particles. Etched. Oil immersion. Scale bar 10 μ.

and Tlacotepec, which, therefore, apparently cooled more slowly, or were reheated to a slightly higher temperature or for a longer time.

There are no macroscopic or microscopic phosphides in Chinga, which is in harmony with the analysis. There are, however, scattered, angular sulfide inclusions, normally about 1 mm in diameter. One, of 3 x 2 mm, mentioned above, is sheared and contains deformation lamellae and brecciated daubreelite bands. Another, 1.5 x 0.4 mm, with about 35 parallel, narrow daubreelite bands, is kneaded and displays a boudinage structure. Still others, far from the zones of heavy plastic deformation, are undisturbed monocrystals. Only the largest have nucleated a 50 μ ferrite rim zone; most others abut directly against a creamcolored nickel-rich taenite. In the metallic matrix there are also a few, scattered, acicular kamacite spindles, typically 100 x 10 μ in size; these sometimes have a minute nucleus of a sulfide but are mostly inclusion-free. They probably represent the very beginning of homogeneously nucleated kamacite lamellae that never had the opportunity to grow. They already show the characteristic ratio between the dimensions length:width:height, about 10:1:3.

Chinga's complex structure may be summarized thus. During cooling on the parent asteroid some movement of the overburden created shear stresses in the supercooled austenite phase, thereby generating long deformation twin bands of millimeter to centimeter width. Upon further cooling, a few α-spindles precipitated while the main mass later converted to α_2, crystallographically oriented with respect to the parent γ-phase. Each α_2-unit decomposed partially to $\alpha + \gamma$, but the decomposition was stopped before the structure became as clearly developed as in most other group IVB irons. The mass was separated from its surroundings, but the fine-grained structure left no indications of this event except for the local heavy shearings discussed above and, perhaps, the high hardness. The mass later, in penetrating the atmosphere, split into numerous fragments that only covered a small area, but were separated later by erosion and funneled down into the Chinge stream bed. It is hardly possible that Chinga landed as an entire mass and only later, through long-term corrosion and erosion, disintegrated into the sharp-edged, lenticular fragments which we now see.

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

287 g monolith (no. 1426, 7.5 x 5 x 1.5 cm)
275 g slice (no. 3451, 7.5 x 5 x 0.9 cm)
1,042 g monolith (no. 3453, 11.5 x 8 x 2.5 cm)

Chulafinnee, Alabama, U.S.A.

33°33'N, 85°39'W; 300 m

Medium octahedrite, Om. Bandwidth 1.10±0.10 mm. Originally decorated Neumann bands.

Group IIIA. 7.42% Ni, 0.50% Co, 0.17% P, 17.8 ppm Ga, 33.7 ppm Ge, 5.5 ppm Ir.

The whole mass was heated in a forge in order to cut a portion from it.

HISTORY

A mass of about 16 kg was turned up in 1873 by the plow when the Rev. J.F. Watson was clearing a piece of land near Chulafinnee in Cleburne County. "He carried it to the village blacksmith to have it tested. After heating one corner in the forge, a piece of about 1.5 kg was cut off and wrought into horseshoe nails and a point for a plow . . . The mass was originally thickly encrusted with scales of rust of a red-brown color, which fell off while being heated in the forge." (Hidden 1880a). The remaining mass of 14.75 kg was acquired by the Vienna Museum where Brezina (1881) described it, however, without noting man's influence on the crust, since he erroneously described beautifully striated melt crust from the atmospheric flight. He correctly observed the microstructural resemblance to Misteca and

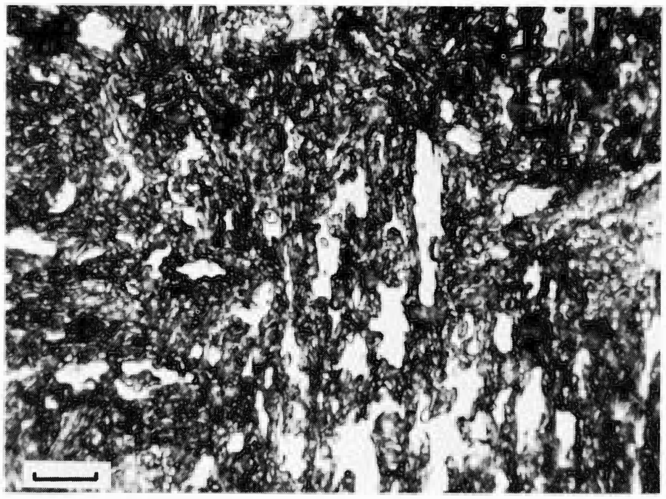

Figure 609. Synthetic meteorite; iron with 15% Ni and 0.2% P. After homogenization in the austenite region (1100° C for 24 hours) the sample was quenched in water. It was then reheated and kept at 550° C for 17 hours. This started the decomposition of metastable α_2 to $\alpha + \gamma$. Etched. Scale bar 10 μ. (Figure 9 in Buchwald 1966.)

CHULAFINNEE – SELECTED CHEMICAL ANALYSES

References	percentage Ni	Co	P	ppm C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Mackintosh 1880	7.37	0.50	0.17									
Wasson 1974 pers. comm.	7.47								17.8	33.7	5.5	

The phosphorus determination appears to be somewhat high.

others but failed to understand that what they had in common was some blacksmith's thorough heating that had created the typical serrated α_2 grains and removed the oriented sheen of the Widmanstätten pattern. Later Brezina (1885: 214) gave the lamella width as 0.6 mm and mentioned scattered troilite-graphite nodules.

COLLECTIONS

Vienna (main mass, about 11.9 kg), Budapest (1,025 g), Berlin (129 g), Washington (119 g), Chicago (116 g), Harvard (103 g), New York (83 g), Prague (65 g), London (60 g), Stockholm (9 g).

DESCRIPTION

The flattened, roughly triangular mass had the overall dimensions 25 x 25 x 6 cm. It had a thick crust of oxides which spalled off in the forge. Corrosion has penetrated to the center of the mass along grain boundaries and inclusions. The original crust from the atmospheric flight has disappeared completely.

Etched sections show a Widmanstätten pattern of long lamellae ($\frac{L}{W} \sim 15$) with a width of 1.10±0.10 mm. There is no oriented sheen because the ferrite has been reheated to the austenite region and upon cooling transformed to serrated α_2 grains, about 50 μ in diameter, which do not show preferred orientation. It would normally be expected that all traces of Neumann bands should disappear by such a heat treatment. In Chulafinnee they are, however, still visible because they are lined with tiny grains, 0.5 μ in diameter, which presumably are austenite grains. The α_2 phase had a hardness of 172±10.

Taenite and comb plessite are common, but all display blurred diffusion borders with thorns protruding into the α-phase. The taenite ribbons (40 μ wide, where tested) have a hardness of 220±10. Similar ribbons in Cape York and numerous other unaltered octahedrites display a hardness of 350±30. Chulafinee's taenite was thus annealed by the artificial reheating.

Schreibersite occurs as partly resorbed 25-50 μ wide grain boundary precipitates substituting for taenite. Rhabdites, 1-2 μ thick, have been rather common in the ferrite matrix, but due to reheating they are almost resorbed. The phosphides have not melted by the reheating, so the temperature to which the meteorite was exposed in the forge did not exceed about 1000° C.

Troilite is present as 0.5-2 mm scattered, angular blebs, but none were present in the microsections, so the detailed structure could not be examined. Graphite, reported by Brezina, could not be confirmed. Hard needles of carlsbergite, the chromium nitride, 10 x 0.5 μ, are scattered in the ferrite, little affected by the heat treatment.

Along the edges and around corroded inclusions characteristic high temperature reaction zones have developed. They resemble laceworks of several undefined oxides in which 1 μ metallic grains are precipitated. The high temperature austenite boundaries are outlined by intercrystalline attack up to 25-100 μ below the surface. Locally hammer marks and overfolding with distorted plessite may be seen. The structure is further opened somewhat along several (111) planes, presumably because these were weakly adhering, due to corrosion, and yielded to the action of the blacksmith.

Chulafinnee is another of those irons of which we know for certain that the whole mass was in a forge (Buchwald 1965). Judging from the structural details, I would estimate that the action in this case took about an hour at a maximum temperature of about 800° C. Before the operation Chulafinnee was an iron very similar to Casas Grandes or Cape York, a typical group IIIA iron with a medium content of phosphides.

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

8 g polished section (no. 81, 1.5 x 1 x 0.5 cm)
55 g part slice (no. 997, 4.5 x 4 x 0.5 cm)
56 g part slice (no. 1586, 5 x 3 x 0.5 cm)

Chupaderos, Chihuahua, Mexico

27°12'N, 104°40'W; 1500 m

Medium octahedrite, Om. Bandwidth 0.65±0.10 mm. ϵ-structure. HV 215±15.

Group IIIB. 9.90% Ni, 0.55% Co, about 0.5% P, 1.4% S, 17.5 ppm Ga, 29.2 ppm Ge, 0.02 ppm Ir.

See also Durango, A, the Humboldt material.

HISTORY

Three large irons will be treated under the heading Chupaderos: Chupaderos I (14.1 ton), Chupaderos II (6.8 ton) and Adargas (3.4 ton, synonym Concepcion). Although opinions differ as to the mutual relationship among these three masses and a fourth mass, Morito (10 ton, synonym San Gregorio), reasons will be given here for the conclusion that the first three belong to one shower, while Morito is an independent monolith. The complex history of the blocks, of which at least Adargas and Morito were known before 1600, is elaborately developed by Fletcher (1890a) in his chapter "The Huejuquilla or Jimenez group." Unfortunately, he had no material but only photographs of the masses at his disposal, and only inferior analyses were known at that time, so he was unable to reach a definite conclusion as to the structure and relation of the masses. Later authors, such as Brezina (1896), Cohen (1905), Farrington (1915) and Haro (1931), were also at a loss when trying to untangle the mess, and nearly all modern catalogs, (e.g., Nininger & Nininger 1950; Mason 1964; Horback & Olsen 1965; Hey 1966; Tuček 1966), list Adargas, Chupaderos and Morito as separate entries instead of combining Adargas with Chupaderos.

All four blocks were originally situated close to the 27th parallel around the ancient town of Huejuquilla, now known as the railway junction Jimenez. The best description of the localities is that given by Castillo (1889) who also presented a map sketch. His information ties up neatly with scattered old reports and with modern maps of the scale 1:250,000. The two blocks of 14.1 and 6.8 tons were found only 250 m apart in a north-south direction on the ranch called Chupaderos, 27 km east-northeast of Jimenez, which corresponds to the coordinates 27°12′N, 104°40′W. Although known to the local population long before, they were apparently first reported by Bartlett (1854) who surveyed the United States-Mexican boundary in connection with the Treaty of Guadalupe Hidalgo, decreed between the United States and Mexico in 1848. However, despite several efforts, he was unable to localize the masses. Smith (1871) and Barcena (1876) made vague references to "a huge meteorite lately discovered"; Urquidi (1872) was the first to use the name Chupaderos. The masses were apparently never moved until Castillo transported them to Mexico City in 1893. They bear no ancient inscriptions.

The third block of 3.4 tons had fallen 40 km farther southwest on a small but well defined mountain range called Sierra de las Adargas, with the coordinates 26°55′N, 104°57′W. This locality is well inside the general north-south trading routes connecting Chihuahua in the north and Durango in the south, and it is almost certain that the mass has been known since the early Spanish explorers passed through the country. A silent witness to this is the ancient chiseled inscription: "A. 1600" and several old signatures like 𝒻 and crosses. The irregular fragment has suffered several attacks made by hacksaws and cold chisels, and several protruding knobs and ears have been detached, so that an estimated total of 5 kg has been removed for the cabinets of early collections. It is, however, important to

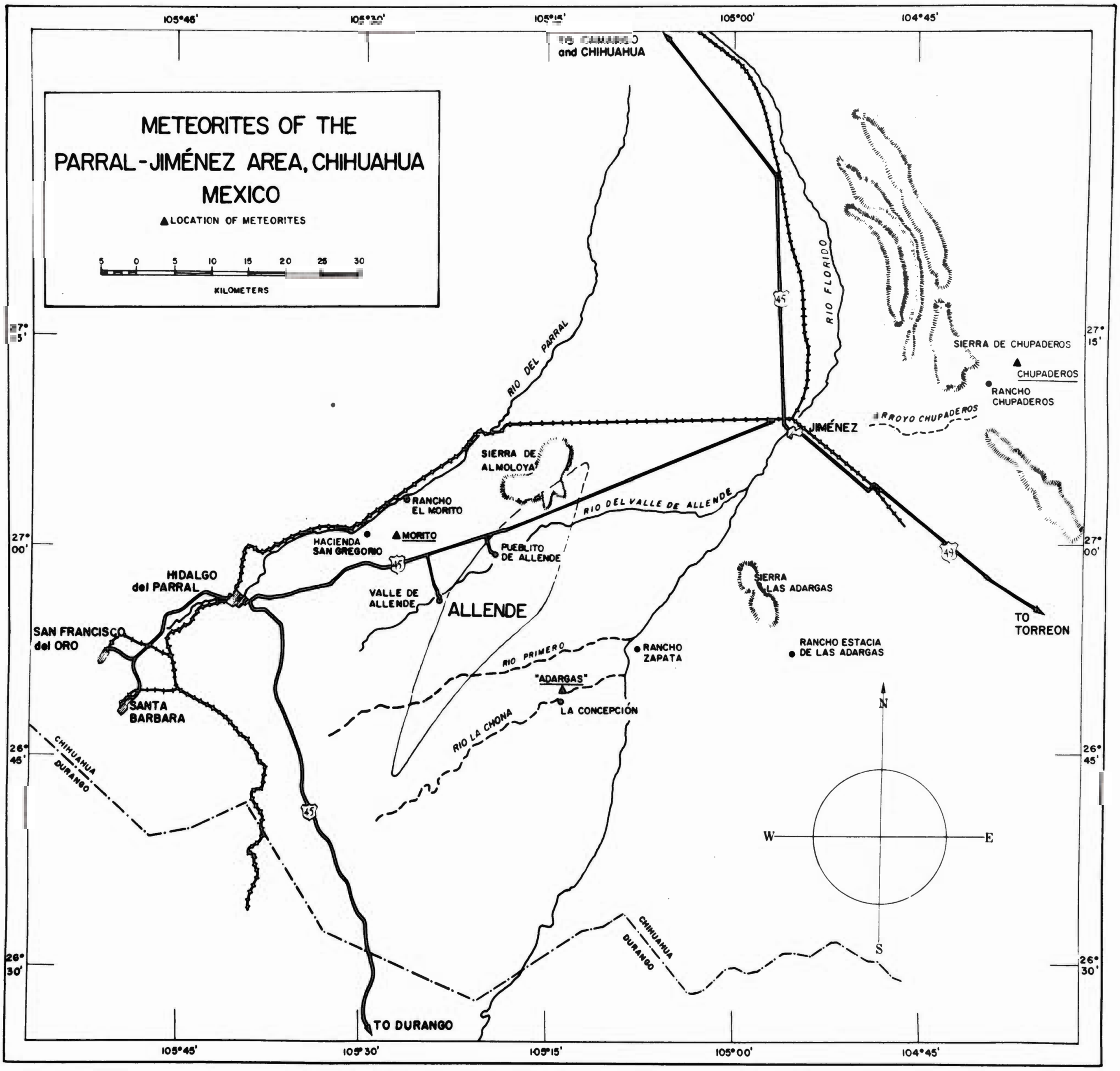

Figure 610. Chupaderos. Sketch map showing the locations of some of the iron meteorites belonging to the Chupaderos shower, Chupaderos (I-II) and Adargas. The locations of the Morito iron meteorite and the Allende stone meteorite shower that fell 8 February 1969 are also shown.

note that such material may be mislabeled "Durango," as the locality before about 1820 was within the province of Durango. During this study the famous Durango mass of Humboldt (1811: volume 1: 293) has been proved to be this mass (see page 550) and has definitely no independent right of existence.

The first reliable information about Adargas was supplied by Bartlett (1854: volume 2: 457f) who discovered the mass at the corner of a large building on the Hacienda la Concepcion, owned by Don Juan Urquidi. According to Castillo (1889) this locality is 22 km southeast of Valle de Allende on a small tributary of the Rio Florido, then called Rio de la Concepcion, but now renamed Rio la Chona. Bartlett presented two sketches and reported that the meteorite "was brought hither with the design of putting it in a blacksmith's shop to be used as an anvil, although it had never been so employed. An attempt was made to reduce it, by building a large fire around it, and heating it to a white heat. But so intense was the heat from so large a mass, that the workmen could not approach it, and all their labor was lost. The expense of this operation was more than one hundred dollars, and resulted in obtaining a piece of the metal large enough to work into a pair of spurs." Smith (1855) gave a brief note accompanied by Bartlett's sketches which were in the form of two woodcuts that showed the mass standing like a post in the earth, resting upon one of its leg-like limbs.

General Carleton (1865) conveyed information from Connolly, the Governor of New Mexico, who was well acquainted with Adargas and said that it had been lying among the houses on Urquidi's hacienda since at least 1826, and Butcher (unpublished letter to Professor Baird in the Smithsonian Institution, 1871) visited the place, removed a few ounces and made a sketch. Finally, Urquidi (1872) and Castillo (1889) provided the essential information that the mass had not always been here but had been transported to Concepcion from Sierra de las Adargas in April 1780. This meant that the distance from the two Chupaderos masses increased from about 40 to 70 km. It is fortunate that this bit of information has been preserved; a distance of 40 km between individual large masses of a shower is, although considerable, still acceptable. We know of several other showers that produced a similar scattering, e.g., Bingera, Campo del Cielo and Gibeon, and quite recently, Allende, Figure 610.

The fourth mass, Morito, which also has been known since the Sixteenth Century, was found near Rio del Parral, about 35 km northwest of Hacienda la Concepcion. It will be discussed separately on page 838.

Finally, some of the specimens listed as Sierra Blanca in Hey (1966), may have been detached from one of the Chupaderos masses (including Adargas) or Morito. They came to the cabinets of Europe in the first part of the nineteenth century at a time when information about the outlying northern Mexican provinces was extremely limited. Burkart (1856) and Fletcher (1890a) refer to a note in Gazetas de Mexico for Wednesday, 8th September 1784 (Volume 11: 146 and 200) which states that various masses of 20/30 and more hundredweights have been discovered near Jimenez. "Fire has been put to them,

Figure 611. Chupaderos I. A flattened mass of 14.1 ton, as exhibited in Tacuba No. 5, Mexico City. Along left edge a late fracture surface measuring 210 x 65 cm. There are also indications of late fracture surfaces in other places along the edge, and on the underside there is a deep and long fissure. The white ruler measures 15 cm.

Figure 612. Chupaderos II. An irregular plate of 6.8 ton, as exhibited in Tacuba No. 5, Mexico City. Well-preserved fusion crust and cylindrical cavities from troilite nodules, lost by ablation during the atmospheric flight. Ruler measures 15 cm.

Figure 613. Chupaderos. The Adargas block of 3.4 ton, as exhibited in Tacuba No. 5, Mexico City. The Mexicans call the mass "La Concepcion" in memory of the hacienda where it was located for a number of years. See also Figure 230. A direct view of the hackly late fracture surface. Below, softly rounded regmaglypts from the atmospheric flight. Ruler measures 15 cm.

and some pieces have been cut off with chisels. They proved to be workable, but owing to the expense the attempts have been given up." As Fletcher (1890a: 149) points out, Sierra Blanca was not – and is not – to be found on any available map, but it may be an old synonym for one of the limestone ranges in the neighborhood of Jimenez. If this is correct, all other information regarding the Sierra Blanca fragments could refer to the various Chupaderos and Morito masses. Some of the Sierra Blanca fragments are, however, from other Mexican irons; see page 1117.

In 1893 the two Chupaderos blocks and the Adargas block were transported to Mexico City, where they are still displayed in the portico of the old School of Mines (Palazzo Mineria), Tacuba no. 5. Very little material has been detached from them; the various descriptions by Brezina (1896), Cohen (1905), Berwerth (1905) and Gratacap (1906) are based upon insufficient, maltreated and partially mislabeled material. Brezina & Cohen (Atlas 1886-1906: plate 33) and Brezina (1896: plate 8) presented descriptions and photomacrographs of authentic undamaged material. Farrington (1907) presented photographs of the meteorites as installed in the School of Mines and also reported an experiment with full-sized models in which he successfully joined the two larger masses to an irregular, tabular mass. About 1900, Ward acquired approximately 30 kg of Chupaderos for cutting, of which 16 kg slices were returned to the Institute of Geology, Mexico City, while the remainder was distributed (Chicago, London, Washing-

Figure 614. Chupaderos. Detail of Figure 613, upper left part. The rough, polished and etched section clearly shows the numerous schreibersite skeleton crystals. Ruler 15 cm.

Figure 615. Chupaderos (Institute of Geology, Mexico City, no. 61). An endpiece which shows eminent orange peel fusion crust and chisel-like scars from ablated schreibersite plates. Scale bar 2 cm.

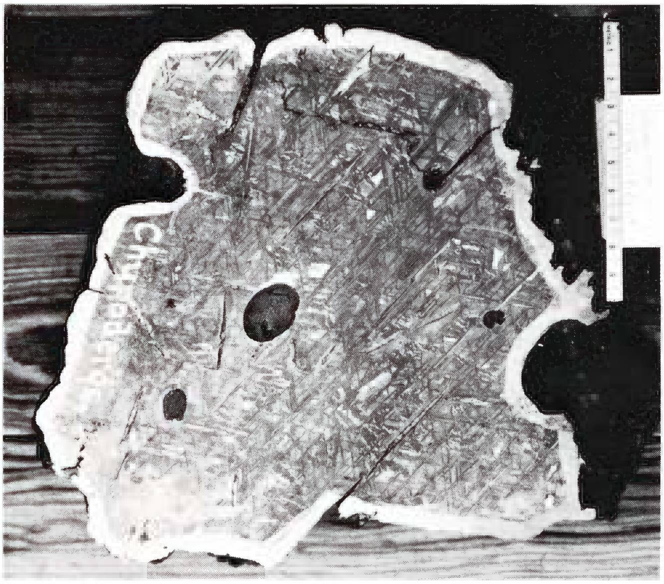

Figure 616. Chupaderos (Institute of Geology, Mexico City, no. 61). A 5.0 kg slice, cut and etched by Ward's Natural Science Establishment about 1900. The glossy rim is a portion of the meteorite which remained unattacked by the etchant, due to wax protection. This etching method was commonly applied to a great many iron meteorite sections in the first part of the twentieth century, and its results should not be confused with heat-affected zones from the atmospheric flight. Scale bar 10 cm.

Figure 617. Chupaderos (Tempe no. 30ax). A hack-sawed corner of the Adargas mass. The schreibersite crystals (black) melted and were partially removed during the atmospheric flight. The kamacite transformed to α_2. Etched. Scale bar in centimeters. (Courtesy of C.B. Moore.)

ton, etc.). Haro (1931) reviewed the older literature and translated it into Spanish while Nininger in an appendix to the same work suggested that Adargas also belonged to the Chupaderos masses and gave some excellent photographs. Further photographs of sections were given by Nininger & Nininger (1950: plate 20). Buchwald (Hey 1966: 6 and 106) warned that detached fragments could be heavily maltreated by hammering and heating, as actually is the case with, e.g., U. S. National Museum no. 913. The ferrous orthophosphates, sarcopside and graftonite, were reported and examined by Olsen & Fredriksson (1966).

COLLECTIONS

Authentic, cut material of Chupaderos: Mexico, Institute of Geology (three slices of 5,200, 5,082 and 1,665 g), Chicago (three slices of 5,438, 2,536 and 2,492 g), Washington (2,516), Tempe (1,294 g), London (1,087 g), Tübingen (861 g), Vienna (658 g), University of Illinois, Urbana (233 g), Berlin (190 g), Prague (149 g), Stockholm (145 g), New York (119 g).

Authentic, cut material of Adargas: London (no. 1959, 941 of 192 g), Tempe (no. 30ax of 171 g), Harvard (4 g, cut by Butcher).

Mislabeled Adargas: Vienna (574 g), Chicago (no. 1013 of 266 g), Washington (no. 3300 of 96 g), Tempe (no. 764 of 78 g), New York (no. 128 of 33 g, no. 716 of 41 g), Berlin (69 g), Prague (no. 104 of 26 g). Most of these specimens appear to come from some coarse octahedrite with bandwidth about 1.35 mm, reheated and hammered by man. They are perhaps Toluca or Misteca specimens, but at this late date it is difficult and hardly worth while identifying these artificially reheated specimens.

DESCRIPTION

Chupaderos I is a 14,114 kg irregular, platy fragment with the maximum dimensions 265 x 220 x 90 cm. Chupaderos II is a 6,767 kg irregular, platy fragment with the maximum dimensions of 175 x 175 x 65 cm. Adargas is a 3,325 kg irregular, rhombohedral fragment with the maximum dimensions of 155 x 85 x 85 cm. The jagged edges that follow the Widmanstätten and schreibersite planes clearly indicate where the three fragments were originally joined. If we rejoin the complementary edges that show torn surfaces, we produce a large irregular plate of 24.2 tons with the approximate maximum dimensions 400 x 265 x 90 cm. Minor fragments were undoubtedly also produced when the meteorite burst in the atmosphere, but none of these have evidently been reported. If found, their size may have invited immediate utilization or forging into agricultural implements, etc. Perhaps Cuernavaca is such a fragment, transported and now with a very uncertain origin attached.

It is interesting to note that Chupaderos I on its present underside displays a 200 x 15 cm deep fissure that

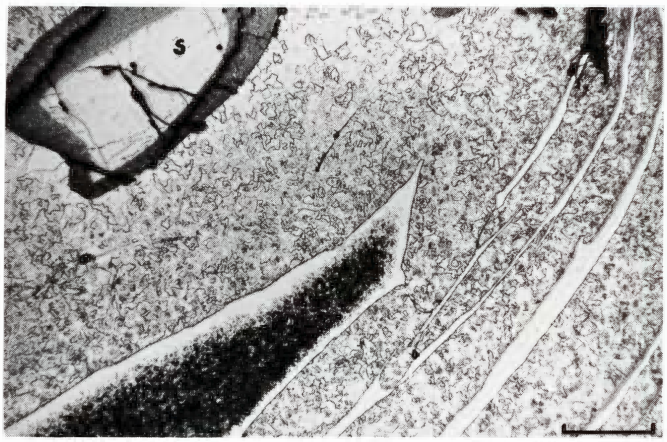

Figure 618. Chupaderos. Detail of Figure 617. Deformed taenite lamellae, partly melted schreibersite (S) and granulated α_2 in near-surface fracture zone. Etched. Scale bar 400 μ.

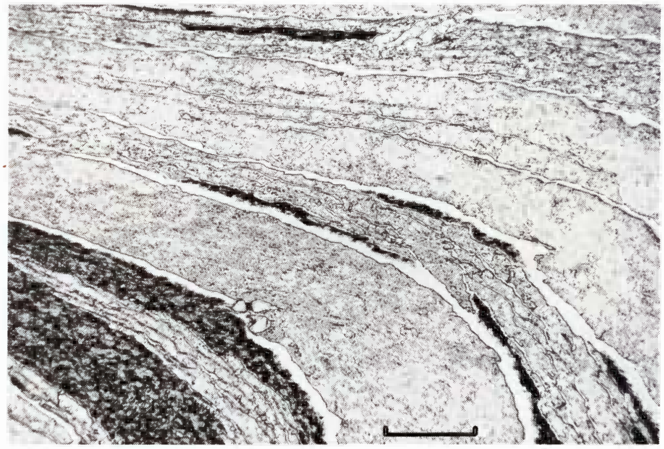

Figure 619. Chupaderos (Tempe no. 31a). Severely deformed Widmanstätten structure in necked areas adjacent to fracture surfaces from the atmospheric disruption. Etched. Scale bar 400 μ.

CHUPADEROS – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Wasson & Kimberlin 1967[1]	9.7								17.4	29.7	0.019	
Moore 1969, pers. comm.[2]	9.81	0.55	0.16	110								
Moore et al. 1969[3]	9.97	0.55	0.47	385	85							
Scott et al. 1973[4]	10.1								17.6	28.7	0.015	

1) On Chicago no. 1045, authentic Chupaderos. As corrected in a personal communication.

2) On Tempe no. 31a, authentic Chupaderos.

3) On Tempe no. 30ax, authentic Adargas.

4) On Tempe no. 30ax, authentic Adargas.

follows the Widmanstätten structure in a typical zigzag fashion, but apparently had insufficient time to progress through the whole mass and produce yet another fragment. As mentioned on page 466, the Adargas mass has several ancient inscriptions; in addition, a newer one [F. J. X 12 - 8 1885] has been found. The temptation to scratch one's signature was apparently irresistible, since Chupaderos II has $\frac{HH}{CP}$ chiseled in, and Chupaderos I has several almost illegible signatures, probably all from the late nineteenth century.

At a number of points on the surface of all three masses "orange peel" patches of the original fusion crust are still preserved as 1-3 mm thick, warty and striated areas. Conical to cylindrical holes, 15-50 mm in diameter and up to 50 mm deep, occur with a frequency of about 1 per 100 cm^2 surface. Their inside is lined with fusion crust and they indicate where troilite nodules burned out in the atmosphere; a few shallow troilite pits are even present on the latest fracture surfaces. On the surface, 1 mm wide, but often centimeter long furrows are also seen; these are the traces of partially burned out schreibersite lamellae. The external appearance of the Chupaderos fall is that of an only slightly weathered meteorite.

Etched sections display a medium Widmanstätten structure with dominant troilite and schreibersite inclusions. The kamacite bandwidth is 0.65±0.10 mm and the lamellae are straight and long ($\frac{L}{W} \sim 25$). However, near some of the fracture zones the lamellae are bent and otherwise deformed due to necking and tearing in the atmosphere. Due to preatmospheric shocks above 130 k bar, the lamellae are transformed to ϵ-structure, but near the ablation-heated surface a normal α_2 zone with melted phosphide inclusions is preserved on many sections. The ϵ-structure is apparently decorated everywhere by less than 0.5 μ particles, which may be phosphides or taenite beads precipitated from a supersaturated ϵ-phase after the deformation took place. The microhardness of 215±15 indicates an annealed ϵ-phase.

It is interesting to note that the only authentic Adargas slice the author has seen in a well polished condition (Tempe no. 30ax) displayed the α_2 structure all over, indicating a thorough heating above 800° C to a depth of at least 25 mm. This might be interpreted as an unusually wide ablation heated α_2-zone, but it might also be a result of reheating in the violent fire mentioned on page 467. Since other specimens from Chupaderos, e.g., Tempe no. 31a, also display an unusually wide α_2 zone – more than 50 mm in places, it is concluded that the heating is from atmospheric penetration. The old reports of the intense heating in the open fire are probably exaggerated.

Dark-etching plessite fields occupy about 50% by area. Most are poorly resolvable duplex $\alpha + \gamma$ structures, others are martensitic, acicular with indications of a significant percentage of dissolved carbon. Fine meshed comb plessite is also present; 1-5 μ phosphide grains substitute for taenite in the interior. The microhardness ranges from 350 in the martensite to 275±25 in the dense, duplex $\alpha + \gamma$ fields. The taenite is only 290±25, indicating some annealing.

Schreibersite is extremely common as branched lamellae and skeleton crystals in dodecahedric arrangement. A typical lamella is 40 x 15 x 1 mm, and it is enveloped in 1-2 mm rims of swathing kamacite. Counting of several sections yielded an average of 2.5% by area of the larger phosphides, corresponding to 0.33% P. Add to this the 0.16% P found by Moore (1969) on material free of large inclusions, and we have an estimate of 0.5% P for the whole mass. The schreibersite is monocrystalline but often brecciated or even crushed, indicating heavy plastic deformation. Its hardness is 920±25. Rhabdites proper were not observed, but several of the ferrite subboundaries are decorated with 0.5-1 μ phosphides.

The troilite nodules are 15-40 mm in diameter and often display conical to subcylindrical form. Locally, the iron matrix injects a tongue or an island into the troilite. Rims of 0.8-1 mm thick schreibersite are common, and the aggregates are enveloped in 1-2 mm of swathing kamacite.

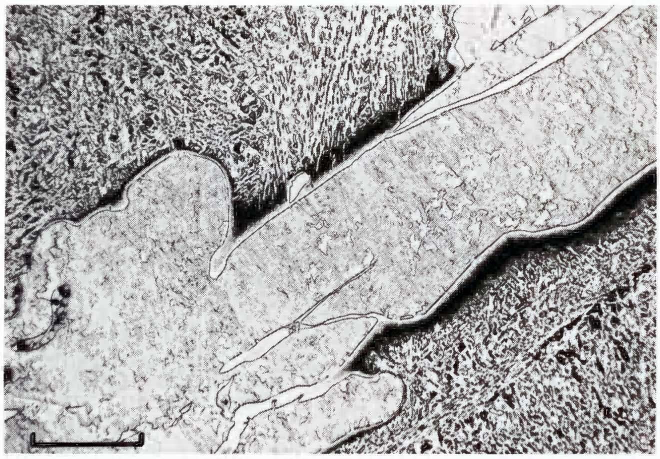

Figure 620. Chupaderos (Tempe no. 31a). Such α_2 transformation is common in near-surface heat-affected samples. Etched. Scale bar 400 μ.

Figure 621. Chupaderos (Tempe no. 31a). The preatmospheric kamacite structure was apparently an annealed shock-hatched transformation product. Very fine beads of taenite and phosphides occur everywhere. Etched. Scale bar 20 μ.

The troilite is a microcrystalline aggregate of 10 μ grains, indicating shock melting. In several places the schreibersite rim is fractured and 10-100 μ fragments from it are dispersed in the troilite, showing that the troilite indeed was of a liquid character for a moment. Point counting of several sections showed that troilite occupies about 6% by area, corresponding to a bulk sulfur content of 1.4%.

Graphite is not present, but a few inclusions of bluish-gray phosphate minerals have been identified in the troilite (Olsen & Fredriksson 1966).

Cohenite, daubreelite, chromite and silicates were not observed.

Chupaderos is a slightly weathered, medium octahedrite with all the characteristics of group IIIB: bandwidth of 0.65 mm, heavy concentration of schreibersite, phosphate crystals in troilite, ϵ-structure and significant proportions of martensitic plessite. The block named Adargas has exactly the same structure and analysis as the Chupaderos blocks and displays the same state of slight weathering. The fragmented edges may be joined together to reconstruct the large slab, that split high in the atmosphere to produce a shower over 40 km. Since Cuernavaca and Espiritu Santo display exactly the same structures, morphology and other characteristics, it is proposed that these are other fragments from Chupaderos which were transported by man and offered for sale as coming from other regions.

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

2,362 g slice (no. 2,722, 22 x 16 x 1 cm)
154 g part slice (no. 700, 4 x 3.5 x 1.2 cm)
24 g chiseled fragments (no. 913; "Adargas," Mexico no. 30)

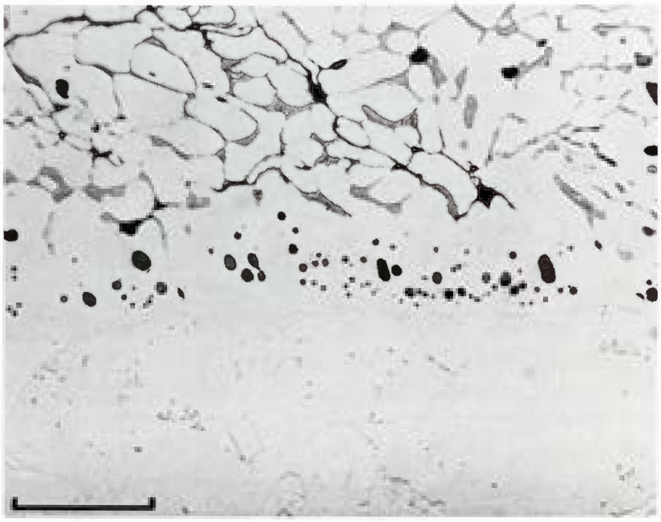

Figure 622. Chupaderos (Tempe no. 31a). Fusion crust (above) and heat-affected α_2 zone (below). There are gas holes and globular iron oxide melts in the fusion crust. Iron-phosphorus-sulfur eutectics are located in the boundaries between primary metallic dendrites. Etched. Scale bar 100 μ.

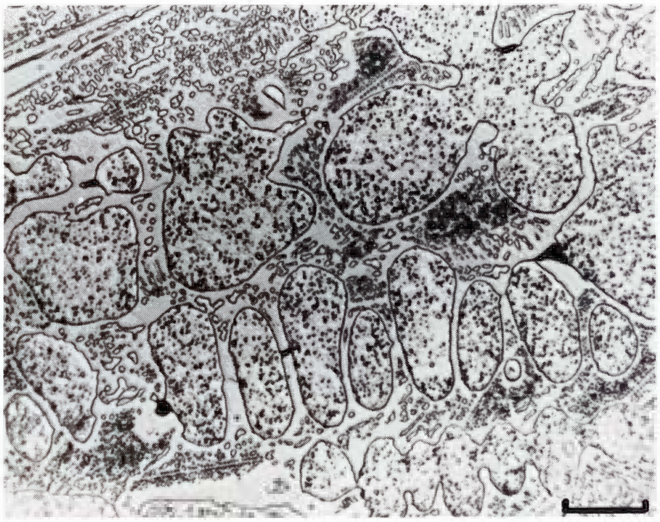

Figure 624. Chupaderos (Tempe no. 30ax). Heavier etching reveals that the metallic dendrites of Figure 623 were austenitic at high temperature but transformed to unequilibrated α_2 upon cooling. Scale bar 20 μ.

Figure 623. Chupaderos (Tempe no. 31a). Fused and rapidly solidified schreibersite lamella, which remained in its rounded cavity. Another part was lost as finely disseminated droplets during atmospheric ablation. Lightly etched. Scale bar 50 μ.

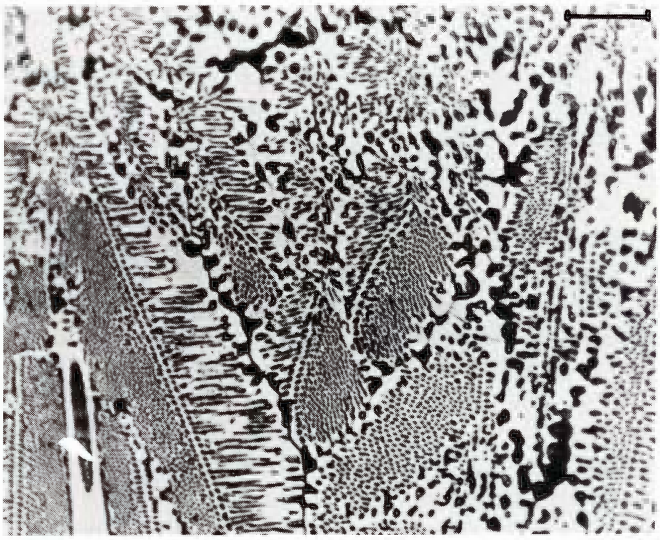

Figure 625. Chupaderos (Tempe no. 30ax). Another fused schreibersite lamella. The fine eutectic Fe-Ni-P structure has been enhanced by terrestrial corrosion that selectively converted the metal phase to limonite. Polished. Scale bar 20 μ.

Figure 626. Chupaderos. Half of the Cuernavaca mass, now in Chicago (Chicago no. 1025, 17.3 kg). Eminent fusion crust and deep scars from ablated schreibersite lamellae. See also Figure 191. Scale bar 3 cm. S.I. neg. M-110A.

Chupaderos (Cuernavaca), Morelos, Mexico.

Coordinates unknown.

Medium octahedrite, Om. Bandwidth 0.68±0.10 mm. ϵ-structure. HV 205±20.

Group IIIB. 10.0% Ni, 0.59% Co, about 0.7% P, 1.5% S, 16.4 ppm Ga, 31.6 ppm Ge, 0.02 ppm Ir.

In all probability a transported piece of the Chupaderos shower.

HISTORY

Castillo (1889: 3) mentioned "a fragment of meteoric iron found, so it is said, on the road from Mexico (City) to Cuernavaca, in the mountains". Ward (1902b) was permitted to cut a mass of about 35 kg, supposed to be "the fragment" of Castillo, and to carry away the smaller half. He described it with photographs and showed it to be similar to Bella Roca but different from Toluca, with which Fletcher (1890a) had associated it. Cohen (1902a: 1905: 379) described it, and Brezina & Cohen (Atlas 1886-1906: plate 36) gave excellent photomacrographs. Jaeger & Lipschutz (1967b) found 400-750 k bar shock structures in the kamacite.

It is not at all clear that the very characteristic mass which Ward cut and distributed (see macrophoto in Ward 1902b: 7; Ward 1904a: plate 8), is identical with "the fragment" mentioned by Castillo. In any case, what is now labeled "Cuernavaca" in Mexico City, Institute of Geology, is a true fragment of less than an ounce weight (no. 23) with the dimensions 22 x 13 x 8 mm. Haro (1931: 76) listed it as the Cuernavaca fragment (then apparently 44.9 g) and gave a photograph (plate 25). About 1930 Nininger obtained a part of the specimen which is now in Tempe (no. 28a, 72.5 g), and has been analyzed by Moore (pers. comm.) to contain 8.43% Ni, in contrast to genuine Cuernavaca with about 10% Ni. On page 474, I will present a metallographic description of no. 28a, which shows it to be a detached fragment from some unknown artificially reheated meteorite.

It will here be supposed that Ward's Cuernavaca is of unknown origin and may in fact be a transported specimen of the Chupaderos shower, while Castillo's Cuernavaca is a small damaged fragment from another unidentified Mexican iron.

COLLECTIONS

Authentic material of this mass is in the following collections: Chicago (17,340 g half mass; 338 g), Harvard (1,315 g), London (1,024 g), Washington (738 g), Vienna

(629 g), New York (292 g), Berlin (214 g), Tübingen (184 g). A 382 g specimen in Budapest was probably lost during the revolution in 1956. These specimens add up to about 22.5 kg.

The half mass (about 20 kg) which Ward left in the National Museum in Mexico City could not be located during my visits to the Museum in 1967 and 1968.

DESCRIPTION

The 35 kg mass had, before being cut by Ward, the maximum dimensions 48 x 15 x 13 cm. It was in the form of a square-sided irregular prism with some protuberances. The weight was, surprisingly enough, not stated by Ward, but from the dimensions and shape, an original weight of 35±3 kg may be estimated. Cohen (1902a) quoted a letter from Ward who estimated the weight as 30-40 kg. There is apparently a discrepancy between Ward's statement that he brought the smaller half to Rochester and the fact that this part provided 22.5 kg slices to which must be added about 1.5 kg shavings, necessarily produced during the cutting. It seems to me that the best explanation is that there is no more material in Mexico, that Chicago now possesses the uncut half piece (no. 1,025, 17.3 kg) and that the remainder has been distributed as slices.

The exterior is slightly weathered, but patches of striated and warty fusion crust reveal small amounts of 50-100 μ thick dendritic oxides, followed by up to 0.8 mm thick, laminated, dendritic metal (HV 335±25). Thumbprint pits (regmaglypts) are common and a few deep holes indicate where troilite nodules burned out during atmospheric flight. One millimeter wide and 10-40 mm long grooves resembling chisel marks are the result of partial burning out of the Brezina-schreibersite lamellae.

The heat-affected rim zone of α_2 is unusually wide, up to 15 mm. It abuts indistinctly against the interior ϵ-structure. The α_2 rim zone has a hardness of 200±15, while the interior has a hardness of 205±20. Both microstructure and hardness are thus very similar.

On one surface, the action of the atmosphere is limited. This is probably the face along which the meteorite was joined to some larger mass before it fractured during entry. Bent Widmanstätten lamellae may be observed at the surface, similarly suggesting an atmospheric breakup. Some frail fissure lines which progress in a zigzag along the large Brezina lamellae deep into the mass are probably likewise a reminiscence of the breakup.

Etched sections show a medium Widmanstätten structure of straight, long ($\frac{L}{W} \sim 20$) kamacite lamellae, averaging 0.68 mm in width. They are, due to shock above 130 k bar, transformed to hatched ϵ-structure. It is interesting to note that the structure is somewhat indistinct in exactly the same way as in Chupaderos (and Bella Roca), due to a profusion of closely spaced less than 0.5 μ precipitated grains. Some of these are phosphides, particularly on the subgrain boundaries, but the great majority are a nickel-rich γ-phase.

Plessite occurs mainly as dark-etching plessite and as a poorly resolvable, duplex $\alpha + \gamma$ structure with embedded 1 μ phosphide grains. A fine-meshed comb plessite is also present; the various plessite areas occupy about 50% of the sections. A typical field displays a yellow taenite border (HV 280±15) followed by a gray indistinct (annealed) martensite (HV 350±40). Next follow duplex $\alpha + \gamma$ mixtures, ranging in hardness from 280 (<0.5 μ γ-particles), through 230 (1 μ γ-particles) to 205 (2 μ γ-particles).

Schreibersite is dominant as typical 40 x 20 x 1 mm lamellae, which follow the $\{110\}$ directions, the so-called Brezina lamellae (HV 915±25). It further occurs as 25-50 μ grain boundary precipitates, and as minute 1 μ precipitates on the ferrite subgrain boundaries. The larger schreibersite crystals are monocrystalline, but brecciated, and sometimes crushed. They are surrounded by 1-2 mm swathing kamacite. The bulk phosphorus content is estimated to be 0.7±0.5%.

Troilite occurs as large and small scattered nodules, 5-30 mm in diameter. They are partly or totally enveloped in 0.5-1 mm thick schreibersite rims, which often are connected to the Brezina lamellae. In some troilite nodules, up to centimeter sized rounded inclusions and tongues of iron that are nicely decomposed to Widmanstätten structure (e.g., Vienna H 4984) may be found. The inclusions are apparently tilted somewhat relative to the surrounding Widmanstätten pattern. Iron phosphates are present as 1-2 mm hard, blackish, shiny inclusions in a few of the troilite nodules. The bulk sulfur content is estimated to be 1.5%.

CUERNAVACA – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Whitfield in Ward 1902b	10.30											
Hildebrand in Cohen 1902a	8.76	1.19	0.33		1200	(0)	500					
Lovering et al. 1957		0.59				3.3	120		13	32		
Wasson & Kimberlin 1967	10.4±0.5								16.4	31.6	0.02	

Hildebrand apparently failed to separate cobalt from nickel quantitatively.

Chromite, daubreelite, cohenite and graphite were not observed.

In the author's opinion, it is difficult to sustain the belief that Cuernavaca is an independent fall. It is more likely a transported fragment of the Chupaderos shower because: (i) Main and trace element chemistry are identical to Chupaderos. (ii) Macrostructure and microstructure are identical. (iii) The exterior morphology of Chupaderos and Cuernavaca indicate an atmospheric break up. (iv) The wide α_2 zone of Cuernavaca is unusual for a small iron but is comparable to that observed on Chupaderos. (v) The state of preservation (fusion crust and α_2 zone relatively well preserved) is the same. (vi) The locality of Cuernavaca is, to say the least, highly uncertain; it is not even certain that Castillo's information was tied to the piece that Ward cut and distributed. (vii) Mexico has provided an anomalously high proportion of group IIIB irons (Adargas, Apoala, Bella Roca, Chupaderos and Cuernavaca). If the Chupaderos shower is accepted as comprising the two Chupaderos blocks, Adargas and Cuernavaca, we are left with only three different IIIB irons: Chupaderos, Bella Roca and Apoala, which is statistically much more satisfactory for a land the size of Mexico.

Pseudo Cuernavaca

The structure of the small specimens mentioned on page 472 will be discussed based upon Tempe no. 28a. This is a fragment of 72 g which has been considerably hammered and displays overfolded patches and several fissures. Corresponding to this, the etched section shows that all original surface is lost and that the matrix is completely converted to α_2. The Widmanstätten structure is bent and has lost its oriented sheen, and the small schreibersite inclusions are melted, all these things indicating artificial reheating to about 1000° C and hammering.

The lamella width is 1.15±0.10 mm, and schreibersite occurs as frequent 50 μ wide grain boundary precipitates. Rhabdites, 4 μ in size, have also been common, but they are now partially resorbed in the matrix because of the blacksmith. The phosphorus content of the mass is estimated to be 0.20% P. Dr. Moore (pers. comm.) analyzed for nickel and found 8.41% and 8.45% in the determinations. He also found 0.47% Co and 0.14% P, in harmony with the amount of phosphides present and, thus, significantly lower than in genuine Cuernavaca material. Pseudo Cuernavaca is a medium octahedrite, probably of group IIIA, related to, e.g., Cumpas, Thule and Trenton. It is at this late date impossible to deduce from where it came, but it will be interesting to see if more material turns up in some collection.

Specimen in the U.S. National Museum in Washington

738 g slice (no. 447, 12 x 11 x 0.9 cm)

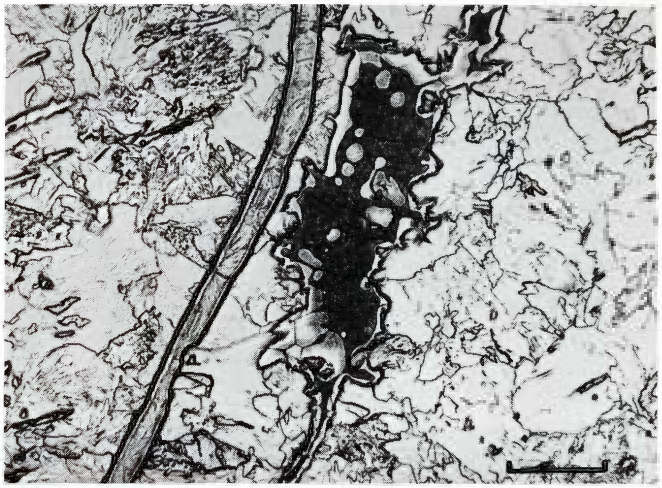

Figure 627. Pseudo Cuernavaca (Tempe no. 28a). A medium octahedrite of group IIIA, but of unknown origin. It has been artificially reheated to about 1000° C, as indicated by the presence of melted schreibersite (center) and unequilibrated α_2. Etched. Scale bar 200 μ.

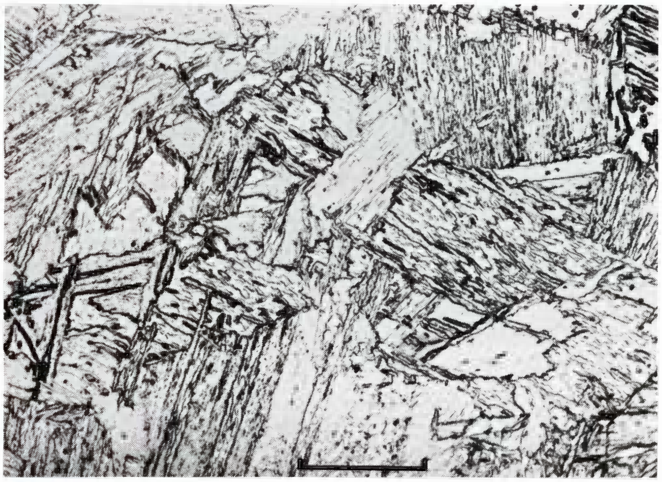

Figure 628. Pseudo Cuernavaca (Tempe no. 28a). Martensitic appearance of rapidly cooled α_2 with 7% nickel in solid solution. Etched. Scale bar 100 μ.

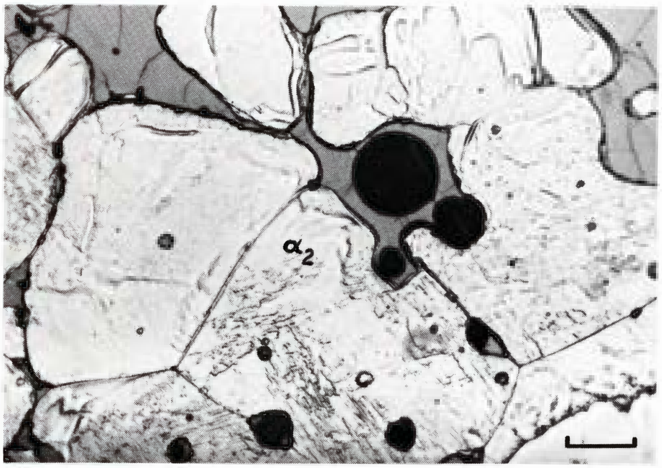

Figure 629. Pseudo Cuernavaca (Tempe no. 28a). Artificially remelted troilite that reacted with oxygen and solidified rapidly. Austenite dendrites (now α_2) and sulfide eutectics with globular iron oxide inclusions (black). Etched. Scale bar 20 μ.

Chupaderos (Espiritu Santo), Mexico

Medium octahedrite, Om. Bandwidth 0.65±0.15 mm. ϵ-structure.

Probably group IIIB with 10% Ni, 0.5% P, judging from the structure.

High probability that it is a transported fragment of Chupaderos.

HISTORY

Nothing is known of the history of this iron, not even its original size. The only preserved piece appears to be a 54 g fragment in the Field Museum in Chicago. It was briefly mentioned by Farrington (1916: 259), but before that it had been listed as part of the Ward-Coonley Collection (Ward 1901a: 3). In Ward's later, much larger catalog (1904a) it was omitted both from the collection and from the list of all known meteorites, which may indicate that Ward had come to consider it a fragment of a well known meteorite.

COLLECTION

Chicago (no. 1056, 54 g).

ANALYSIS

No analysis has been performed, but the author would expect from the structural characteristics, about 10% Ni and 0.5% P, with a trace element content characteristic of group IIIB.

DESCRIPTION

The only known specimen was kindly lent to me by Dr. E. Olsen, Field Museum, Chicago. It is a part slice, 5 x 3 x 1 cm, with one polished and etched surface of 10 cm^2. The slight superficial damage is apparently due to hammering and chiseling while trying to separate the specimen from some larger mass. It is corroded very little showing only incipient attack along some near-surface inclusions.

The etched section reveals a beautiful medium Widmanstätten structure with oriented sheen and with straight, long ($\frac{L}{W} \sim 25$) kamacite lamellae with a width of 0.65±0.15 mm. Since the section happens to be almost parallel to the fourth (111) direction, probably because the mechanical chiseling was easiest this way, the fourth set of lamellae show up as a few, irregular, 2-3 mm wide ribbons. The lamellae are bent, and the phosphide inclusions are broken at the surface due to hammering. The kamacitic matrix is of the hatched ϵ-structure associated with shock pressures above 130 k bar. Plessite occupies about 50% by area, partly as comb and net plessite with tiny, concave taenite islands, partly as brown-etching martensite which displays the four directions of the bulk Widmanstätten pattern.

Schreibersite is common as 0.5-4 mm monocrystalline skeleton crystals, and as 40-80 μ grain boundary precipitates. Further, as 3-25 μ vermicular bodies inside the various plessite fields. Rhabdites were not observed, but the subgrain boundaries of the kamacite are decorated with 1-2 μ phosphides.

Troilite occurs in the small section only as 0.3-0.8 mm bodies associated with, or embedded in, schreibersite crystals. The troilite is an aggregate of 10-25 μ anisotropic grains with a few 1-2 μ metallic inclusions. The troilite appears to have been shock melted, since it displays ragged edges against the surrounding kamacite where a little metal has been dissolved. The borderline against the schreibersite is, as usual, smooth, indicating that no reaction takes place easily between troilite and schreibersite upon reheating.

The specimen displays an unusually wide, heat-affected α_2 zone, about 8 mm thick. Rather coarse-grained, micro-melted phosphide bodies are found to a depth of about 4 mm. A similar, wide heat-affected zone was observed on specimens of Chupaderos.

Comparison, point for point, of specimens of Chupaderos with Espiritu Santo fails to reveal any structural difference between the two. The slight corrosion and the wide, heat-affected zone are also identical. Furthermore, Espiritu Santo appears to be a detached fragment from some larger mass and to be the only meteorite known from the state of Michoacan. I think, therefore, that it is, in fact, a fragment chiseled off Chupaderos at some early date, transported to Michoacan and then acquired by Ward upon one of his numerous visits to Mexico about the year 1900. It appears, furthermore, that Ward himself had come to a similar conclusion since he omitted the meteorite as a separate entry in his 1904 catalog, at a time when he certainly otherwise worked hard to increase the number of entries, in competition with the collections of Vienna and London.

Cincinnati, Ohio, U.S.A.

39°7'N, 84°30'W; 200 m

Reheated hexahedrite. Structure originally probably as Coahuila.

Group IIA. About 5.4% Ni, 0.2% P.

All specimens in collections have been artificially reheated to 1,000° C.

HISTORY

The iron was found during excavation for a new house in Cincinnati in 1870. The Swiss mineralogist Hosaeus acquired it, and, upon his death, two slices of about 300 g total weight came into the possession of the Geological Museum of Basel (letter from C. Wendler of June 3, 1927, in the Smithsonian Institution). Part of this material was sold to the British Museum (51 g) and the U.S. National Museum (31 g).

COLLECTIONS

Vienna (about 250 g), New York (84 g), Chicago (61 g; 1 g) and Harvard (38 g). Some of these specimens may have been acquired through the same channel. Others came directly from Hosaeus, such as the 28 g specimen in Munich, which was described by Cohen (1905: 51) as a nickel-poor staxite of the Siratik group. The meteorite was