Cookeville is a typical inclusion-rich coarse octahedrite, closely related to such group I irons as Cranbourne and Canyon Diablo. The probability that it is a transported fragment of the Smithville shower is very high, since the macro- and microstructure, the microhardness, the main and trace elements, and the state of corrosion are identical. Cookeville, the town in which the mass first appeared, is only 35 km northeast of Smithville.

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

371 g endpiece (no. 518, 7 x 7 x 2 cm)
15 g oxidized fragment (no. 1587, detached from no. 518)
72 g oxidized fragments (no. 2731, 4 x 2.5 x 0.8 cm, and smaller)

Social Circle, Georgia, U.S.A.
33°39'N, 83°42'W

Fine octahedrite, Of. Bandwidth 0.30±0.04 mm. Recrystallized. HV 166±8.

Group IVA. 7.61% Ni, 0.38% Co, about 0.05% P, 1.63 ppm Ga, 0.092 ppm Ge, 2.8 ppm Ir.

HISTORY

A mass of 219 pounds (100 kg) was found in 1926 while plowing was underway in a field on the plantation of W.B. Spearman, a few miles from Social Circle, Walton County. The actual location of find may have been just over the border line in the neighboring Newton County (E.P. Henderson, personal communication). The coordinates given above are for Social Circle. The mass was recognized as a meteorite by the state geologist of Georgia, S.W. McCallie, who acquired it from the owner. McCallie (1927) described it on the basis of a small wedge-shaped section that had been removed by a Colored man who used 11 hacksaw blades in the process. Merrill (1927b) suggested that Social Circle was related to Western Arkansas. This happened to be correct, although the premises were two analyses which by a curious coincidence were both much – but to about the same degree – deficient in nickel (5.02 and 5.12% Ni, respectively). Henderson & Perry (1951b) and Henderson & Furcron (1957) reexamined the meteorite and produced photomacrographs of the exterior and of etched slices. On that occasion the meteorite was cut, essentially parallel to its long dimension; and several slices were taken from the smaller specimen at right angles to the direction of the long cut. They found the iron to be homogeneously granulated throughout the entire mass and suggested that the effect was due to a near-solar passage.

COLLECTIONS

Georgia State Museum, Atlanta (about 70 kg), Washington (22.2 kg), Chicago (341 g), Agnes Scott College, Decatur, Georgia (300 g), Albuquerque (68 g).

DESCRIPTION

The mass had, according to McCallie (1927), the average dimensions of 37 x 32 x 22 cm and had the shape

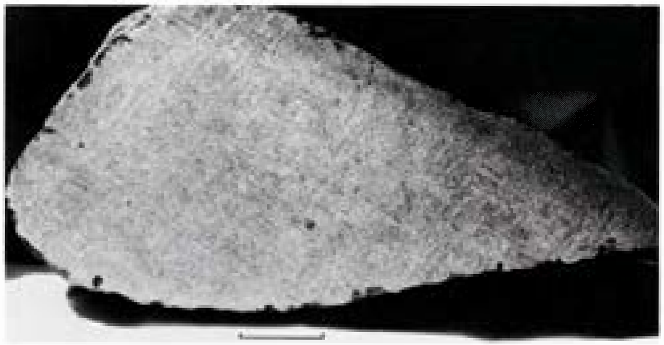

Figure 1668. Social Circle (U.S.N.M. no. 2580). The meteorite has been cut parallel to its lengthwise direction. Deep-etched. Scale bar approximately 5 cm. S.I. neg. 38600.

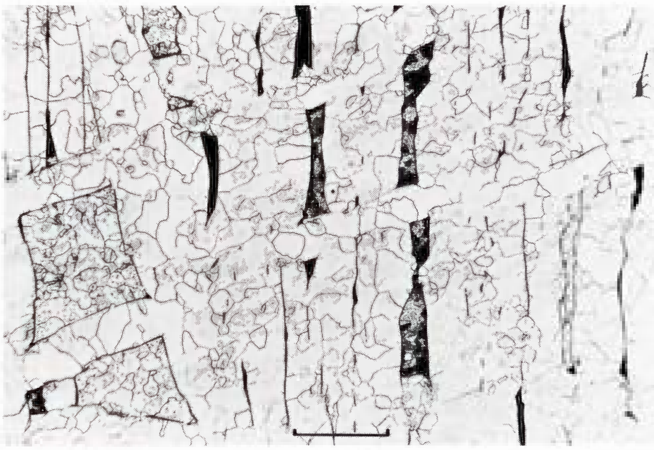

Figure 1669. Social Circle (U.S.N.M. no. 1675). A recrystallized fine octahedrite of group IVA. Comb, net and cellular plessite fields are common and some are unresolvable and black at this magnification. Etched. Scale bar 600 μ.

SOCIAL CIRCLE – SELECTED CHEMICAL ANALYSES

Henderson & Furcron (1957) believed that the cobalt analysis was too low and suggested 0.50% as a correct value. This appears, however, to be an erroneous assumption; a redetermination is considered necessary before the original value can be disqualified.

	percentage			ppm							
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Henderson & Perry 1951b	7.44	0.38										
Wasson & Kimberlin 1967	7.78								1.63	0.092	2.8	

of a smoothly rounded but irregular low cone. The slices in the U.S. National Museum show no regmaglypts and no fusion crusts. Even the heat-affected α_2 zone seems to have been removed by terrestrial corrosion. Various oxide crusts cover the surface in thick laminated sheets of 0.5-2 mm. No hardness gradient could be detected from the interior of the mass towards the edge. It appears that, on the average, about 5 mm has been lost by weathering.

Etched sections reveal a fine Widmanstätten structure of straight, long kamacite lamellae with a width of 0.30±0.04 mm. The taenite ribbons and plessite fields between the kamacite lamellae cover 45-50% by area. The plessite varieties comprise comb, net and cellular types, while martensitic and acicular types are absent.

All kamacite is recrystallized. The new ferrite grains are rather coarse, 100-400 μ across, in the kamacite lamellae but considerably smaller inside the plessite fields (10-100 μ). The new grain boundaries are high angle boundaries between almost isometric grains, and the angles have frequently attained equilibrium angles of 100-120°. Grain growth has also occurred. In numerous places, successive positions of grain boundaries are visible as ghost-lines, and it is clearly seen how three- and four-sided grains have become unstable and decreased in size, until they have finally been completely erased. In other places, the significance of precipitates as obstacles for grain growth is clearly demonstrated. Grain boundaries may be bulging over a wide front, suspended between 1-5 μ particles (mainly of taenite). Also the final variation in grain size (about 0.3 mm in the lamellae but only 0.03 mm in the fields) must be due mainly to the different size and spacing of precipitates.

Neumann bands were originally present in the kamacite. They can still be detected as parallel ghost-lines, extending uniformly through many recrystallized, independently oriented ferrite grains. They are apparently mainly visible because they were previously somewhat decorated by precipitates, which only to a minor extent dissolved during recrystallization. A recent generation of Neumann bands is present locally at the surface. These bands are undecorated and change their orientation from grain to grain, according to the orientation of the recrystallized units. They are thus of post-recrystallization date and were either formed by the atmospheric deceleration and fissuring or by some artificial cold working. The quantity of new Neumann bands, however, is very modest.

The microhardness of the recrystallized kamacite is 166±8. In the Neumann band containing near-surface grains, the hardness increases to 195±10 because of the deformation.

All taenite and plessite fields are somewhat decomposed to an incipient stage of spheroidizing. The hardness of the taenite is 175±10. The taenite is still continuous, but numerous reentrant angles indicate how a somewhat more extensive reheating would have broken the taenite up into spheroidized units, resembling Maria Elena and Roebourne.

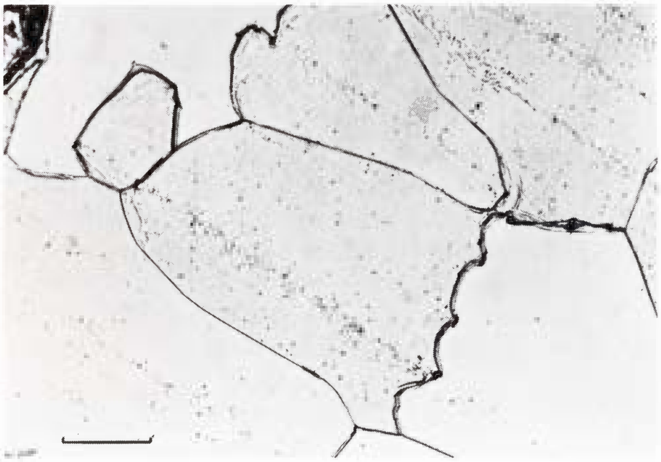

Figure 1671. Social Circle. Detail of Figure 1670. Indistinct remnants of parallel shear zones, probably Neumann bands. Grain growth restricted by fine γ-particles on the boundaries. Etched. Scale bar 40 μ.

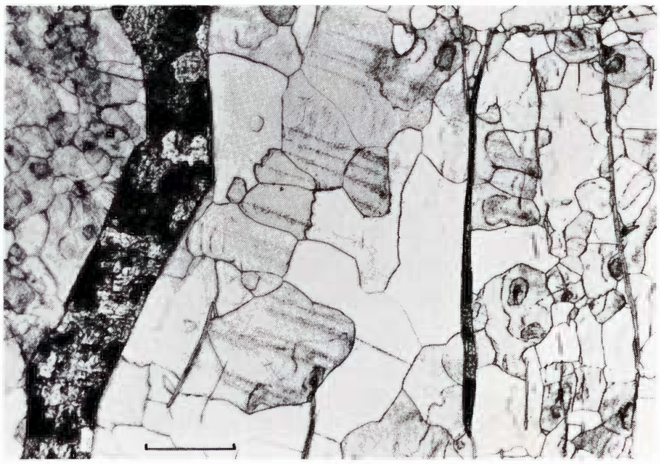

Figure 1670. Social Circle (U.S.N.M. no. 1675). Black cellular plessite to the left and open-meshed comb plessite to the right, both well-annealed. The recrystallized grains vary in size according to number and size of taenite particles. Etched. Scale bar 200 μ.

Figure 1672. Social Circle. (U.S.N.M. no. 1675). Grain growth with successive growth lines indicating several periods of rest. Distorted taenite lamellae vertically across the picture. Etched. Scale bar 100 μ. See also Figure 220.

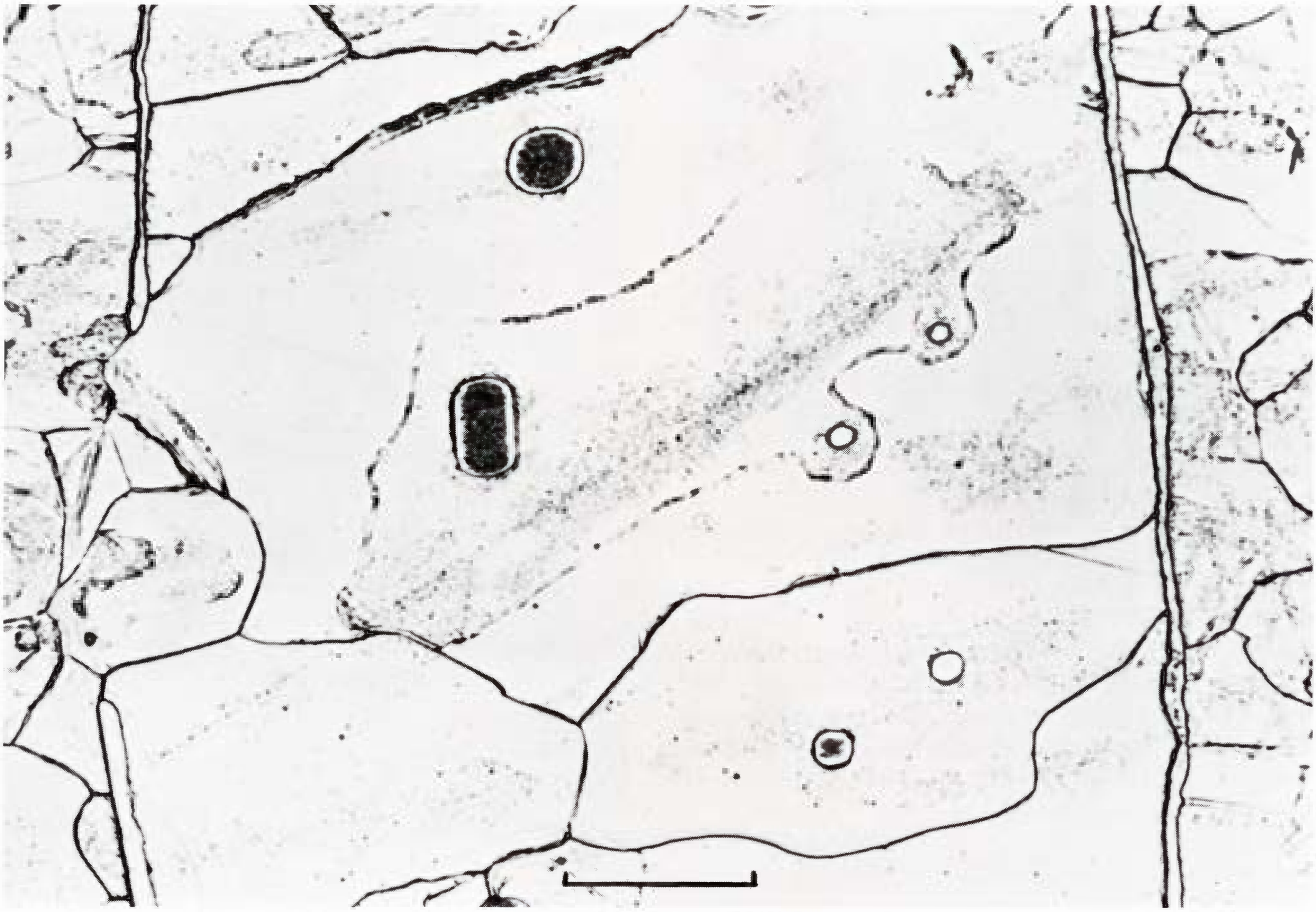

Figure 1673. Social Circle (U.S.N.M. no. 1675). A degenerated net plessite field with only a few unresorbed taenite particles. They are spheroidized and two have acted as obstacles for the kamacite grain growth. Etched. Scale bar 100 μ.

Phosphides were only detected as rare, 2-5 μ wide grain boundary precipitates; the bulk phosphorus concentration is probably about 0.05%.

Troilite is common as rounded, oval or lamellar aggregates, ranging from 30 mm to 0.2 mm in size. The troilite is extremely altered due to shock melting. It is decomposed to 1-3 μ fine-grained eutectics of troilite and metal, in which fragments and droplets of daubreelite are dispersed. The original smooth interface between metal and sulfide is now a serrated fringed border, from which a few fine veinlets penetrate one millimeter into the surrounding metal. In some nodules, parallel daubreelite lamellae 50-200 μ thick, have survived relatively intact. They are, however, penetrated by extremely fine troilite-filled veinlets. The textures correspond closely to those present in, e.g., Gibeon, Huizopa and Roebourne.

Chromite grains are present locally in the kamacite as angular, cubic blocks, 10-30 μ in size. Small daubreelite (or possibly brezinaite) grains are also common in the kamacite. Lawrencite was reported by Henderson & Perry (1951b); it was not identified, however, and the chlorine no doubt was introduced by terrestrial ground water which slowly penetrated about 1 cm into the mass during weathering in the soil.

A close inspection of the corrosion products failed to detect any signs of artificial reheating. The structure of the meteorite is, therefore, genuinely cosmic, produced before the meteorite entered the atmosphere. It appears that a thorough soaking to temperatures of about 500° C would be sufficient to create the observed recrystallization and

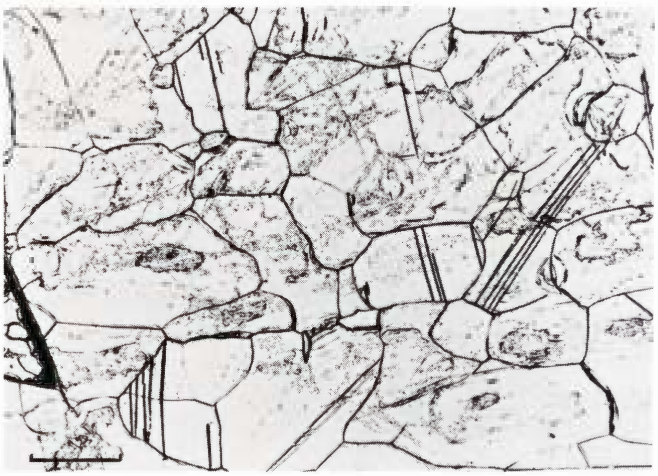

Figure 1674. Social Circle (U.S.N.M. no. 1675). Near internal cracks the recrystallized grains display a young generation of Neumann bands, probably dating from the atmospheric deceleration. Etched. Scale bar 100 μ.

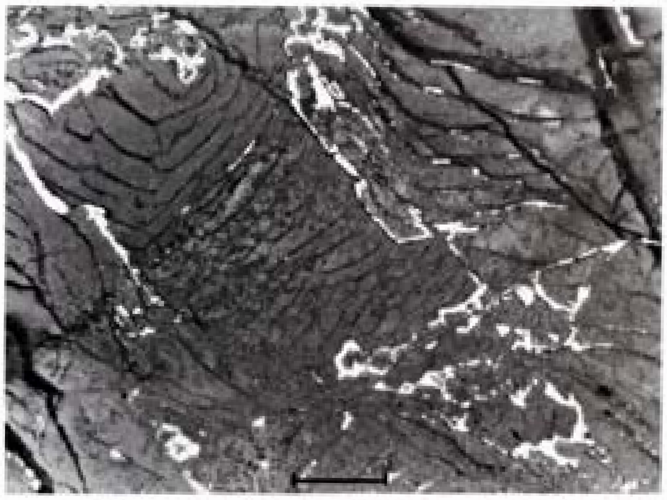

Figure 1675. Social Circle (U.S.N.M. no. 1675). Terrestrial corrosion products. The limonite preserves a fossil pattern of grain boundaries and growth lines from the recrystallized kamacite. Polished. Scale bar 30 μ.

spheroidization. The rhythmic growth lines which are developed over large parts of the specimens indicate that the meteorite was reheated several times to approximately the same temperature. Each time, some grain boundary movement was accomplished. A logical possibility to consider is that the mass in its orbit repeatedly strayed in close enough to the Sun to be heat-treated, in much the same way as suggested for Indian Valley by Buchwald (1966).

Social Circle is a fine octahedrite of group IVA, which in its composition and primary structure is closely related to Gibeon, Bishop Canyon, Bristol, Huizopa, Charlotte and several other phosphorus-poor fine octahedrites. Its secondary structure was produced by cosmic reheating, probably comprising two separate events. A shock event released the mass from its parent body and created Neumann bands and the shock-melted troilite. Later, repeated orbital passages near the Sun recrystallized and spheroidized the metallic components. Finally, a superficial reheating in our atmosphere took place during the fall. This zone is now lost by weathering, however. Similar secondary structures are present in, e.g., Maria Elena, Serrania de Varas, Huizopa, Roebourne and Bingera, where they may have the same explanation.

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

69 g slice (no. 782, 7 x 5.5 x 0.3 cm)
1.3 kg part slice (no. 1463)
204 g part slice (no. 1620, 9 x 6 x 0.5 cm)
101 g part slice (no. 1675)
20.6 kg endpiece (no. 2580)

Soper, Oklahoma, U.S.A.

34°4′N, 95°38′W; 160 m

Anomalous. Recrystallized super-dendrite. 0.1-0.3 mm equiaxial ferrite grains. HV 155±5.

Anomalous. 5.68% Ni, 0.54% Co, 2.1% P, 9.7 ppm Ga, 10.8 ppm Ge, 0.011 ppm Ir.

HISTORY

A mass of 3.70 kg was found in or before 1938 by T.J. Stockton of Soper, Choctaw County, while he was working on a farm. The exact location was 12 km northwest of Hugo in NE 1/4 Section 4, Township 6S, Range 16E, corresponding to the coordinates given above. The meteorite was acquired by the Oklahoma Geological Survey and described, with photographs of the exterior and of an etched slice, by Wood & Merritt (1939). They noted its granulated structure and its exceptionally high phosphorus content, putting it apart from most other meteorites. Perry (1944: plate 11) gave two photomicrographs, and Henderson & Perry (1948b) reexamined the material and confirmed the first description, presenting a new analysis and an additional photomicrograph. Hintenberger et al. (1967) measured the noble gas concentrations and concluded that a substantial loss of tritium had occurred, relative to what was expected in unaltered iron meteorites.

COLLECTIONS

Museum of Geology, University of Oklahoma, Norman (1.63 kg), Washington (1.08 kg), Chicago (165 g), Ann Arbor (108 g), Forth Worth (about 60 g), London (48 g), Tempe (39 g).

DESCRIPTION

The angular, pointed mass had the extreme dimensions of 16 x 13 x 7.5 cm. Several regmaglypts, 10-25 mm in diameter and 5-10 mm deep, may be recognized, but the mass is weathered and covered with 0.5-2 mm thick crusts of terrestrial oxides. Locally, 5-6 mm deep pits are completely limonitized. Only a few recognizable traces of weathered fusion crust remain. Sections show that the

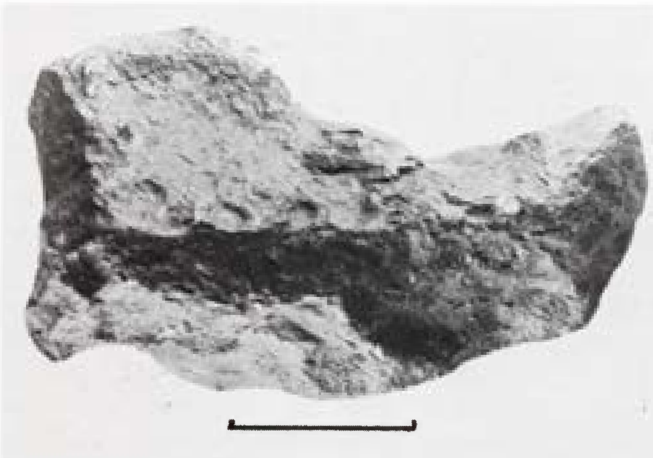

Figure 1676. Soper. Main mass of 3.7 kg before cutting. The meteorite is weathered, but occasionally – on sections – a 1 mm wide heat-affected α_2 zone may still be identified. Scale bar approximately 5 cm.

heat-affected α_2 zone is up to 1 mm thick in places; on the average about 2 mm of the exterior appears to have been lost by weathering.

Etched sections present a unique appearance. The deep-etched surface of U.S. National Museum No. 1315, 15 x 6 cm in size, is divided into three smoothly rounded ovoid cells by channels of a more coarse-grained material. The cells are about 4 cm across, and the concave space between them is 1-2 cm wide. This pattern is discontinued because a part of the surface was ablated during the fall. It appears as if Soper represents a portion of a huge dendrite with some 50 mm between the individual arms. The corresponding distance between dendritic arms in cast iron is of the order 0.05-0.1 mm; see, e.g., Hume-Rothery (1966: figures 11.5 and 11.13). A close examination of the two structural varieties on a polished microsection confirms the interpretation. The dendritic arms are relatively low in phosphides, while the interdendritic space shows a high concentration of phosphides, about three times that of the dendrites. This would be expected from slow solidification of an iron-nickel-phosphorus alloy. The first solidifying dendrites would be relatively phosphorus-poor, while the remaining phosphorus-rich eutectic would fill the interstices.

The kamacitic matrix is composed of equiaxial grains, 0.1-0.3 mm in size, which show little variation across the section. The grain boundaries are rather sensitive to both corrosion and etching reagents. The grains are divided into a mosaic with a net size of 10-100 μ. No Neumann bands are present. The hardness of the interior is 155±5. The heat alteration zone with α_2 shows a hardness of 175±8; the hardness drops in a recovered, transitional region just inside the α_2-zone to 140±5 (hardness curve type II). All hardness values are unusually low but are in accordance with a relatively nickel- and phosphorus-poor kamacite (4.1% Ni and "0"% P according to Henderson & Perry 1948b).

The schreibersite of the dendrites forms 10-100 μ irregular blebs and lenses, mainly located in the kamacite grain boundaries. The hardness is 790±20. The bulk phosphorus content is estimated to be about 1%, which is no more than all phosphides observed here can have precipitated from solid solution below about 900° C. The schreibersite in the interdendritic spaces is estimated to correspond to a bulk value of about 3%. In addition to the grain boundary precipitates similar to those mentioned above, there are a large number of coarse, ragged bodies, typically 0.3-0.8 mm across and with a hardness of 875±25. These have many cavities, channels and reentrant portions, generally 2-25 μ wide. Upon etching, the irregularities are carved out, and my first impression was that they represented real cavities. Repolishing shows, however, that there are no internal cavities; the channels and pits are the result of selective removal by polishing and etching of a very sensitive, fine-grained (< 0.5 μ), unequilibrated material

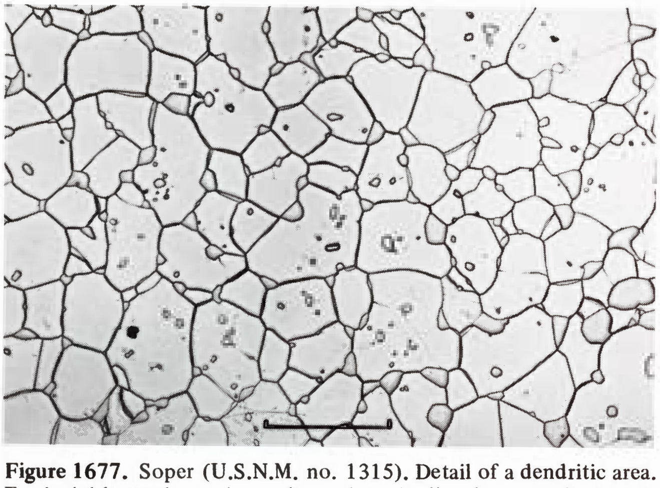

Figure 1677. Soper (U.S.N.M. no. 1315). Detail of a dendritic area. Equiaxial kamacite grains and angular schreibersite crystals, mainly in the grain boundaries. Etched. Scale bar 200 μ. (Henderson & Perry 1948b.)

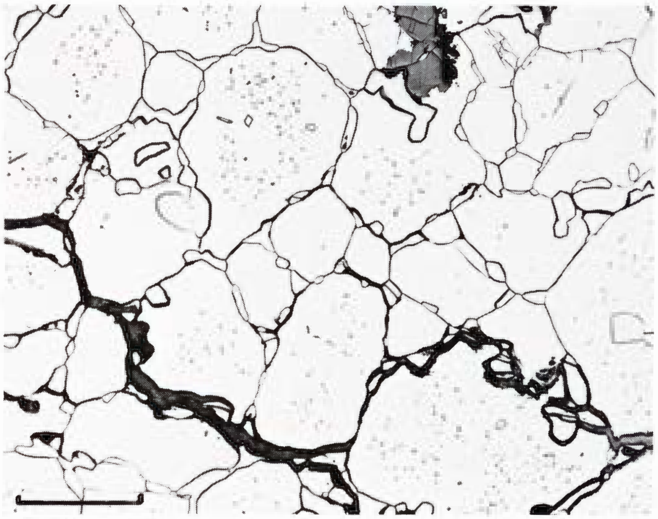

Figure 1678. Soper (U.S.N.M. no. 1315). Near-surface section showing terrestrial corrosion along the grain boundaries (black). Etched. Scale bar 200 μ. (Perry 1950: volume 4.)

SOPER – SELECTED CHEMICAL ANALYSES

Henderson & Perry also isolated the schreibersite and found it to contain 15.6% Ni, 0.77% Co and 15.4% P. The kamacite alone contained 4.11% Ni, 0.51% Co and 0% P.

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Henderson & Perry 1948b	5.66	0.54	2.08									
Wasson & Schaudy 1971	5.70								9.71	10.8	0.011	

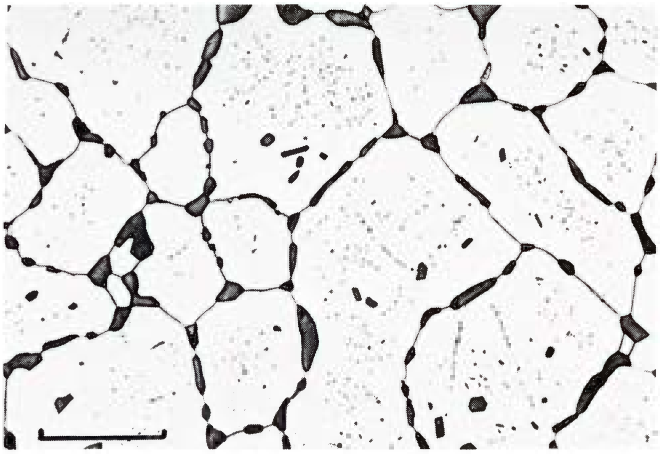

Figure 1679. Soper (U.S.N.M. no. 1315). The phosphides in the grain boundaries are tinted after having been exposed to a light picral etch followed by neutral sodium picrate. Scale bar 200 μ. (Perry 1944: plate 11.)

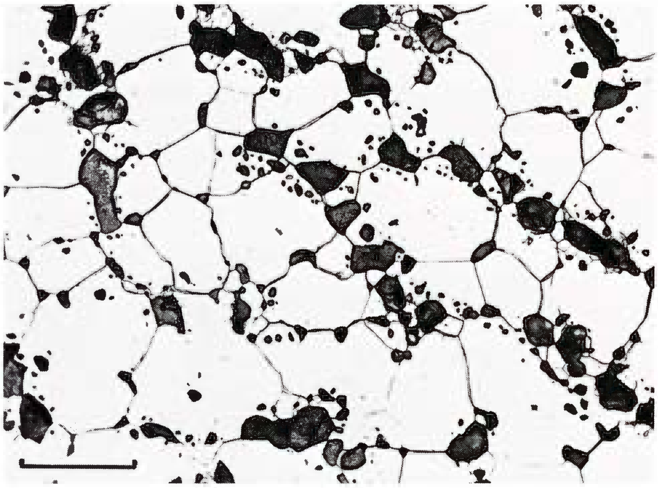

Figure 1680. Soper (U.S.N.M. no. 1315). Detail of an interdendritic area. The high concentration of phosphorus is evidenced by the dense population of phosphides. Etched as Figure 1679. Scale bar 200 μ. (Perry 1950: volume 4.)

which looks like an iron-phosphide eutectic. Its hypersensitivity is also seen in near-surface sections where it is selectively corroded. In the heat-altered zone it is seen to be the first to micromelt. Somewhat similar structures are found in Hammond, Reed City and, to a minor extent, several other shocked irons.

No troilite, daubreelite or other meteoritic minerals were observed, and no taenite is present.

Soper is an interesting meteorite which appears to be a unique, huge iron-nickel-phosphorus dendrite. The cooling rate, although slow by a technological scale, must have been rapid geologically speaking, since virtually no homogenization has taken place. Material of this bulk composition will form rather homogeneous, monocrystalline kamacite crystals with large hieroglyphic skeleton crystals of schreibersite under a lower cooling rate; see, e.g., Bellsbank, La Primitiva and Tombigbee. Soper continued to cool rapidly to low temperatures, and even on a microscale it is unequilibrated – as witnessed by the fine-grained, sensitive material in and around the schreibersite bodies. In this respect it somewhat corresponds to Kopjes Vlei, Holland's Store, Mejillones and other reheated hexahedrites.

Another possibility is that Soper suffered two consecutive reheatings. The first was sufficient to completely remelt the material and let it cool rapidly to a dendritic structure. The second reheating, perhaps caused by shock, may have occurred much later and recrystallized the material and formed the sensitive zones. Upon the second reheating the material may have lost a large fraction of its helium as suggested by Hintenberger et al. (1967). Soper is a highly anomalous meteorite which deserves further work.

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

1,030 g slice (no. 1315, 15 x 6 x 2 cm)
46 g polished, part slice (no. 1315, 3.5 x 3 x 0.6 cm)

Soroti, Teso district, Uganda
1°42′N, 33°38′E

Polycrystalline, troilite-rich, finest octahedrite, Off. Bandwidth 0.13±0.04 mm. ε-structure. HV 290±25.

Anomalous. Metal phase: 12.84% Ni, 0.6% Co, 0.15% P, 14 ppm Ga, 5.2 ppm Ge, 0.06 ppm Ir.

HISTORY

The Soroti meteorite fell as a small shower on September 17, 1945, at 1:10 p.m. near Soroti in the Teso

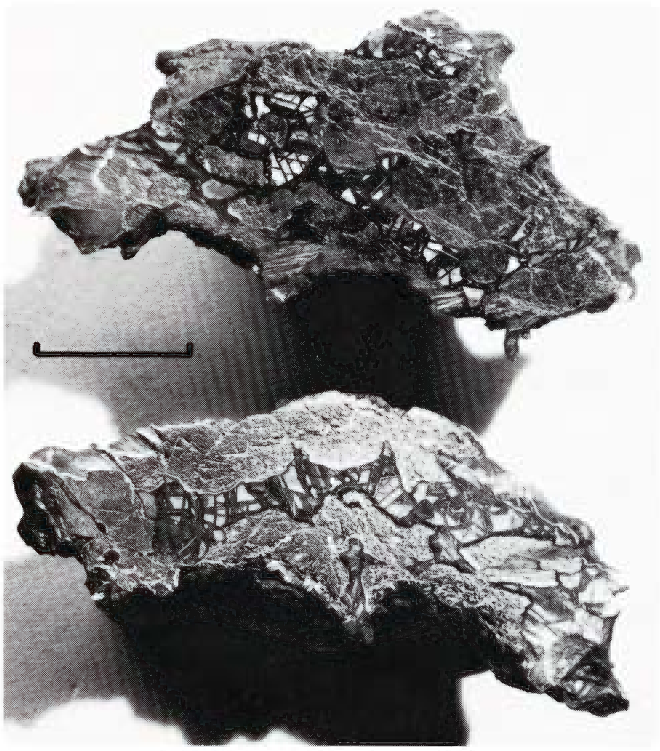

Figure 1681. Soroti (U.S.N.M. nos. 1516 and 1621). Two samples showing a sponge-like intergrowth of metal and troilite. The metal displays a finest octahedral structure. Etched. Scale bar 2 cm. S.I. neg. 42025.

district. According to Roberts (1947) who collected eyewitness reports and gave a preliminary description with photographs of the four recovered masses, the trail and the thunderous noises were observed from an area of at least 10,000 km^2. However, fragments were only recovered from the village Melok, three miles southwest of Katine Etem (Gombolola) and nine miles northwest of Soroti. Some fragments were believed to have fallen in the Omunyal Swamp and others near Toroma and east of Malera. The meteorite was estimated to have come from a southwestern direction. The trail extended across the clear blue sky but disintegrated after about five minutes – before valid ovservations could be made.

Many of the natives thought it was Judgment Day, and a woman from Melok said:

> "I was sitting in my hut with my three children yesterday morning. I heard something like thunder. As there were no clouds in the sky I thought that there was something harmful. So I went out of my hut and went to a tree nearby with my eldest child. I told him to kneel down and pray to God. We had just knelt down, when a thing came from the sky and went into the ground near the tree. I and my child were blinded by smoke for a little while. When we could see again I went to the place where the thing had fallen."

A small hole, about 35 cm wide, was found only one meter from the spot where they had been praying. When the hole was excavated the meteorite was found in two fragments about a foot down.

Three separate pieces fell about one mile south-southwest of the other; one of these remained in private possession. Four of the five recovered specimens were brought to the District Commissioner and came from there to the Geological Survey of Uganda where they were described by Roberts (1947). They weighed 1000, 700, 180 and 170 g, and the specific gravity of the largest was found to be only 5.86. Roberts estimated that the fragment consisted of 2/3 troilite and 1/3 nickel-iron.

Henderson & Perry (1958: 383) reexamined the two small fragments and gave several photomicrographs, confirming Roberts' report. The densities of the small fragments were 6.05 and 6.20 and contained about 60% of troilite by volume.

COLLECTIONS

Geological Survey of Uganda, Entebbe (about 1.7 kg), Washington (154 g), New York (61 g).

DESCRIPTION

The four recovered fragments differ in size but show the same ragged exterior morphology. The two small fragments, of 180 and 170 g, had the extreme dimensions of 7 x 5 x 3 cm and 8 x 4 x 2 cm. They have been cut into halves, and the following description is based upon them. The surface is extremely irregular. Horns and knobs of metal protrude above the low lying troilite-rich parts which were preferentially removed by ablational burning in the atmosphere. Some of the fused troilite has been redeposited on the surface and covers large parts of it as a lead-gray matte crust which is different from the normal bluish-black glossy iron-oxide crust. Other parts of the surface show fractures through the bronze-colored troilite. These fractures are so late that they are not covered by fusion crust; they may represent fracturing upon impact with the ground in accordance with the eyewitness reports. The meteorites have patches of adherent laterite soil and are corroded much more than would be expected with a rapid recovery. Terrestrial oxides locally form 0.1 mm thick crusts, and 10-50 μ wide limonite veins penetrate and surround the

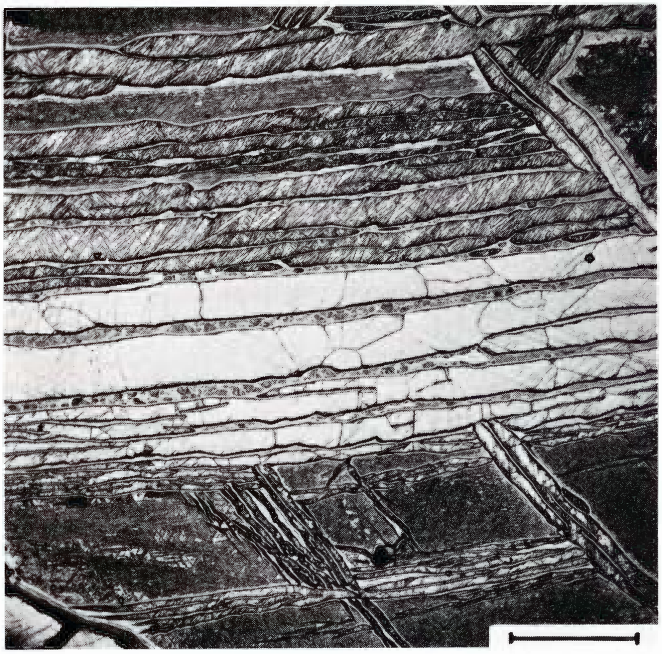

Figure 1682. Soroti (U.S.N.M. no. 1621). Shock-hatched kamacite lamellae and cloudy taenite lamellae. Etched. Scale bar 400 μ. (Perry 1950: volume 9.)

SOROTI – SELECTED CHEMICAL ANALYSES

These analyses were on the metallic portion which was free from visible troilite. Using a spark source mass spectrometer, Mason & Graham (1970) found the following elements in the troilite (all vallues in ppm): 10 Sc, 22 Ti, 5 V, 730 Cr, 860 Mn, 42 Co, 570 Ni, 130 Cu, 0.5 Y, 3 Zr, and 1 Ba.

	percentage			ppm							
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Henderson & Perry 1958	12.80	0.62	0.15									
Wasson & Schaudy 1971	12.88								14.1	5.22	0.06	

Figure 1683. Soroti (U.S.N.M. no. 1621). An angular chromite crystal (black) with associated monocrystalline troilite (T) and schreibersite (S). Shock-hatched kamacite (K) and acicular and martensitic plessite fields. Etched. Scale bar 400 μ. (Henderson & Perry 1958: plate 19 – a different interpretation is given by them).

brecciated troilite. Evidently the smaller fragments were exposed to some corrosion before being finally deposited in the collection.

Etched sections show an unusual mixture of metal and troilite, which somewhat resembles the pallasitic morphology of, e.g., Imilac. The troilite constitutes 60-65% by area, mostly as 5-12 mm monocrystalline, well rounded crystals. The metal probably forms a coherent, spongy network between the troilite nodules, as is the case in Krasnojarsk. However, the metal of Soroti is composed of a number of original austenite grains, each 3-10 mm across and thus of about the same size as the troilite nodules. Upon cooling, kamacite first nucleated and grew from the troilite and the austenite grain boundaries, whereby a characteristic pattern of 0.2-0.5 mm wide veins of swathing kamacite developed. Later, each austenite grain independently formed its Widmanstätten structure.

The kamacite lamellae are straight and long ($\frac{L}{W} \sim 20$) and have a width of 0.13±0.04 mm. The kamacite has subboundaries and shows a shock-hardened ϵ-structure with a hardness ranging from 265 to 315.

Taenite and plessite cover more than 60% by area, mostly as comb plessite and marked, martensitic fields. A typical field, 0.5 mm across, will display a lightly etched taenite rim (HV 380±20) followed by a light-etching martensitic transition zone (HV 440±25). Farther inwards there follow annealed, dark-etching martensite (HV 390±20) and finally, in some fields, a duplex fine-grained $\alpha + \gamma$ mixture (HV 325±20). Within each original austenite grain the martensitic platelets are uniformly oriented parallel to the bulk Widmanstätten pattern.

Schreibersite occurs as 0.2-1 mm skeleton crystals and as 0.1-0.2 mm thick rims on troilite. A trifle is present in the grain boundaries as 10-30 μ veinlets.

The troilite is monocrystalline but displays some twins due to a slight shear-displacement. Its hardness is 265±15. It has little or no daubreelite, but at least three other sulfides occur in small amounts as 10-100 μ blebs and specks, often at the periphery. Dr. Ramdohr (personal communication) has tentatively identified chalcopyrrhotite, mackinawite and alabandite in troilite concentrates from Soroti. A number of minor and trace elements in the troilite were determined by Mason & Graham (1970) as mentioned on page 1157.

Graphite is present as 0.1-0.5 mm nodules; they are never found inside the troilite but adjacent to them or freely in the metal. They are microcrystalline (about 1 μ), but show an interior texture reminiscent of cliftonite. They are surrounded by 0.1-0.5 mm wide rims of swathing kamacite and seem to be a rather early precipitate.

The fusion crust is 0.1-0.2 mm thick and consists of fine-grained Fe-S-O eutectics with numerous 1-50 μ gasholes. It is very different from normal metallic fusion crusts which are only found to a very limited extent on Soroti. Under the crust is a narrow, heat-affected zone. The hardness of the α-lamellae drops from about 300 in the interior to 215±10 at the surface. Where the sulfide eutectics are deposited upon troilite nodules, the troilite is recrystallized to 5-30 μ grains to a depth of less than 0.2 mm. The heat alterations are shallower and less profound than in meteorites which are mainly iron, the reason probably being that the peak temperature of the fused sulfide-rich exterior layer was only about 1000° C, against 1500° C on irons.

Soroti is difficult to classify. Its mixture of troilite and metal is not altogether unique, since Pitts and Persimmon Creek show similar structures. Moreover, the accessory minerals, the polycrystallinity, the bandwidth in the metal and the bulk chemical composition are very similar to these meteorites. Structurally Soroti thus forms a good triplet with Pitts and Persimmon Creek. The trace-element data indicate, however, that Soroti is much too depleted in Ga, Ge and Ir to fall in the same chemical group as the two other irons, and from this standpoint Soroti is unique or, perhaps, weakly related to Carlton. It will be remembered that Carlton showed local troilite-rich, polycrystalline patches, resembling Soroti (page 428).

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

82 g half mass with one polished face (no. 1516, 6 x 3 x 2.5 cm)
63 g half mass with one polished face (no. 1621, 4 x 3.5 x 2 cm)
9 g polished slice (no. 1621, 35 x 12 x 2 mm)

South Byron, New York, U.S.A.

43°2'N, 78°4'W

Nickel-rich ataxite, D. Numerous 5-10 μ wide kamacite spindles in a duplex $\alpha + \gamma$ matrix. HV 230±10.

Anomalous. 18.0% Ni, 0.84% Co, 0.22% P, 20 ppm Ga, 45 ppm Ge, 28 ppm Ir.

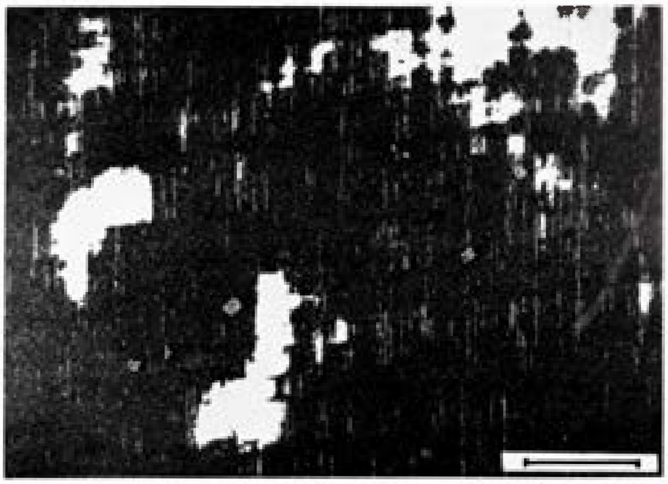

Figure 1684. South Byron (Chicago no. 2553). An anomalous nickel-rich ataxite. Dark and light shaded areas alternate. Occasional sulfide and chromite inclusions are indistinctly seen. Etched. Scale bar 5 mm. S.I. neg. 1374.

HISTORY

A mass weighing nearly 6 kg was found about half a mile west of South Byron, Genesee County, in 1915. It was acquired by the Field Museum in Chicago where it was briefly examined by Nichols and Farrington who classified it as a nickel-rich ataxite (Prior 1927: 42; Hey 1966: 459; Horback & Olsen 1965: 299). Except for these catalog entries, very little has been published about the meteorite; not even its shape and exterior appearance are known. The coordinates above are those obtained from a modern map.

Voshage (1967) deduced from $^{41}K/^{40}K$ measurements a cosmic ray exposure age of 210±70 million years, while Schultz & Hintenberger (1967) analyzed for several of the noble gas isotopes, such as ^{3}He, ^{4}He, ^{21}Ne, ^{22}Ne, ^{36}Ar and ^{38}Ar.

COLLECTIONS

Chicago (2,685 g half mass and 147 g slices), Paris (633 g ?), Washington (466 g), Tempe (187 g), London (166 g).

DESCRIPTION

While I have not seen the half mass (2.6 kg) in Chicago, I have had an opportunity to examine in some detail the slices in Tempe, Washington, London and Chicago. These are parallel, 0.5-1 cm thick sections through the mass, the Tempe specimen of 8 x 3 x 1.1 cm being closest to the end.

The polished sections have a very homogeneous appearance, except for the presence of tiny, diffuse patches which are well scattered. They are 0.4-1 mm in cross section and occur with a frequency of one per cm^2. High magnification reveals that each bleb was previously a troilite-daubreelite inclusion situated in a duplex metallic matrix. The inclusions are now severely altered, no doubt as a consequence of a heavy shock. They are composed of intricate eutectics of kamacite, taenite and sulfides with a grain size of 1-5 μ. The original daubreelite lamellae are not completely melted but may be identified as scattered, rounded fragments 2-5 μ across. Original chromite is non-melted, but fissured and somewhat penetrated by the eutectics. The diffuse appearance at low magnification is due to finely serrated borders against the metallic matrix, with 1 μ thick veinlets of eutectics penetrating 10-50 μ outwards from the fully melted pockets.

Etched sections are ataxitic and no components – except for the sulfides mentioned – can be identified until high magnification is applied. The metal is a homogeneous mixture of microscopic kamacite platelets and a fine-grained, duplex $\alpha + \gamma$ matrix. The kamacite platelets are arranged in a Widmanstätten pattern and prove that the mass was once a single austenite crystal. The kamacite platelets are 5-10 μ wide and 5-10 times as long as their width. They occur with a frequency of about 400 per mm^2 and are frequently developed around tiny, 1-15 μ thick, schreibersite crystals. The matrix between the α-platelets is a duplex $\alpha + \gamma$ mixture where the α-units are 0.5-2 μ wide and the γ-units 0.1-0.3 μ wide, separating the α-units as

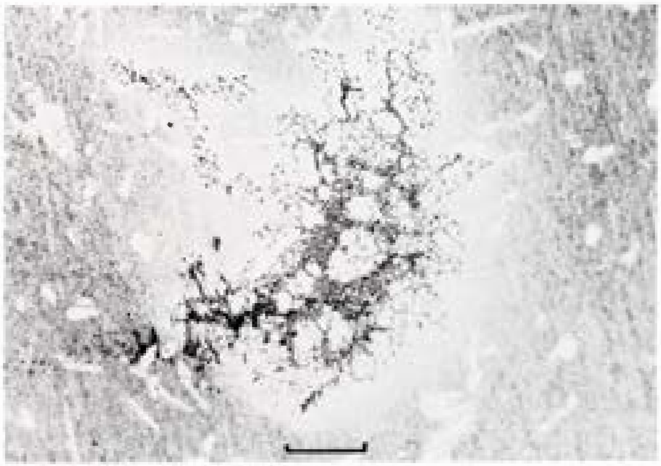

Figure 1685. South Byron (Chicago no. 2553). A totally disintegrated shock-melted troilite inclusion. Lightly etched. Scale bar 50 μ.

SOUTH BYRON – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Lovering et al. 1957		0.92				21	370		13	51		
Wasson & Kimberlin 1967	17.8±0.7								20.0	44.6	27.6	
Moore et al. 1969	18.17	0.76	0.22	60	95		360					

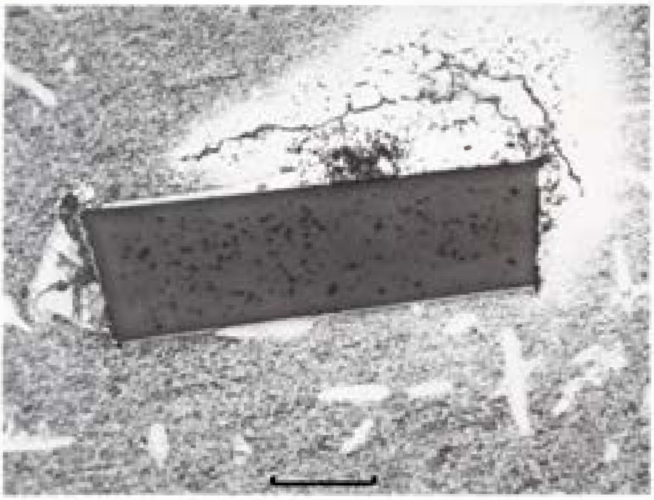

Figure 1686. South Byron (Chicago no. 2553). A chromite bar with an associated troilite-daubreelite nodule (above). The troilite is shock-melted and contains shattered daubreelite fragments. (The white halo is due to imperfect polishing). Etched. Scale bar 50 μ.

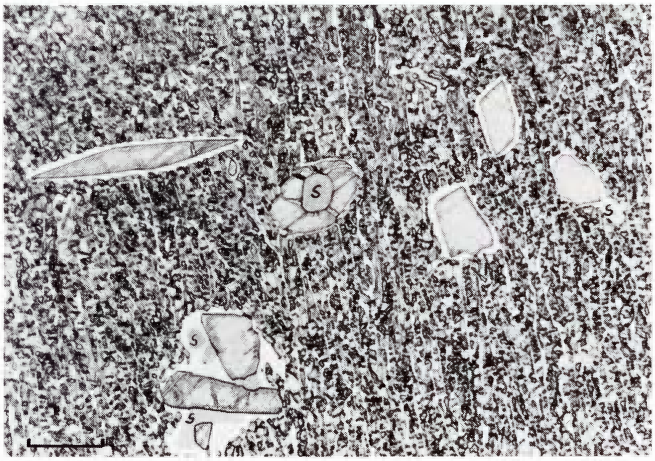

Figure 1687. South Byron (Chicago no. 2553). Fine kamacite spindles with schreibersite particles (S) in an almost unresolvable duplex $\alpha + \gamma$ matrix. Etched. Oil immersion. Scale bar 10 μ.

vermicular networks. The microhardness, integrating over numerous $\alpha + \gamma$ units, is 230±10 (100 g Vickers), suggesting some cold-deformation, possibly by the shock mentioned before.

When the sections are rotated, it is seen that bright and dull patches of square centimeter size alternate in a fashion similar to Hoba and Tlacotepec. On the examined sections, there were only two kinds of reflections, but any of these would appear dull or bright according to the position of the light source. Under high magnification no difference was found between the two kinds of patches, except for their microorientation. Both are identical duplex $\alpha + \gamma$ mixtures, but the detailed striation – or rather the linear parts of the mixture – are systematically changed when passing a borderline which is dull-bright. This systematic variation no doubt reflects some crystallographic relationship between the various parts, possibly indicating original twin relations in the high temperature austenite crystal.

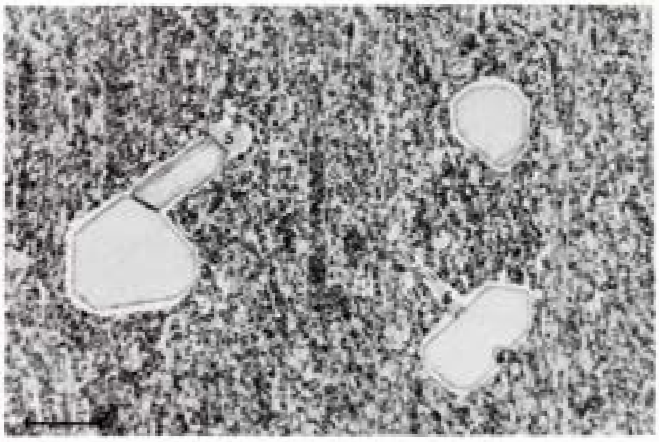

Figure 1688. South Byron (Chicago no. 2553). Fine kamacite spindles with schreibersite particles (S) in an almost unresolvable duplex $\alpha + \gamma$ matrix. Etched. Oil immersion. Scale bar 10 μ.

Schreibersite is very common as well dispersed 1-15 μ thick subangular blebs which occur with a frequency of about 400 per mm^2. Most of them form nuclei for the kamacite platelets. No large schreibersite crystals were observed and rhabdites are absent.

Chromite occurs as angular bars (200 x 15 μ) or cubes (150 x 150 μ), often associated with troilite and daubreelite. While the sulfides are shock-damaged, little has happened to the chromite crystals except for some fissuring.

South Byron is corroded and covered by 0.1-1 mm thick adhering oxide-shales. The corrosion has selectively attacked the near-surface kamacite phase. In such places the microstructure is developed in full and beautiful contrast. No fusion crust and no heat-affected zone from atmospheric penetration were identified. On the other hand, hardness traverses from the interior towards the surface showed a small but significant drop from 230 to 190 in the outermost millimeter. This may be interpreted as an annealing effect from the atmospheric penetration and indicates that, on the average, only 2-3 mm is lost by terrestrial weathering.

South Byron is a nickel-rich ataxite of a rare type. In several respects it is related to Hoba, Tlacotepec and other meteorites of group IVB. In detail, however, South Byron clearly deviates from these in its structure and its composition, particularly its high copper content. It should preferably be compared to Troost's Iron, Babb's Mill. Wasson's analytical data also support this relationship.

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

466 g slice (no. 771, 9 x 7 x 1 cm)

South Dahna, Rub'al Khali, Arabia

22°34'N, 48°18'E

A broken mass, estimated to have weighed about 275 kg, was found in 1957 in the Rub'al Khali desert, about 250 km northwest of the

Wabar crater field. It was briefly described by Holm (1962), who collected many pieces, totaling about 170 kg. The meteorite lay in a compact heap and no single fragment was larger than 12.5 kg. It covered an area of roughly 4 x 6 m and 0.3 m deep. It was lying on a low platform of limestone about 0.4 m above the surrounding ground, partly covered by loose drift sand. The block had apparently fallen in one piece and later had become separated by weathering. Preliminary examinations indicated that Widmanstätten structure was present, but the examined fragments were almost entirely converted to oxides.

Southern Arizona, Arizona, U.S.A.

Unknown coordinates

Coarse octahedrite, Og. Bandwidth 1.5±0.2 mm. Neumann bands. HV 220±20.

Group I. 8.06 Ni, about 0.17% P, 66 ppm Ga, 242 ppm Ge, 1.9 ppm Ir.

Probably a mislabeled Toluca specimen.

HISTORY

The only information available as to the history of this meteorite is in the U.S. National Museum files, "An unidentified iron was received May 29, 1947, as an exchange from the University of Arizona, Tucson, through F.W. Galbraith. It was one specimen of 622 grams." The specimen was divided and one slice of 266 g came to S.H. Perry, who later donated it to Chicago. The rest remained in the U.S. National Museum. No details of the locality are known. Hey (1966) listed the meteorite as doubtful and suggested that it might belong to one of the known coarse octahedrites of Arizona. However, Wasson (1968), in his comprehensive survey of the Arizona octahedrites, came to the conclusion that the mass represented an independent small fall, significantly different from other Arizona irons.

COLLECTIONS

Washington (282 g), Chicago (245 g).

DESCRIPTION

The specimens in Washington and Chicago are two slices through a mass, which measured at least 9 x 5 x 5 cm before it was cut. Where the other material is and, in particular the two endpieces is not known. The original weight must have been at least 1 kg.

The specimens are corroded. No fusion crust and no heat-affected α_2 zones are preserved, so at least 3 mm must have been lost by terrestrial weathering. Corrosion penetrates deep into the specimens along phosphides. The α-phase of pearlitic and acicular plessite fields is selectively corroded, and parts of the troilite are veined with pentlandite.

Etched sections display a coarse Widmanstätten structure of bulky, rather short ($\frac{L}{W} \sim 15$) kamacite lamellae with a width of 1.50±0.20 mm. The kamacite is rich in subboundaries decorated with prominent rhabdites, 1-5 μ across. Distinct Neumann bands are present in abundance, locally with some additional bending. The hardness is 220±20.

Taenite and plessite cover about 15% by area, mostly as martensitic, acicular, pearlitic and comb plessite fields. The comb plessite attains sizes of 2 x 2 mm, while the other fields are smaller. A typical martensite field will show a tarnished taenite rim (HV 370±15) followed by transitional, light-etching martensite (HV 440±40) which finally merges into a martensitic-bainitic interior (HV 380±40).

Schreibersite is present as millimeter-sized lamellae and as 20-80 μ wide grain boundary precipitates. The troilite-silicate-graphite aggregate is sheathed in a 200 μ wide schreibersite rim with a hardness of 925±25. Rhabdites are abundant as 5-15 μ tetragonal prisms. The phosphides are frequently shear-displaced 5-10 μ, and the larger ones are fragmented. The bulk phosphorus content is estimated to be 0.15-0.20%.

Troilite occurs as a 30 x 10 mm elongated body in which numerous silicate, graphite and chromite crystals are embedded. The troilite itself is monocrystalline or composed of 0.1-1 mm units; a few twins from mild plastic deformation occur. The graphite forms irregular 0.1-2 mm cakes and clusters, whereas good cliftonitic development was not detected. The silicates are subangular crystals, 50-100 μ across, frequently forming millimeter-sized aggregates. Tiny, 5-50 μ troilite droplets are common inside the silicates. One of the silicates was identified as olivine; the others appear to be diopside and plagioclase. The chromite forms angular, imperfect crystals, 10-100 μ across, intergrown with troilite and silicate.

Daubreelite and cohenite were not detected.

Southern Arizona is a coarse, inclusion-rich octahedrite of group I. It belongs to the same general group of coarse octahedrites as Canyon Diablo and Seligman, but I agree with Wasson that it is different in important respects, such a major and minor elements, bandwidth, plessite amount and nodule composition.

It is, however, an interesting fact that Southern Arizona corresponds extremely well to Toluca in every respect. Both major and minor elements, bandwidth, plessite quantity, microhardness, nodule composition, degree of weathering and overall size fit exactly with known specimens of Toluca. Could it be that a Toluca specimen was traded from adjacent Mexico to Arizona, and was later labeled as an independent meteorite?

SOUTHERN ARIZONA – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Wasson 1968	8.06								66.2	242	1.9	

Specimen in the U.S. National Museum in Washington:
282 g slice (no. 1445, 8.5 x 5 x 1 cm)

Spearman, Texas, U.S.A.

36°12'N, 101°12'W; 925 m

Medium octahedrite, Om. Bandwidth 1.15±0.15 mm. ε-structure. HV 325±20.

Group IIIA. 8.61% Ni, 0.55% Co, 0.36% P, 20.2 ppm Ga, 46.0 ppm Ge, 0.7 ppm Ir.

HISTORY

A mass of 10.4 kg was found in 1934 near Spearman, Hansford County (A.D. Nininger 1937), but the circumstances of finding have never been published. The coordinates above are for the town of Spearman. Short & Andersen (1965) X-rayed the kamacite and found diffuse Laue spots, a result which was interpreted by Jaeger & Lipschutz (1967a, b) as lattice deformation induced by shock in the 400-750 k bar range. Short & Andersen (op. cit.) also examined the detailed nickel gradient in various kamacite and plessite areas and estimated the cooling rate.

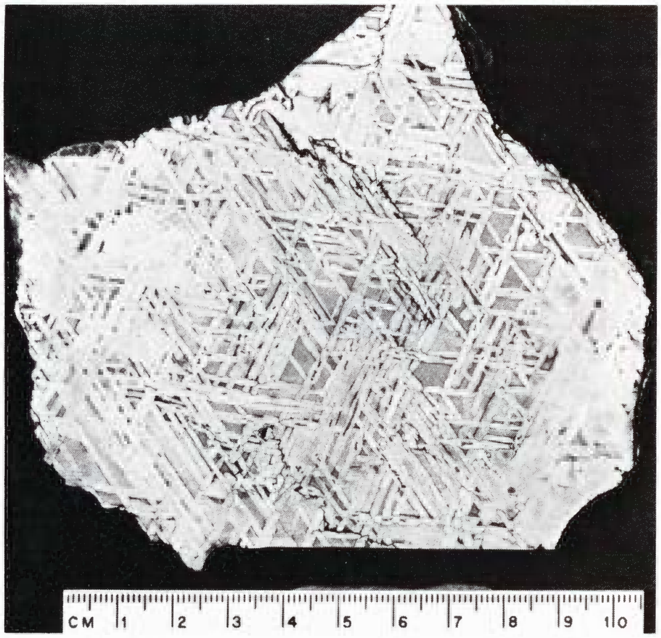

Figure 1689. Spearman (Tempe no. 230.3). A shocked medium octahedrite of group IIIA. Note the many schreibersite crystals aligned within the kamacite lamellae. Deep-etched. Scale in centimeters. (Courtesy C.B. Moore.)

COLLECTIONS

Washington (870 g), Chicago (751 g), Harvard (656 g), Tempe (515 g), London (69 g), Los Angeles (53 g). A major part of the balance is in private collections.

DESCRIPTION

The size and shape of the mass is unknown; it was thoroughly cut and distributed in the 1930s by Nininger. The slices known to the author indicate, however, that the mass was irregular and angular with the average dimensions 16 x 16 x 10 cm. The specimens are weathered and covered by 0.2-2 mm thick crusts of terrestrial oxides. No fusion crust and no heat alteration zone could be identified and

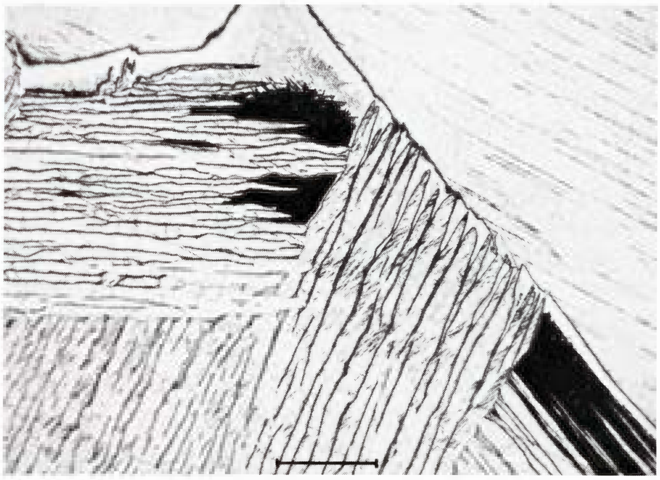

Figure 1690. Spearman (Tempe no. 230.3). Comb plessite with patches of black taenite. Shock-hatched hard kamacite. Etched. Scale bar 400 μ. See also Figure 123.

SPEARMAN – SELECTED CHEMICAL ANALYSES

Goldberg et al. (1951) reported two nickel determinations of 8.00 and 8.78%. The higher value is preferred since, in this case, there was no undissolved residue.

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Goldberg et al. 1951	8.78	0.56							21.4			
Lovering et al. 1957		0.58				28	176		19	53		
Nishimura & Sandell 1964								8				
Nichiporuk & Brown 1965											0.4	6.7
Smales et al. 1967						6.0	124			44		
Wasson & Kimberlin 1967	8.61								20.2	46.0	0.71	
Moore et al. 1969	8.43	0.52	0.36	125	40		130					

there is no hardness decrease towards the surface. Therefore, it is estimated that, on the average, at least 5 mm was lost by corrosion.

Etched sections display a medium Widmanstätten structure of straight, long ($\frac{L}{W} \sim 25$) kamacite lamellae with a width of 1.15±0.15 mm. Locally there are irregular patches of kamacite without regular taenite and plessite. They attain sizes of 5-15 mm and appear to be swathing kamacite rims around schreibersite, although the schreibersite itself is outside the plane of section. The kamacite has subboundaries, decorated with 1-2 μ phosphides. It is shock-hardened (HV 325±25) and shows a typical cross-hatched ϵ-structure. At high magnification numerous tiny (<1 μ across) rhabdite precipitates are seen throughout the kamacite.

Taenite and plessite cover 30-35% by area, mostly as dense net plessite and martensitic fields. Comb plessite and dark-etching duplex fields are also common. A typical rhomboidal field will show a tarnished taenite rim (HV 435±10) followed by light-etching martensite platelets developed parallel to the bulk Widmanstätten structure (HV 480±15). Then follows a similar martensite annealed to dark-etching structures (HV 420±30) and, finally, various duplex mixtures. The almost unresolvable plessite fields have hardnesses of 350±10, while the easily resolvable ones, with 1-2 μ wide γ-blebs, have hardnesses of 335±10. The open-meshed comb and net plessite have hardnesses of 325±20, similar to the adjacent kamacite lamellae.

Schreibersite is present as branched skeleton crystals, typically 25 x 10 x 1 mm in size. When the section happens to be parallel to the backbone of the schreibersite and cuts only the successive branches, it appears as if numerous schreibersite blebs each, e.g., 1 x 0.4 mm in size, are independently aligned in the kamacite lamellae. The schreibersite is monocrystalline, with a hardness of 825±20. It is brecciated and frequently shear-displaced 1-25 μ along a sequence of subparallel shear zones. Schreibersite is also common as 10-50 μ wide grain boundary precipitates and as 5-50 μ irregular blebs in the plessite fields. The extremely fine generation of microrhabdites was mentioned above. In several places around martensitic and duplex, dark-etching plessite fields the microrhabdites occur in large numbers, densely decorating the slipplanes in the kamacite. The hardness here is at the low end of the kamacite range (HV 305±5), presumably because some phosphorus has disappeared from solid solution. Compare Thule, Trenton and others.

Troilite occurs as scattered nodules and blebs, less than 1 mm across. It is monocrystalline with a few lenticular twin lamellae from plastic deformation.

Chromite was observed in several places, often as very extended and regular plates, e.g., 3.5 x 2 x 0.02 mm in size. They are somewhat bent and sheared from cosmic deformation. They have served as a substrate for precipitates of

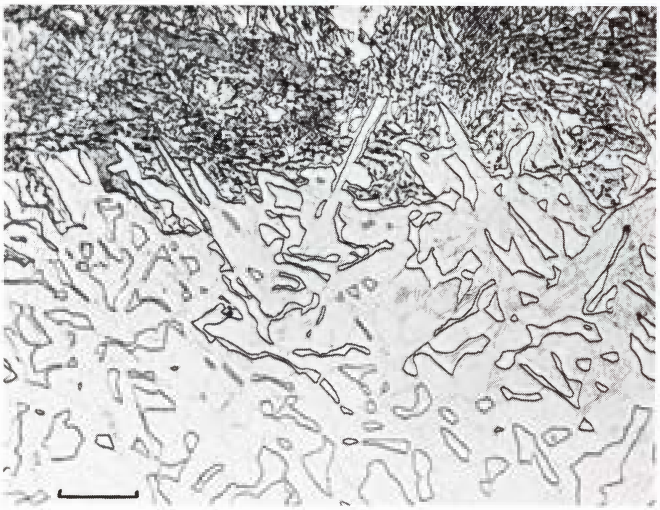

Figure 1691. Spearman (Tempe no. 230.3). Transition from cloudy taenite (outside the picture above) via tempered martensitic zones (dark) to duplex plessite with concave γ-particles in shock-hatched kamacite. Lightly etched. Scale bar 20 μ.

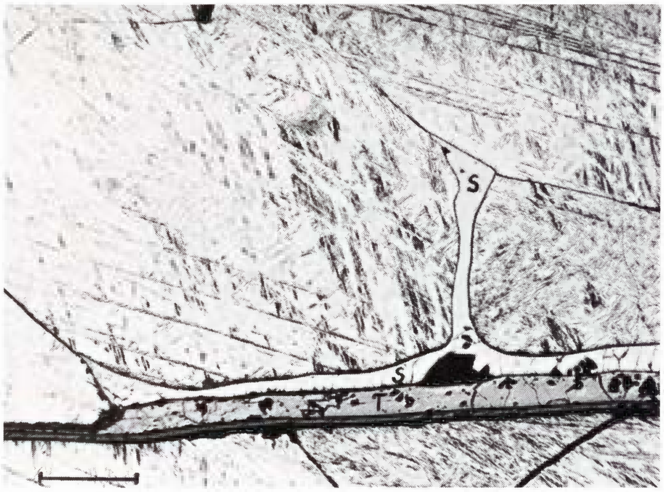

Figure 1692. Spearman (Tempe no. 230.3). A Reichenbach lamella composed of a thin chromite lamella (below) which has nucleated troilite (T) and schreibersite (S). Shock-hatched kamacite. Etched. Scale bar 200 μ.

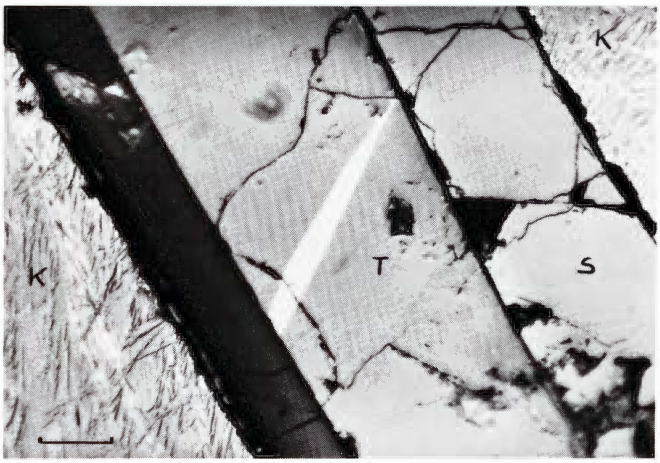

Figure 1693. Spearman. Detail of Figure 1692. Chromite (left) followed by troilite with a twinned portion (light), and schreibersite (S). Shock-hatched kamacite (K) on either side. Etched. Crossed polars. Scale bar 20 μ.

troilite films, and at a later period 20-50 μ thick schreibersite crystals have also precipitated here. Similar aggregates are present in Kayakent, Thule, Trenton and other irons, and they are probably not Reichenbach lamellae *sensu strictu* since they have formed around preexisting chromite.

Along a few preterrestrial fissures corrosion has penetrated to the center of the mass, selectively attacking the α-phase.

Spearman is a shock-hardened medium octahedrite which is closely related to Bartlett, Aggie Creek, Orange River, Trenton and Drum Mountains. Chemically, it is transitional between group IIIA and IIIB.

Specimen in the U.S. National Museum in Washington:
870 g slice (no. 1204, 16 x 10 x 1 cm)

Ssyromolotovo, Boguchansky Region, RSFSR
58°37′N, 98°56′E

Medium octahedrite, Om. Bandwidth 0.95±0.10 mm. Neumann bands. HV 166±5.

Group IIIA. 7.86% Ni, 0.44% Co, 0.15% P.

The sample examined in this study has been artificially reheated to about 650° C. Whether the main mass was reheated on the same occasion is unknown.

HISTORY

A mass of about 12 Russian Pud (equal to 197 kg) was discovered in the Yenisey region by the farmer F. Rukossujev in 1873. The meteorite was freely exposed on the dry yellow sands of a plain near the left bank of the Angara River. The exact locality was 2 km west of Angara and 6 km from the Keshma County line, somewhat south of the village Ssyromolotovo. The nearest larger town appears to be Boguchany.

Some specimens were detached with hammer and chisel by a blacksmith and sent to St. Petersburg with a couple of photographs. This material was the basis for the only published description by Goebel (1874). Later, the whole mass was donated to the St. Petersburg Academy of Sciences, and still later the mass was apparently transferred, with the USSR Academy of Sciences, to Moscow. The 12 Russian Pud (197 kg) quoted by Goebel (1874), was only an estimate; the weight appears rather to have been about 220 kg, since 216.7 kg is now in Moscow (Kvasha 1962: 149), and several small samples have been exchanged or used up in various examinations.

The coordinates are given above; the place of fall is incorrectly mapped by Millman (1938) in Transbaikal. Zavaritskij & Kvasha (1952: 58) gave a brief metallographic description with a sketch of the structure. Supplementary observations were published by Zavaritskij (1954) with two photomicrographs.

COLLECTIONS

Moscow (216.7 kg main mass and 39 g slice), Chicago (22 g), Vienna (6 g), Berlin (2 g), Paris (0.7 g).

DESCRIPTION

According to the wood cuts given by Goebel (1874) the mass is irregularly pear-shaped with reentrant portions. The dimensions are unreported, but approximately 40 x 40 x 35 cm. The surface is covered with numerous cavities with rounded ridges in between. They are roughly 3-4 cm in diameter, about one-tenth of the diameter of the mass, and appear to be regmaglypts, which are only insignificantly altered by weathering. From the figures alone, it thus appears that the meteorite is in a very good state of preservation.

The present description is based on a small specimen, the 22 g fragment, No. 1148 from Chicago. It is one of the

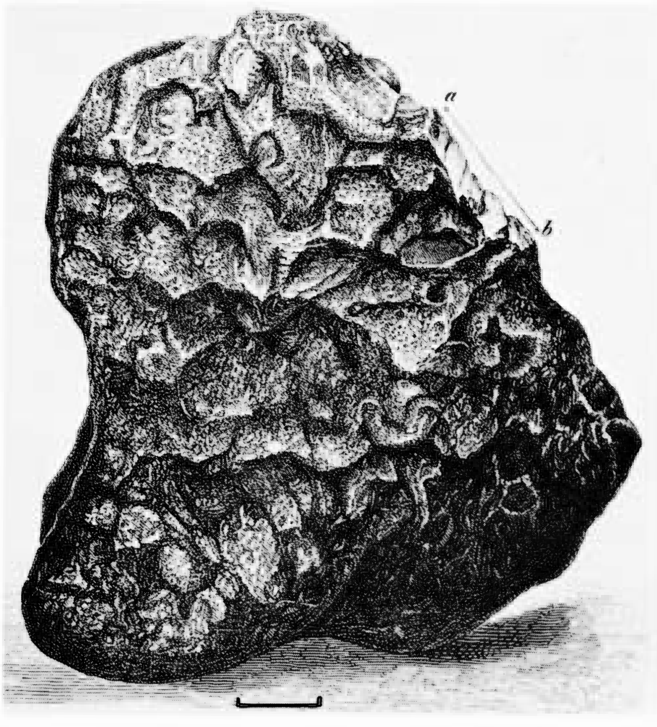

Figure 1694. Ssyromolotovo. The 216 kg main mass in Moscow shows distinct regmaglypts. A sample has been removed at ab, probably by hot chiseling. Scale bar approximately 5 cm. (Wood cut from Goebel 1874.)

SSYROMOLOTOVO – SELECTED CHEMICAL ANALYSES

Reference	percentage Ni	Co	P	ppm C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Dyakonova & Charitonova 1963	7.86	0.44	0.15				200					

very few samples ever taken from Ssyromolotovo, since the whole mass is still undivided in Moscow. The fragment was clearly detached from the main mass with the aid of a hammer and chisel, showing plastic deformation and fissures from the work.

The etched section exhibits a medium Widmanstätten pattern of straight, long ($\frac{L}{W} \sim 20$) kamacite lamellae with a width of 0.95±0.10 mm. The kamacite is rich in subboundaries decorated with 1-3 μ phosphides. It also shows well developed Neumann bands without decoration.

Taenite and plessite cover about 25% by area. Open comb and net plessite varieties are most abundant, but duplex unresolvable $\alpha + \gamma$ fields (black taenite) are also common.

Schreibersite occurs as 10-50 μ wide grain boundary veinlets and as 4-30 μ irregular particles inside the plessite fields, where it substitutes for γ-particles of the same size. Rhabdites are common, but they are small, generally only

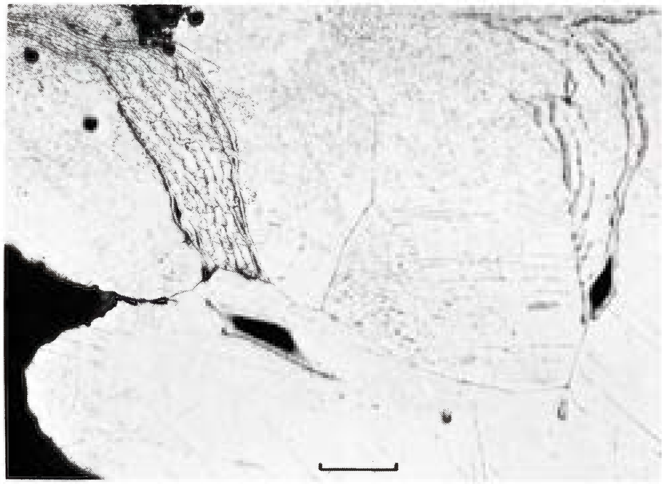

Figure 1695. Ssyromolotovo (Chicago no. 1148). A sample which was detached by a blacksmith during the application of heat. Distorted Widmanstätten structure and granulated kamacite (above). Etched. Scale bar 500 μ.

1-2 μ thick. The bulk phosphorus content is estimated to be about 0.15%, in accordance with the reported 0.15% (Dyakonova) and 0.163% (Goebel) by wet chemical analyses.

Troilite was observed only once, and then as a lenticular body 15 x 5 mm in size, embedded in terrestrial corrosion products. The troilite showed multiple twinning from slight plastic deformation. Daubreelite was not observed in the troilite but was found to be present as small angular inclusions, 5-30 μ across, in the kamacite.

The examined sample shows numerous features, indicative of an artificial reheating. (i) The hammered and cold-worked near-surface zones have recrystallized to almost equiaxial ferrite grains, ranging in size from 25 to 75 μ. Their hardness is correspondingly low, 166±5. (ii) In the interior only partial recrystallization has occurred, evidently because the artificial working did not extend beyond 2-3 mm depth. The recrystallized ferrite units in the interior are situated at Neumann band intersections, along grain boundaries, and along schreibersite crystals. These places are the first to recrystallize because they exhibit maximum of deformation and minimum of nickel and phosphorus in solid solution. The hardness is 166±5. (iii) The rhabdites have been partly dissolved in the kamacite. (iv) The plessite fields are slightly diffuse, because of the beginning solution of the γ-particles. (v) The taenite lamellae are very soft, HV 180±20, as a result of annealing. (vi) There are numerous high temperature reaction halos, 1-5 μ thick, between the phosphides and the terrestrial corrosion products. (vii) The terrestrial limonite is decomposed to laceworks along the interface with kamacite, and it shows internal minute (~ ½ μ) metal particles.

The observed alterations are best explained on the assumption that the sample was reheated for some time (½-1 hour) to about 650° C. Similar structures and hardnesses were obtained by the author when simulating the blacksmith's operation on small samples of Cape York

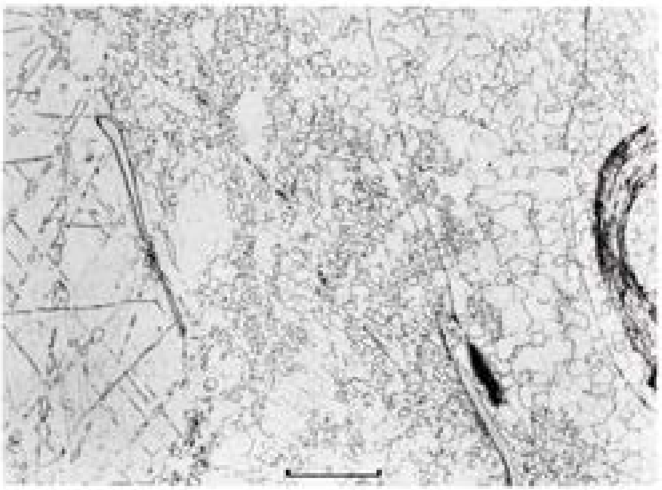

Figure 1696. Ssyromolotovo (Chicago no. 1148). Detail of the recrystallized surface zone, showing distorted taenite lamellae and brecciated schreibersite (black). Etched. Scale bar 300 μ.

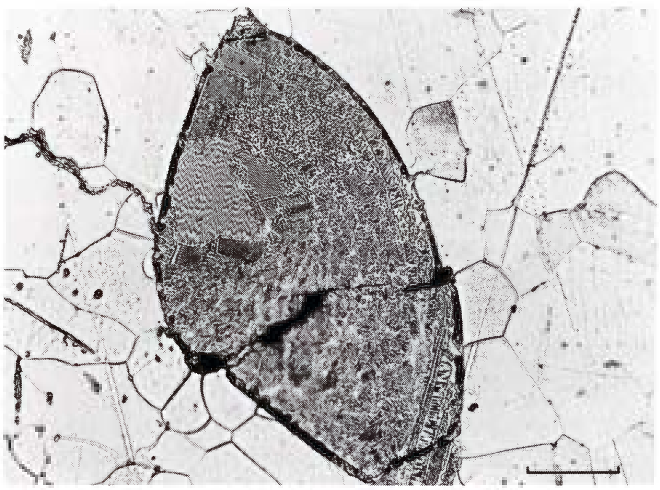

Figure 1697. Ssyromolotovo (Chicago no. 1148). A fused schreibersite crystal from the heat-affected surface zone. Etched. Oil immersion. Scale bar 20 μ.

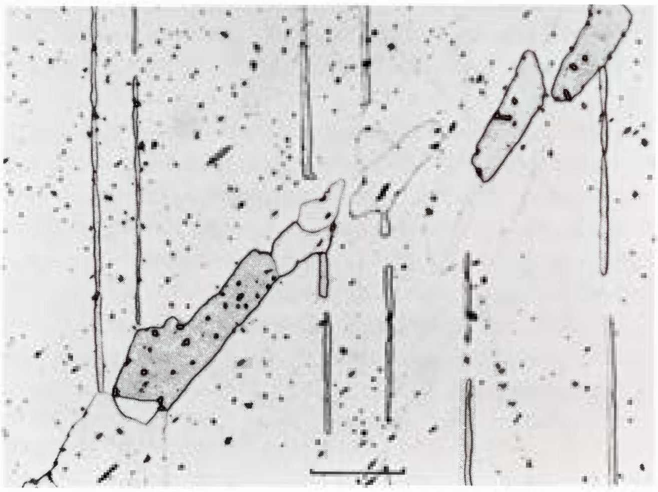

Figure 1698. Ssyromolotovo (Chicago no. 1148). Kamacite which shows annealed Neumann bands and small recrystallized ferrite grains. Etched. Scale bar 40 μ.

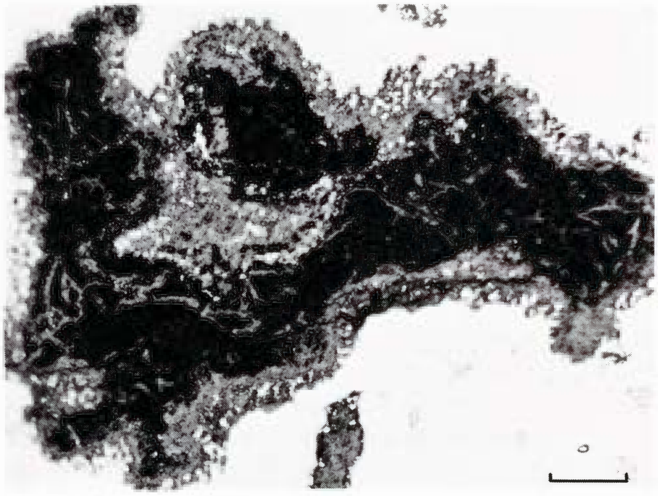

Figure 1699. Ssyromolotovo (Chicago no. 1148). Pocket of corrosion products (black) which have been decomposed by artificial reheating to about 650° C. Laceworks of metal and oxides along interfaces. Lightly etched. Oil immersion. Scale bar 10 μ. See also Figure 25.

which has a composition and structure very similar to Ssyromolotovo.

With this admittedly small and somewhat damaged sample for examination, it is difficult to be precise as to the bulk structure of Ssyromolotovo. It is, e.g., not known whether the whole mass was exposed to reheating or whether only the detached samples were reheated. On the main mass fusion crust and heat-affected α_2 zones should be present, but these could not be detected due to the extensive damage inflicted on the small piece examined.

On the whole, Ssyromolotovo must be chemically and structurally closely related to Cape York, Casas Grandes and Toubil River. Its trace-element composition will no doubt be found to place it well inside the resolved chemical group IIIA.

[J.T. Wasson (personal communication 1974): Group IIIA with 7.85% Ni, 19.6 ppm Ga, 40.9 ppm Ge and 3.3 ppm Ir].

Staunton, Virginia, U.S.A.

38°13'N, 79°3'W; 450 m

Coarse octahedrite, Og. Bandwidth 1.60±0.30 mm. Neumann bands. HV 252±18.

Group IIIE. 8.62% Ni, 0.49% Co, 0.31% P, 18.9 ppm Ga, 36.6 ppm Ge, 0.11 ppm Ir.

HISTORY

Two different meteorites are presently in collections under the name of Staunton. Both are octahedrites with 8-9% nickel, but they differ in kamacite bandwidth and hardness and in the amount of carbides and phosphides. They also show significant differences in the amount of minor and trace elements. In the following I will treat the one fall for which I propose to retain the name Staunton, while an account of the other material will be found under the entry Augusta County.

Mallet (1871) reported the discovery about 1869 of three irons of 25.4 kg (No. 1), 16.4 kg (No. 2) and 1.64 kg (No. 3). They had been plowed up north of Staunton, the largest by R. Van Lear in 1869, five miles north and a little east of Staunton; the other two, one mile southeast and one and one-half miles southeast of No. 1, respectively. Mallet reproduced figures of the exterior and of etched sections. He also presented chemical analyses of all three masses, unfortunately, however, he arrived at an erroneously high nickel value (10%) for all three. Since the problem today is to reidentify the original masses as found – they have later been cut and distributed with little information as to the mass from which the individual specimens were cut, – we can only rely on the structure and on one particular, significant element, phosphorus, which even at that early date was determined with sufficient precision. Mallet found 0.34-0.37% P in all three masses, and I think this is, together with the structure, in this case enough to conclude that Nos. 1, 2 and 3 really belonged to the same fall. Modern analyses on material that I have identified as coming from Nos. 1-3 will be found below.

Another mass (No. 4), of about 1 kg, was briefly described and pictured by Kunz (1887b) as coming from a place near No. 1. Mallet's analytical techniques and experience had improved considerably during the 16 years which had passed, so his analysis is quoted below.

Staunton material has been examined by several authors both chemically and structurally and also analyzed for gases. However, since the sources are rarely given, it is difficult at this date to detect whether the papers refer to the four masses discussed here or to the two discussed under Augusta County.

Perhaps the best cataloged and most comprehensive collection today of specimens from the various blocks is in