ing that created an incipient recrystallization and a few other anomalous features in Sierra Blanca.

Sierra Gorda, Antofagasta, Chile

22°54'S, 69°21'W

Hexahedrite, H. Single crystal larger than 14 cm. Decorated Neumann bands. HV 205±15.

Group IIA. 5.48% Ni, 0.53% Co, 0.23% P, 61 ppm Ga, 170 ppm Ge, 43 ppm Ir.

HISTORY

A mass was found at the coordinates given above, on the railway between Calama and Antofagasta, close to Sierra Gorda, the location of a silver mine (E.P. Henderson 1939; as quoted by Hey 1966: 448). Henderson (1941a) gave slightly different coordinates and an analysis; but since he assumed Sierra Gorda to be just another of the North Chilean hexahedrites, no further description was given. The meteorite was allegedly found in 1898, but the original weight is unknown (E.P. Henderson, personal communication). Perry (1944: 78, plate 52) presented two photomicrographs. Recently Wasson & Goldstein (1968) reexamined the iron and gave a photomicrograph. They concluded that it is a separate fall, unassociated with the eight hexahedrites of the North Chilean group. The same conclusion is reached by the present author. Bauer (1963) determined the quantity of helium-3 and helium-4 and deduced a cosmic ray exposure age of 110 million years.

COLLECTIONS

Washington (17.3 kg), Ferry Building, San Francisco (about 7 kg), Chicago (550 g), New York (315 g), Ann Arbor (165 g). The original mass evidently weighed at least 26 kg.

DESCRIPTION

According to Roy S. Clarke (personal communication) the main mass now weighs 16.3 kg and measures 22 x 15 x 13 cm. A large endpiece of 7 kg and several slices have been removed, leaving a cut surface of 17 x 10 cm. The mass has a relatively smooth domed surface (22 x 15 cm) overlying a concave surface with irregular depressions, from a few cm to 8 cm in length. There is a series of what appears to be chisel marks around the center of the domed surface over an area of 6 x 7 cm. Other small areas on the edges of the specimen could also be the result of hammering; but the damage is only superficial, and artificial reheating has not occurred. The meteorite is severely weathered; the oxide crust on the domed surface is paper-thin and between 1-2 mm on the concave surface.

Etched slices show that Sierra Gorda belongs to the hexahedrites. It is a single kamacite crystal with Neumann bands extending from edge to edge with no directional changes. No fusion crust and no heat-affected α_2 zones were detected on the specimens examined. In one place a hardness gradient to low values of 168±5 (recovery) was observed – which indicates that the α_2 zone here had only

Figure 1614. Sierra Gorda (U.S.N.M. no. 1307). Hexahedrite with light and dark shaded areas. Several prominent cracks follow the cubic cleavage planes in the kamacite. Etched. Scale bar 1 mm. See also Figure 202.

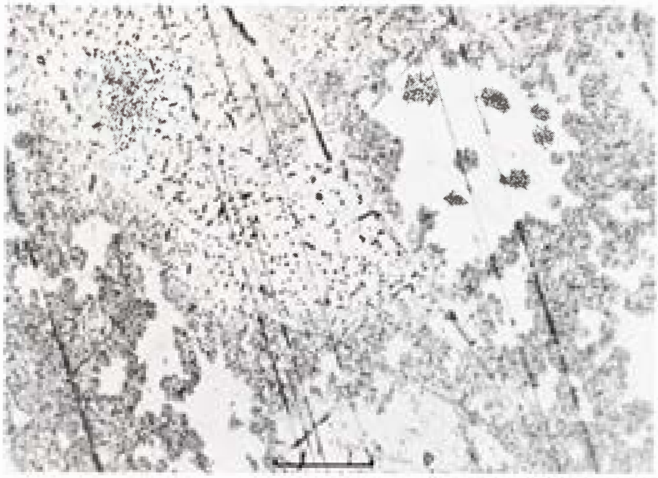

Figure 1615. Sierra Gorda (U.S.N.M. no. 1307). The light areas are clear precipitate-free kamacite, while the dark areas are rich in rhabdites of various dimensions. Etched. Scale bar 200 μ.

SIERRA GORDA – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Henderson 1941a	5.58	0.25	0.23									
Goldberg et al. 1951	5.59	0.53							65.5			
Wasson 1969	5.27								57.4	170	43	

Wasson & Goldstein (1968) found the kamacite to be rather inhomogeneous with an average composition of 5.51±0.5% Ni and 0.25±0.05% P.

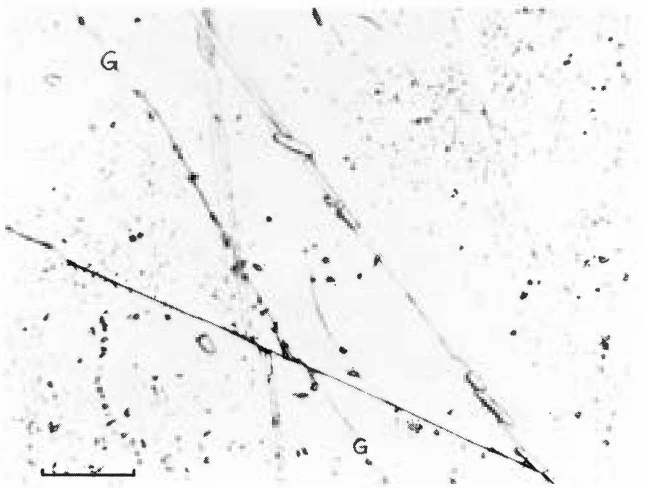

Figure 1616. Sierra Gorda (U.S.N.M. no. 1307). A narrow fissure along $(100)_\alpha$ cuts across a subboundary, G-G, and sets of annealed Neumann bands. Etched. Scale bar 40 μ.

been one millimeter away. It is estimated that on the average more than 4 mm has been lost by weathering.

The kamacite has subboundaries decorated with 1-2 μ rhabdites. It is rather inhomogeneous, having a spotted appearance under low magnification. Dull areas rapidly and irregularly alternate with bright areas. The individual, softly outlined areas range from 50-300 μ in size. The bright areas are clear, precipitate-free kamacite, while the dull areas are rich in rhabdites which occur as dense clouds of particles, each less than 1 μ across. The hardness is highly variable, ranging from 185-225, perhaps with a tendency for the hardest values to occur in the clear areas. This would indicate that these are supersaturated with respect to phosphorus.

Rhabdites occur as scattered plates, typically 1000 x 2 μ or 100 x 10 μ in section. They are not arranged in parallel planes, and they are not abundant. Smaller, prismatic rhabdites, 1-10 μ across, occur locally in clusters. In addition, one of the Neumann band directions is decorated with 1-10 μ rhabdites, while the bands themselves are partially annealed out.

Troilite occurs as lenticular or platelike bodies, 10 x 0.8, 35 x 2 or 3 x 2 mm in size. They are rich in daubreelite. They are shock-melted and converted to fine-grained iron-sulfur eutectics with fringed edges bordering against the adjacent kamacite. Preexisting 30 μ wide schreibersite rims have been shattered and partially dispersed in the troilite melt, and all daubreelite lamellae are equally brecciated and dispersed.

Several silicate crystals were noted in association with one troilite-aggregate. They formed 100 x 10 μ laths or hexagonal bodies 60 μ in diameter. They were brecciated and invaded by troilite melts.

Perry (1944: plate 78) gave a photomicrograph of what he supposed to be a plessite field. Similar structures were not detected in this study and it is doubtful whether Perry's interpretation of the photograph is correct. It may have been a poorly prepared, shock-melted troilite aggregate. Plessite would not be expected on this low bulk nickel composition of 5.5%.

Sierra Gorda shows several marks of cosmic deformation, in addition to the shock-melted troilite. The kamacite is rather hard and the rhabdites are often brecciated and shear-displaced. Finally, there are numerous internal, microscopic fissures, frequently about 1 mm long, but only 1-2 μ wide. They follow the cubic cleavage planes (100), and where they are situated near the surface, they are filled with terrestrial oxidation products.

Sierra Gorda is a hexahedrite with shock-melted troilite and with only insignificant recovery. Its structure and composition place it close to Scottsville and Bennett County, while it is unrelated to the North Chilean group of hexahedrites.

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

16.3 kg main mass (no. 1307, 22 x 15 x 13 cm)
759 g slice and 207 g slice (no. 1307)

Sierra Sandon, Antofagasta, Chile

Approximately 25°10'S, 69°17'W; 3,400 m

Medium octahedrite, Om. Bandwidth 1.00±0.10 mm. ϵ-structure. HV 295±20.

Group IIIA. 8.55% Ni, about 0.3% P, 20.8 ppm Ga, 43.8 ppm Ge, 0.28 ppm Ir.

HISTORY

A mass of 6.33 kg was found by a miner near the ancient silver mine of Sierra Sandon, a locality in the desert east of Taltal corresponding to the coordinates given above (Palache 1926a). The meteorite was acquired by Ward's Establishment, through which the entire mass came to Harvard University in 1923. Palache (ibid.) briefly described the mass and gave excellent photomacrographs of the exterior which exhibits the characteristic corrosion

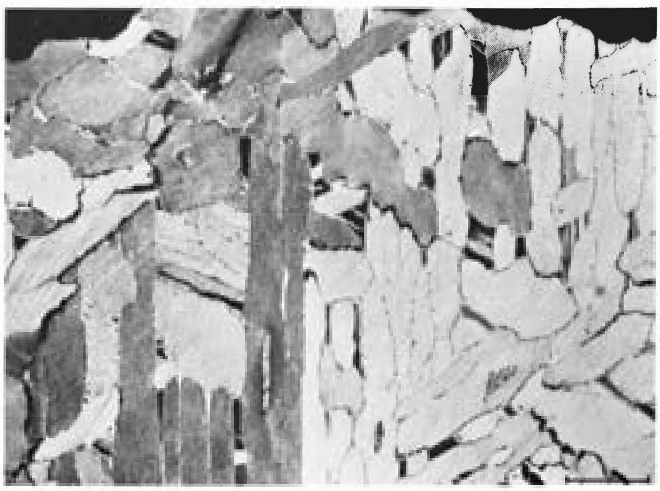

Figure 1617. Sierra Sandon (U.S.N.M. no. 737). A shock-hatched medium octahedrite which is transitional between group IIIA and IIIB. Sharp-edged pits are seen along the corroded surface. Deep-etched. Scale bar 3 mm.

from the Chilean salt desert. Palache classified Sierra Sandon as a coarse octahedrite, a conclusion which was accepted in all later catalogs, as for instance Hey (1966: 448). This is, however, incorrect by any standard of classification, since the bandwidth is only 1 mm.

COLLECTIONS

Harvard (6.3 kg main mass), Washington (72 g).

DESCRIPTION

According to Palache (1926a) the maximum dimensions of the mass are 30 x 16 x 7 cm.

The entire meteorite is in Harvard, except for a small slice of 72 g which has been cut from one end and is now in Washington. The mass is flattened and somewhat resembles the head of an alligator; this impression is reinforced by the pitted, reptile-like surface. The pits are mainly present on the top surface, where they form sharp-edged grooves, 2-4 mm in diameter and 0.5-2 mm deep. Sections perpendicular to the surface show that the fusion crust and the heat-affected α_2 zone have completely disappeared by weathering. The pits are mainly developed by dissolution of the kamacite phase, but on the other hand the attack is not primarily conditioned by the structure, since similar pitted surfaces have developed on both hexahedrites and ataxites exposed to the Chilean desert. The common belief, also advanced by Palache (1926a), that the pitting is due to erosion by wind-driven sand cannot be supported. It is clearly a corrosion phenomenon as also discussed under Baquedano, Iquique and others.

In several places there are large cup-shaped cavities, 3-6 cm in diameter and 1-4 cm deep. In three places the flat meteorite is completely penetrated by 1-2 cm holes, starting from the bottom of these cavities. Indications are that the meteorite has lost more material from the top side (1 cm?) than from the bottom side (1 mm?) by terrestrial weathering, but since only one small section from the edge is available, the problem cannot yet be solved.

The etched section displays a medium Widmanstätten structure of straight, long ($\frac{L}{W} \sim 20$) kamacite lamellae with a width of 1.00±0.10 mm. Some rather broad lamellae are due to the oblique cutting through the fourth Widmanstätten direction and also to irregular rims of swathing kamacite. Traces of the pattern are faintly visible on the corroded surface. The kamacite has inconspicuous subboundaries decorated with rhabdites smaller than 0.5 μ. All kamacite has been transformed by a shock event above 130 kbar to hatched, contrast-rich ϵ-structures which display a hardness of 295±20. Additional plastic deformation of the hatched structure has locally increased the hardness above 330, particularly near brecciated and shear-displaced schreibersite.

Taenite and plessite cover about 30% by area, both as comb and net plessite and as dense fields with interiors of brown martensite developed parallel to the bulk Widmanstätten structure. A typical field, 1.5 mm across, will display a tarnished taenite rim (HV 435±25) followed by transition zones of (111) martensite (HV 480±20). Further inwards there follow decomposed martensite or bainite (HV 410±25) and unresolvable, duplex $\alpha + \gamma$ structures ("black taenite").

Schreibersite is common as angular blebs, 0.5-2 mm in size, or as discontinuous lamellae, e.g., 3 x 0.2 mm in cross section. They are enveloped in asymmetric 0.3-0.6 mm

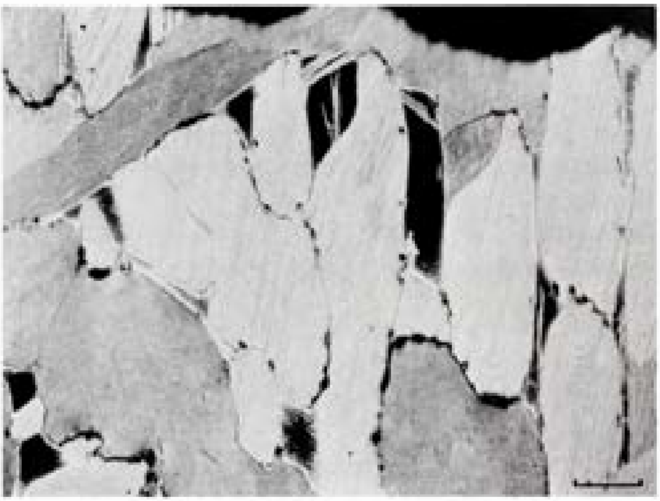

Figure 1618. Sierra Sandon. Detail of Figure 1617 showing various shades of shock-hatched kamacite. Terrestrial corrosion along schreibersite-filled Widmanstätten boundaries (black). Etched. Scale bar 1 mm.

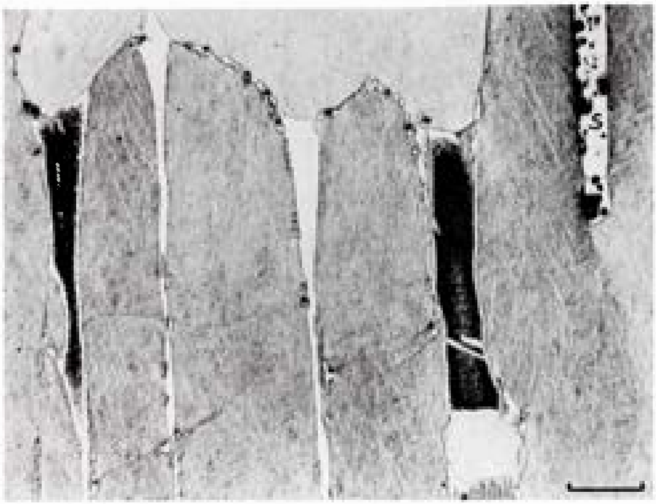

Figure 1619. Sierra Sandon. Detail of Figure 1617 showing various shades of shock-hatched kamacite. A large schreibersite crystal (right) and numerous small ones as island arcs along taenite and plessite. Etched. Scale bar 50 μ.

SIERRA SANDON – SELECTED CHEMICAL ANALYSES

	percentage			ppm							
Reference	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Scott et al. 1973	8.55								20.8	43.8	0.28	

wide rims of swathing kamacite. Schreibersite is further common as 20-80 μ grain boundary precipitates and as 2-20 μ blebs inside plessite. Characteristic are the numerous 10-20 μ thick bodies that form "island arcs" 5-20 μ outside taenite and plessite. Rhabdites above 1 μ in size were not detected. All larger phosphides are severely brecciated and the fissures are open to the surface so that terrestrial corrosion has had easy play. The schreibersite breccias are recemented by "limonite." The bulk phosphorus content is estimated to be 0.3%.

Troilite and other meteoritic minerals were not detected in the small section available. What appears to be a Reichenbach lamella is present in one place as a 12 mm long and 0.1 mm wide, straight foil. It may originally have been a troilite lamella with associated schreibersite blebs. It is, however, now severely corroded and transformed to a schreibersite breccia impregnated by limonite.

Sierra Sandon is a shock-hardened octahedrite of group IIIA. It is closely related to Tamarugal, Caperr, Spearman, Veliko-Nikolaevsky Priisk and other irons, transitional between group IIIA and IIIB. It is also related to Baquedano, which was found in the same state; but the chance that Baquedano and Sierra Sandon should be a paired fall is very small, since the detailed microstructure and composition appear to be sufficiently different.

Specimen in the U.S. National Museum in Washington:
72 g endpiece (no. 737, 5 x 3 x 1.5 cm)

Figure 1620. Sierra Sandon (U.S.N.M. no. 737). Apparently a Reichenbach lamella (black). On both sides irregular schreibersite bodies (S) have nucleated and grown. Terrestrial corrosion penetrates along the lamella and the grain boundaries, to the right. Etched. Scale bar 1 mm.

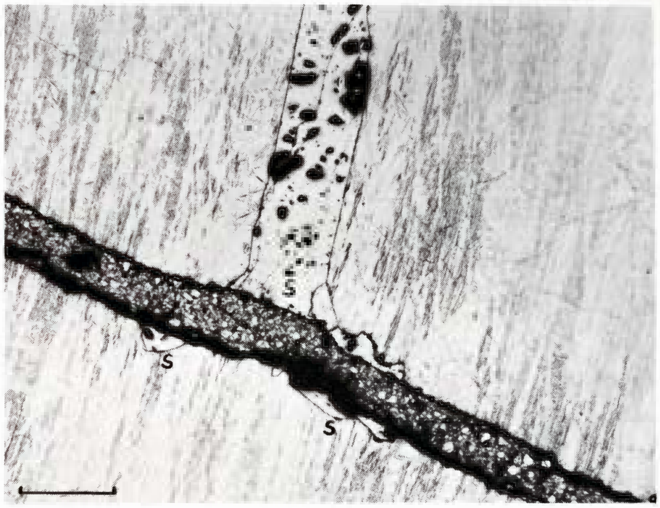

Figure 1621. Sierra Sandon. Detail of Figure 1620. The Reichenbach lamella is altered and now displays schreibersite breccias recemented by terrestrial limonite. Schreibersite (S) and shock-hatched kamacite with subboundaries. Etched. Scale bar 200 μ.

Signal Mountain, Lower California, Mexico

Approximately 32°30′N, 115°45′W

Fine octahedrite, Of. Bandwidth 0.28±0.04 mm. Neumann bands. HV 175±8.

Group IVA. 7.85% Ni, 0.04% P, 2.11 ppm Ga, 0.12 ppm Ge, 2.5 ppm Ir.

HISTORY

A piece of about 60 g which had been forwarded to Washington in July 1919 from the owner M.C. Ressinger of Calexico, California, was briefly described by Merrill (1922a). Although the accompanying photomicrograph clearly demonstrates that Signal Mountain is a fine octahedrite, Merrill stated that it was a medium; and this error is repeated in all catalogs, as in Hey (1966: 449). Merrill quoted a letter from the finder who believed to have observed the meteorite to fall "several years" before 1919. However, this is out of the question considering the corrosion present. The locality of find is only known very approximately, as (south of) Signal Mountain, corresponding to the coordinates given above.

The whole mass, of 58 kg, was acquired in 1919 for the American Museum of Natural History (Reeds 1937: 527).

COLLECTIONS

New York (57.83 kg), Washington (41 g).

SIGNAL MOUNTAIN – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Whitfield in Merrill 1922a	7.86	0.60	0.041		20		150					
Schaudy et al. 1972	7.84								2.11	0.121	2.5	

The cobalt determination is probably 50% too high.

Figure 1622. Signal Mountain (New York no. 291). A fine octahedrite of group IVA. Regmaglypts cover the right side of the main mass. Terrestrial corrosion has modified the sculpture of the left side, creating numerous densely spaced pits. Scale bar approximately 10 cm.

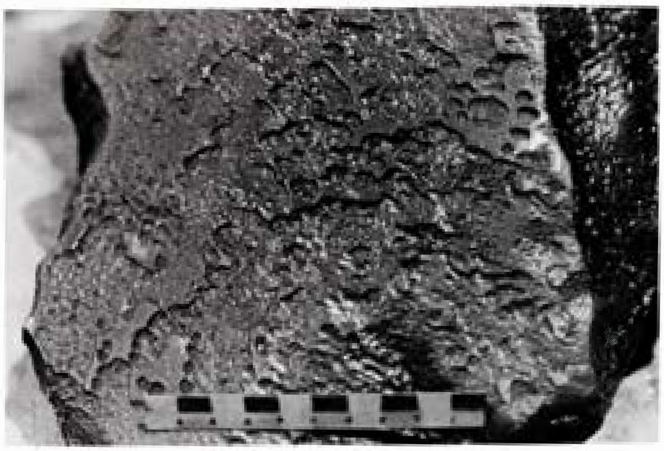

Figure 1623. Signal Mountain (New York no. 291). Close-up of the "sole" of the mass showing the anomalous corrosion attack. Ruler is 10 cm.

DESCRIPTION

The main mass in New York, from which 100 g at most has been removed, has a peculiar irregular shape. Its shape may perhaps be very roughly compared to an oversize human foot, 40 cm long, 20 cm wide and 22 cm high. The "sole" is slightly concave, while the opposite part, where the "leg" should continue, is smoothly terminated by a convex cap, 16 x 14 cm in size. The mass is deeply indented by hemispherical cavities, 3-8 cm in diameter, while typical regmaglypts, 2-4 cm across, cover other parts of the surface. The "sole," is remarkable by its pattern, however; the rather flat surface is penetrated by pits, 1-2 mm deep and with steep walls. The pits may coalesce to areas, 5-30 mm across, but the depth does not increase. The pattern appears to be corrosion-controlled, with delicate and unpredictable variations between active pitted areas and passive protected areas; and the pattern appears to be a variation of what is seen on the pitted-checkered surfaces of such North Chilean irons as Filomena and Maria Elena. Except for the pits, which are also present to a minor extent on other parts of the surface, the meteorite is well preserved, and all major sculpturing appears to have originated during the atmospheric flight. On the other hand, the corrosion must have required thousands of years to develop, so it is out of the question that the mass can be associated with the fireball observed by Merrill's informer (1922a).

Etched sections display a fine Widmanstätten structure of straight, long ($\frac{L}{W} \sim 30$) kamacite lamellae with a width of 0.28±0.04 mm. The kamacite is pure and has indistinct subboundaries with very few precipitates. Neumann bands are common. The hardness is 175±8. The only examined sections (No. 611) are from a protruding knob on the surface, which has been well exposed to the ablation heat. The heat-affected α_2 zone is, therefore, no less than 6 mm thick in places, its hardness being 189±8. At the transition to the unaltered kamacite the hardness reaches a minimum of 150 (hardness curve type II). Corrosion has, in an irregular way, removed 0.2-2 mm of the surface in several places.

Taenite and plessite cover about 40% by area, mostly as comb and net plessite and as an abundance of parallel taenite ribbons. Cellular plessite, with 50-300 μ wide cells within which the taenite rods are uniformly oriented, are also common. Finger plessite and duplex, poorly resolvable, small plessite wedges occur in minor amounts. The taenite rims have a hardness of 270±20, and show indistinct, martensitic transition zones (HV 290±20) to the duplex interiors (HV 200±15).

Schreibersite and rhabdites are not present under any form – in harmony with the analytical value of 0.041% P – which is low enough for all phosphorus to be in solid solution.

Troilite is, no doubt, present in the mass but was not encountered in the sections. Almost euhedral daubreelite bodies, 10-50 μ wide, are common in the kamacite phase.

Signal Mountain is very closely related to Gibeon and San Francisco Mountains, in structural as well as in chemical respects.

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

41 g protruding knob from the mass (no. 611, 27 x 15 x 13 mm)

Sikhote-Alin, Maritime Territory, RSFSR

46°9.6'N, 134°39.2'E; 200-250 m

Coarsest octahedrite, Ogg. Bandwidth 9±5 mm and centimeter-sized equiaxial kamacite. Neumann bands and significant additional distortion. HV 180-270.

Group IIB. 5.90% Ni, 0.42% Co, 0.46% P, 0.28% S, 52 ppm Ga, 161 ppm Ge, 0.03 ppm Ir.

HISTORY

The largest shower in historical time occurred in Eastern Siberia on February 12, 1947. In full daylight, a fireball moved from north to south and, about 10:38 a.m. local time, fragmented in the Earth's atmosphere (Fesenkov 1947; Shipulin 1947). The debris covered an elliptical area of 1.6 km^2 on the snow-covered western spurs of the

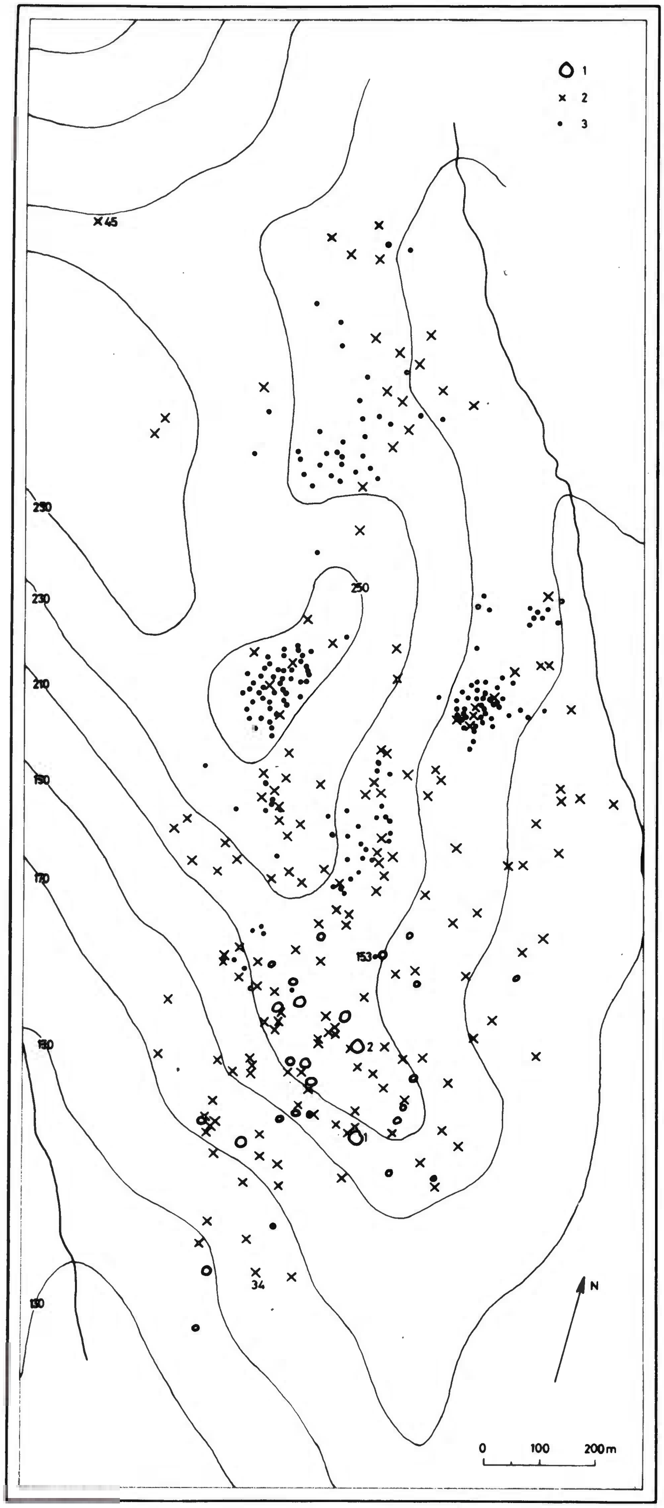

Figure 1624. Sikhote-Alin. Map sketch of the pine-covered hill crest where the meteorite shower landed. Contour lines at 20 m intervals. Two creeks to the left and right. Signatures: 1, impact holes 5-28 m in diameter; 2, impact holes smaller than 5 m in diameter; 3, meteorite fragments from 0.1 to 100 kg size. Redrawn from Fesenkov and Krinov (1959: figure 21).

Sikhote-Alin mountains. The unique phenomenon was observed by many eyewitnesses and has been the subject of numerous, very thorough studies by Russian scientists. Each year from 1946 to 1950, the Meteorite Committee of the USSR Academy of Sciences sent an expedition to the area to study the fall and collect samples. The results were published in individual papers, and as a two-volume monograph, edited by Fesenkov & Krinov (1959; 1963). After an intermission of 17 years, new expeditions visited the site in 1967 and following summers. Krinov (1969; 1970) was amazed at the generally unchanged state of the impact holes, but he noted that young birch trees, aralia and chokecherries were slowly invading the pits.

Fesenkov & Krinov (1959: Volume 1: 5-18) gave a summary of the expeditionary work with numerous photographs, one showing the recovery of the largest mass of 1,745 kg. Shipulin & Chettjikov (Volume 1: 19-25) discussed the geological features of the mountain range, noting that coarse-grained tuffs and quartz-free albite-porphyrs covered most of the area. Most of the impacting meteorites did not, however, penetrate the eluvial and alluvial debris which covered the bedrock with 1-2 m thick layers, and moreover, at the time of impact, were solidly frozen to a depth of one meter.

Divari (Volume 1: 26-98) collected numerous eyewitness accounts from places up to 180 km from the fall. He concluded that the fireball had approached from a direction N15°E and had an initial declination of 41°, but that this had increased to 60-70° at the time of impact. The apparent diameter of the bolide with its luminous envelope was estimated to be 600 m, and the length of the smoke trail was 33±9 km. The brightness of the bolide exceeded that of the sun, according to eyewitnesses, and the dust trail was observed for several hours before the particles precipitated or were scattered by the wind. The point of complete breakup ("*Hemmungspunkt*") was apparently not well determined but may be estimated to have occurred at an altitude of 4-6 km. Several eyewitness sketches of the appearance of the bolide from various points were included. Light and sound phenomena were observed from an area 300-400 km in radius, but only inconspicuous seismic disturbances occurred at the Vladivostok seismic station, situated 500 km away. Additional data on the trajectory are to be found in the recent catalog of bright meteors by Nielsen (1968).

Krinov (Volume 1: 99-156) described the field work and gave numerous photographs of the impact holes, of violently damaged trees and of individual fragments. About 8,500 specimens, ranging from 1 g to 1,745 kg and totaling more than 23 tons have been collected. Several tables and drawings were presented to illustrate the relationship between the size of the impacting body and the resulting pit. Altogether 122 impact holes were found with diameters ranging from 26 to 0.5 m and with depths ranging from 12 to 1 m. In addition, 78 smaller pits were studied. Figure 61 and Table 11 on page 153 give the weight distribution of the individuals: apparently two maxima occurred, at 10-100 g weight and at 10-100 kg weight. Only one specimen above 1,000 kg was recovered. The shower covered an elliptical area of 1.6 km^2; the major north-south axis was 2.1 km, the minor east-west axis, 1.0 km. How-

Figure 1625. Sikhote-Alin (Moscow). The largest specimen recovered so far weighed 1,745 kg. It is a shield-shaped mass over 1 m across with eminent regmaglypts radiating from the apex. A 20-40 cm deep fissure extends from the apex and almost divides the mass into two halves.

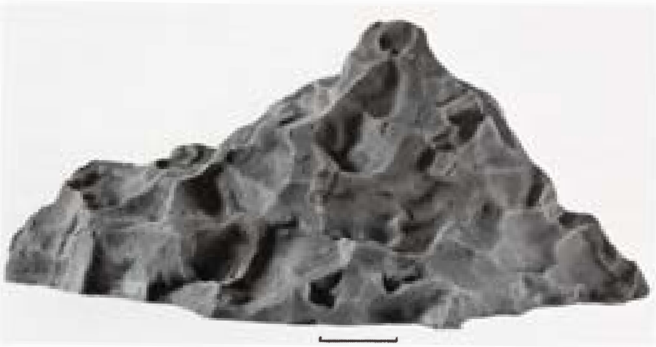

Figure 1626. Sikhote-Alin (U.S.N.M. no. 1708A). Endpiece of a 38 kg individual showing beautiful angular regmaglypts developed from the long independent flight. Smoked with NH_4Cl. Scale bar approximately 2 cm. S.I. neg. 74. See also Figure 1633.

ever, according to the map, Figure 1624, by far the greater amount of material was found within an even smaller ellipse, only 0.75 x 0.30 km in size. The largest masses were close to the southern limit of the area, in accordance with the direction of fall. In the northern part where the small meteorites fell, no impact holes were formed – except in the 0.5-1 m thick snow blanket, – and the samples were found lying on the surface of the ground. From the number and sizes of the pits and from the amount of recovered specimens, 23 t, it is estimated that a total of 70 t fell, including dust.

Krinov & Fonton (Volume 1: 157-303) presented a detailed study of selected pits. About 180 of the 200 pits were excavated, the remainder being left for future generations to study. In many holes the impacting body had survived as an entity, but in a number of other holes it had broken up completely. Thus, pit No. 34, 5.4 m in diameter and 1.6 m deep, on excavation furnished 464 specimens totaling 256 kg. In the largest hole, 26 m in diameter and 6 m deep, numerous fragments ranging from 0.5 to 25 kg in weight were found, totaling several hundred kilograms. The largest unbroken individual specimen, of 1,745 kg, was first discovered in 1950 in a rather small pit, No. 45, 3.5 m in diameter and 0.8 m deep. Several fragments had hit the trees of the dense taiga forest and had either broken them or damaged them. A 13.6 kg specimen was thus found firmly embedded in a partly split, 70 cm thick cedar tree (No. 153 on the map sketch).

Sarbatyrov (Volume 1: 304-311) described the results of an aerial photogrammetric survey, and Fonton (Volume 1: 312-21) described the magnetometric method of locating buried samples. Krinov (Volume 1: 322-63) gave a complete inventory of the recovered fragments with their sizes and locations.

In Volume 2 (1963) Krinov (pages 3-239) discussed in great detail the morphology of the specimens and presented numerous photographs of entire specimens, of ragged fragments resembling bombshells, and of beautiful fusion

Figure 1627. Sikhote-Alin. Detail of the fusion crust on the 38 kg specimen in Figure 1626. Scale bar 4 mm. S.I. neg. 74C.

crusts. Table 3 contains an interesting compilation of data on regmaglypt sizes. The ratio between the diameter of the regmaglypts and of the fragments ranges from 0.05 to 0.25, with the majority giving 0.08-0.10, for specimens 5-45 cm in size. Krinov (Volume 2: 240-79) also described the micrometeorites collected from the soil up to 1.5 km from the impact center. Most of them proved to be hollow magnetite spherules, 30-100 μ in diameter. Kvasha (Volume 2: 280-344) gave a detailed report of the structure of numerous cut specimens. The very coarse Widmanstätten structure is well exposed in, e.g., specimens Nos. 1631 and 1651. Zavaritskij & Kvasha (1952: 36) had previously made a report on the structure and presented various figures.

Dyakonova (Volume 2: 345-350) presented analyses of various components, see below. Yavnel (Volume 2: 351-371) studied the trace elements and the mechanical properties of the metal. Small specimens (d=2 mm, 1=10 mm) were tensile tested and found to have tensile strengths ranging from 43 kg/mm^2 at 15% elongation to 49 kg/mm^2 at 9% elongation. Larger specimens with inclusions or grain boundaries had much lower tensile strengths, of about 5 kg/mm^2.

Fesenkov (1951a) estimated the geocentric velocity upon entering the atmosphere as 14.5 km/sec and the preatmospheric mass as 1,000 tons. This estimate is probably high, according to Krinov who noted that the mass deposited in the dust trail was apparently overestimated. Fesenkov (1951b) and Fesenkov & Tulenkova (1954) calculated the orbit and found that before the meteoroid entered the Earth's atmosphere, it had been moving around the Sun in a typically asteroidal orbit with the following elements: semimajor axis (a) – 2.162 astronomical units; eccentricity (e) – 0.544; angular distance between perihelion and node (w) – 181°15′; orbital inclination (i) – 9°25′; length of ascending node – 322°28′; and date – 13.050 February 1947.

Divari (1962) compared various pits and the associated impacting masses and concluded that the final velocities had ranged from 0.1 to 1.0 km/sec. Kolomenskij & Yudin (1958) studied the fusion crust and identified wüstite (synonym: iozite), presenting both optical and X-ray diffraction data. Marvin (1963) independently identified wüstite by X-ray diffraction work in the fusion crust of Sikhote-Alin, Bogou and other irons. Further examinations of the magnetite, wüstite and hematite minerals, made from the meteoritic dust collected at the impact site, were presented by Zaslavskaja (1968). Lovering & Parry (1962) included the meteorite in their thermomagnetic survey. Garber et al. (1968) studied the mechanical properties of the metal at temperatures ranging from 4°K to 300°K and also examined the effects of annealing at temperatures from 150 to 650° C. Kozmanov et al. (1968) studied the high temperature oxidation characteristics, heating various specimens to 700°-1200° C for 10 hours in air. They presented pictures of diffusion zones and of the lace-like networks, which the present author has noted in numerous artificially reheated meteoritic irons. Berkey & Fisher (1967) found an extremely low concentration of chlorine (<0.4 ppm) except in near-surface grain boundaries which had 10-15 ppm. The chlorine may in its entirety be of extraterrestrial origin or, if the specimen was collected on one of the later expeditions, it may have been introduced in part by terrestrial ground water. Goel & Kohman (1963) also found negligible chlorine contents.

Goel & Kohman (1963) measured and discussed the small amounts of cosmic ray produced ^{14}C and ^{36}Cl isotopes. McCorkell et al. (1968) measured the ^{59}Ni and ^{36}Cl activities and came to the surprising result that Sikhote-Alin had a preatmospheric radius of 56 cm, which clearly cannot be the case. The noble gas isotopes were studied by Vinogradov et al. (1957), Schaeffer & Zähringer (1960), Signer & Nier (1962), Hintenberger & Wänke (1964), Schaeffer & Heymann (1965), Lipschutz et al. (1965), and Hintenberger et al. (1967). The estimated cosmic ray ages range from 50 to 700 million years. Voshage (1967) found by the ^{40}K/^{41}K method 355±70 million years, but Chang & Wänke (1969) found by the

Figure 1628. Sikhote-Alin (Moscow; Krinov Inventory no. 1637). A 10.2 kg individual showing distinct fracturing along the very coarse Widmanstätten boundaries (center). Ablation has partly obscured it and created eminent regmaglypts. Scale bar 5 cm. (Courtesy E.L. Krinov.)

$^{36}Ar/^{10}Be$ method 75±10 million years. The discrepancies are large and not understood as yet.

Numerous other papers have appeared. Some of them may be found in the excellent summaries given by Krinov (1956a, b; 1957) Heide (1958) and Hey (1966: 449). Only a few summaries are available in English, notably Fesenkov (1955), and Krinov's translated works, "Principles of Meteoritics" (1960a) and "Giant Meteorites" (1966a: 266-376), which are also abundant in maps and figures of the individual specimens. The most recent field work has been described by Krinov (1970).

COLLECTIONS

Moscow (more than 22 tons), Tartu (56.5 kg), Albuquerque (7.3 kg), Copenhagen (4.9 kg), Washington (4.1 kg), Tempe (3.3 kg), Budapest (2.65 kg), London (1.6 kg), Leningrad (650 g), New York (375 g), Los Angeles (321 g), Perth (233 g), Sydney (139 g), Chicago (86 g), Harvard (16 g).

DESCRIPTION

It appears plausible that the incoming bolide had a mass of about 70 tons as estimated by Krinov and coworkers. It split finally at an altitude of about 6 km and scattered thousands of fragments within an elliptical area, with the axes 2.1 and 1.0 km. From maps published (e.g., Fesenkov & Krinov 1959: Volume 1: 112) it appears that the distribution of specimens indicates a direction of fall from N10°W rather than from N15°E as deduced by Divari (ibid.: 42). Whether the discrepancy is due to the wind drift or is within the natural error associated with the estimate of fall directions, is difficult to say.

The small area over which specimens are scattered suggests that the meteorite broke up very late in the atmosphere. Divari estimated from eyewitness accounts that this breakup occurred at an altitude of 6 km. The reports indicate, I think, that the trajectory up to the breakup point was straight and inclined about 40° to the horizontal. They also indicate that many fragments were detached early in the flight and that these proceeded as "sputniks" along with the main mass. This may explain how a few large masses flew long enough to develop a cone shape and deep regmaglypts, and sometimes landed far from the impact center. The largest mass thus fell at a rather isolated spot 600 m north-northwest from the large impact holes and, in fact, well outside the scatter ellipse as defined by the bulk of the specimens.

A large number (~300) of the smaller fragments also had time to develop deeply sculptured regmaglypts on all surfaces. Perhaps one-fifth of the total mass came down as such fragments; and, since they had been slowed down during the long flight, they generally fell in the rear area of the ellipse and had too low a velocity to make conspicuous holes or to fragment upon impact. The "A" specimens (see below) belong to this category.

The remaining core split at an altitude of 6 km, and the fragments proceeded with velocities of perhaps 1000 m/sec. Under these conditions no deep sculpturing and no thick fusion crusts would be expected, as is actually the case with a large number of fragments. They show ragged surfaces that are barely smoothed by ablation and are only thinly covered with fusion crust. These fragments generally fell in

SIKHOTE-ALIN – SELECTED CHEMICAL ANALYSES

References	percentage Ni	Co	P	ppm C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Trofimov 1950				170								
Dyakonova 1958b	5.94	0.38	0.46		2800		300					
Nichiporuk & Brown 1965											<0.3	3.9
Yavnel in Krinov 1966a												4.6
Cobb 1967		0.46					114		52.5		<0.4	
Wasson 1969	5.87								51.8	161	0.029	
Rosman 1972								0.58				

Dyakonova (1958b) provided a thorough analytical study of many specimens and reached the above mentioned values as a true average bulk composition. The following minerals have also been analyzed.

References	Mineral	weight percentage Fe	Ni	Co	P	S	Cr	Mg	Cu	Mn	V	Ti
Yavnel 1956	Schreibersite			0.075			0.01					
Dyakonova 1958b	Schreibersite	69.8	14.8	0.16	15.34							
ibid.	Kamacite	93.32	6.00	0.47	0.28	0.00			0.03			
ibid.	Chromite	12.38					48.74	7.16		0.8	0.3	0.04
ibid.	Troilite	62.7				34.50	1.07		0.06			
Nichiporuk & Chodos 1959	Troilite	62.6	0.91	0.012			1.58		0.08		0.007	

Figure 1629. Sikhote-Alin (U.S.N.M. no. 1708B). A distorted fragment of 1.28 kg produced during the impact with the frozen ground. Slicken-sided surfaces alternate with twisted and ragged portions. Scale bar 2 cm. S.I. neg. 75A.

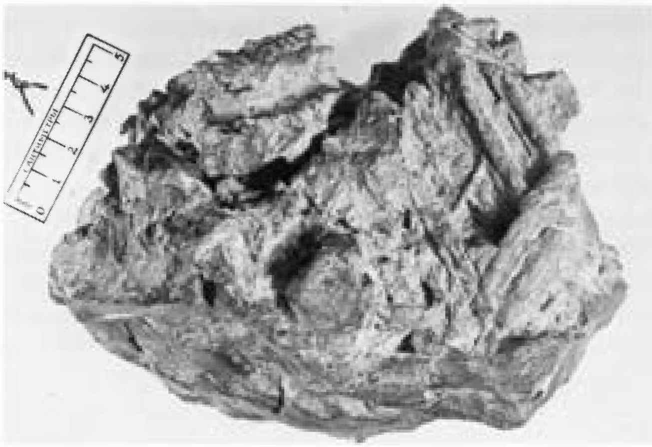

Figure 1630. Sikhote-Alin (Moscow). Another fragment with distinct octahedral parting. Scale bar 5 cm. (Courtesy E.L. Krinov.)

the forward part of the ellipse and had sufficient velocity to form large impact holes. They also broke up a second time upon impact with the ground, forming the ragged, bombshell-like fragments. The "B" and "C" specimens below appear to belong to this category.

The collected material falls roughly into five categories:

A. Unbroken specimens with full fusion crust (Volume 2: 3-7), totaled 313 specimens and weighed 11,840 kg, distributed as shown in the table below.

B. Coarse fragments with partial fusion crust: altogether 42 specimens from 27 different individual samples, totaling 6,167 kg.

C. Medium sized fragments with little fusion crust (>5 kg): altogether 185 specimens, totaling 2,793 kg.

D. Small fragments (<5 kg), altogether 7,742 specimens, totaling 2,408 kg.

E. Meteoritic dust (Volume 2: 240 ff.), ranging from four millimeters in diameter and downwards, the bulk being less than one millimeter and with individual weights less than one milligram.

The largest sample of 1,745 kg, is a shield-shaped mass, measuring approximately 1.2 x 1.0 x 0.5 m. It is covered with regmaglypts, 4-8 cm in diameter, that radiate away from the apex of the low cone. Along the edges, the regmaglypts form elongated grooves parallel to the direction of flight. A fissure, 20-40 cm deep, extends from the apex and almost divides the mass into two halves, see Figure 1625.

The largest specimen in the U.S. National Museum is a 2.7 kg endpiece from a 38 kg sample, excavated in 1947 from pit No. 132 (Fesenkov & Krinov 1959: Volume 1: 222; Volume 2: 44). The whole specimen measured 33 x 24 x 17 cm and the beautiful regmaglypts measure 1-3 cm in diameter. Under the fusion crust is a 1-2 mm wide heat-affected α_2 zone with a hardness of 190±10 (hardness curve type IV). See Figures 1626-1627.

The smaller specimen in the U.S. National Museum is a torn fragment of 1.3 kg with ragged edges. It is one out of approximately 200 similar fragments, totaling 300 kg and excavated in 1948 from pit No. 28 (ibid., Volume 1: 180; Volume 2: 193). The external shape clearly shows how the major fractures formed upon impact and followed the schreibersite-loaded grain boundaries and the schreibersite-troilite inclusions. The fracture faces are rich in distortions and ridged, semi-polished slickensides created at the moment of breakup. Similar heavily gouged surfaces are present on many Imilac samples. Deep fissures along the Widmanstätten planes subdivide the fragment into various ears and lobes. A 6 x 6 cm surface area is apparently a part of the exterior of the impacting body, because a 0.1 mm thick fusion crust is present there. See Figure 1629.

Etched sections, but in particular the disrupted fragments, clearly show that Sikhote-Alin is a coarsest octahedrite, composed of kamacite lamellae of finger-shape and finger-size. A typical lamella measures 80 x 25 x 9 mm, and thus resembles a flattened finger. The kamacite lamellae, as measured on various polished sections, are stubby and irregular ($\frac{L}{W} \sim 8$) and have a bandwidth of 9±5 mm. Approximately one-half of the exposed sections show no

Unbroken specimens of category A

weight range	number	weight range	number
- 1 g	6 specimens	1 - 10 kg	27 specimens
1 - 10 g	40 specimens	10 - 100 kg	81 specimens
10 - 100 g	70 specimens	100 - 1000 kg	33 specimens
100 - 1000 g	55 specimens	1000 - 10,000 kg	1 specimen

Widmanstätten structure, but only more or less equiaxial kamacite grains, 2-3 cm in diameter and developed around large schreibersite and troilite inclusions. This granular kamacite is, in fact, an extreme example of the swathing kamacite so frequently seen in medium octahedrites.

Even the largest sections through Sikhote-Alin fail to disclose parent taenite grain boundaries, so the meteorite was composed of taenite crystals larger than, at least, 30 cm.

The kamacite has subboundaries decorated with 1 μ phosphides. Neumann bands are abundant. They are undecorated and range in width from 1 μ – where they pass through a matrix loaded with 1 μ rhabdites – to 10 μ – where they pass through an obstacle-free matrix with large rhabdites or with no rhabdites at all. The kamacite has a hardness of 220±10, which is relatively high and suggests some cold working. The hardness increases to 260±10 in visibly distorted zones near the surface where lenticular deformation bands and conspicuous shear zones are present. Here the phosphides are brecciated and sheared; the phosphide fragments are frequently separated by cold-deformed metal with flow structures. In the most severely worked shear zones, the metal has recrystallized to 1-10 μ α-grains, and the hardness has dropped to 190±10. In addition to the fissures along grain boundaries and inclusions, fissures also occur along the cubic cleavage planes of the kamacite; these seem to have played a minor role during the fragmentation, however.

Taenite and plessite occur sparsely and then mainly in the Widmanstätten-textured sections. The taenite forms 10-100 μ wide ribbons, which show tarnished rim zones (HV 360±25) and acicular, martensitic interiors (HV 470±15). Plessite fields up to 5 x 1 mm in size occur but are rare (one per 25 cm^2), in accordance with the low bulk nickel content of the meteorite.

Schreibersite is dominant as angular skeleton crystals, typically 10 x 5 x 4 mm in size. Crystals or aggregates of crystals up to 60 x 10 x 4 mm in size are not rare. The schreibersite is monocrystalline but often violently brecciated, and it has a hardness of 850±25. Schreibersite is also ubiquitous in the grain boundaries as veinlets ranging from 10 to 200 μ in width. Rhabdites are abundant, generally in the form of tetragonal prisms 1-10 μ across.

Troilite occurs in minor amounts, mostly associated with the schreibersite skeleton crystals which in many instances may have nucleated upon the troilite. The troilite forms 1-10 mm nodules and lenticular bodies. In most cases it forms the central part of centimeter-sized, intricate, lace-like textures where schreibersite filaments and hieroglyphs radiate from the troilite in structures that suggest coarse-grained eutectics. Similar structures are present in, e.g., Sandia Mountains, Santa Luzia and São Julião. The troilite appeared to be monocrystalline, but no further details could be seen on the one available troilite-bearing

Figure 1631. Sikhote-Alin (Copenhagen no. 1964, 119; Krinov Inventory no 7339). A fragment of 4.4 kg excavated together with 414 other fragments, totaling 210 kg, from impact hole no 30. The fracture follows coarse Widmanstätten boundaries. The opposite surface (not visible) contains the exterior, showing coarse regmaglypts and eminent fusion crusts. Scale bar approximately 3 cm.

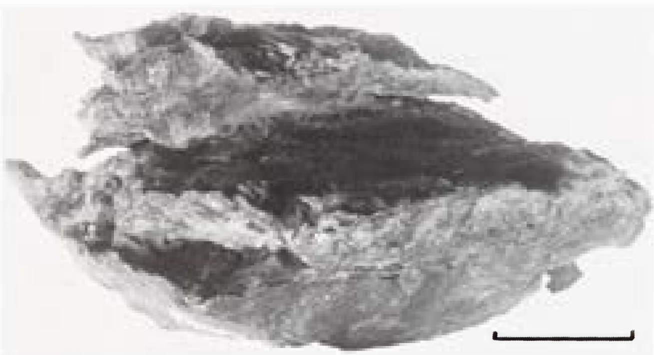

Figure 1632. Sikhote-Alin (Moscow). A highly deformed fragment with ragged razor-sharp edges. Scale bar 2 cm. (Courtesy E.L. Krinov.)

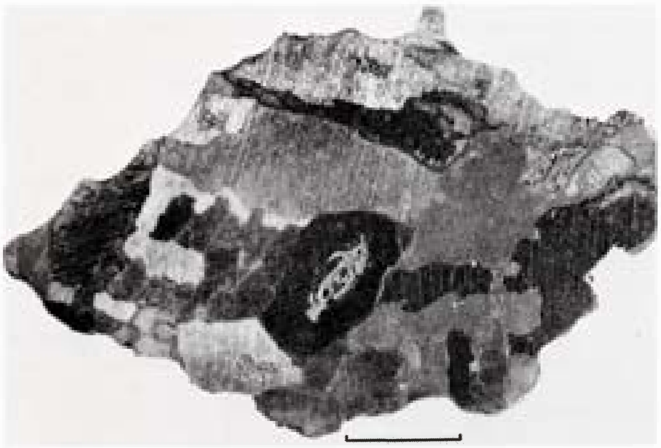

Figure 1633. Sikhote-Alin (U.S.N.M. no. 1708A). Same as Figure 1626 but showing the deep-etched end section. Several schreibersite and schreibersite-troilite aggregates within very wide rims of swathing kamacite. Scale bar 30 mm. S.I. neg. 107. See also Figure 67.

specimen, which was a large, deeply etched exhibition specimen.

Chromite is present as an accessory mineral, both as minute inclusions in troilite and as euhedral crystals in the kamacite (Fesenkov & Krinov 1963: Volume 2: 334). Dr. Kvasha thus identified a 8 x 4 cm eight-sided chromite crystal on a section from the 1,745 kg specimen. This seems to be the largest chromite crystal ever reported, larger than the centimeter-sized crystals present in some sections of Bendego, Brenham and Sacramento Mountains. The Sikhote-Alin chromite was analyzed to 12.4% Fe, 48.7% Cr and 7.16% Mg, and the specific gravity was 4.65. The lattice parameter was 8.829±0.002 kX.

Kvasha (ibid.) also reported very minor amounts of olivine, associated with troilite and chromite. The olivine crystals were of millimeter size, and the optical properties indicated that they had forsterite composition.

Sikhote-Alin has given the science of meteoritics an unusual opportunity to study a fresh iron-meteorite fall. The Russian scientists must be complimented for the extensive work already published and for the continued interest and support of actual field work on the remote site.

Sikhote-Alin is an unannealed coarsest octahedrite which, structurally and chemically, is closely related to Sandia Mountains, Santa Luzia and São Julião. Chemically, it is a typical group IIB iron.

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

2,715 g endpiece (no. 1708A, 18 x 10 x 7 cm). Krinov inventory No. 1590.
1,280 g twisted fragment (no. 1708B, 13 x 7 x 6 cm). Krinov inventory No. 4306.
Slide with tiny fragments and a few spherical globules (no. 1759). Krinov inventory No. 22, probe 21, 1948.

Figure 1634. Silver Bell (Tucson). The main mass of 5.1 kg before cutting. Scale bar approximately 5 cm.

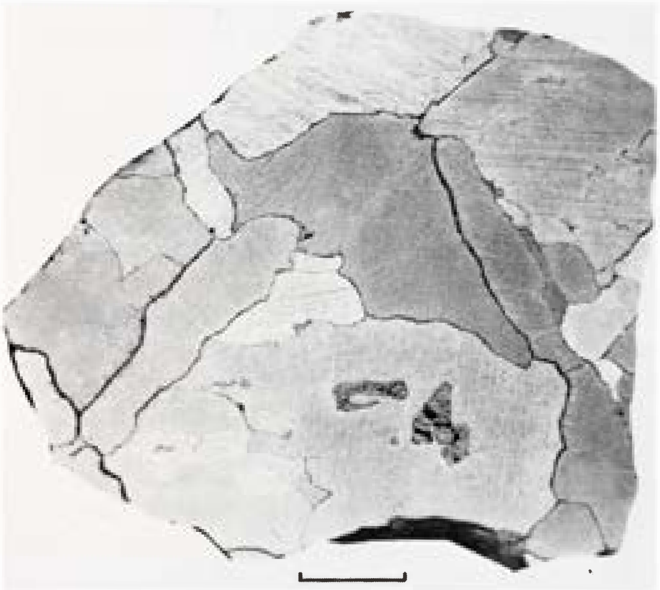

Figure 1635. Silver Bell (U.S.N.M. no. 1619). A coarsest octahedrite of group IIB. Cluster of schreibersite crystals below. Terrestrial corrosion along grain boundaries. Deep-etched. Scale bar 10 mm. (Perry 1950: volume 7.)

Silver Bell, Arizona, U.S.A.

Approximately 32°26'N, 111°31'W; 600 m

Coarsest octahedrite, Ogg. Bandwidth 5±2 mm and 5 cm grains. Neumann bands. HV 190±10.

Group IIB. 6.43% Ni, 0.50% Co, 0.8% P, 45.6 ppm Ga, 111 ppm Ge, 0.012 ppm Ir.

HISTORY

A mass of 5.1 kg was found by Harrison Schmidt before 1939 near the mining settlement of Silver Bell, 60 km northwest of Tucson, Pima County. It was donated to the University of Arizona in 1940 and was analyzed by F.G. Hawley, see below. In 1947 S.H. Perry visited the university and noted the meteorite. He obtained the two slices, which are now in the U.S. National Museum, and left unpublished notes and photomicrographs of the meteorite. After repeated cuttings, in the 1940s and recently, the main mas has now been reduced to 3,375 g (the history and

SILVER BELL – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
F.G. Hawley 1941 unpubl.	6.42	0.53	0.31	600	500	100	500					
Moore et al. 1969	6.43	0.48	0.24	220	35		110					
Wasson 1969	6.43								45.6	111	0.012	

weights based upon a letter from Mrs. T.V. Murchison, Assistant Curator of the Tucson Collection).

COLLECTIONS

Tucson (3,375 g), Tempe (300 g), Washington (191 g), Chicago (89 g).

DESCRIPTION

The mass is roughly shaped like the head of a small terrier with the average dimensions of 15 x 9 x 8 cm. It is weathered and covered with 0.1-1 mm thick terrestrial oxides. Shallow regmaglypts, 1-2 cm in diameter, are still discernible, and a large cavity, 3 x 5 cm in aperture and 1 cm deep, also seems to have been carved by the atmospheric ablation and not by corrosion. Sections perpendicular to the surface support this interpretation because the heat-affected α_2 zone is still present here and there. On the average, 2 mm appears to have been lost by weathering. Corrosion penetrates to the center of the mass along the phosphide-filled grain boundaries, forming 25-200 μ wide limonitic veins.

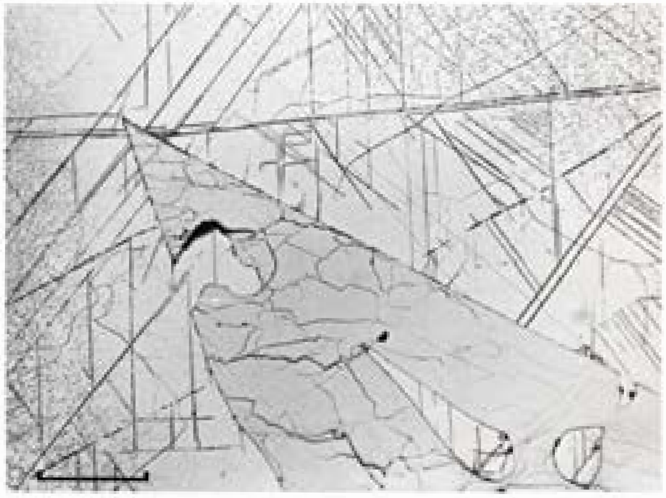

Figure 1636. Silver Bell (Tempe no. 793). A large skeleton schreibersite crystal with internal kamacite islands. Surrounding kamacite is depleted in Ni and P, but farther away numerous fine phosphides are precipitated. Subboundaries and Neumann bands are prominent. Etched. Scale bar 400 μ.

Etched sections display an equal mixture of Widmanstätten and granular areas. The kamacite bands are straight, but short ($\frac{L}{W} \sim 4$), with a width of 5±2 mm. It is, in fact, difficult to perceive the Widmanstätten pattern on the available sections, partly because of their small size and partly because late grain growth has altered many of the previously straight lamella boundaries. The granular areas are composed of rounded, homogeneous kamacite grains ranging from 5-40 mm in diameter and with irregular rosettes or skeleton crystals of schreibersite in their centers. The kamacite is rich in subboundaries with conspicuous, 1-4 μ thick rhabdite precipitates. Neumann bands are common, and best developed in the precipitate-free matrix around schreibersite. Some Neumann bands are decorated with 2-5 μ thick rhabdites. The hardness is 190±10, except in the nickel- and phosphorus-depleted zones near schreibersite where it drops to 160±5.

Taenite and plessite cover less than 1% by area, but occur in very characteristic forms, as comb, pearlite and sphero plessite. Haxonite-taenite intergrowths are present locally. The pearlite plessite (HV 250±10) is composed of alternating 1 μ wide taenite and 2 μ wide kamacite lamellae where it is best developed. The spheroidized plessite may occur right next to the pearlitic forms and exhibits 1-20 μ thick taenite globules. Finally, these fields merge locally with haxonite-rich parts, where haxonite constitutes 50% by area in an intricate, myrmekitic intergrowth with taenite. The haxonite branches are 1-5 μ wide, and the whole aggregate has a hardness (100 g load, whereby at least 4-5 units are averaged) of 650±40. This rather low hardness may be expected when the haxonite (H ~ 1000) is mixed with taenite (H ~ 250) in the ratio of 1:1. The intergrowths are related to the haxonite roses of Carbo, Carlton, Coopertown, etc., but the individual units are rather small in Silver Bell.

Schreibersite is a dominant mineral, forming massive skeleton crystals up to 10 x 6 x 5 mm in size. Winding,

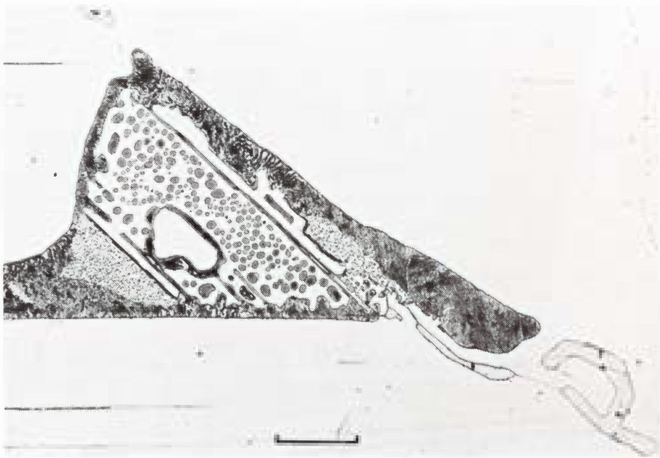

Figure 1637. Silver Bell (Tempe no. 793). Plessite field with pearlitic edges and spheroidized interior. Schreibersite to the right. Etched. Scale bar 200 μ.

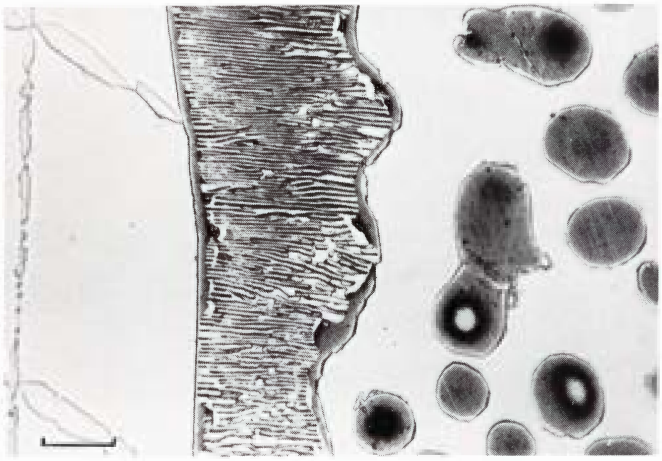

Figure 1638. Silver Bell. Detail of Figure 1637, showing finely lamellar pearlitic edge and cloudy taenite spherules. Neumann bands. Scale bar 20 μ.

Figure 1639. Silver Bell. Detail of Figure 1638 showing one of the coarsest pearlite areas. Taenite lamellae are slightly cloudy and stand in low relief above the kamacite phase which is partly etched away. Scale bar 20 μ.

1 mm wide ribbons, as in Santa Luzia and São Julião, are also common. The hardness is 900±25. These large crystals are enveloped by 5-20 mm wide rims of swathing kamacite, thus forming the granular areas noted above. Schreibersite is further present as 0.1-0.2 mm wide grain boundary veins and as smaller veinlets associated with the plessite fields. Rhabdites are common but mainly as rather small, 1-2 μ thick prisms. The bulk phosphorus content was estimated by point counting of sections totaling 48 cm^2, and found to be about 0.8%.

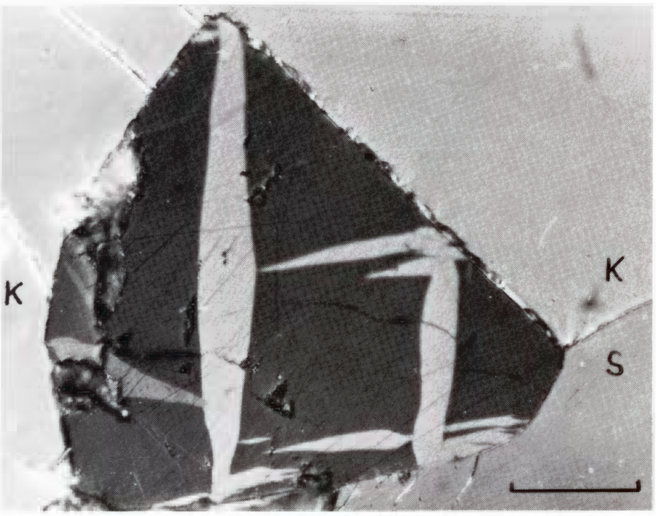

Figure 1640. Silver Bell (Tempe no. 793). Troilite crystal at a kamacite (K)-schreibersite (S) interface. The troilite shows multiple twinning from mechanical deformation. Etched. Crossed polars. Scale bar 30 μ.

Troilite was only observed in minor amounts as 1-6 mm nodules. They are monocrystalline but display some twinning from plastic deformation. They appear to be closely associated with the larger schreibersite crystals which are often brecciated and displaced a few microns by shear.

Silver Bell is a small iron of the coarsest type, closely related to the larger Sikhote-Alin, São Julião and Santa Luzia meteorites. Chemically, it is a typical group IIB as shown by Wasson (1969).

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

77 g slice (no. 1442, 6 x 4 x 0.3 cm)
114 g slice (no. 1619, 6 x 5.5 x 0.5 cm)

Silver Crown, Wyoming, U.S.A.

41°10′N, 105°20′W; about 2,000 m

Coarse octahedrite, Og. Bandwidth 2.1±0.4 mm. Neumann bands. HV 210±25.

Probably group I. About 6.9% Ni, 0.45% Co, 0.16% P.

HISTORY

A mass of 11.62 kg was found in 1887 by Edward J. Sweet, while he was prospecting in the Silver Crown District, Laramie County. The exact position was

Figure 1641. Silver Crown (Vienna no. F6406). A 4 mm thick part slice showing fusion crust and heat-affected α_2 zone above. Several troilite-graphite nodules, one of which is partially ablated away. Deep-etched. Scale bar 20 mm.

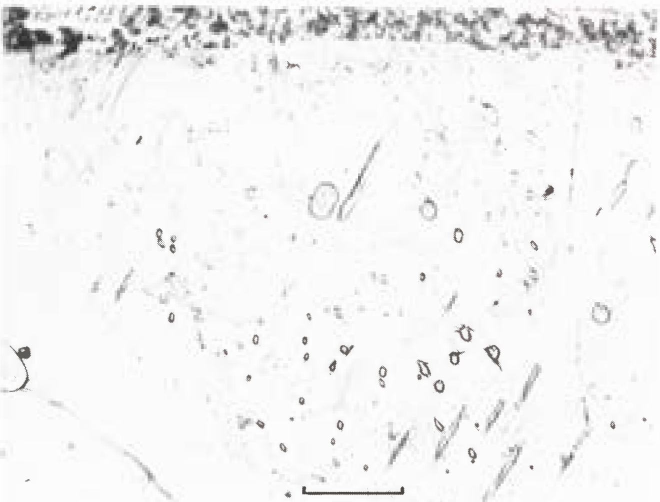

Figure 1642. Silver Crown (U.S.N.M. no. 522). Multilayered metallic fusion crust above. Heat-affected A zone with fused rhabdites solidified by heat conduction from the cold interior. Unequilibrated α_2. Etched. Scale bar 100 μ.

"almost in the center of town(ship) 14, range 70, between the middle and south fork of Crow Creek, about 21 miles west of Cheyenne. . . . When found it was half buried in decomposed granite and earth. After being a ten days' wonder among the miners at the camp, it was sent to Dr. Wilbur C. Knight, of Cheyenne, Wyoming, through whom it came into my possession."(Kunz 1888)

When Kunz' mineral collection was sold, the entire specimen came to Vienna (Brezina 1896: 234) where it was cut extensively and described (ibid.: 287). Kunz (1888) had presented woodcuts of the exterior shape and of a small macroetched section; later Mauroy (1913: plate 1) gave a photomacrograph of a somewhat larger section.

COLLECTIONS

Vienna (5.75 kg main mass and 1.3 kg slices), London (583 g), Budapest (253 g, perhaps lost in 1956), Chicago (176 g), Berlin (172 g), Washington (169 g), Prague (158 g), New York (136 g), Rome (100 g), Bonn (74 g), Stockholm (74 g), Strasbourg (72 g), Ottawa (49 g), Vatican (48 g), Yale (46 g), Greifswald (41 g), Harvard (26 g).

ANALYSES

Only an erroneous analysis (8.31% Ni, trace cobalt) by McIlvain (Kunz 1888) is known. From the structure, the present author would estimate the following composition: 6.9±0.2% Ni, 0.45% Co, 0.16±0.03% P, a significant amount of carbon, and Ga, Ge and Ir trace elements corresponding to chemical group I, such as Canyon Diablo.

DESCRIPTION

According to Kunz (1888) and Brezina (1896), the mass somewhat resembled an anvil and was 17.5 cm high, 14 cm thick at the center and 19 cm at the widest point.

Its general state of preservation is excellent. There are well developed regmaglypts 12-25 mm in size and locally there are deeper, cylindrical pits where troilite nodules have been removed by ablational melting. Much of the surface is covered with a black or slightly rusty fusion crust. Sections

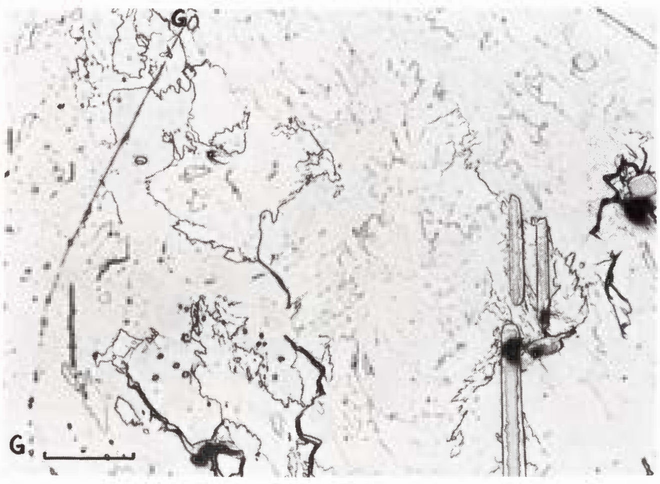

Figure 1643. Silver Crown (U.S.N.M. no. 522). Distinct unequilibrated α_2 structure in the heat-affected A zone. Several large fused rhabdites and a curved subboundary, G-G. Zigzagging phosphide melts below. Etched. Scale bar 100 μ. See also Figures 50, 99 and 152.

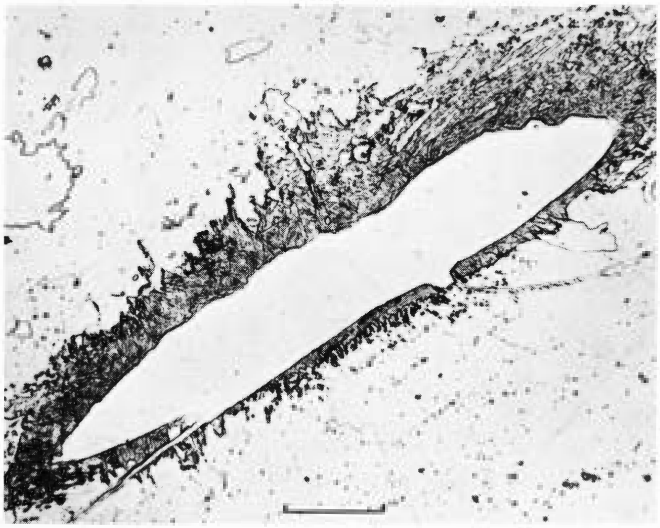

Figure 1644. Silver Crown (U.S.N.M. no. 522). A taenite body in the heat-affected α_2 zone. Upon reheating carbon diffused outwards and, upon cooling, formed bainitic reaction rims (black). Etched. Scale bar 40 μ.

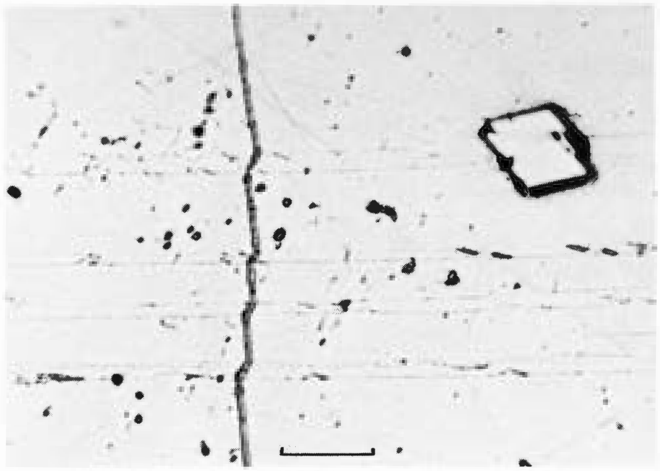

Figure 1645. Silver Crown (U.S.N.M. no. 522). Horizontal sets of Neumann bands displace a subboundary and a large rhabdite crystal. Etched. Scale bar 40 μ.

through it reveal an exterior magnetite-wüstite layer, generally 50-100 μ thick, underlain by a laminated sheet of dendritic metallic melts. Each of the metallic layers is 20-50 μ thick; they cover the surface irregularly, wedging out and reappearing, frequently with tiny 1-25 μ nodules of oxides embedded in them. Some late terrestrial corrosion products are also present in the fusion crust.

Under the fusion crust follows the heat-affected α_2 zone which ranges from 1.5-2.5 mm in thickness; the zone is relatively narrow at the bottom of the regmaglypts but may increase to 6 mm under protruding knobs where the heat influx simultaneously came from different sides. The phosphides are micromelted in the exterior half of the α_2 zone and rhabdite pools here are often interconnected by 1-5 μ wide, intercrystalline fissures filled with phosphide melts. The tarnished taenite has lost its color and appears pure yellow; its solid solution-carbon is now found in the surrounding kamacite where it has created 10-30 μ wide, dark-etching bainitic rims. Neumann bands are not visible in the α_2 zone; otherwise the zone very much resembles that of the fresh fall Yardymly. The hardness of the α_2 phase is 195±15. In the recovered transition zone from α_2 to the unaffected interior, the hardness drops to 170±10 (hardness curve type IV).

Etched sections display a coarse Widmanstätten structure of short, bulky ($\frac{L}{W} \sim 8$) kamacite lamellae with a width of 2.1±0.4 mm. In addition, local grain growth has created almost equiaxial kamacite grains, 10-20 mm across. The kamacite is rich in subboundaries decorated with 0.5-2 μ rhabdites. Neumann bands are common (undecorated), but additional cold-work with folding and shearing is also present. Thus, many rhabdites are shear-displaced their own thickness, 5-20 μ. The microhardness of the kamacite ranges from 185 to 235, reflecting the different degrees of deformation.

Taenite and plessite cover 2-5% by area. The taenite has tarnished rims and is very hard, due to deformation. Typical, 40 μ wide taenite ribbons are 425±15. Acicular and comb plessite fields are common, whereas pearlitic and spheroidized fields were not detected. However, they may be present in cohenite-bearing specimens.

Schreibersite occurs as 0.5 mm thick rims around troilite, and occasionally as 0.2-1 mm thick and centimeter-long lamellae in the kamacite. It is also common as 20-100 μ wide grain boundary precipitates. Most schreibersite crystals are brecciated and frequently the fissures are impregnated by terrestrial corrosion products. Rhabdites occur in profusion as 5-25 μ thick tetragonal prisms and as smaller units on the subboundaries.

Troilite nodules are present in some sections as oval inclusions 5-20 mm across. Unfortunately, none were available for a detailed examination. Carlsbergite, the chromium nitride CrN, occurs as scattered, oriented platelets, 20 x 1 μ in size, in the kamacite. Cohenite, graphite and silicates were not detected in the U.S. National Museum specimen but may be present elsewhere.

Silver Crown is a well-preserved coarse octahedrite which is related to Campo del Cielo, Seeläsgen and Canyon Diablo. It is no doubt a member of the chemical group I.

[J.T. Wasson (personal communication 1974): Group I with 6.98% Ni, 81.6 ppm Ga, 320 ppm Ge and 1.7 ppm Ir.]

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

36 g part slice (no. 522, 6 x 2 x 0.4 cm)
133 g part slice (no. 3071, 7.5 x 5 x 0.5 cm)

Siratik, Senegal, now Mali, Africa

Approximately 14½°N, 11½°W

Previously classified as a stony-iron (Fletcher 1888: 71), or a nickel-poor ataxite (Brezina 1896; Cohen 1905; Hey 1966). Numerous specimens examined by the author are, however, artificial