several authors. In some specimens, e.g., Moscow’s 400 g plate, 3 x 2 mm phosphate inclusions are located in the troilite. Material from a Chicago specimen was identified by Olsen & Fredriksson (1966) as sarcopside (Fe,Mn,Ca)₃(PO₄)₂ with minor amounts of graftonite, with the same empirical formula, but calcium-free.

In U.S. National Museum no. 224, small rounded grains 30-300 μ across in the kamacite phase are tentatively identified as phosphates. They appear under optical examination as semi-transparent, grayish-blue to green, and weakly anisotropic, showing thin, parallel laths. If the identification is valid, the phosphates are not restricted to occur within the troilite, but may occur distributed in the metal phase. Chromite occurs locally as 100 μ euhedric bluish-gray hard crystals associated with schreibersite.

Augustinovka is structurally and chemically a typical group IIIIB, closely related to Chupadero and Grant. It is an old, weathered fall which has developed shales of sizes comparable to Canyon Diablo and Santa Apolonia. Specimens labeled Verkhne Dnieprovsk are in every detail identical to Augustinovka, e.g., bandwidth, e-structure, plessite development, amount and morphology of schreibersite-troilite, phosphate minerals and weathering. For these and reasons given above it is concluded that the two meteorites are in fact identical, having only reached the scientific world at different times and through different channels.

Specimens in the U.S. National Museum in Washington:
- 65 g part slice, A. (no. 224, 3 x 2.5 x 0.8 cm)
- 34 g part slice, A. (no. 2639, 3 x 3 x 0.5 cm, figured by Brezina and Cohen 1886-1906: plate 37, figure 4)
- 82 g shale fragments, A. (no. 960, largest is 2 cm thick)
- 127 g laminated shale, A. (no. 2641, 2 cm thick)

Avče, Slovenia, Yugoslavia
46°6'20"N, 13°41'E; 150 m

Hexahedrite, H. Kamacite single crystal larger than 10 cm. Neumann bands.
Group IIA, judging from the structure, with about 5.5% Ni and 0.2% P.

HISTORY
Although Avče is a well-documented fall, hardly anything is known about it. Berwerth (1908), who published a preliminary account, believed it to be an octahedrite, but in later catalog entries the hexahedral nature of the mass is indicated.

According to Berwerth (1908) a mass of 1,230 g was observed to fall at 8:45 a.m. on March 31, 1908, near Avče, in the Isonzo Valley. The coordinates given by him are, however, erroneous, and the locality is not in Italy, as believed by Baldanza (1965), Hey (1966) and Buchwald (1968a: map no. 11). Avče (Italian Auza), was then a village on the Austrian side of the Austrian-Italian border; it is now a part of Yugoslavia.

Johann Kolenc of Avče, who was working in a field at the time of fall, reported the “cannon ball” to the gendarmerie and said that he had heard a detonation in the air, immediately followed by a whistling and sizzling noise. This lasted more than two minutes, and then suddenly he saw that a 5 cm thick branch of an apple tree was broken and soil was scattered from the impact site only 40 m away. Believing it to be a cannon ball fired from the Italian side of the border, Kolenc dared not approach the site until the afternoon; he excavated the mass from a depth of about 30 cm. It is interesting to note that Kolenc neither saw the meteoritic trail nor any kind of light phenomena; consequently he had only imprecise ideas of the direction from which the mass came. The noises were, however, said to come from the northwest. Unfortunately, Berwerth, who acquired the entire meteorite for the Vienna collection, never instituted a thorough search for other witnesses so that the above report is all that is known today of the circumstances of fall.

COLLECTIONS
Vienna (main mass).

CHEMICAL ANALYSES
An inappropriate analysis may be found in Doelter’s Handbuch der Mineralkemi, volume 3: 575: 5.10% Ni, 95.17% Fe, 0.36% Co, 0.12% Si.

DESCRIPTIONS
The eminent mass, which is a softly rounded wedge or crescent, weighs 1.23 kg and measures approximately 11 x 6 x 5 cm in three perpendicular directions. The entire surface is covered with a black fusion crust of iron oxides to which virtually no damage has occurred. On the section examined, the thickness of the crust ranges from 0.05 to 0.8 mm. The direction of the fine striae in the crust indicates that the convex surface was the apex during the flight, while the opposite concave or flat part was the posterior surface. The apex and the adjacent sides are smooth while the posterior shows shallow but distinct channels.

Figure 275. Avče (Vienna H 10,029). A full slice through the smoothly rounded hexahedrite, shown in Figure 41. The heat-affected α₂ zone is seen as a continuous matte rim. Etched. Scale bar 20 mm.
regmaglypts 10-15 mm across. In size and ablative sculpture Avca considerably resembles the octahedrite Bushman Land.

Avca was sectioned and a 5 mm thick, full slice removed, whereupon the mass was restored to its original shape. The section shows that Avca is a normal hexahedrite with Neumann bands extending from side to side. Only in the heat-affected α₂ zone do the bands disappear. This zone is 2 mm wide along most of the periphery, but increases to 4 mm under "horns" and decreases to 1 mm under the troughs. No troilite or schreibersite inclusions were noted on the 7 x 4 cm section (Vienna no. 10029), but since it was deep etched it was not suited for further examination.

Avca appears to be a normal hexahedrite related to Negrillos and Bruno. Since it belongs to the few authentic hexahedrite falls, detailed examination and analysis are recommended.

---

**Avoca, Western Australia**

30°56'S, 122°16'E

Medium octahedrite, Om. Bandwidth 0.90±0.15 mm. Partly recrystallized e-structure. HV 225±10.

Group IIIAB, judging from the structure, with about 8.8% Ni and 0.3% P.

**HISTORY**

A mass of 37.85 kg was found in 1966 slightly buried in the soil. The finder, Nobby Nixon, who donated the meteorite to the Western Australian Museum, reported the place of discovery to be 2.5 miles on bearing 300° from Avoca Downs Homestead, which is itself situated four miles east of Randell Siding on the Trans-Australian Railway. A preliminary note appeared in Hey (1966: 628), while a full description, with photographs of the exterior and of a macroetched slice, was given by McCall (1968a).

**COLLECTIONS**

Perth (about 36 kg main mass), London (225 g), Kalgoorlie School of Mines.

**CHEMICAL ANALYSES**

McCall (1968a) reported a partial chemical analysis, giving 8.65% Ni and 0.52% Co. De Laeter (1972) and Rosman (1972) reported 8.86% Ni, 21.9 ppm Ga, 51 ppm Ge, and 1.26 ppm Zn.

**DESCRIPTION**

According to McCall, the mass is a highly pitted, complete meteorite formed as an elongated, ridged cone with a flattened, slightly concave base. It is about 38 cm long and 10 cm thick, while the width varies irregularly, being 25 cm on the average. A visit to the site of discovery did not reveal further fragments.

For the present study the sample in London (B.M. 1967, 254; 225 g) was kindly put at my disposal. Avoca is a medium octahedrite with somewhat swollen, long (W ~ 25) kamacite lamellae with a width of 0.90±0.15 mm. On the deep-etched sections there is an unusually strong oriented sheen giving the meteorite a beautiful appearance. The kamacite is rich in subboundaries, decorated with less than 1 μ phosphide precipitates; some boundaries have moved 5-10 μ, having served as the nucleation site for the precipitates. In several places around martensitic and duplex, dark-etching plessite fields, microrhabdites occur in large numbers, densely decorating the slipplanes of the kamacite.

The kamacite shows a mixture of Neumann bands, hatched structures and recrystallized grains. The recrystallized grains are equiaxial, 5-25 μ wide, and cover on the average 15% by area. They are concentrated in the Ni- and P-depleted zones around the larger schreibersite lamellae, along α-α grain boundaries and along some Neumann bands. There are Neumann bands which along their entire length have recrystallized to 10-25 μ units, apparently randomly oriented. The microhardness is 225±10.

---

Figure 276. Avoca (B.M. 1967, 254). A general view of the macrostructure. A large skeleton crystal of schreibersite (S) is enveloped in swathing kamacite. Etched. Scale bar 2 mm.

Figure 277. Avoca (B.M. 1967, 254). Shock-annulled kamacite which shows recrystallization, particularly in the shear-zone (z-z). Cloudy taenite and fissured schreibersite (S) are also visible. Etched. Scale bar 100 μ.
Taenite and plessite cover about one third by area, as comb and net plessite, and as dark-etching fields with duplex interiors. A typical field 500 μ across will exhibit a cloudy yellowish-blue rim zone (HV 235±25) followed by indistinct tempered martensitic structures (HV 325±25). Next follows tempered, dark martensite, developed parallel to the bulk Widmanslätt structure (HV 290±20); finally easily resolvable duplex α + γ structures occur with 1-2 μ γ-particles and hardnesses similar to that of the adjacent kamacite lamellae. In the cloudy taenite, a densely spaced grid is distinctly seen. The distance between parallel lines is less than i μ; the lines are apparently not parallel to 111 γ, which seems to exclude the possibility that they are decorated slipplanes in the austenite.

Schreibersite is very common, both as imperfect Brezina lamellae and as 20-100 μ wide grain boundary precipitates. The Brezina lamellae are typically 6 x 1 or 12 x 0.3 mm in size and enveloped in 0.5-1.8 mm wide rims of swathing kamacite. The phosphides have often grown around a nucleus of a different material, either chromite, troilite or phosphate(?), and have developed more or less asymmetrically around these. Sometimes a 50 μ euhedric chromite crystal forms the nucleus for a 200 μ troilite crystal that again has served as the nucleating substrate for schreibersite. Rhabdites proper are absent, but there is a large population of less than 0.6 μ angular microrhabdites. The bulk phosphorus composition is estimated to be 0.30±0.05%.

Troilite was seen as substantial nodules by McCall (1968) when he examined the main mass. On the sections studied here, it is only present as 50-300 μ globules or

Figure 278. Same as Figure 277, but with slightly crossed polars. The recrystallized kamacite grains develop better contrasts. Scale bar 100 μ. See also Figure 218.

Figure 279. Avoca (Brit. Mus. 1967, 254). Neumann bands with partial recrystallization. Etched. Scale bar 50 μ. See also Figure 218.
Avoca — Babb’s Mill, Blake’s Iron

3 x 0.3 mm bars, normally associated with schreibersite as stated above. The troilite nodules were once monocristalline, but are now polycrystalline aggregates of 10-200 μm grains, presumably due to deformation plus recrystallization. Chromite occurs as euhedral 20-60 μm crystals. Two unidentified minerals were also noted. One was a strongly anisotropic mineral, forming smoothly rounded spindles, e.g., 100 x 30 μm across, perhaps a silicate (olivine?). The other, which was only weakly birefringent and coke-gray in reflected light, formed subangular crystals 200-400 μm across. This is possibly a phosphate like sarcopside and grafitite. Carbides, graphite and daubreelite were not detected.

All minerals are distorted and brecciated. The large schreibersite lamellae may be shear-displaced along several consecutive steps, each displaying 5-20 μm shear. Recrystalization is particularly common in the adjacent kamacite, which has been extensively strained and is nickel- and phosphorus-depleted.

No fusion crust and no heat-affected α2 zone were present on the section. There was no hardness gradient toward the surface, so it is estimated that at least 5 mm has been lost by exposure to the terrestrial environment. Corrosion penetrates the grain boundaries and has formed 5-50 μm wide limonitic veinlets. The α-phase of the near-surface plessite fields is selectively transformed, and the brecciated schreibersite lamellae are recemented by corrosion products.

Avoca is a medium octahedrite which is related to Spearman, Bartlett, Lenarto and Caperr. It appears to be a member of the resolved chemical group III, transitional between IIIA and IIIB. It is unrelated to the other Western Australian octahedrites Haig, Duketon, Yari, Youndegin and Mount Dooling. The details of the structure suggest that Avoca, after a normal primary cooling, was exposed to a cosmic shock that hardened the kamacite and produced Neumann bands and hatched structures. A later, perhaps associated, reheating annealed the kamacite and taenite and even partially recrystallized the kamacite and troilite. There are no indications of artificial reheating.

**Figure 280. Avoca (B.M. 1967, 254). An unidentified mineral (black), possibly a phosphate. It is associated with recrystallized troilite (T) and fissured schreibersite (S). Etched. Slightly crossed polars. Scale bar 50 μm.**

### Babb’s Mill, Blake’s Iron, Tennessee, U.S.A.

**Approximately 36°16’N, 82°52’W; 300m**

Ataxite, D. Polycrystalline; 30 μ kamacite grains with dispersed 10 μ taenite particles.

Anomalous. 11.8% Ni, 0.74% Co, less than 0.05% P, 0.20 ppm Ga, 0.03 ppm Ge, 1.7 ppm Ir.

**HISTORY**

Before 1896, a mass of about 135 kg (300 lbs) was plowed up in Greene County, not far from where the Babb’s Mill, Troost’s Iron, fragments were discovered. The meter-long cigar-shaped mass had been entirely covered by earth. In 1876 it was sent by General J.T. Wilder to the International Exhibition at Philadelphia, and later was acquired by W.P. Blake who described it thoroughly (1886). Through Kunz and the banker Zwiklitz, the big meteorite was donated to the Vienna collection, where Brezina (1896: 234, 297, 301) described it briefly. Brezina stated that the structure was similar to Troost’s Iron and he had no hesitation in combining the two in one fall, Babb’s Mill.

Cohen (1905: 104) and his coworkers Weinschenk and Fahrenhorst analyzed the irons and were surprised to find a big difference between them in nickel content. However, since the structures were believed to be completely identical, and the fall of two nickel-rich ataxites within the same county appeared unlikely, it was concluded that all masses belonged to the same fall. A secondary result of the investigation showed that Blake’s Iron had the same chemical composition at both ends of the 90 cm long body, see below.

Berwerth (1918) gave a photomicrograph and compared the structure to that of Hammond and Rafterti. He concluded that Blake’s Iron was an artificial product that had been regarded as being of meteoric origin because of its high nickel content.

The Prior-Hey catalog (1953) and Hey (1966: 35) listed Blake’s Iron and Troost’s Iron under a common entry. Buchwald (1967a) gave a photomacrograph of an etched slice and made it apparent that Blake’s Iron was genuinely cosmic and completely different from Troost’s Iron. The new analysis by Schaudy et al., see below, which confirms the previously known analyses, proves beyond doubt that Blake’s Iron is of cosmic origin and different from Troost’s Iron.

**COLLECTIONS**

Vienna (main mass of 128.7 kg; 360 g slices).

**DESCRIPTION**

The mass is shaped like a somewhat flattened cigar, measuring 91 x 25 x 15 cm. The surface is scaly and rusty, but in general smoothly curved towards the two pointed ends, from which small samples have been cut. No fusion crust and no heat-affected zones were detected. Locally,
there are shallow depressions but regmaglypts proper cannot be distinguished. In numerous places the surface is exfoliating, producing irregular flaky shales that disintegrate into dust. Blake (1886) gave a vivid and precise description of the surface deterioration which may also be applied to a number of other meteoritic irons exposed for a period of time to the terrestrial environment and the chlorine content of ground waters. It is estimated that Blake's Iron has lost more than 10 mm on the average by weathering, thereby losing most of its atmospheric sculpturing.

Etched sections display an homogeneous ataxitic structure without visible inclusions of troilite, schreibersite, graphite or silicates. High magnification reveals a polycrystalline mosaic of kamacite and taenite grains. The kamacite grains are 10-50 μ across and relatively equilibrated, judging from the grain boundary angles. In the grain boundaries, or occasionally in the grain interiors, large numbers of irregular amoeba-like particles of cloudy brown taenite particles occur. They are typically 4-15 μ across and display reentrant angles and internal 1 μ kamacite windows. The taenite particles cover roughly 20% by area.

A texture like this is found within restricted areas of some octahedrites. For example, Seneca Falls, Maria Elena, Reed City and Hammond display similar α-γ mixtures in taenite lamellae and plessite fields which have been severely altered due to shock-reheating.

There are also meteorites which, like Blake's Iron, are entirely converted to polycrystalline α-γ aggregates, notably Rafúti, Washington County, Santiago Papasquiaro, Juromenha and Smithland. It appears that Bab's Mill, Blake's Iron, although different from these in composition, has been exposed to similar conditions in space, involving shock-reheating and annealing. Chemically Blake's Iron is anomalous, with no close relatives. Somewhat distant relatives are Nordheim, Guffey and Deep Springs; all, however, are of an entirely different structure.

Artificial reheating has probably not occurred. There are distinct hammer- and chisel-marks locally, but these are only superficial.

**Babb's Mill, Troost's Iron, Tennessee, U.S.A.**

36°16'N, 82°52'W; about 300 m

Nickel-rich ataxite, D. A few 10 μ wide α-spindles in a duplex α + γ matrix, HV 233±10.

Anomalous. 17.5% Ni, 0.95% Co, 0.12% P, 18 ppm Ga, 40 ppm Ge, 35 ppm Ir.

Many samples of this meteorite have been artificially heat-treated and even forged.

**HISTORY**

A mass of about 6 kg was plowed up near Babb's Mill, Greene County, some time before 1842. It passed through several hands before being described by Troost (1845). A smaller iron of 2.7 kg from the same locality was described by Shepard (1847). In a later list of meteorites (Shepard 1872) it is implied that this latter mass already had been found in 1818. The confusing descriptions by Troost, Shepard and many later authors have been discussed by Buchwald (1965; 1967a), who reexamined several of the disputed specimens and presented photomacrographs and

**BABB'S MILL, BLAKE'S IRON -- SELECTED CHEMICAL ANALYSES**

Blake (1886) reported chlorine qualitatively, and Cohen (1905: 111) found 0.02% Cl in one end, 0.01% in the opposite end. It has always been assumed that chlorine in iron meteorites is of cosmic origin and bound in the mineral lawrencite. As indicated in the present book and in Buchwald (1971c), the major part of the chlorine must have been introduced by the terrestrial ground waters; the cosmic mineral lawrencite does not exist.

<table>
<thead>
<tr>
<th>References</th>
<th>Ni</th>
<th>Co</th>
<th>P</th>
<th>C</th>
<th>S</th>
<th>Cr</th>
<th>Cu</th>
<th>ppm Zn</th>
<th>Ga</th>
<th>Ge</th>
<th>Ir</th>
<th>Pt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fahrenhorst in Cohen</td>
<td>11.09</td>
<td>0.76</td>
<td>tr.</td>
<td>300</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ibid, the opposite end</td>
<td>11.01</td>
<td>0.72</td>
<td>tr.</td>
<td>300</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schaudy et al. 1972</td>
<td>11.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0.203 0.029 1.7
micrographs. He showed (i) that the 6 kg mass had been thoroughly heat treated and somewhat forged early in its history; (ii) that the 2.7 kg mass had survived intact, but its present location was not known; and (iii) that the 136 kg meteorite, which was plowed up in 1876 in the same county, had nothing to do with the first two specimens. This large cigar-shaped mass, which has become known as Babb's Mill, Blake's Iron, has been treated separately on page 284. When Blake's Iron appeared, the previously known specimens were often distinguished as Troost's Iron, probably after a suggestion by Farrington (1915: 41). It has now been proposed (Buchwald 1967a) to separate the two falls completely and use the entries Blake's Iron and Troost's Iron respectively.

Owen & Burns (1939) and Owen (1940) performed X-ray experiments on a sample from Harvard. They found no reflections from the γ-phase, and only blurred reflections from the α-phase, originating from the α₂ cell. Owen drew very far-reaching conclusions on the cooling mechanism of meteorites, conclusions based in part on this investigation. As shown by Buchwald (1965; 1967a), he was unfortunate in working with material which had been artificially heat treated.

Figure 282. Babb's Mill, Troost's Iron (Amherst). A 1.8 kg undamaged sample, relocated at Amherst. Scale bar in cm.

BABB'S MILL, TROOST'S IRON - SELECTED CHEMICAL ANALYSES

<table>
<thead>
<tr>
<th>References</th>
<th>percentage</th>
<th></th>
<th>ppm</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>Ni</td>
<td>Co</td>
<td>P</td>
<td>C</td>
<td>S</td>
<td>Cr</td>
<td>Cu</td>
<td>Zn</td>
<td>Ga</td>
</tr>
<tr>
<td>Cohen 1892</td>
<td>17.7</td>
<td>1.26</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fahrenhorst, in Cohen 1905</td>
<td>17.30</td>
<td>1.67</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bothwell in Hey 1966</td>
<td>17.7</td>
<td>0.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smales et al. 1967</td>
<td>17.4±0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wasson 1967a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crocket 1972</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Perry (1944: plate 26) presented two photomicrographs which exhibited the undamaged structure of Troost's Iron very well, but he nevertheless believed (ibid.: 71) that the structure was a result of an artificial reheating when the meteorite was tested for silver. Schultz & Hintenberger (1967) measured the content of the noble gases and their various isotopes. From these data, Voshage (1967) estimated the cosmic ray exposure age to be 15-30 million years.

COLLECTIONS

The following data represent an attempt to identify individual samples from the 6 and 2.7 kg masses:

From the reheated 6 kg mass: London (1,989 g endpiece; 70 g slice), Harvard (793 g; 202 g), Chicago (203 g on four samples; at least no. 906 of 47 g heat treated), Washington (132 g on five samples), Copenhagen (63 g), Vienna (20 g).

From the undamaged 2.7 kg mass: Amherst (1,857 g), Tempe (184 g), Stockholm (66 g), New York (58 g), Berlin (47 g), Tübingen (33 g).

Unidentified samples: Göttingen (69 g; 24 g), Calcutta (65 g), Vatican (64 g), Paris (55 g), Prague (45 g), Moscow (19 g; 17.5 g), Budapest (33 g), Dresden (3.6 g), Denver (unknown weight).

DESCRIPTION

It is not known how far apart the two individual specimens of 6 and 2.7 kg were found, and the location is only known in very general terms. Thus, the coordinates given above are for a locality 10 miles north of Greeneville on Lick Creek, which appears to be close to the place of find.

A. Original undamaged material: Shepard's 2.7 kg mass. As will be seen from the above listing of specimens in collections, it has been possible to reidentify the major part of the two original meteorite fragments. Of special interest is the 1,857 g Amherst sample which for generations had been "lost," but now has been rediscovered in Amherst, Massachusetts. This constitutes two-thirds of Shepard's original undamaged mass of which he (1847) reproduced a woodcut which helps in the reidentification. To mark the occasion of his 70th birthday on January 29, 1874, Professor Charles Upham Shepard, Sr., arranged for his extensive collections, which were deposited in Wood's
Cabinet of Amherst College and used for instruction, to be purchased by the college; this had been previously discussed and agreed upon. Among these collections was part of Shepard's meteorite collection, then one of the largest assembled. Evidently, the Shepard mass of Troost's Iron was incorporated on that occasion into the Pratt Museum of Amherst College.

The mass, Figure 282, is an endpiece measuring 9 x 7 x 5.5 cm and exhibiting an 8 x 7 cm cut and polished face. It now weighs 1,857 g; one of the larger specimens cut from it and still preserved is the 7 x 7 x 0.6 cm full slice (184 g) in Tempe. The Amherst sample shows several corroded regmaglypts, 10-15 mm in diameter, on one side, while its opposite side is almost flat and more corroded. A 0.5-1 mm thick crust of terrestrial oxide shales is to be found here, and there are numerous 1-2 mm pockmarks, indicating that the original fusion crust was lost to corrosion. There are no hammer marks or other indications of artificial reheating. This was confirmed by an examination of the 58 g slice in New York (no. 98) which is a part slice of 46 x 30 x 3 mm through the Amherst mass. The meteorite is selectively corroded, the α-phase always having been transformed to limonite before the coexisting γ-phase. In places the weathering forms shallow pits, 5-10 mm deep, of rhythmic concentric shales of increasing oxide content nearer the surface. It appears that on the average no more than 2 mm of the surface has been lost to corrosion.

Etched sections have an ataxitic appearance. At low magnification only scattered lenticular sulfide inclusions, 0.1-4 mm in size, are seen. They occur with a frequency of about one per 3 cm² and consist of monocrystalline troilite, in which parallel daubreelite bars are exsolved. The troilite shows a few lenticular twins from slight deformation, but it is non-melted and non-recrystallized. The daubreelite lamellae are 5-100 μ wide and constitute 5-20% by volume of the sulfides. Within the same troilite nodules, the daubreelite lamellae are mutually parallel, but adjacent troilite crystals show random orientations of the daubreelite. From this it may be concluded that the troilite crystals are randomly oriented with respect to the metallic matrix.

High magnification reveals that the metallic matrix is a very uniform and a pure duplex α + γ mixture. The γ-phase forms 1-4 μ wide veinlets, and the α-phase forms 2-6 μ wide veinlets with a fine cellular network of subboundaries, clearly visible in the near-surface corroded regions and also revealed by good polishing and etching. A few spindle-shaped kamacite needles occur scattered throughout the α + γ matrix. They are 10±4 μ wide (W ~ 10) and are often nucleated by a minute 1-5 μ daubreelite particle. These spindles occur with a very low frequency (about 70 per cm²), a significant difference from South Byron, which Troost's Iron resembles in chemical composition. Both the α + γ matrix and the kamacite spindles are uniformly oriented in a Widmanstätten pattern, proving that the parent austenite phase was monocrystalline. The microhardness, integrating over several α + γ units, is 233±10, suggesting some cold-deformation without annealing.
No phosphides were detected at all. The analytical result of 0.12% P is probably a little high. All phosphorus appears to be in solid solution, particularly in the α-phase. The rhabdites reported by Klein (1906: 134) apparently are misinterpreted kamacite spindles. No graphite, carbides or silicates were identified. At high magnification, numerous sulfide blebs were detected, in addition to those revealed under the stereomicroscope. The sulfides consist of monocrystalline troilite with daubreelite bars and range in size from 2 mm to 30 μ. They normally exhibit a 1-10 μ wide rim of swathing kamacite.

The samples discussed above represent genuine, undamaged material from Troost's Iron, judging from the exterior appearance and from the macro- and microstructure. There is one more slice (no. 2211 of 33 g; Figure 286. Babb's Mill, Troost's Iron (A.M.N.H. no. 98). A lenticular troilite inclusion with multiple deformation twinning (white). Also several parallel daubreelite lamellae (gray). Polished, Crossed polars. Scale bar 40 μ.

Figure 287. Babb's Mill, Troost's Iron (Copenhagen no. 1876, 38). The spotted diffuse appearance is due to artificial reheating in a forge. Etched, Scale bar 200 μ.

Buchwald 1967a: figure 17) of this undamaged material in Tübingen. It is particularly interesting because of the attached label, written by its original owner, C.U. Shepard: “This mass was never heated: all the others now in collections have been; and some of them have been worked, C.U.S. Vienna. Aug. 25, 1862.” The note provides independent proof of the existence of the two types of Troost's Iron, one undamaged, the other artificially reheated.

B. Artificially reheated material: Troost's 6 kg mass. Samples of this material have been thoroughly described and illustrated by Buchwald (1967a). The 1,989 g specimen in the British Museum (no.18490) is a 12 x 8 x 6 cm endpiece from Troost's 6 kg mass. It exhibits remnants of 1-3 cm wide regmaglypts and there are indications of a

Figure 288. Detail of Figure 287. The artificial reheating has created unequilibrated structures with diffuse taenite particles. Etched. Scale bar 25 μ.

Figure 289. Babb's Mill, Troost's Iron (B.M. no. 18490). A section near the flat-hammered surface. The action was fortunately not so violent that the corroded crust spalled off. When the meteorite was heated by a smith, the metallic part transformed to austenite, but in the crust, converted by corrosion to limonite with γ-particles, this transformation was impossible. Thus the original microstructure is preserved "fossilized" in the crust. The black limonite represents ferrite and the white irregular particles are the original austenite. High temperature oxidation has penetrated slightly along the austenite grain boundaries; the austenite grains themselves transformed, upon cooling, to α₂. Scale bar 25 μ.
small amount of preserved fusion crust. Were it not for the hammering and reheating, the meteorite would be in excellent condition. There are several flat surfaces, of 6 x 2, 3 x 3 and 3 x 2 cm, produced by a sledge hammer. A section through one of these areas clearly shows the effect of hammering at elevated temperatures: the diffuse \( \gamma \)-particles have been rotated into ghost-lines, subparallel to the worked surface to a depth of a few millimeters.

The specimens in the U.S. National Museum apparently all belong to this category. Etched sections show diffuse networks and irregular patches of light- and dark-etching matrix. At higher magnification, it is seen that the original \( \gamma \)-particles are partly or wholly dissolved in the matrix. The microhardness is 280±20, rather high and irregular. Terrestrial corrosion products are decomposed to metal and high temperature oxides which form intricate intergrowths.

Structural details may be explained by assuming that the original fine-grained \( \alpha + \gamma \) structure was partially transformed to a polygonal network of austenite grains by heat treatment at about 900-1000° C. Since time and temperature were too limited to effect a complete homogenization, traces of blurred non-dissolved \( \gamma \)-particles are still visible. When the sample was again cooled, the austenite transformed back to typical granulated \( \alpha_2 \) with a characteristic high hardness (∼280).

**C. Conclusion.** The undamaged 2.7 kg Troost’s Iron block, originally in Shepard’s possession, is an ataxite with 15.7% Ni and sufficiently low phosphorus content and high cooling rate to exhibit no phosphides. Although it is closely related chemically to South Byron, the low number of kamacite spindles, the absence of phosphides and the easily resolvable \( \alpha + \gamma \) matrix clearly distinguish Troost’s Iron from South Byron.

The artificially heat-treated 6 kg block shows diffuse structures similar to those present in Smithland and Skookum Gulch. Samples of this block are of little use in structural discussions, but they are probably good enough for chemical and gas-analytic work, providing that the reheating is taken into account.

**Specimens in the U.S. National Museum in Washington:**
- 38 g part slice (no. 98, 6 x 4 x 0.2 cm)
- 20 g part slice (no. 1578, 4 x 3.2 x 0.3 cm) (neighbor slices
c- 32 g part slice (no. 2646, 3.7 x 3.2 x 0.5 cm)
- 20 g part slice (no. 3233, 4 x 3.5 x 0.3 cm) neighbor to no. 98
- 20 g filings and 2 g polished section (no. 962, originally in Shepard’s collection)

All specimens apparently have been reheated artificially to 900-1000° C.

**Bacubirito, Sinaloa, Mexico**

\[ 25°44'N, 107°52'W \]

Finest octahedrite, Off. Bandwidth 0.08±0.02 mm. Neumann bands. HV 220±20.

Anomalous. 9.70% Ni, 0.76% Co, 0.16% P, 18 ppm Ga, 31 ppm Ge, 4.9 ppm Ir.

**HISTORY**

A large mass was reported by Barcena (1876), Castillo (1889) and others as having been discovered in the state of Sinaloa. However, only fragments of the mass and incomplete descriptions had reached the scientific world by 1900 (see, e.g., Wülfing 1897), but in 1902 H.A. Ward set out to locate, photograph and obtain material from the giant specimen. His detailed account (1902a) of the journey to the distant place and of the excavation, provided with many photographs, will remain a classic in the meteoritic annals. He gave the maximum dimensions as 13’1” in length, 6’2” in width and 5’4” in thickness, and estimated the weight as 50 tons, comparable to that of the largest Cape York specimen which Peary had brought to New York in 1897, and which was then still stored in the Brooklyn Navy Yard. Angermann (1903) stated that Bacubirito was discovered in 1863, and gave a better estimate of its weight, 25 tons.

Bacubirito was found partly covered by soil in a cornfield on the Ranchito farm seven miles due south of the old mining town of Bacubirito; corresponding annals. He gave the maximum dimensions as 13’1” in length, 6’2” in width and 5’4” in thickness, and estimated the weight as 50 tons, comparable to that of the largest Cape York specimen which Peary had brought to New York in 1897, and which was then still stored in the Brooklyn Navy Yard. Angermann (1903) stated that Bacubirito was discovered in 1863, and gave a better estimate of its weight, 25 tons.

Little has been written about Bacubirito. Cohen (1903a; 1905) reviewed the literature and presented an analysis, and Merrill (1916a) noted that “the mass has been protected from vandalism by the building over it of a stone house with doors of iron grating, through which the occasional visitor may view the monster.” Brezina & Cohen (Atlas 1886-1906: plate 30), Brezina (1896) and Perry (1944) presented photomicrographs.

In 1959 the meteorite was moved about 150 km to the capital of Sinaloa, Culiacan, where it presently is exhibited in the museum, Centro Civico Constitucion. Unfortunately,
it was neither weighed nor cut on that occasion and the label still reads "50 tons weight," which is based on the old estimates by Eastman (1892), Wülfing (1897) and Ward (1902a). According to my estimate, after remeasuring the mass in Culiacan, the weight is 22 tons, ±10%, see Figures 31 and 290.

COLLECTIONS

Chicago (1,795 g), Mexico City, Facultad de Ingenieria (1,122 g; labeled Chupaderos, but in fact a 9 x 7 x 6 cm edge piece of Bacubirito), London (1,107 g), Washington (997 g), Rome (891 g), Harvard (493 g), Berlin (365 g), Tubingen (304 g), Mexico City, Institute of Geology (227 g), Tempe (210 g), Helsinki (188 g), Ottawa (136 g), Budapest (112 g), Prague (105 g) and Yale (98 g). Some Bacubirito specimens are still listed under the previously common synonym: Ranchito.

DESCRIPTION

The mass is shaped like a huge human ear with a total length of 425 cm. The width varies between 100 and 185 cm, and the thickness between 30 and 75 cm. At one end the mass tapers out to a broad wedge, and at the opposite end it forms a massive, rectangular chunk, about 70 x 100 cm in size. Due to the intricate, curved shape of the "ear," it is difficult to calculate the exact volume. However, from my drawings and photographs I estimate the projected area to be 7.5 m², and by subdividing the mass and calculating each section, I arrive at a total volume of 2.80 m³ ±10%, corresponding to a weight of about 22 tons.

Many large meteorites split in the atmosphere and produced showers, e.g., Campo del Cielo, Cape York, Chupaderos and Sikhote-Alin, but Bacubirito only started to break up. This is apparent by a deep, 200 cm long crack which runs almost horizontally through the mass. At one end it is not possible to insert a knife blade, but at the other end the opening is wide and deep enough to admit an arm. A crescent-shaped area, 100 x 50 cm at the side of the crack, probably indicates where a fragment separated in the atmosphere, but this has never been found. That the huge, flat mass successfully penetrated the atmosphere as an entire unit is probably due to the very limited amount of inclusions, if one may extrapolate from what is observed on the available, near-surface specimens, and on the exposed surface.

The surface is slightly corroded and is covered by shallow regmaglypts, 5-15 cm in diameter, but no heat-affected α₂ zone could be found on the several sections.

BACUBIRITO - SELECTED CHEMICAL ANALYSES

<table>
<thead>
<tr>
<th>References</th>
<th>Ni</th>
<th>Co</th>
<th>P</th>
<th>C</th>
<th>S</th>
<th>Cr</th>
<th>Cu</th>
<th>Zn</th>
<th>Ga</th>
<th>Ge</th>
<th>Ir</th>
<th>Pt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hildebrand in Cohen</td>
<td>9.40</td>
<td>0.98</td>
<td>0.12</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>175</td>
<td>133</td>
<td>&lt;1</td>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>Smales et al. 1967</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wasson 1968, pers. comm.</td>
<td>9.62</td>
<td>0.76</td>
<td>0.16</td>
<td>305</td>
<td>40</td>
<td></td>
<td></td>
<td>17.7</td>
<td>31.9</td>
<td>4.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moore &amp; Lewis 1968</td>
<td>9.78</td>
<td>0.76</td>
<td>0.16</td>
<td>305</td>
<td>40</td>
<td></td>
<td></td>
<td>17.7</td>
<td>31.9</td>
<td>4.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hildebrand’s analysis is good for its day, and better than Whitfield’s in Ward (1902a), which is not quoted here. However, the analysis is not good enough for calculating the average composition.
Schreibersite occurs as 100-200 μ monocrystalline blocks in the α-lamellae intersections, as small grain boundary precipitates, and as 5-20 μ angular blebs in the plessite. Rhabdites were not observed. Troilite is scarce; one inclusion of 1 mm was seen, and a few 50-500 μ in diameter. They are anisotropic, monocrystalline or with a few twin sparks from mild plastic deformation, and have parallel 10-100 μ wide daubreelite bands and minor amounts of schreibersite precipitated along the rim. No cohenite, graphite or chromite was observed. No indications of significant cosmic reheating are present.

Bacubirito, although somewhat similar to Ballinoo and group IIIC, is different in having long, straight bundles of alpha lamellae of an almost martensitic appearance, and in having fewer phosphide and sulfide inclusions. No other similar iron is known. While most of the structurally and chemically anomalous irons are small, often very small, masses, a few others of large size are known, notably Mbosi, Santa Catarina and Tucson.

Undamaged specimens have straight lamellae with a bandwidth of 80±20 μ and a length of 1.3 mm. Neumann bands are present, even in kamacite areas as small as 10-20 μ. The kamacite has abundant subgrain boundaries and a microhardness of 220±20. Thin taenite lamellae (~8 μ) line the kamacite and are locally substituted by similarly sized schreibersite. The plessite is a micro-Widmanstätten arrangement with acicular kamacite, or it may be developed as comb plessite or as open net plessite where the individual taenite blebs are concave islands 10-20 μ across. Schreibersite is common in these fields as blocks of the same size. The black taenite, under high magnification, is seen to be composed of duplex α + γ, difficult to resolve. Between the interior duplex fields and the sharply defined 2 μ wide yellow taenite borders, intercalated narrow martensitic areas are often present. The microhardness of the duplex plessite fields ranges from 200 to 300, depending upon the actual morphology.

Figure 293. Bacubirito (Tempe no. 17a). This near-surface section shows extensive coldwork due to hammering and chiseling. The metallic matrix is work hardened and the schreibersite crystals (S) are faulted. Etched, Scale bar 20 μ. See also Figure 23.

Figure 294. Bacubirito (Tempe no. 17a). Plessitic field, showing various taenite and plessite islands in kamacite. Numerous schreibersite particles (S) are also present. Etched. Scale bar 50 μ.

Figure 295. Bacubirito (Tempe no. 17a). Detail of a plessite field with schreibersite crystals (S). Even in the small taenite wedges there are steep nickel gradients as may be seen from the structure. Etched. Scale bar 20 μ.
Specimens in the U.S. National Museum in Washington:

<table>
<thead>
<tr>
<th>Type</th>
<th>Mass</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>619 g fragment</td>
<td>392</td>
<td>9 x 5 x 3 cm</td>
</tr>
<tr>
<td>139 g fragment</td>
<td>392</td>
<td>7 x 4 x 1 cm</td>
</tr>
<tr>
<td>172 g endpiece, forged</td>
<td>1121</td>
<td>5 x 3 x 2.5 cm</td>
</tr>
<tr>
<td>65 g fragment</td>
<td>264</td>
<td>5 x 4 x 1 cm</td>
</tr>
</tbody>
</table>

Bagdad, Arizona, U.S.A.

34°32'N, 113°25'W; 700 m

Medium octahedrite, Om. Bandwidth 1.10±0.10 mm. e-structure. HV 275±15.

Group IIIA. 8.17% Ni, 0.45% Co, 0.12% P, 19.8 ppm Ga, 39.7 ppm Ge, 6.8 ppm Ir.

HISTORY

A mass of 2.2 kg was found in March 1960 by Donald Stout along Burro Creek, 20 km west of Bagdad, Mohave County. It was acquired by Arizona State University and was reported in the Meteoritical Bulletin (No. 25, 1962) and by Moore & Tackett (1963). Bunch & Keil (1971) reported the chromite inclusions to be almost stoichiometric FeCr₂O₄ with very minor contents of MnO, ZnO, Al₂O₃, V₂O₃, TiO₂ and MgO; these oxides totaled about 0.65 weight percent.

COLLECTIONS

Tempe (main mass), Copenhagen (38 g).

DESCRIPTION

Bagdad is a well-rounded mass with a few flat to concave faces, giving the impression of an orange having been packed too tightly with other oranges in a box. Its maximum dimensions are 10.5 x 8.5 x 7 cm, and the weight as recovered was 2,205 g. Most of the fusion crust has spalled off due to terrestrial corrosion, but no severe attack has developed. The meteorite still preserves a smoothly rounded outline, broken only by two shallow regmaglypts on what was probably the rear side during atmospheric entry. Avé and Bushman Land are other small irons with a similar exterior morphology.

The meteorite has been opened with four parallel cuts, yielding two endpieces and three slices with a total of 240 cm² exposed interior. The etched sections display a medium Widmanstätten structure of straight, long (W ~ 30) kamacite lamellae with a width of 1.10±0.10 mm. They also show a beautiful, oriented sheen, which at high magnification is seen to be due to a marked, crosshatched e-structure. The shock-hardened kamacite displays the hatching to varying degrees, but the microhardness varies little, being 275±15. The kamacite has subboundaries decorated with 0.5-μm rhabdites. In addition to the shock-transformation, some plastic distortion has occurred locally along a shear plane through the middle of the mass, visibly offsetting the Widmanstätten lamellae 0.5-1 mm. The same plastic deformation has also opened a few fine fissures along the phosphide-filled grain boundaries; these are now filled with 0.1 mm wide veinlets of terrestrial oxides. It appears that all deformation, including the fissures, dates back to preatmospheric collisions, probably of very old age. As support for this opinion, it may be added that the atmospheric heat alteration zone abruptly stops at one particular fissure, showing that the fissure was...
already there and prevented a smooth heat-flow inwards from the surface.

Taenite and plessite cover about 25% by area, mostly as comb and net plessite and as wedges with martensitic or duplex interiors. As usual, the kamacite cells within the open-meshed comb and net plessite fields have participated in the shock-transformation and possess hatched e-structures. A typical plessite wedge, 500 μ across, will show a tarnished taenite rim (HV 360±15) followed by a light-etching, martensitic transition zone (HV 425±25). Then follow dark-etching, “annealed” martensite (HV 375±25) and duplex, poorly resolvable α + γ mixtures (HV 325±20). Finally, the central interior may show easily resolvable α + γ mixtures, with hardnesses only slightly above that of the adjacent kamacite lamellae.

Schreibersite occurs as 10-50 μ wide grain boundary precipitates, and as 5-50 μ irregular bodies inside the plessite fields. Locally, a population of very small (< 0.5 μ) rhabdites may be found in the e-matrix.

Four small, but well developed chromite crystals were identified in the sections. A cubic crystal, 0.75 mm in diameter, was situated inside a 1 mm troilite nodule. Two other chromite crystals have grown as thin plates, 2 x 0.05 and 2 x 0.085 mm in size, respectively. Both have served as nucleation sites for irregular rims of 0.4-3 mm wide troilite. The fourth chromite crystal, 0.5 mm across, has well-developed cubic faces and is situated directly in the e-phase with no foreign precipitates. No troilite inclusions have been observed other than those developed around the three chromite crystals. The troilite is monocrystalline, but exhibits spindle-shaped twin lamellae from slight plastic deformation. A little schreibersite has precipitated upon it.

The heat alteration zone is 1.5-2.5 mm wide, but increases to 6 mm under the highly convex parts of the surface. Schreibersite crystals which happen to be present in the exterior 50% of the visibly altered zone were micromelted and rapidly solidified to fine-grained eutectic structures. Very little of the meteorite has been lost by weathering as indicated by microscopic remnants of the fusion crust preserved in numerous places. The oxidic fusion crust consists of an outer 25-50 μ single-phase, purplish-gray oxide, probably magnetite, and of an interior 25-50 μ thick gray oxide (wüstite), in which cubic skeleton crystals, 1-3 μ across, of the exterior oxide are dispersed.

This small 2.2 kg meteorite probably lost a large fraction of its initial mass during atmospheric penetration. Buchwald (1961b) estimated that Thule lost 1.6 mm per second in the later part of its flight. Assuming 20 seconds as the ablation time for Bagdad it may have had the original dimensions 17 x 15 x 13 cm, corresponding to a preatmospheric mass of about 13 kg. Though this is only a rough estimate it serves to indicate that initially small iron meteorites may have difficulty surviving atmospheric passage.

The little corroded meteorite provides a good opportunity for examination of the behavior of the kamacite lamellae and the taenite ribbons during the brief reheating in the atmosphere. The hardness of the shock-hardened kamacite drops from an interior, unaffected level of 275±15 to 185±8 in the α2 zone. The α2 phase consists of serrated units, 5-25 μ in size, fine-grained as always when the α2 zone forms upon shock-deformed iron meteorites (hardness curve type I). Taenite was examined in congruent positions of various 40 μ wide ribbons, located at different depths below the surface. It is tarnished and shows irregular brown to blue patches below the α2 zone, but displays a mosaic structure in the inner part of the α2 zone. In the exterior part of this zone, the taenite is light-etching and structureless. It is surrounded here by 10-25 μ bainitic-martensitic zones (HV 245±10), presumably due to carbon diffusing away from it, and it shows a pronounced decrease from 360±15 in the interior to 195±5 at the transition to the α2 zone. From there it appears to increase to 240±10 at the surface. These hardness curves are typical for a large...
number of octahedrites, as will be noted in the pertinent descriptions. Compare also page 56.

Baghdad is a shock-hardened medium octahedrite which is related to Kayakent, Augusta County and Cumpas. Chemically it is a typical group IIIA.

Bahjoi. See Bendegó

---

Bahjoi, Moradabad District, India
28°29'N, 78°30'E

Coarse octahedrite, Og. Bandwidth 1.50±0.25 mm. Neumann bands. HV 165±10.

Group I. 7.65% Ni, 0.48% Co, about 0.2% P, 70 ppm Ga, 265 ppm Ge, 2.3 ppm Ir.

HISTORY

A fireball was observed at Delhi and in several neighboring districts at 9:30 p.m., July 23, 1934. Some cowherds in the village Chandankati Muazam, which is about 15 km southwest of Moradabad and 2.5 km northwest of Bahjoi, saw a flashing, bluish-white light and heard three low sounds as if guns were fired. Other eyewitnesses believed they saw the fireball split into at least two portions about 20° above the horizon. On the 25th the cowherd witnesses found one mass of 10.3 kg slightly buried in a grazing land, but other pieces were never recovered. The meteorite was delivered to the local police station, then cut into two equal portions in the railway workshops, and a very irregular triangular slab with protruding knobs and ears, it was cut and broken open; thus, some specimens in collections show fractured surfaces which are not original. The mass is covered with irregular regmaglypts 2 to 3 cm in diameter, and the paper-thin, black magnetite skin shows delicate striae and warts. Locally, 1 cm deep funnel-shaped holes indicate where troilite-graphite nodules have partly melted out. If, as reported by some eyewitnesses, the meteorite fragmented during entry, it must have done so at a high altitude because the recovered mass is completely covered with ablation grooves and fusion crust.

The etched section has a well-developed Widmanstätten pattern with a bandwidth of 150±0.25 mm. Neumann bands are common, and the microhardness of the kamacite ranges from 165±10 in the interior through a minimum of 145 to 190±10 in the reheated α₂ rim zone (hardness curve type II). Plessite fields, which cover about 5% by area, have pearlitic, spheroidised or martensitic interiors, or are decomposed to an ultrafine aggregate of α and γ particles. Some repeat the Widmanstätten array on a finer scale. In a few plessite fields some carbide roses were noted, evidently haxenite intergrown with taenite, kamacite and schreibersite.

Schreibersite is present as 0.5-1 mm rims around the nodules, and as 25-50 μ wide grain boundary precipitates. Rhabdites occur everywhere as 2.5 μ broken and often sheared needles. The bulk phosphorus content is estimated to be 0.20±0.03%.

Complex troilite-graphite-silicate nodules, 1-3 cm in diameter, appear to be common. These are surrounded by almost continuous rims of schreibersite. Upon the schreibersite, cohenite has precipitated and formed a 0.1-0.5 mm wide rim. Apparently most of the other minerals eventually grew around the silicates, which are 25-100 μ subhedral grains of olivine and pyroxene in irregular clusters, and which are enveloped in 50-100 μ wide graphite rims. The silicates have micron-sized inclusions of metal and troilitie. Troilitie, schreibersite and cohenite surround more or less concentric silicate-graphite complexes, but graphite is additionally present as 25-100 μ cliftonite crystals or almost spherical grains composed of radiating sheaves of graphite crystals. The graphite occurs in troilitie, kamacite, cohenite and schreibersite and must therefore be an early component. The troilitie is monocrystalline and unshocked.

The heated rim zone of α₂ is about 2 mm thick. It is interesting to observe that numerous cracks and fissures extend from the crust-covered surface through the α₂ zone to a depth of 2-3 mm. At least some of these fissures were previously filled with schreibersite but, as this melted and was partly swept away, the opening could accept oxide melts. These fill the cracks very irregularly to about a depth of 1 mm.

---

BAHJOI — SELECTED CHEMICAL ANALYSES

<table>
<thead>
<tr>
<th>References</th>
<th>Ni</th>
<th>Co</th>
<th>P</th>
<th>C</th>
<th>S</th>
<th>Cr</th>
<th>Cu</th>
<th>Zn</th>
<th>Ga</th>
<th>Ge</th>
<th>Ir</th>
<th>Pt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobb 1967</td>
<td>7.35</td>
<td>0.48</td>
<td></td>
<td>154</td>
<td>77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Wasson 1970a</td>
<td>7.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.9</td>
</tr>
</tbody>
</table>
Immediately under the metallic fusion crust is a 10-20 µ thick carburized zone. The reason for this is, no doubt, that the metallic melt, produced from the carbon-rich meteorite, had sufficiently high carbon activity to carburize a thin surface layer, even if the time was short. Upon cooling, this zone developed the usual bainitic-martensitic structures. It may also be observed how the bluish-gray taenite of the interior, in the αS zone changes to a yellow-etching taenite. An adjacent, 10 µ wide kamacite zone has simultaneously transformed to martensite, proving that carbon has redistributed itself by diffusion from the taenite ribbons. The microhardness of the martensitic areas is as high as 375, in contrast to 190 of the normal, heat-affected αS zone.

Bahjoi is structurally and chemically a typical group I iron, closely related to, e.g., Odessa and Toluca.

Specimen in the U.S. National Museum in Washington:
497 g endpiece (no. 1807, 7 x 5 x 3 cm)

Bald Eagle, Pennsylvania, U.S.A.
41°12'N, 77°7'W

Medium octahedrite, Om, Bandwidth 0.80±0.15 mm, Distorted Neumann bands.
Group IIb, 9.41% Ni, 0.52% Co, 0.27% P, 18.1 ppm Ga, 37.1 ppm Ge, 0.018 ppm Ir.

HISTORY
A mass of 3.2 kg (7 lbs, 1 oz) was discovered in 1891 on the east side of Bald Eagle Mountain, seven miles south of the Park Hotel, Williamsport, in Lycoming County. “At this point the mountain comes down to the edge of the Susquehanna River, a road bed for the Philadelphia-Erie Railway having been cut in the mountain side. Numerous transverse depressions occur in the mountain side and some of these are filled with loose sandstone, varying in size from a few cubic inches to several cubic feet in volume.” In one of these depressions some Italian laborers, while excavating stones for a stone-crusher, found the mass in a bed of loose stones about 2 m deep. When several attempts to break it or cut it with a cold chisel failed, the mass was discarded. Some weeks later it was donated to Bucknell University, where it was described by Professor W.G. Owens (1892) who also contributed the exact data quoted above on the circumstances of discovery. On modern maps the locality is seen to be seven miles west-southwest rather than south of Williamsport. The corresponding coordinates are given above.

Ward (1902b) borrowed the mass for examination and cutting. He provided a photograph of the exterior and a photomacrograph of an etched slice, and assumed the meteorite to be quite unique in shape as well as in structure. Ward (1904a: plate 7) reprinted the photograph of the slice. Farrington (1915: 47) and Stone & Starr (1967) reviewed the literature. The latter also presented three new photographs of the exterior, demonstrating how the meteorite strikingly resembled a small deformed or club foot. Noting that the meteorite was for a while feared lost in the Bucknell Museum fire of August 27, 1932 (it was recovered intact), they speculated that the difference between the original weight and the current weight might be due to the evaporation of water from the specimen or by some damage from the fire. This is, however, not the case. The cumulative weight of known samples cut from the Bald Eagle mass is 3,005 g, see below. If we assume a loss of 2 g per cm² cut and polished section we will have to add (5 x 4) + (8 x 12) x 2 = 232 g, and this brings us reasonably close to the reported original weight, which was 7 lbs, 1 oz, equal to 3.3 kg (Owens 1892). However, 7 lbs, 1 oz is only 3.2 kg.

COLLECTIONS
Bucknell University Museum, Lewisburg, Pennsylvania (2,639 g), Chicago (300 g), Berlin (51 g), London (15 g of filings).

Figure 300. Bald Eagle, Main mass in the Bucknell University Museum, Lewisburg, Pennsylvania. Scale bar 30 mm.

<table>
<thead>
<tr>
<th>References</th>
<th>percentage</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ni</td>
<td>Co</td>
</tr>
<tr>
<td>Moore 1969, pers. comm.</td>
<td>9.56</td>
<td>0.52</td>
</tr>
<tr>
<td>Scott et al, 1973</td>
<td>9.25</td>
<td></td>
</tr>
</tbody>
</table>