lost except one piece of some 80 kg (175 pounds), which was relocated in Yorktown, Texas.

The collector responsible for the shipment was a Mr. Haberle who was employed by a railroad company and assisted in the construction of water tanks on the line to California. He had evidently acquired the numerous samples, estimated to consist of five or six large masses and a large number of smaller ones, shortly after Foote (1891) had announced the discovery and initiated the systematic search for samples around Meteor Crater. Mr. Haberle was, however, less successful than Foote in transforming the meteorites into money since he was unable to sell them, and they were finally abandoned in a storage building which was later demolished.

Canyon Diablo (Wickenburg), Arizona, U.S.A.

33°58'N, 112°44'W

A mass of 250 g was preliminarily listed as Wickenburg by A.D. Nininger (1940) and Nininger & Nininger (1950). The size, shape and structure suggested, however, that the Wickenburg mass was a transported sample from the vicinity of Meteor Crater. This was confirmed by Wasson (1968) who reported 7.07% Ni, 82.6 ppm Ga, 321 ppm Ge and 1.8 ppm Ir, values which are identical to Canyon Diablo, within analytical and sampling error.

COLLECTIONS

London (50 g), Tempe (47 g). The 1.5 kg sample listed by Hey (1966: 519) as being in Chicago is a specimen of the *chondrite* Wickenburg (stone).

Cape of Good Hope, Cape Province, South Africa

Approximately 33½°S, 26°E

Nickel-rich ataxite, D. Duplex $\alpha + \gamma$ with broad twins and a few 30 μ wide α-spindles. HV 244±8.

Group IVB. 16.32% Ni, 0.84% Co, 0.12% P, 0.20 ppm Ga, 0.06 ppm Ge, 36 ppm Ir.

HISTORY

A mass of about 300 pounds (135 kg) was found in the Dutch Cape Colony on a plain east of the Great Fish River close enough to the coast so that it was assumed to be part of a ship's anchor carried away by the Kaffers (Barrow 1801: 225-26). According to Dankelmann (1805) the mass had been transported to Capetown by the soldier-adventurer Carl Sternberg, from whom Dankelmann acquired a fragment of 84 kg on behalf of the Dutch government. Sternberg told that he had found the mass himself in 1793 about five miles from the coast between two small rivers, Karega and Gasoga. Although Dankelmann assumed these to be nonexistent, they may be located on Barrow's map (1801: volume 1) as Kareeka and Kasowka, about 750 km straight east of Cape of Good Hope, near the present-day Port Alfred. Dankelmann did not believe Sternberg's story and discovered later by actual travel and inquiry in the region that the mass had been found by a farmer, Royen, long before 1793, farther west, but still about 700 km east of Cape of Good Hope. The locality was on a plain northeast of Swartkops River between Sondags and Boesmans Rivers. Since this version of the find appears to be the most plausible, the corresponding coordinates are given above. Royen's father had from time to time dislodged fragments from the mass and forged hoes and plowshares, and the family regretted very much that they had disposed of their iron lump, since iron was difficult to acquire.

While 84 kg arrived in Haarlem in 1803 and was described as meteoritic by Marum (1804), another large fragment came to London where Tennant (1806) confirmed its meteoritic nature by finding 10% Ni in an analysis. The mass proved to be malleable and very ductile so that James Sowerby in 1814 was able to forge a slightly curved sword, 60 cm long and 3.5 cm wide, from it. The sword was presented to Czar Alexander in gratitude for Russia's stand against Napoleon. "The blade has been hammered at a red heat, without admixture, out of a single piece of this iron, an inch thick, ground and polished. Its spring was given it by hammering when cold. The haft was lengthened by welding on a small piece of steel. It was found to work very pleasantly, the whole operation taking about ten hours." (Sowerby 1820). An attempt in 1937 to trace the whereabouts of this sword resulted in a negative reply from Dr. J. Astapowitsch, of the Sternberg Astronomical Institute of Moscow (Khan: 1944). In the British Museum, however, a few specimens (no. 15143; no. 1935, 47) of forged material from Sowerby's experiments are still preserved.

Stromeyer (1817) found cobalt in the iron, and Chladni (1819: 317; 331-33) reviewed the older literature. In the nineteenth century, Cape of Good Hope was

CAPE OF GOOD HOPE – SELECTED CHEMICAL ANALYSES

References	percentage Ni	Co	P	ppm C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Wöhler in Rose 1864a	16.22	0.73	0.15									
Fahrenhorst in Cohen 1900a; 1905	15.67	0.95	0.09	300		400	300					
Goldberg et al. 1951	16.48								0.43			
Nichiporuk & Brown 1965											8.5	11.8
Schaudy et al. 1972	16.92								0.198	0.059	36	

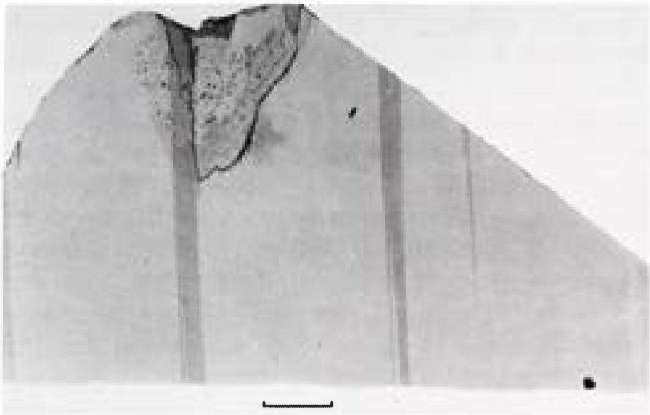

Figure 489. Cape of Good Hope (U.S.N.M. no. 985). An etched slice which exhibits the characteristic diffuse streaks of the group IVB ataxites. The streaks are parallel, and often thin out over a length of several centimeters. The dark spotted appearance at top is due to terrestrial corrosion. Etched. Scale bar 10 mm. S.I. neg. M-1369.

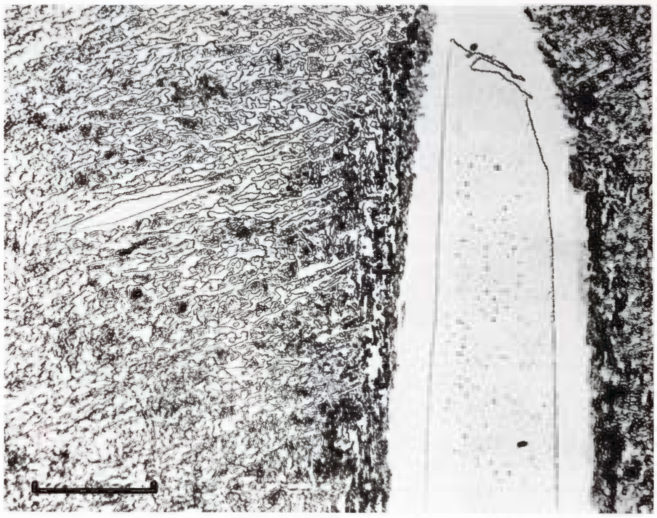

Figure 490. Cape of Good Hope (U.S.N.M. no. 985). A kamacite spindle with its case of cloudy taenite. Unresolvable transition zones lead to a duplex $\alpha + \gamma$ matrix of the kind which Perry called "paraeutectoid." Etched. Scale bar 40 μ. (Perry 1944: plate 22.)

examined by numerous other workers, among whom Rose (1864a: 70, plate 3) and Baumhauer (1867: 3 figures) gave important information. The significant mass of 66.2 kg in Baumhauer's private collection was, after his death, purchased by B. Stürtz in Bonn (Stürtz 1890), together with numerous other meteorites and minerals. The mass was later acquired for the Hungarian National Collection (Tokody & Dudich 1951: 66; Ravasz 1969: 22).

Cohen (1900a) gave an extensive summary of previous work and added several observations and a new analysis. Brezina (1896) printed a picture, and Berwerth (1918) gave two photomicrographs. Further structural pictures were presented by Vogel (1928) and Perry (1944: plate 22). Owen & Burns (1939) determined the lattice parameter of the α-phase as 2.8630A but found the γ-phase diffuse. Reed (1965b) found an average concentration of 17% Ni in the fine plessite. Schultz & Hintenberger (1967) measured the concentrations of noble gases, and Voshage (1967) found a cosmic ray exposure age of 630±70 million years.

COLLECTIONS

Budapest (66 kg + two slices: 900 g), Vienna (947 g), Berlin (744 g), London (318 g), Paris (230 g), Washington (207 g), Göttingen (205 g), Amherst (200 g), Chicago (196 g), New York (119 g), Harvard (101 g), Stockholm (88 g), Bonn (86 g), Rome (69 g), Tempe (64 g), Ann Arbor (59 g), Cape Town (55 g), Strasbourg (48 g), Tübingen (47 g), Ottawa (36 g), Calcutta (26 g), Oslo (13 g, worked), Chicago (12 g).

DESCRIPTION

The mass received by van Marum (1804) was a flattened fragment of 84 kg with the dimensions 64 x 41 x (9-12) cm. It was corroded and covered by rounded cavities, 4-9 cm in diameter and 1-3 cm deep, as is well shown in the two lithographs reproduced by Baumhauer (1867). No fusion crust or heat-affected rim zone are preserved.

Etched sections display a dull, fine-grained structure which is resolvable with a 45x objective. When larger sections are available, it is observed macroscopically that the structure is composed of parallel, 1-30 mm wide bands which reflect the light differently. Only one section is known to the author (Vienna, a 500 g specimen) that shows two intersecting sets of parallel bands. A close examination of the various bands shows that they consist of an ultrafine, rhythmic aggregate of α and γ particles elongated parallel to the bands visible to the naked eye. The irregular, vermicular taenite particles are generally 0.5-2 μ wide, and separated by somewhat broader, winding channels of kamacite. The structure, which is more fine-grained than in Kokomo, is perhaps best observed in the corroded rim zones where the taenite phase is distinctly yellow on a background of purplish-gray oxides originating from selectively corroded kamacite. In the optical microscope no structural difference between "dull" and "bright" bands can be observed; Baumhauer (1867) had already found that their chemical composition was the same. Also the hardness is the same, within experimental error, being 244±8. The author is inclined to think that the bands are parts of the original austenite monocrystal that were in twin position and which, therefore, now possess slightly different orientations of the α and γ grains from band to band. However, since the grains are so fine-grained, this hypothesis is difficult to prove for Cape of Good Hope.

A few kamacite spindles, typically 30 x 300 μ, occur scattered through the matrix. They have 3-5 μ wide, yellowish taenite rims that gradually merge with the surrounding plessite. Some of the spindles have tiny schreibersite nuclei, others have daubreelite or troilite nuclei, but many are apparently inclusion-free. However, it is believed that inclusions are present above or below the plane of the section.

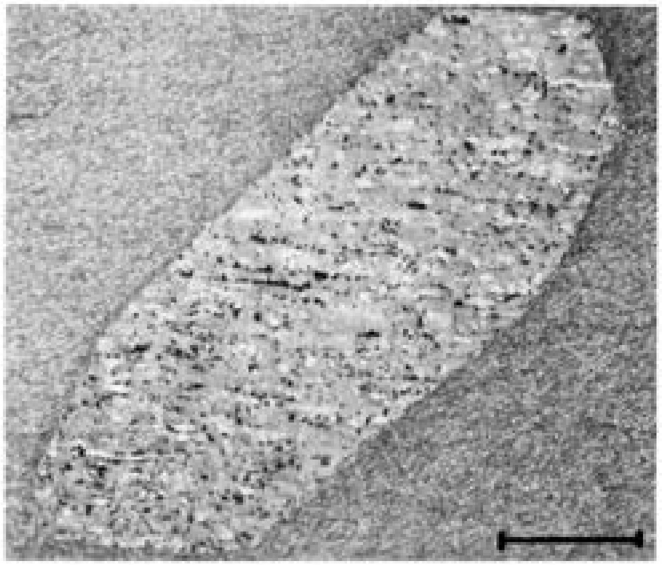

Figure 491. Cape of Good Hope (U.S.N.M. no. 985). A troilite nodule with parallel daubreelite lamellae. The nodule is distorted and the troilite has recrystallized. Etched. Slightly crossed polars. Scale bar 300 μ. S.I. neg. M-1369B.

Schreibersite is present as numerous minute grains, 0.5-2 μ across, in the plessitic matrix, where it substitutes for taenite. It is further present as a discontinuous rim, a few micron wide, around some troilite inclusions and as 5-25 μ angular blebs inside some of the kamacite spindles.

Troilite is visible with the naked eye as 0.1-3 mm nodules that occur about one per 25 cm^2. A typical nodule contains about 30% daubreelite by area, which is precipitated in parallel, 3-30 μ wide bands. Due to slight plastic deformation all daubreelite lamellae are distorted and broken, and the troilite has recrystallized to 2-25 μ units. Graphite has been reported, but the observation could not be supported by this study.

Cape of Good Hope is a severely corroded, nickel-rich ataxite with twin bands. It resembles Chinga, Tlacotepec and Kokomo but is somewhat more fine-grained than the last mentioned. It is chemically a typical group IVB iron.

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

18 g part slice (no. 36, 3 x 1.5 x 0.6 cm)
183 g part slice (no. 985, 9 x 5 x 0.5 cm; Shepard no. 10)
6 g part slice (no. 2706, 6 x 0.8 x 0.15 cm)

Caperr, Comodoro Rivadaviva, Argentina
45°17′S, 70°29′W

Medium octahedrite, Om. Bandwidth 1.00±0.15 mm. ϵ-structure. HV 280±15.

Group IIIA. 8.58% Ni, 0.24% P, 22.8 ppm Ga, 47.2 ppm Ge, 0.24 ppm Ir.

HISTORY

A mass of iron was reported to lie in the middle of a barren Patagonian plain and to be regarded by the Indians with superstitious awe (Musters 1871: 101). The 250-pound mass (114 kg) was located in 1896 and was transported to the La Plata Museum by its founder and director F.P. Moreno (1898: 304, plate 34). A fragment and a cast were brought to London where the meteorite and its history were described by Fletcher (1899). The locality of the find was revised by Fletcher (1904b) and, in modern Argentinean publications (e.g., Radice 1959), it is given as Caperr in Lomas del Caicheque, southeast of Arroyo Verde, on the plateau south of Rio Senguerr.

Kantor (1921) gave two photographs of the exterior and of an etched section, while Radice (1948; 1959: 51) reviewed the literature and discussed the confusion as to the circumstances of discovery.

COLLECTIONS

Main mass in La Plata Museum (about 113 kg), Chicago (370 g), London (270 g), Paris (99 g), Washington (36 g), Vatican (3 g).

DESCRIPTION

The 113 kg main mass in the La Plata Museum is an irregular, shield-shaped mass with average dimensions of 46 x 32 x 25 cm and with a cut and polished face of 16 x 7 cm at one end. Regmaglypts 2-4 cm across and 1 cm deep are common, and some of them are developed as elongated grooves, e.g., 10 x 2 cm and 1 cm deep. A cylindrical hole, 2 cm across, indicates where a troilite nodule was ablated away. In the troughs of many regmaglypts warty and striated fusion crusts are preserved, albeit slightly weathered. Locally, an indistinct Widmanstätten grid has been developed due to terrestrial corrosion, but the general state of preservation is very good.

Etched sections display a medium octahedral structure of long ($\frac{L}{W} \sim 15$) kamacite lamellae, 1.00 mm wide. Plessitic fields occupy 35-40% by area. The kamacite is, due to shock above 130 k bar, converted to the typical hatched ϵ-structure, but the previous subgrain boundaries of the ferrite phase with $< 1\ \mu$ precipitates are still visible. The shock-hardened kamacite displays hardness values of 280±15. It shows a distinct drop toward the heat-affected α_2 zone.

CAPERR – SELECTED CHEMICAL ANALYSES

References	percentage Ni	Co	P	ppm C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Smales et al. 1967						7.7	140	<1	24.6	49		
Crocket 1972											0.20	7.3
Scott et al. 1973	8.58								21.0	45.3	0.24	

An old analysis by Fletcher (1899) showed 0.24% P, which is in harmony with the following structural observations.

The plessite is mostly developed as martensite (HV 390±30) with individual laths parallel to the overall Widmanstätten structure. Poorly resolvable $\alpha + \gamma$ mixtures (HV 340±15) are also common, as are cellular plessite where 20-50 μ kamacite cells have 5-20 μ taenite blebs in the grain boundaries (HV 300±20). The kamacite cells show independently oriented ϵ-structures.

Schreibersite occurs centrally in the α-lamellae as bodies, 0.3-0.5 mm wide and 1-2 mm long. They are monocrystalline but brecciated; they have sometimes developed around a small nucleus of an unidentified bluish isotropic mineral which might possibly be chromite or phosphate. Schreibersite is further common as an island chain in front of taenite and plessite. The individual grains are typically 10 x 50 μ in size and situated 5-20 μ outside the present austenite boundary. A similar morphology is characteristic of several other high-nickel medium octahedrites, e.g., Apoala, Bear Creek and Narraburra.

Troilite occurs as 1-2 cm scattered nodules with some schreibersite along the rim and a 1-1.5 mm outer zone of swathing kamacite. Reichenbach lamellae, up to 30 mm long, are common and occur with a frequency of one per seven cm^2. Cohenite and graphite are not present.

Inspection of the main mass shows that all crests and edges of regmaglypts are somewhat distorted and overfolded as though worked or hammered by the natives. This interpretation was confirmed upon examination of the small slice in the U.S. National Museum: the plessite and kamacite are heavily folded, and the schreibersite crystals brecciated, but no effects of working are visible below depths of 1-2 mm.

Caperr is a shock-hardened medium octahedrite with the characteristic garland schreibersite morphology which is otherwise mostly associated with group IIIB irons, such as Apoala and others.

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

36 g part slice [no. 1542, 4 x 2 x 1.5 cm, part of the original type specimen of Fletcher (1899)].

Cape York, Melville Bay, Northwest Greenland

Ahnighito: 76°4′N, 64°58′W; 24 m

Medium octahedrite, Om. Bandwidth 1.20±0.20 mm. Neumann bands. HV 180-315.

Group IIIA. 7.84% Ni, 0.50% Co, 0.15% P, 0.02% C, 1.3% S, 19 ppm Ga, 36 ppm Ge, 5 ppm Ir.

Synonyms: Agpalilik, Ahnighito, Akpohon, Dog, Iron Mountain, Melville Bay, North Star Bay, Savik, Saviksue, Sowallick, Tent, Woman.

HISTORY

Probably no other meteorite has been so intimately connected with the life and fate of so many people as Cape York. We know now that we are dealing with the largest shower ever recorded, comprising at least eight specimens and totaling 58 tons, and we also know that the fall must have taken place in the distant past, probably long before the Melville Bay region became inhabited by the Eskimos around 1000 A.D. The Polar Eskimos, called "Arctic Highlanders" by Ross (1819) and "Thule Eskimos" by Rasmussen (1914), comprise only about 300 individuals,

Figure 492. H.M.S. "Isabella" and "Alexander" secured by ice anchors to the ice about six miles south of Bushnan Island, east of Cape York. Captains Ross and Sabine trade shirts and necklaces for narwhale tusks and implements with meteoritic cutting edges. The Eskimo interpreter Zachaeus made this colored drawing of the situation. (From John Ross 1819.)

Figure 493. Two knives acquired from the Eskimos by Ross and now in the British Museum (nos. 87561 and 87562). Flakes of the Cape York meteorites have been cold hammered and inserted into long grooves in the walrus handles. Scale bar 50 mm. British Museum neg. CG17.

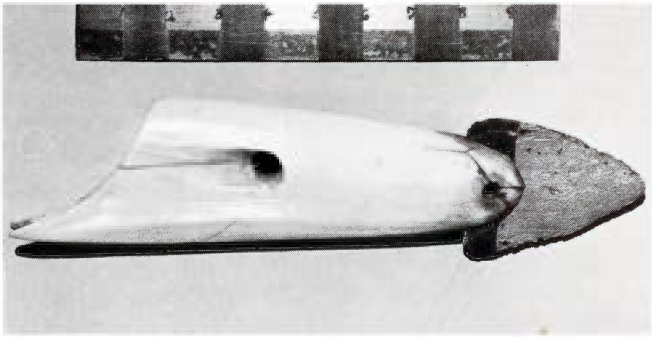

Figure 494. Harpoon point of meteoritic iron on a walrusbone shaft. Copenhagen.

Figure 495. Tools with iron blades that have been excavated by Danish archeologists in North Greenland. From left to right are seen: (L-3-12004): a ulo or woman-knife from Inuarfigssuak, Dorset culture. A cold-hammered piece of meteoritic iron 0.6 mm thick has been placed in a handle of walrus tooth. (L-3-662): ax (?) from Inuarfigssuak, Dorset culture or Thule culture. Blade of meteoritic iron, now badly corroded. (L-3-528): small knife with handle of caribou bone, Inuarfigssuak, Dorset culture. A nickel content has been demonstrated by spectographic analysis, so the blade is probably of meteoritic origin. (L-3-3604): harpoon point from Thule, house no. 8, Thule culture. The blade is not of meteoritic origin but has a structure with polyhedral ferritic grains, typical for a European wrought iron. It shows that even the Polar Eskimos had some trading connection with the Scandinavian settlements in South Greenland several hundred years ago. Scale bar 32 mm. See also Figure 503.

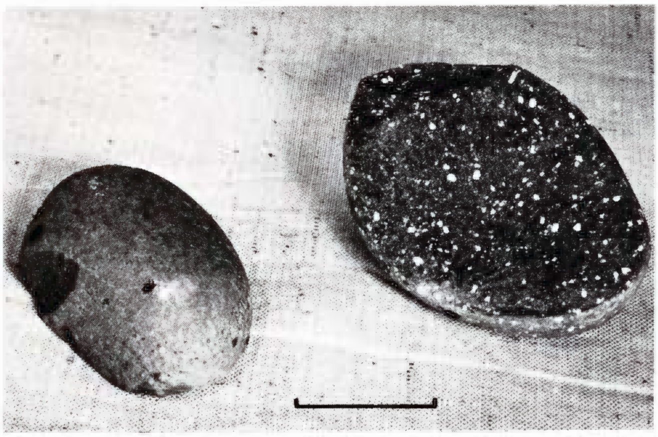

Figure 496. Two basalt boulders which were transported by the Eskimos more than 50 km in order to be used as hammers on Savik (Figure 497). Each hammer weighed originally 1 to 10 kg, but was ultimately discarded when it broke. The pile of discarded basalt hammers around Woman is 8-10 m in diameter, suggesting that the Eskimos worked the meteorite for many hundred years. Scale bar 10 cm.

and live a nomadic hunting life on the barren northwestern coast of Greenland between Savigsivik in Melville Bay and Siorapaluk and Etah at Smith Sound.

Cut off from regular supplies of wood and iron they learned at an early date to make their hunting weapons, such as harpoons, arrow heads and knives, from walrus, narwhale tusk and reindeer stag, and to provide them with cutting edges of meteoritic iron (Ross 1819; Peary 1898; Buchwald & Munck 1965: figures 1-7). In order to secure the iron they regularly visited the site of the iron masses, which lies 50 km east-northeast of Cape York. It must be assumed that, in due time, they combed the area of the smaller easily transportable blocks. Indirect proof of this assumption is the discovery of small specimens in Eskimo possession and in the recovery of small blocks by archaeological excavation of Eskimo settlements (Holtved 1944). A small fragment of a few hundred grams, covered with vivianite, was recognized by the author among material excavated by Danish anthropologists at Dundas, 100 km northwest of Savigsivik. In 1928 another small fragment of 292 g was obtained by Dr. Knud Rasmussen from an Eskino on Northumberland Island, 250 km northwest of the fall area.

Perhaps the most impressive transport of a block is provided by the discovery in 1914 of Akpohon, a 1.6 kg mass, near an ancient settlement on Ellesmere Island, about 500 km by sledge in a northwesterly direction. Since Akpohon has previously been considered an individual fall, see e.g., Hey 1966, it will be treated separately on page 425.

The Eskimos also worked the large blocks known to them, particularly the 3 ton Woman and the 400 kg Dog, see table, page 416. Evidence of this is seen on the blocks

Figure 497. Cape York. The 3.4 ton Savik specimen (Copenhagen no. 1925) had been known and worked by the Eskimos for centuries when it was rediscovered in 1913 by Knud Rasmussen and Peter Freuchen. In 1925 it was transported to Copenhagen where the bottom end of about 100 kg was cut away for examination and exchange. Dimensions 150 x 70 x 70 cm.

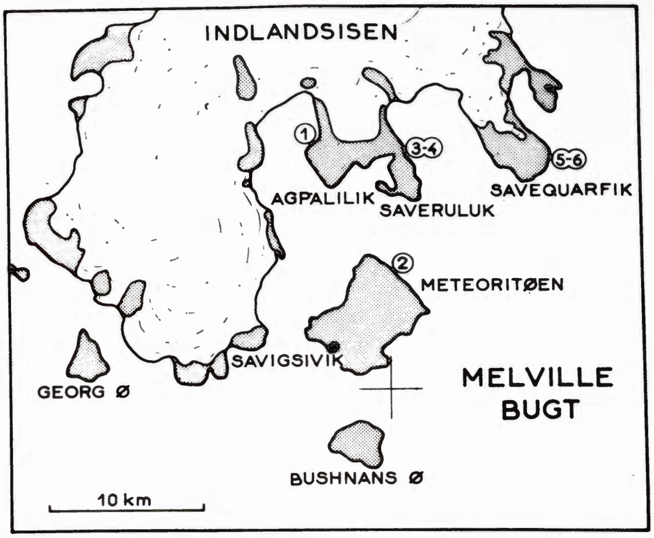

Figure 498. Map of the Melville Bay region where the Cape York meteorites have been recovered. The cross indicates 76° northern latitude and 65° western longitude. White indicates glaciers, gray is usually snow- and ice-free one month every summer. 1) Agpalilik. 2) Ahnighito. 3) Woman. 4) Dog. 5) Savik (I). 6) Savik II. Savigsivik is an Eskimo settlement of about 60 people.

themselves and on the ground around the finding places. While only a few dozen hammer stones are present around Savik I, Ahnighito and Dog, an estimated total of 10,000 rounded blocks or fragments of blocks, each weighing 1-10 kg, has been accumulated around Woman and now form a pile 8-10 m in diameter. For countless generations the Eskimos must have traveled to the distant place in order to renew their stock of iron for implements. Each sledge party brought new hammer stones of hard and tough basalt with them because the hunters knew that the gneissic boulders at the site were too fragile to be of any use in the tedious work of wrestling small pieces from the Woman.

Peary (1898: volume II: 146) mentioned that the Woman used to be larger and higher, but that long before his time Eskimos from Peterahwik broke off the head and carried it away. Inspection of the mass, now in New York, leaves little doubt of the authenticity of this report. It is also possible that the Dog, which at Peary's time lay 29 m away and a few meters lower than Woman, was originally part of the irregular Woman but had become detached and worked and, in the process, was rolled downwards.

The existence of the tribe of Polar Eskimos was unknown until 1818 when Captain John Ross explored the upper reaches of Baffin Bay searching for the Northwest Passage. Numerous geographic names in the area date back to this expedition (Ross 1819; Sabine 1819). When icebound near Bushnan Island, his ships were visited several times by the "Arctic Highlanders." The Eskimos traded narwhale tusks – and even a complete sledge – for mirrors, cotton cloth and glass beads. The British officers also acquired a few knives and harpoons with cutting edges of iron. In explaining the origin of the iron, the authors described the locality as Sowallick, which was translated as the Iron Mountain although it seems clear from the text that what was meant was two or three distinct blocks of iron. The unique sledge and the knives are now exhibited in the British Museum, while one of the harpoon heads went to Vienna (Partsch 1843: 135) where it is still exhibited. At the request of Sir Joseph Banks the material was analyzed and found to contain more than 3% Ni, satisfying the contention that it was of meteoritic origin (Sabine 1819; Chladni 1819: 344).

In the nineteenth century numerous expeditions were dispatched from Denmark, Sweden, England and the United States to Greenland and the Canadian archipelago, and a secondary goal for many of these was to locate the Iron Mountain of Melville Bay (Peary 1898; Garboe 1961; 1964; Buchwald 1964b). In little known notes by Hayes (1862) and Shepard (1866), the place name Savigsivik appears for the first time. On his expedition in 1861 the arctic explorer I.I. Hayes had acquired some small fragments from the Eskimos who told him that there was a mass of several tons at a place called "Savisavik" which they frequently visited to obtain material. The name of the place is derived from "savik", i.e. knife, and means the place where knife material could be found. From Savigsivik to Port Foulke, near Etah, where Hayes obtained the fragments, is a distance of 400 km, again proving the intense interest the Eskimos showed in the iron masses. The 21.5 g fragments are now in Philadelphia's Academy of Sciences.

Iron masses, accepted as meteorites and often believed to come from the same general area, were also reported from other parts of West Greenland. In 1847, H. Rink received a 9.7 kg block from the Eskimos at Niakornak, and Rudolph obtained an 11.8 kg mass from Fortuna Bay on Disko Island (Buchner 1863: 154). Finally, Nordenskiöld (1870b) located the main source of this material at Ovifak (Uivfaq) on the south coast of Disko Island. This place is 850 km south-southeast of Savigsivik and it has repeatedly been shown, first by Steenstrup (1875) and later by others (see, e.g., Meunier 1884: 384; Flight 1887: 26, 185; Löfquist & Benedicks 1941; Vaasjoki 1964; Melson & Switzer 1966) that the enormous Ovifak masses, totaling over 35 tons, are of terrestrial origin, and perhaps even more exciting in their unusual composition than the meteorites.

The Arctic Manual (1875, Editor R. Jones) was prepared for the British Arctic Expedition in 1875-76 under the command of Nares. It contains a wealth of information on Greenland and also all the data on the supposed meteorites from Savigsivik and Ovifak.

At the end of the century the Savigsivik and Sowallick specimens were discredited as meteorites, partly because of the unsuccessful attempts to locate the masses and partly because the Ovifak masses had been shown to be of terrestrial origin (Brezina 1885: 221; 1896: 297; Wülfing 1897: 405).

But in 1891 Peary started his arctic travels with the ultimate goal of reaching the North Pole. He made friends with the Polar Eskimos with whom he lived on and off for 19 years, and in 1894 two of them, Tallakoteah and Kessuh, took him on a sledge trip to the places they knew and showed him Woman, Dog and Ahnighito (the Tent). The struggle during the following years to recover the three huge masses is related in a masterly way by Peary (1898:

Figure 499. One of the controversial iron blocks from Ovifak, on the south coast of Disko Island, 850 km south-southeast of Savigsivik. This block, of 3 tons, is exhibited in the Kaisaniemi Park, Helsinki. The Ovifak blocks are of terrestrial origin and perhaps still more unusual than the meteoritic irons. The ruler measures 10 cm.

Figure 500. The Agpalilik specimen of 20 tons was located at X on a northwesterly slope, about 75 m above sea level. The bays are frozen over two out of three summers in this part of the world. The opposite, glacier-covered coast is 4 km distant. Compare the map, Figure 498.

Figure 501. Three Polar Eskimos assembled around Savik I when the meteorite was rediscovered in the early summer of 1913. Only the very top protruded above the snow, but since its whereabouts was more or less known, it was possible to locate and uncover the meteorite.

Figure 502. Detail of the cutting edge of an old ulu, i.e., a woman Eskimo knife (Copenhagen). From the northwest coast of Greenland, but otherwise of unknown origin. The metal is cold-worked nickel-rich ferrite with sulfide inclusions. Corrosion has converted the sulfide to pentlandite and most of the metal to limonite. The metal for the knife probably came from the Cape York meteorites. Etched. Scale bar 100 μ.

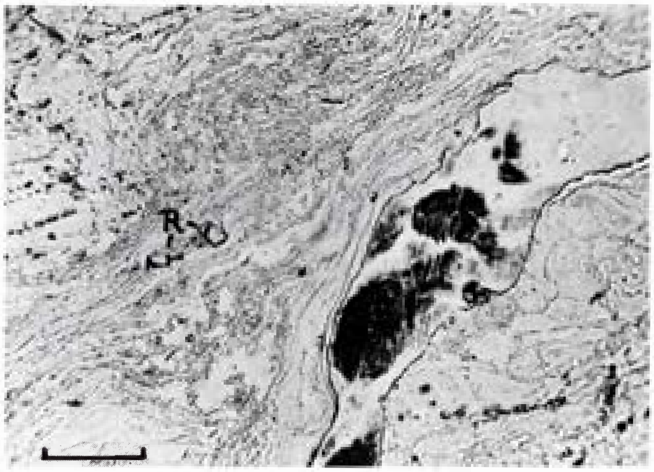

Figure 503. Microstructure of the cold-worked knife blade L-3-12004 in Figure 495. The kamacite is severely distorted and the small rhabdites (R) are sheared. The cloudy taenite lamella is also bent. Etched. Scale bar 40 μ.

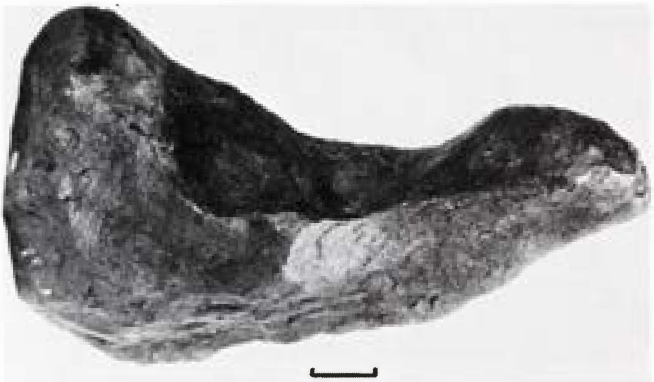

Figure 504. Cape York. The Savik II mass of 7.8 kg, discovered late in 1961, after the Eskimos had been encouraged by the author to report any unusual boulder in the Cape York district. Scale bar 25 mm.

volume II: 121, 553), who also presented numerous pictures. The 3 ton Woman and the 400 kg Dog were shipped to New York on the schooner Kite in 1895, while the 31 ton Ahnighito – which he believed to weigh between 90 and 100 tons – was shipped to New York on the larger schooner Hope in 1897. One good reason for believing in Ahnighito's enormous weight dates back to October 2, 1897, when a 50 ton floating crane at the New York Naval Shipyard in Brooklyn broke under its weight. In 1954 a large scale was installed in a permanent position under Ahnighito, and the weight could be registered as 68,085 pounds, or 30.88 tons (Washington Post, February 16, 1954; Leonard 1956b).

There was some uncertainty as to the eventual fate of the masses (Prometheus 1896: Volume 7, No. 361: 782; ibid. 1897: Volume 8, No. 373: 143; ibid. 1905: Volume 16: 476; Nature 1897: Volume 56: 569; Scientific American 1900: Volume 82, April 7: 212; ibid. 1904: Volume 91: November 19: 351). Ahnighito was in the Brooklyn Navy Yard until 1904 when it was transferred to the American Museum of Natural History. Hovey (1907: 23) briefly described and figured the masses after they had been installed in the museum. The acquisition was made possible through a gift of $40,000 from Mrs. Morris K. Jesup (Reeds 1937: 522). Peary certainly needed the money for the provisioning of further expeditions.

Recognition was slow to come. Both Brezina (1898) and Berwerth (1902: 47) expressed doubts as to the meteoritic origin, and, curiously enough, the masses have never been examined since they were analyzed by Whitfield in 1897 (Peary 1898: volume II: 602). However, Peary was convinced from the first day that they were meteoritic and, in one place, calls the Widmanstätten figures the celestial trademark (volume II: 604). Figgins (in Nininger 1933: 133) and Rickard (1941) have given summaries of Peary's account and Nininger (1952a: 146) also briefly summarized the case. Recently Hogg (1963) has retold the story of Peary's work and provided previously unpublished photographs of the action.

While operating the trading post Thule in Wolstenholme Bay, beginning in 1910, Knud Rasmussen and Peter Freuchen encouraged the Eskimos to look for more meteorites. A 3.4 ton mass, Savik I, was the bonus; it was discovered in 1913 on the promontory Saveqarfik 10 km east of Woman-Dog but had evidently been known to previous generations of Eskimos, since basaltic hammer stones were located around it. Due to World War I little could be done immediately, but in 1923-24 the mass was hauled from the top of the cliff to the seashore. With 14 sledges and 175 dogs, Henry Nielsen, the manager of Thule, pulled the meteorite across 25 km of sea ice to the Bushnan Island. Here, open water allowed the ship Sökongen to pick it up and sail with it to Copenhagen where it was unloaded in 1925 and thoroughly described by Böggild (1927). He gave several figures of the exterior and of etched slices and discussed in particular the orientation of the rhabdites and of the crystallographic relationship between kamacite and

Figure 505. Cape York. The 20 ton Agpalilik specimen in August 1963, shortly after its discovery by the author. Some 20 gneissic boulders which almost covered its top side have been broken and removed to expose the mass.

Figure 506. Cape York. The Agpalilik mass was excavated and hauled to the beach on a prefabricated sledge during a two week hectic campaign in August 1965. The sledge was moved by hand winches along a "railroad" of heavy timbers. The road was broken behind the meteorite when the sledge had passed, and the timbers were reused in front of it, in order to save construction material. Midnight sun is almost due north.

taenite. The 3,402 kg mass was cut at the Naval Yard in Copenhagen, producing a main mass of 3,270 kg and about 100 kg of slices for exchange and study. Practically all previous papers relating to Cape York have been based on this material.

Since the localities from which the four large masses were hauled were only vaguely known and since no reliable maps existed of the area, I decided to visit the Thule district in order to map the extent of the shower and to encourage the Eskimos to look for more material. In 1961 a small, complete mass of 7.8 kg, Savik II, was discovered at the coast 1 km east of the site of Savik I. It was found between gneissic boulders at the foot of a cliff by the

Figure 507. Cape York. Part of the way to the coast was covered by snow and ice. All work was carried out by hand since the place was inaccessible for machines. August 1965.

Eskimo Augo Suerssaq while on a hunting trip (Buchwald 1964b; Buchwald & Munck 1965).

In the summer of 1961 I had the opportunity to work from the Thule Air Base and received information on an unrecorded specimen of the Thule meteorite, page 1191. Later, in the summer of 1963, I was fortunate enough to be able to visit the islands and peninsulas in Melville Bay between Cape York and Cape Melville. These regions are extremely inaccessible, but thanks to the assistance of a U.S. helicopter, stationed at the Thule Air Base, and to a couple of Eskimos with a motorboat, I was able to investigate the area. I relocated the four major meteorite sites, recognizable by the bluish-black basalt hammers, and

Figure 508. Cape York. A situation which shows the timber framework over which Agpalilik was hauled. August 1965.

found a new 20 ton mass, Agpalilik, unknown even to the Eskimos (Buchwald 1963; 1964a; Meteoritical Bulletin, No. 28, 1963). It rested on a slope between large, gneissic boulders and was partly covered by them; the lower part was solidly anchored in the permafrost ground, which formed a concrete-like matrix of gravel, silt, clay and ice. No vegetation was possible in the block field which is covered by snow 11 or sometimes 12 months of the year. A small, hanging glacier was located about 100 m further south. No rocks crushed by impact could be identified, and no crater or even impact hole was present. There were no Eskimoic hammer stones around it, and the mass had apparently never been known to the Eskimos, probably because it was covered by snow and ice most of the year.

The localities are shown on the map, Figure 498, where it will be seen that the distance between Agpalilik and Savik II is 16 km in an east-west direction and between

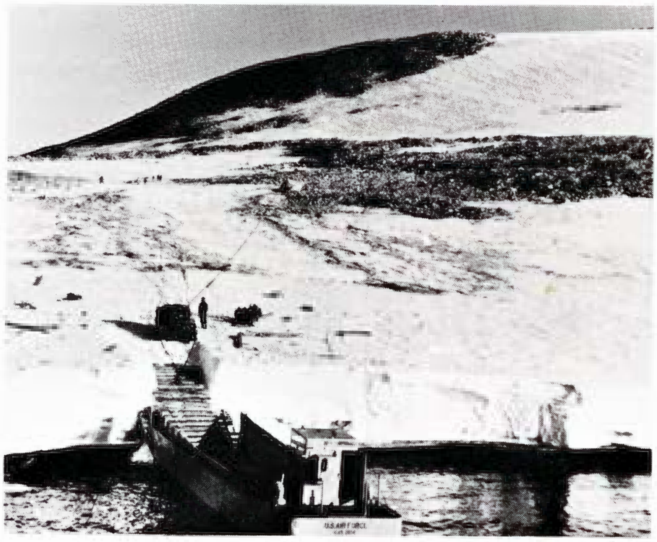

Figure 509. Cape York. In August 1967 the meteorite was hauled on board a landing craft and immediately transferred to the ocean going ship M/S Edith Nielsen. Note the transport pad which has been cut into the ice foot.

Figure 510. Cape York. The 20 ton Agpalilik mass being cut in October 1970. A wire saw fed with a carborundum water slurry was applied. The two cuts, 5 cm apart, each took 195 hours to complete.

Woman-Dog and Ahnighito 10 km in a north-south direction. There is no systematic distribution of the blocks, so it has been proposed that they were transported by glaciers. An examination of the surface of the masses does not reveal any damage from glacial transport, and my field survey did not support the idea but rather indicated that the masses fell at a date when the region was completely covered by a thick sheet of ice and snow which later receded, leaving the meteorites where they fell. The random

Summary of individuals with coordinates and approximate altitude above the sea and distance to the sea. The overall nearness to the sea suggests that several other masses are to be found at the bottom of the bays which are mostly ice covered.

	Date of Find	Reference	Weight kg	Coordinates N – W	Altitude m	Distance to the Sea m	Locality
Ahnighito	1894	Peary 1898	30,880	76°4′–64°58′	24	100	Meteorite Island
Woman	1894	Peary 1898	3,000	76°9′–64°56′	30	500	Saveruluk
Dog	1894	Peary 1898	407	76°9′–64°56′	24	500	Saveruluk
Savik I	1913	Böggild 1927	3,402	76°8′–64°36′	270	1,000	Saveqarfik
Akpohon	1914	Hovey 1918	1.66	79°5′–76°30′	–	–	Ellesmere Land
Northumberland	1928	Buchwald & Munck 1965	0.29	77°20′–72°	–	–	Northumberland Island
Savik II	1961	Buchwald 1963	7.8	76°8′–64°35′	5	10	Saveqarfik
Agpalilik	1963	Buchwald 1963	20,140	76°9′–65°10′	75	500	Agpalilik

distribution of the masses is probably due to the fact that only a small amount of the total shower has been located.

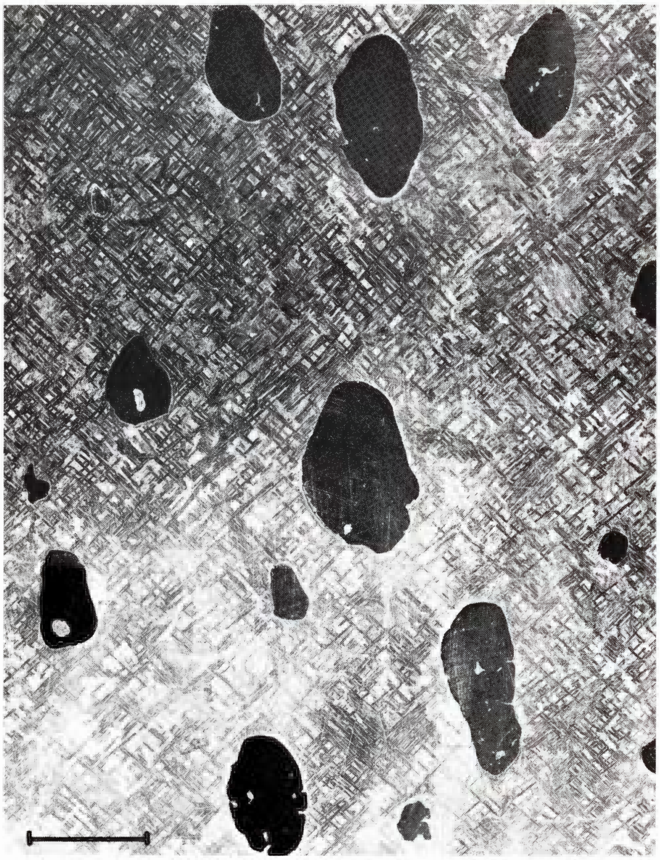

Figure 511. Cape York. A part of the slab in Figures 510 and 189C. Elongated troilite nodules with internal metal blebs, exhibiting swathing kamacite and Widmanstätten structure. Etched. Scale bar 50 mm. Compare Figures 91 and 158.

Grants from the Carlsberg Foundation and from the Mineralogical Museum of the University of Copenhagen provided the necessary financial support for the small expeditions sent out in 1964, 1965, 1966 and 1967 to recover the Agpalilik mass. The unlimited assistance given by Departementschef Eske Brun, Grønlandsministeriet, and

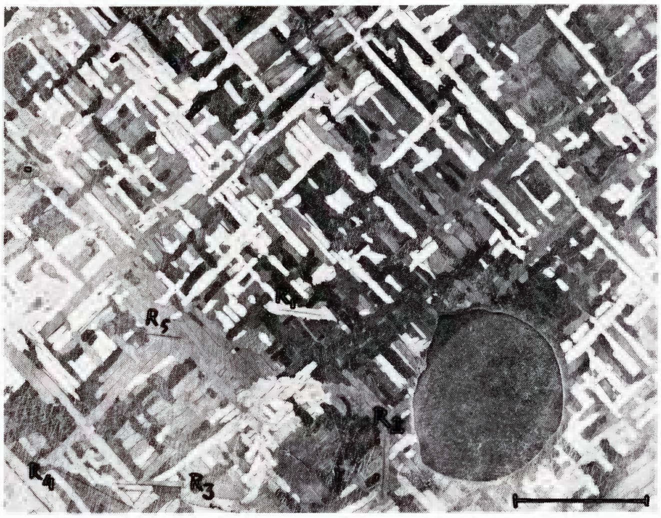

Figure 512. Cape York. Agpalilik (Copenhagen no. 1967, 410). A slice cut almost parallel to $(100)_\gamma$, with only two Widmanstätten directions. Troilite nodule with asymmetric rim of swathing kamacite. Indistinct chromite-Reichenbach lamellae R_1-R_5. Deep-etched. Scale bar 20 mm. See also Figure 186.

Chief Engineer, H.J. Hansen, Greenland's Technical Organization, is gratefully acknowledged. In collaboration with G.T.O., the detailed plans were worked out (Buchwald & Munck 1965: figure 13), and each summer a small group

CAPE YORK – SELECTED CHEMICAL ANALYSES

	percentage			ppm								
References	Ni	Co	P	C	S	Cr	Cu	Zn	Ga	Ge	Ir	Pt
Whitfield in Peary 1898, Ahnighito	7.79	0.53	0.20	230			140					
Whitfield in Peary 1898, Woman	7.78	0.53	0.19	200			180					
Whitfield in Peary 1898, Dog	8.27	0.53	0.17	140	190		160					
Buchwald 1966, Savik I	7.94	0.50	0.15		250				18			
Smales et al. 1967, Savik I						51	163	4.2	15	37		
Moore et al. 1969, Savik I	7.65	0.48	0.14	395	60							
Crocket 1972, Savik I												4.5
Scott et al. 1973, Savik I	7.58								19.2	36.0	5.0	

Note: The reported data for sulfur are valid for the metallic phases. The bulk sulfur content is very much larger, 1.25%, based upon planimetry of 1.9 m^2 sections through Agpalilik, see below.

started for Savigsivik under the supervision of the author and engineer Thue Andersen, G.T.O. While the ice conditions in 1964 and 1966 prevented the expeditions from reaching Melville Bay – in August 1964 our ship M/S Elfy North had to require icebreaking assistance from the U.S. Coast Guard Westwind stationed in Thule, – we were able in 1965 to put up camp for two weeks a few hundred meters from the meteorite. Agpalilik was excavated and hauled to the beach on a prefabricated sledge, and an 8 mm film showing the various phases of the work was taken (Buchwald 1967c). Finally, in August 1967, Captain J.E. Leo succeeded in bringing his 3,700 ton M/S Edith Nielsen through the uncharted and iceberg-filled waters to the foot of the ice below Agpalilik. In a hectic campaign lasting 60 hours the mass was hauled down into a landing craft, using the capstans and wires of the ship, and then the mass was lifted on board. It arrived in Copenhagen in September 1967 and was found to weigh 20.14 tons on the scales at the docks.

A thorough discussion of a newly developed method for cutting large iron meteorites was given by Buchwald (1971a). The method made use of a rapidly rotating circular steel wire which, fed by a carborundum water slurry, proved to cut relatively swiftly through metal, troilite and cohenite. The Agpalilik mass was subdivided in

Figure 513. Cape York. Agpalilik, an endpiece of 658 kg. Distinct regmaglypts and slight corrosion on the left side which was above the soil line. Layered limonitic crusts on the right side which was below soil line and in contact with water (ice) permeated silt. Scale bar approximately 10 cm.

a 1.4 m^2 slab, 5 cm thick and weighing 560 kg, and six slabs and endpieces of 428, 445, 658, 698, 840 and 893 kg, respectively. The cutting method proceeded at a rate of about 1 cm^2 per minute; and a total of 760 hours was used in cutting the mentioned samples. The large plate was polished and etched on the lower half; it is now exhibited in the Mineralogical Museum of Copenhagen.

Since about 1850 the Eskimos of Savigsivik had been independent of the iron masses, since they were provided with iron from whale ships, Peary and the Thule trading post; and they had almost forgotten their existence. However, upon hearing of the new find, many had a tale to tell, and one of the more exciting was a report of a 1 m mass on the small island of Ituvsalik, southeast of Kraulshavn. Whether this occurrence is an authentic meteorite, or perhaps magnetite, only time will show.

Perry (1944: plate 7) gave a photomicrograph, Buchwald & Munck (1965) and Buchwald (1966: figure 27) gave several others. Photographs of the exteriors were presented by Peary (1898), Hovey (1907), Bøggild (1927), Mason (1962a: figure 12), Hogg (1963), Buchwald (1963; 1964a,b; 1971a) and Buchwald & Munck (1965). El Goresy (1965) examined various troilite-daubreelite inclusions and presented some excellent micrographs. Jain & Lipschutz (1969) estimated from X-ray diffraction data that their material had suffered shock intensities of 130-400 k bar. As we shall see below, the meteorites show a wide range in hardness and cold working effects, so a single X-ray value is only of limited value. Jago (1974) examined the dislocation networks with thin-film transmission electronmicroscopy.

Gas-analytical data were collected by Paneth and co-workers. They found (Chackett et al. 1953) extremely small amounts of helium, a result which Bauer (1947; 1963) attributed to the exponential attenuation of the

Figure 514. Cape York. The Woman specimen (New York no. 868). Well-developed comb and net plessite, and numerous black taenite wedges. The distorted surface must in part be the result of intensive cold work by the Eskimos to obtain small flakes for their tools. Etched. Scale bar 2 mm.

cosmic radiation while passing through a large mass. Martin (1953) doubted, curiously enough, that Woman and Dog belonged with the other masses because he found widely different helium concentrations. This doubt is, however, unfounded. Müller & Zähringer (1966) found a K/Ar solidification age of above 5.9 x 10^9 years, another interpretation which appears unfounded (Rancitelli & Fisher 1968).

COLLECTIONS

New York (34.2 ton), Copenhagen (23.5 ton), Moscow (5.0 kg), Stockholm (2.52 kg), Washington (2.07 kg), London (1.63 kg and Eskimo knives), Olso (1.42 kg), Paris (1.26 kg), Prague (1.09 kg), Ann Arbor (380 g), Tempe (327 g), Philadelphia (21 g from Hayes 1861), Vienna (harpoon point from Ross 1819), Museum of the American Indian, New York (harpoon point and Eskimo knives, collected 1931).

DESCRIPTION

The dimensions are given in the table below. An attempt has been made to estimate the total volume of the larger masses, mainly in order to check whether the meteorites may be assumed to be wholly metallic or to contain significant amounts of low-density inclusions, such as silicates. This is especially interesting since the account given by the Eskimos to Ross (1819) might indicate that Woman was relatively easy to work because it contained silicate-rich parts. It must also be pointed out that the 2,000 kg El Taco specimen of the Campo del Cielo shower upon cutting turned out to be silicate-rich. The very approximate data in the table do not, however, suggest that Cape York should contain silicates, and a careful examination of the surfaces and sections likewise fails to disclose any.

The exterior shape varies from the well rounded, almost ellipsoidal shape of the Dog, to the pointed, triangular pyramid of Savik I, and the irregular, angular forms with many reentrant portions of Ahnighito and Agpalilik. There is no obvious solution to the puzzle of reassembling the pieces into one parent body, probably because major specimens are still missing.

Agpalilik, Ahnighito, Savik I and Savik II are covered with shallow pits and depressions, ranging from 5-50 cm in size. Some of the depressions, particularly on one side of Savik I, resemble regmaglypts from the atmospheric flight. In addition, the surfaces are irregularly pock-marked with small pits 1-7 mm in diameter and 1-2 mm deep. These are typical corrosion pits, and they may be observed still forming on Savik I which is exhibited in free air in

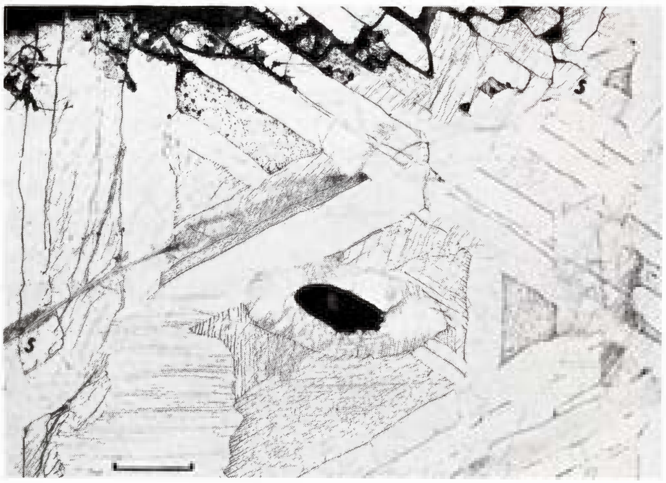

Figure 515. Cape York. The Savik II specimen (Copenhagen no. 1961). Terrestrial corrosion attacks along the near-surface Widmanstätten grain boundaries. This weathering may have eased the job of the Eskimos when obtaining small flakes for their tools. A troilite nodule (black) with swathing kamacite, and severe shear deformation (S-S) from atmospheric breakup are also seen. Etched. Scale bar 2 mm.

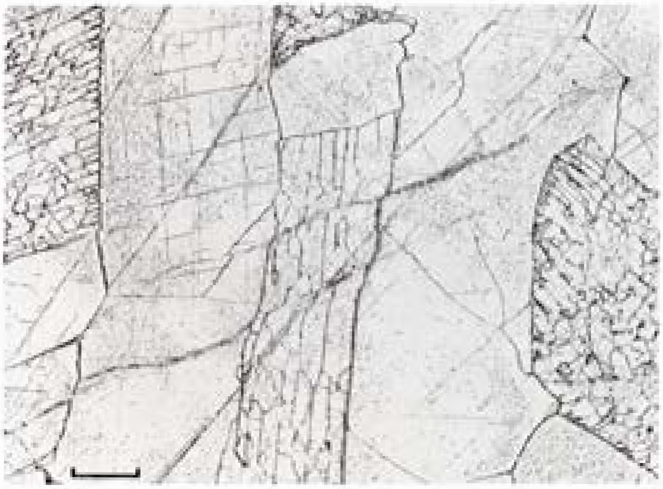

Figure 516. Cape York. Savik II (Copenhagen no. 1961). Open-meshed comb and net plessite showing plastic deformation due to breakup in the atmosphere. Etched. Scale bar 500 μ.

Dimensions and hardness ranges (100 g Vickers in the kamacite phase) of the individual Cape York specimens.

	Weight kg	Maximum Dimensions cm	Calculated Volume dm^3	Calculated Density g/cm^3	Hardness Range kg/mm^2
Ahnighito	30,880	325 x 210 x 160	3,800	8.1±0.4	195-235
Woman	3,000	131 x 97 x 55	383	7.8±0.4	180-225
Dog	407	64 x 51 x 35	52	7.8±0.4	–
Savik I	3,402	150 x 71 x 69	435	7.8±0.2	185-260
Akpohon	1.66	9.8 x 9.7 x 4.6	–	–	225-285
Northumberland	0.29	6 x 5 x 3	–	–	–
Savik II	7.8	25 x 18 x 7	1.0	7.8±0.2	220-315
Agpalilik	20,140	210 x 200 x 150	2,550	7.9±0.4	195-265

Copenhagen. Indications are, however, that they now form more slowly than they did immediately after the block was received in Copenhagen, one reason being that the near-surface chlorides have by now been washed out of the meteorite.

Ahnighito shows a prominent ridge or keel on its upper part, as exhibited today in New York. Below the keel is an elongated depression extending the length of the meteorite. A comparison with Peary's original description and photographs shows that the ridge protruded above the ground, while turf and soil covered the lower parts. The widely different morphologies of the ridge and the depression below are due to corrosion which was particularly active just below the surface of the soil, while the exposed crest was attacked only to a minor degree. The loss by corrosion in the depressed region is estimated to be about 1 cm.

Peary (1898: volume II: 559, 611) assumed that the Eskimos saw the meteorites fall, because they related a story to the effect that the irons had originally been a sewing woman, who with her tent (Ahnighito) and curled up dog had been hurled from heaven by the evil spirit Tornarsuk. If it was observed, the fall can hardly be more than 1,000 years old because archaeological evidence indicates immigration took place about 1000 A.D.

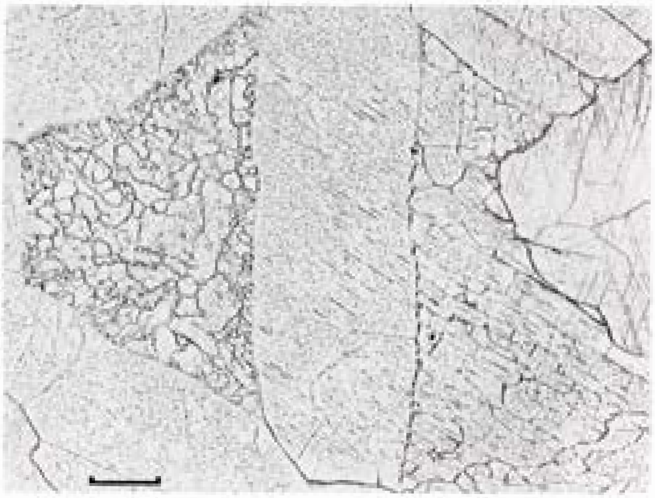

Figure 517. Cape York. Savik II (Copenhagen no. 1961). Almost undistorted material. The Neumann bands are, however, slightly wavy and the schreibersite inclusions faulted. The oriented streaks in the kamacite are rhabdites. Etched. Scale bar 500 μ.

Considering that Ross (1819) and other Arctic explorers never heard of this story, I am more inclined to believe that the narrative is an example of the Eskimos' willingness to provide the guest with a good story built on what they were expected to know; namely, that the irons were meteoritic. It appears likely that the Eskimos, until they met with the white explorers, just considered the blocks as a natural iron deposit and that no man, in fact, had witnessed the fall.

The large section of 180 x 130 x 5 cm through Agpalilik (Buchwald 1971b) shows heat-affected α_2 zones

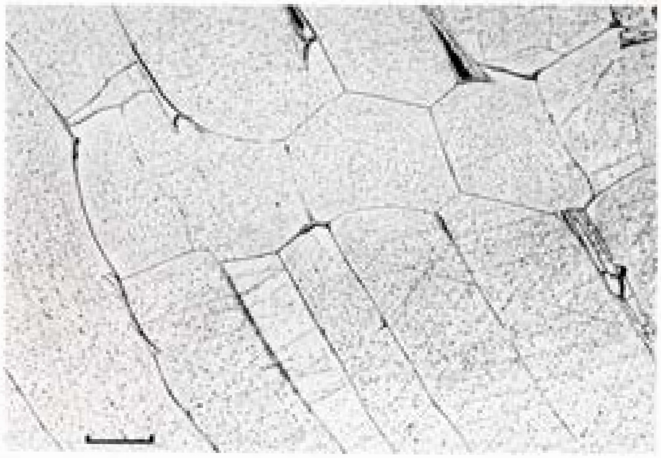

Figure 518. Cape York. Savik I (Copenhagen no. 1925). Kamacite exhibiting grain growth. Almost resorbed plessite and taenite wedges and a few schreibersite bodies are situated in the present and former grain boundaries. Numerous rhabdites in the kamacite. Etched. Scale bar 500 μ.

along much of the periphery. Indistinct cylindrical cavities, 2-3 cm across, indicate where troilite nodules were partly removed by ablational melting in the atmosphere. Regmaglypts, 5-20 cm across, and distinct 2 mm wide α_2 zones are well developed on that part of the meteorite which was above "the soil line" when it was found. It is estimated that on the average only 0.5 mm has been lost by corrosion here. The underside, below the soil line, shows a more severe attack, and it is estimated that, on the average,

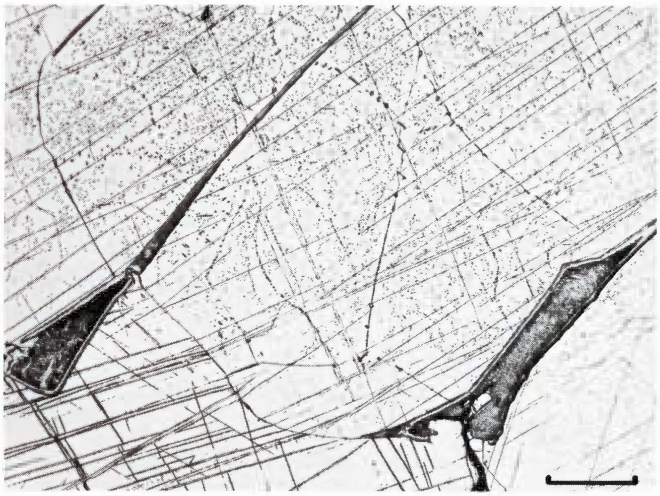

Figure 519. Cape York. Woman (New York no. 868). Subboundaries with fine phosphide precipitates. Neumann bands. Plessite fields with cloudy taenite rims and martensitic interiors. Etched. Scale bar 300 μ.

more than 2 mm has been removed. Chlorides are present in significant amounts here, and, if studied in the nineteenth century, Agpalilik would certainly have been reported to contain lawrencite since an exudation of greenish droplets is common on near-surface sections. However, the chloride ions have been introduced with the terrestrial ground water;

as these meteorites lay close to the sea, fog and salt water spray may be expected to have contributed significantly to the chloride contamination. Material below a depth of 1-2 cm is generally unattacked and free of chloride, except in fissures along schreibersite-filled grain boundaries. Here, the alpha phase is selectively corroded, and 5-50 μ wide zones along schreibersite and around rhabdites are also corroded. The Neumann bands are not corroded, presumably because no sensitization with phosphides had occurred during space recovery. The terrestrial age is probably above 2,000 years, but other methods will have to be called upon for a quantitative estimate.

The α_2 zone displays micromelted phosphides in its exterior part. Its microhardness is 190±15; in the recovered transition zone the hardness decreases to 155±5, before it again increases to typical interior values of 250 (hardness curve type I, IV).

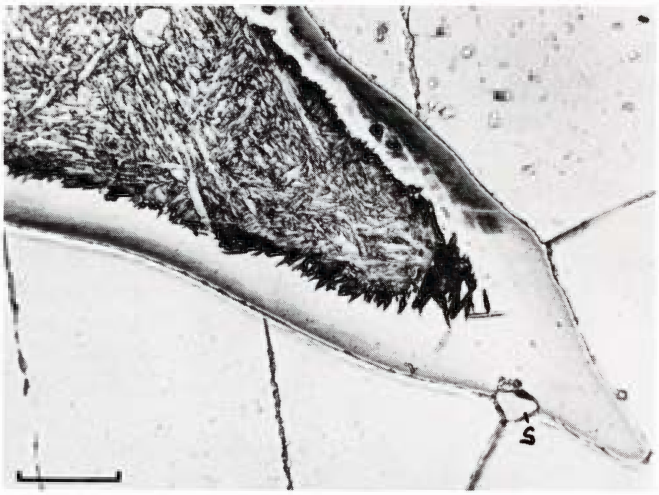

Figure 520. Cape York. Woman (New York no. 868). The pointed end of a plessite field shows a cloudy taenite border with an indistinct grid due to shock-deformation. The interior shows acicular martensite. A schreibersite particle is located at a grain boundary. Etched. Scale bar 30 μ.

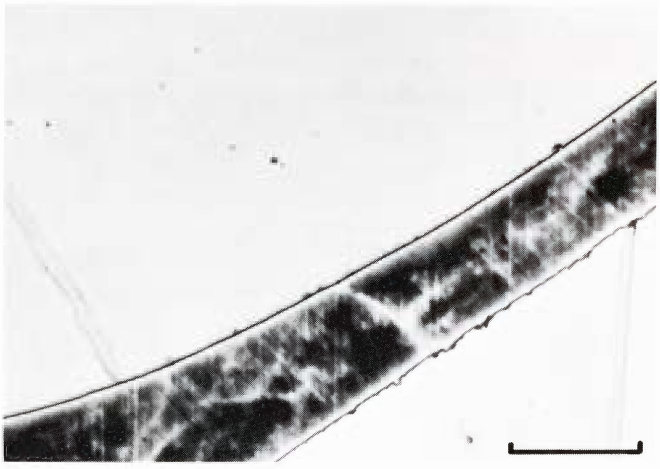

Figure 521. Cape York. Agpalilik (Copenhagen). Deformation grid parallel to $(111)_\gamma$ certainly caused by shock-deformation. Two Neumann bands in the kamacite. Etched. Oil immersion. Scale bar 20 μ. Compare Figures 101 and 102.

Three sides of Woman and all of Dog show the effects of artificial hammering to an unprecedented degree. Most of the surface is violently beaten and smoothed out, with several examples of overfolding of the ductile metal. The fracture surface where the Eskimos detached the head of the Woman (page 418) is no longer visible, presumably due to continued hammering of the area. What may once have been regmaglypts are very altered due to the continued beating. As evident from Figure 514, the plastic deformation wrought by the hammering fades out below a depth of 3-5 mm. It may not be a coincidence that the block which the Eskimos chose to attack is the softest of the blocks known to them; see table on page 419.

The hardness range is mainly due to the varying degree of cold work suffered during the fracturing in the

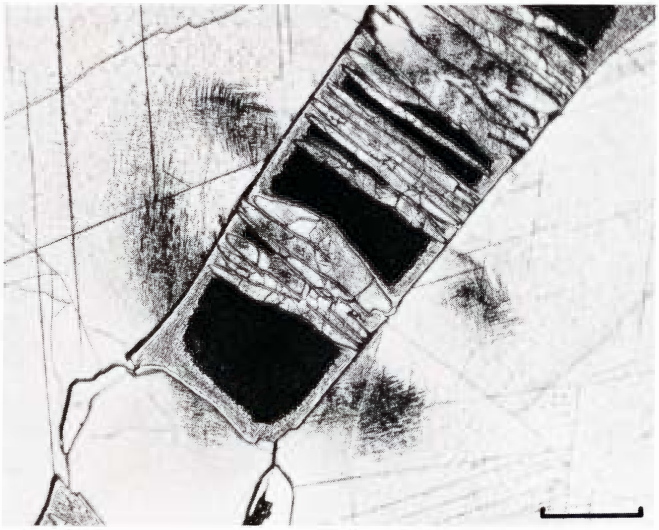

Figure 522. Cape York. Agpalilik (Copenhagen no. 1967, 410). Around black taenite fields the kamacite often exhibits fine striations decorated with submicroscopic precipitates. Etched. Scale bar 300 μ.

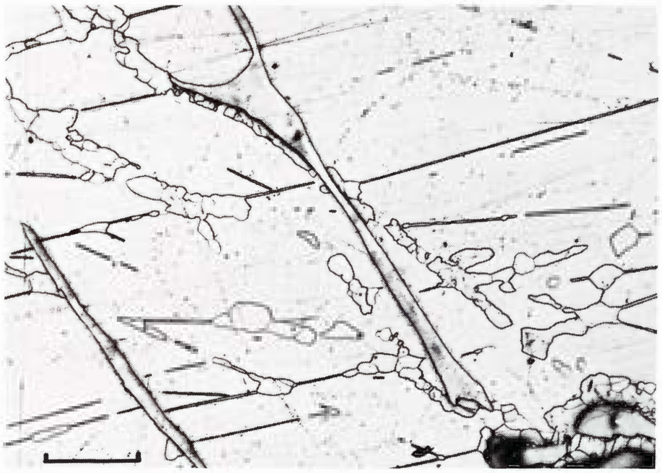

Figure 523. Cape York. Agpalilik (Copenhagen). Experimentally reheated to 600° C for 320 minutes and then water cooled. The cold-worked kamacite recrystallized first in shear zones, at Neumann band intersections, and in the nickel- and phosphorus-depleted kamacite around sheared schreibersite inclusions. Etched. Scale bar 200 μ.

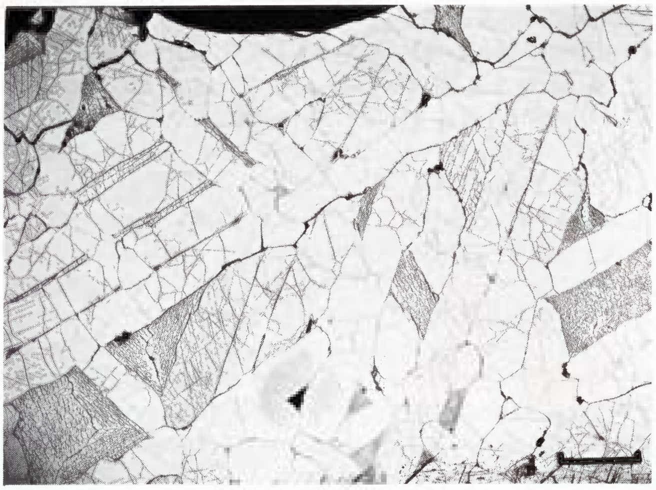

Figure 524. Cape York. Ahnighito (New York no. 867). Section including surface (above) showing the typical structure of a medium octahedrite. Numerous subboundaries are visible in the kamacite lamellae. Etched. Scale bar 2 mm.

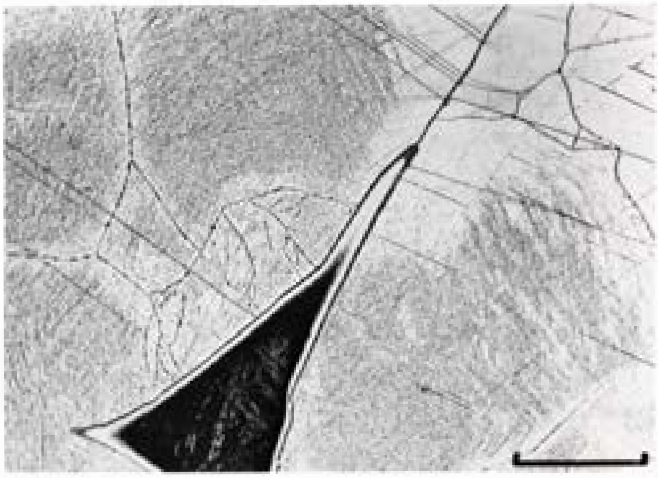

Figure 525. Cape York. Detail of Figure 524. The kamacite around the black taenite shows slip bands rich in submicroscopic precipitates. Compare Figure 522. Etched. Scale bar 300 μ.

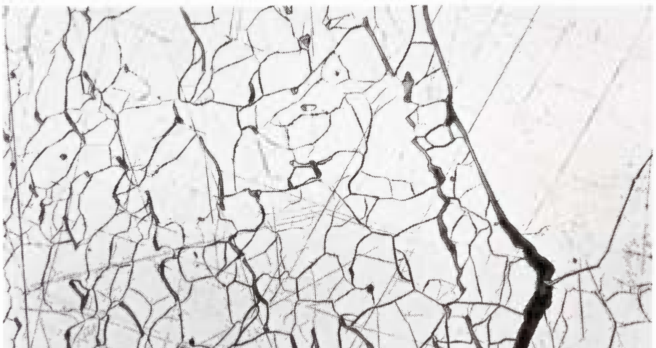

Figure 526. Cape York. Ahnighito (New York no. 867). Open-meshed net plessite. All taenite lamellae have a cloudy appearance, probably due to submicroscopic decomposition to α and γ. Compare Figure 106 and 109. Etched. Scale bar 300 μ.

atmosphere or, possibly, still earlier. Under the optical microscope the kamacite is visibly sheared and kneaded in many places to a depth of 10-20 cm. The shear zones are 50-200 μ wide and have peak hardnesses above 300. Lenticular deformation bands are also present, and the Neumann bands are frequently distorted. In such areas the hardness is usually 230-280. When the hardness falls below about 225, the microscopic examination fails to reveal any effects; but this is to be expected since the initial stages in cold working of metals, up to 10-20% reduction are best disclosed by hardness or X-ray diffraction studies and less available to microscopic studies. The hardness range, from 180 to 315, is quite impressive but not unique, since, as shown herein, such ranges appear to be natural to the shower-producing irons, like Glorieta Mountain, the North Chilean hexahedrites, Campo del Cielo, Gibeon, etc.

Etched sections display a medium Widmanstätten structure of straight long ($\frac{L}{W} \sim 25$) kamacite lamellae with a width of 1.20±0.20 mm. Locally, late grain growth of the kamacite has left taenite, originally in grain boundaries, fully inside the kamacite lamellae. The kamacite has numerous subboundaries, well decorated with 0.5-2 μ thick rhabdites. Neumann bands are common, and, as noted above, in several places the deformation is sufficiently heavy to be seen as distorted Neumann bands and lenticular deformation bands. The hardness ranges from 180 to 315, with a median value at 225±10. No precipitation has occurred upon the Neumann bands, and other structural elements also indicate that the masses have never been significantly reheated. Martin (1953) suggested, in order to explain his gas analytical data, that the masses had been severely reheated or even melted by a passage near the Sun, but this hypothesis is quite untenable.

Taenite and plessite cover 25-35% by area, mostly as isolated taenite ribbons, as comb and net plessite and as small wedges of acicular or martensitic plessite, sometimes with cores of poorly resolvable, black-etching, duplex $\alpha + \gamma$. A typical field will exhibit a stained taenite rim (HV 340±20) followed by an indistinct martensitic (or bainitic) transition zone (HV 385±35). Then follows poorly resolvable, duplex mixtures which become increasingly softer as the structural elements become resolvable (HV 300±50). Finally, the center may be developed as comb or net plessite, or as fine-grained $\alpha + \gamma$ mixtures with vermicular γ-grains, 1-2 μ in size. The hardnesses of these open-meshed structures are only slightly above that of the surrounding kamacite lamellae.

Schreibersite is common as 10-100 μ wide grain boundary precipitates but never occurs as separate skeleton crystals. It also occurs as irregular 5-50 μ bodies inside the plessite. Frequently the smaller phosphides are still attached to the taenite. The schreibersite is monocrystalline but often heavily brecciated, and it has a hardness of 790±30. Rhabdites are very common, mostly as 1-3 μ thick tetragonal prisms. They do, however, occasionally reach thicknesses of 25 μ.

Slender, hard platelets and irregular hooks, typically 15 x 10 x 1 μ in size, occur frequently in the kamacite, Figure 149B. The plate-shaped precipitates are crystallographically oriented within the kamacite lattice, while the irregular bodies are located at the grain boundaries. They must have precipitated before all phosphorus had precipitated from the kamacite, because they are often embedded in, or covered by 5-10 μ of phosphides. The precipitates were identified as a new mineral CrN, which was named carlsbergite in recognition of the support given by the Danish Carlsberg Foundation during the recovery and cutting of Agpalilik (Buchwald & Scott 1971).

Troilite is common as Reichenbach lamellae that typically measure 10 x 5 x 0.05 mm in size and occur with a frequency of about one per 20 cm^2. A large number, but not all, are parallel to the austenite cube faces $(100)_\gamma$. A close examination of the Reichenbach lamellae reveals that they are always composed of a primary "backbone" of chromite, usually only 2-10 μ thick, but extremely long and wide, upon which 10-50 μ troilite and 10-50 μ schreibersite have later irregularly precipitated. Electron microprobe analysis of several selected lamellae confirmed this identification. It appears that the Reichenbach chromite lamellae precipitated from solid solution while the metal was still austenitic. Later, some troilite was nucleated by them and, below about 800° C, schreibersite also precipitated upon them. Irregular 0.5-1.5 mm wide rims of swathing kamacite finally developed.

Large troilite nodules are exceedingly common as evidenced by the newly cut 20 ton Agpalilik mass. A total of about 10 m^2 cut surface has been exposed so far by wire cutting and traditional cutting, and all sections have proved to be rather uniformly covered with troilite inclusions. Planimetry of three typical sections, mutually perpendicular and covering a total of 1.9 m^2, indicated an average

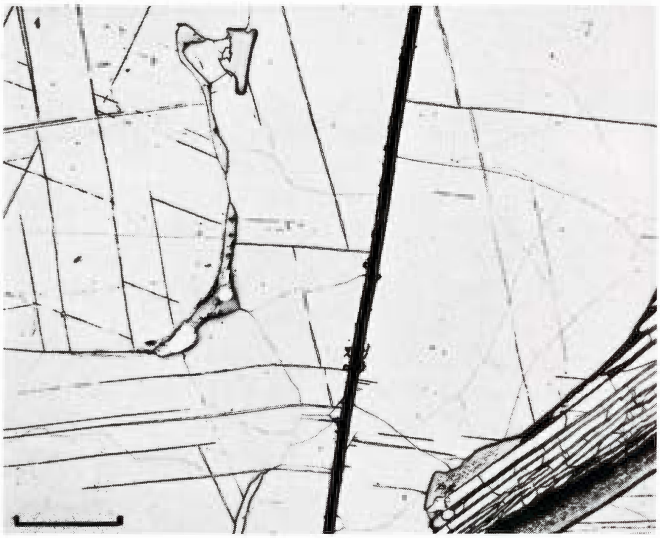

Figure 527. Cape York. Agpalilik (Copenhagen no. 1967, 410). A Reichenbach lamella (black). Electron microprobe examination showed chromite to be the essential component. Precipitates of troilite and schreibersite, outside the picture field, swamp the original, thin chromite platelet. Etched. Scale bar 300 μ.

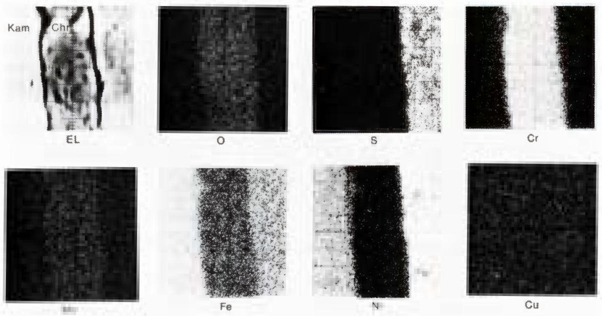

Figure 528. Cape York. Agpalilik (Copenhagen). Scanning X-ray picture of a Reichenbach lamella (Chr) between kamacite and an unidentified mineral which is rich in Fe, Ni and S. The Reichenbach lamellae consist of chromite, $FeCr_2O_4$, with significant amounts of Mn (and Zn, V, Ti) in solid solution. Compare Figures 162B and 175. Scale bar 20 μ.

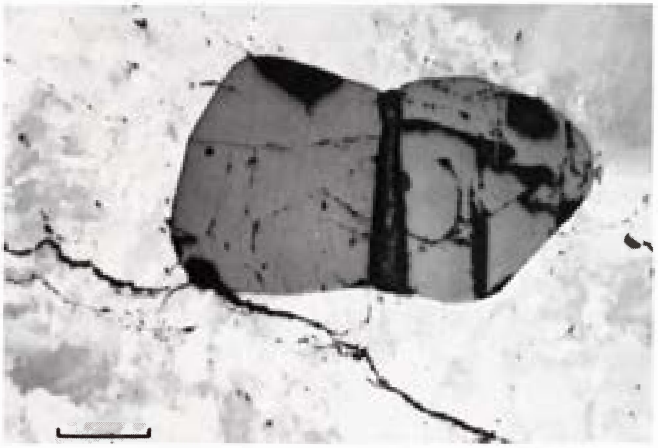

Figure 529. Cape York. Agpalilik (Copenhagen). One of the chromite inclusions that frequently are clustered at one end of the elongated troilite inclusions. It is associated with accessory phosphates, see Figure 176. The troilite is polycrystalline, or shows undulatory extinction. Slightly crossed polars. Scale bar 100 μ.

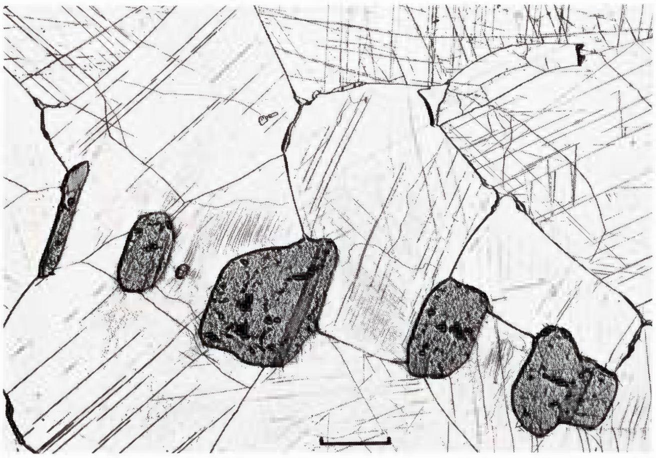

Figure 530. Cape York. Savik I (Copenhagen no. 1925). Five troilite bodies, with parallel daubreelite lamellae in Nos. 1, 3 and 5. When I commented on this photograph on an earlier occasion (Buchwald & Munck 1965: plate 3), I stated that daubreelite is not common in octahedrites. Today, I would prefer to say that it *is* common, as an accessory mineral in both the troilite and kamacite of many octahedrites. Etched. Scale bar 500 μ.

troilite content of 5.60% by volume which corresponds to 1.25% of sulfur by weight in the whole meteorite. It is estimated that an additional 0.05% S is present in the Reichenbach lamellae and in inclusions smaller than 1 mm in diameter, which could not be counted during the planimetric analysis of the large, roughly polished surfaces. The bulk sulfur content is thus 1.3%. This appears very high for an iron meteorite, but, on consideration, it is probably quite typical for a number of group IIIA and IIIB meteorites. It is just that we do not usually see large sections through such masses. Besides, during the atmospheric disintegration and rupture the fractures will tend to follow the sulfides. Consequently, these will be preferentially lost so that estimates of troilite contents from sections through small masses will be systematically on the low side of the true value.

Sections oriented parallel to the austenite cube faces $(100)_\gamma$ show that above 700° C Agpalilik was a huge single austenite crystal, more than 200 cm in diameter, and without indications of growth twinning. Whether the other blocks are also single austenite crystals is still unknown, but it appears plausible. Perhaps the large masses are individual austenite crystals separated by grain boundary fissuring, or perhaps all of the parent mass (200 t ?) was one huge austenite crystal. We will not know unless Ahnighito, in particular, is subjected to a close study.

The troilite inclusions form parallel sausage-shaped bodies, all elongated in the same direction, parallel to $[100]_\gamma$. Their sizes range from about one centimeter to large bodies that pinch and swell irregularly, and reach dimensions of 18 x 3 x 3 cm. The troilite is enveloped in asymmetric 0.3-1.5 mm wide rims of swathing kamacite. Due to the low bulk phosphorus content only insignificant and discontinuous 50 μ wide rims of schreibersite have been precipitated on the troilite.

The troilite inclusions were originally monocrystalline or composed of a few large units. The cosmic shocks that hardened the metallic phases also damaged the troilite so that it now exhibits multiple twinning and undulatory extinction. In several sections with high hardnesses of the metal the troilite has recrystallized to 10-50 μ grains and local micromelting has occurred, especially along interfaces where the energy input has peaked due to shock wave attenuation. The troilite inclusions thus show a range of secondary damage corresponding to the plastic deformation of the metallic matrix.

The troilite contains several accessory minerals which are distributed in two different ways. One group comprises the exsolution products of troilite, as daubreelite, which is believed to have formed by low temperature-solid state precipitation. The daubreelite forms 1-100 μ wide lamellae parallel to (0001) of the troilite, and it is rather evenly distributed. The ratio of daubreelite to troilite increases as the size of the troilite bodies decreases below 5 mm.

The other group comprises minerals which are undissolvable in troilite, even at high temperatures. The most important, chromite, is rather common as 0.3-2 mm euhedral cubic crystals dispersed in the troilite. The chromite contains minor quantities of vanadium, manganese and zinc in solid solution, while native copper grains and veins, usually only of micron size, are seen on various occasions. Other minerals, tentatively identified as $NaMnPO_4$ and $Fe_3(PO_4)_2$, occur associated with chromite but in minor amounts and only attaining sizes of 0.1-0.2 mm. It is interesting to note that these minerals, apparently having scavenged the meteorite system for oxygen, are always concentrated at one end of the elongated troilite bodies. It appears that they formed before the troilite solidified and were able to gravitate to one end of the troilite where they were trapped and clustered shoulder to shoulder.

The structural examination indicates that the Cape York material has been through a molten stage on a parent planet with a gravity field. While the metallic solidification front advanced parallel to $[100]_\gamma$, a known growth direction for austenite, the sulfur-enriched melt residue accumulated in interdendritic pockets, elongated roughly parallel to the growth direction of the austenite. Any mineral that formed or was concentrated in the troilite melt residue would sink or float according to its density relative to the sulfide melt under the prevailing pressure and temperature conditions. An accurate study of the inclusions and calculations of their densities, etc., would doubtless supply information as to the orientation of the Cape York material in the gravity field and perhaps an estimate of the strength of this field. The size of the parent body could also probably be calculated. While scattered evidence has previously been interpreted in favor of a molten stage with subsequent bulk solidification, Agpalilik seems to provide unambiguous proof that the very common group III iron meteorites have, at least at one point in their early history, been through a molten stage.

Cape York is a normal medium octahedrite with no indications of cosmic annealing. It is a type member of the resolved chemical group IIIA and, as such, is important because what we can learn from it may be extrapolated to cover all other irons of the very common group III. Chemically, it is closely related to Casas Grandes, Rowton, Willamette, Merceditas and Sacramento Mountains. In structural details there are, however, numerous differences due to secondary shocks and reheatings in space.

When Cape York hit the atmosphere with a mass of perhaps 200 tons, it split into several fragments of which eight totaling 57.8 tons have been recorded. It is possible that the fracture was initiated by preexisting fissures already induced when the mass was dislodged from its parent body. As far as we can say, the shower covered an area extending at least 20 km in an east-west direction, and 10 km in a north-south direction. The area may well have been larger, but the field work is seriously hindered by glaciers, perennial snow sheets and ice-covered bays that make up more than 50% of the area. An estimate of the fall direction is difficult for the same reasons. However, this much is certain: that the parent body must have been the largest ever to enter our atmosphere and survive in sizable fragments.

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

964 g part slice (no. 837, 10 x 10 x 1.2 cm) Savik I
86 g part slice (no. 837, 5.5 x 2.5 x 1.1 cm) Savik I
757 g part slice (no. 2145, 10.5 x 6.5 x 1.2 cm) Savik I
270 g oxidized scales, borings, etc. (nos. 384, 818, 1191)

Cape York (Akpohon), Ellesmere Land, Canada
79°5'N, 76°30'W

Medium octahedrite, Om. Bandwidth 1.20±0.15 mm. Deformed Neumann bands. HV 250±25.

Group IIIA with about 7.8% Ni on basis of the structure.

HISTORY

W.E. Ekblaw, of the Crocker Land Expedition, secured from an Eskimo a small specimen of 1,660 g which was found near an ancient igloo site at Eskimopolis at the eastern end of Knud Peninsula, Ellesmere Land, in 1914 (Hovey 1918). The main mass, now 1,473 g, is in the American Museum of Natural History (Reeds 1937; Mason 1964).

ANALYSES

No analysis is available, but the structure suggests a composition of about 7.8% Ni and 0.15% P, and with Ga, Ge and Ir placing it in group IIIA.

DESCRIPTION

Hovey (1918) gave the major dimensions as 9.8 x 9.7 x 4.6 cm, and stated that its oval shape had artificial edges produced by hammering. On the polished section in the U.S. National Museum, indications of the Eskimos' working are also seen where troilite is brecciated and schreibersite and rhabdite often show boudinage. The Neumann bands are bent, and lenticular deformation bands locally offset Neumann bands and minerals. Taenite and comb plessite are present, and rhabdites are rather common. The taenite ribbons are often bent and sheared. The significant plastic deformation is reflected in the microhardness of the kamacite phase; this ranges from 225 to 285, indicating varying degrees of cold work, most of it probably caused by the atmospheric breakup.

Several polycrystalline troilite nodules 1-4 mm in diameter with intergrown daubreelite lamellae were identified. A hard, rose-white, extremely fine, platy mineral, approximately 5 x 1 μ, occurs in the ferrite phase. The author identified this as carlsbergite, a chromium nitride. The heated rim zone of α_2 is removed by corrosion. The oxidation products in the near-surface of the meteorite are brecciated which proves that a part of the mechanical deformation took place after corrosion on the Earth for some time, and thus was due to work done on the mass by the Eskimos. The structure is identical to that of Cape York, and Akpohon is, no doubt, a transported specimen of this shower. We know that the Eskimos traveled long distances to obtain meteoritic iron from this place for their implements (Ross 1819; Peary 1898), and tools with cutting edges of meteoritic iron have been collected from many places in the Northwest Greenland-Ellesmere Land area (Buchwald & Munck, 1965: 11, figures 1-7).

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

82 g slice (no. 1367, 8 x 4 x 0.5 cm)

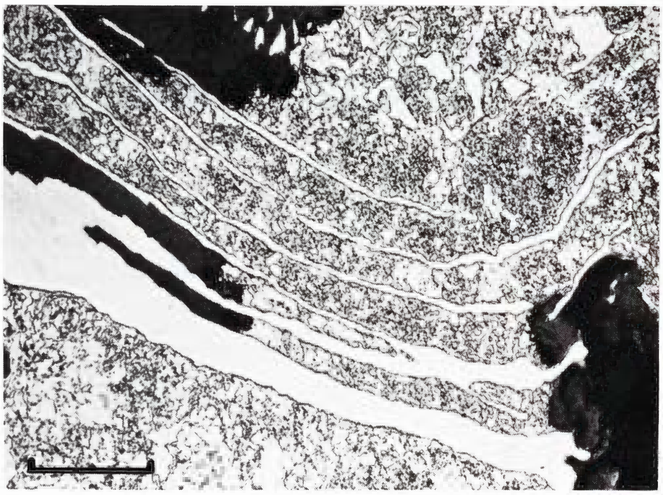

Figure 531. Cape York. The Eskimos collected the small masses of the Cape York shower and kept them as treasures and as stock from which to produce tools. Akpohon is an example. This photograph shows a section through another 100 g mass, found by archeologists in field 14[7] of Comer's Midden (Inugsuk Culture), Thule. (Copenhagen L3-9918). The comb plessite is severely distorted, the taenite is yellow, and the kamacite displays unequilibrated α_2 structures. The material has been artificially reheated to about 800° C. Etched. Scale bar 100 μ.

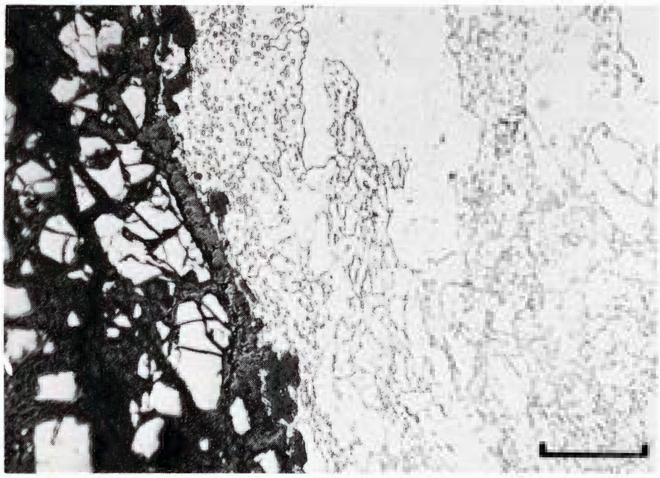

Figure 532. Cape York. Same as Figure 531. The small mass was entirely covered by vivianite, probably due to reaction between the meteorite and weathered bones of the midden. Schreibersite is unattacked (left), but enveloped by weathering products. The kamacite shows α_2 structure and fine precipitates, probably of austenite. It is not clear whether the reheating was associated with a deliberate attempt of forging, or the result of an accidental camp fire. Etched. Scale bar 40 μ.