forms together occur with a frequency of about 600 per mm². The α-phase has subboundaries, but neither Neumann bands nor hatched structures were observed.

The plessitic matrix appears to be of a bainitic, duplex type, but requires electron microscopy for any details to be seen. It appears striped at low magnification, apparently along the Widmanstätten directions, as defined by the scattered α-lamellae. The hardness is 300±15 and rather uniform right to the corroded edge of the specimens.

Schreibersite occurs as a few, “large” crystals, 40 x 60 or 120 x 20 μ in size, but most of the phosphides are present as evenly distributed blebs, 1-10 μ across. They have nucleated narrow rims of swathing kamacite, but the phosphide blebs are frequently still attached along one or two sides to the parent taenite. Because of this, the schreibersite is easily mistaken for taenite and is overlooked.

Troilitie occurs with a frequency of about one per 15 cm². The individual nodules are small, 0.2-4 mm across, and have frayed edges against the metal. The troilitie has been shock-melted and has dissolved part of the surrounding metal; the melts have solidified to fine-grained (~1 μ) eutectics of sulfide and metal.

Daubreelite fragments, 5-50 μ wide, are dispersed through the melts, and what appear to be tiny silicate or glass slivers are also present. The hardness of the troilitie composites is 235±10.

Weaver Mountains is closely related to Tawallah Valley which it resembles structurally and chemically. However, its hardness is significantly different. Weaver is a member of group IVB but does not resemble the phosphorus-poor members very much because, when phosphides are precipitated, they tend to create blebs of swathing kamacite which conspicuously interrupt the monotonous ataxitic structure. Furthermore, the matrix of Tawallah and Weaver is bainitic and optically unresolvable, while the matrix of, e.g., Hoba and Kokomo, is easily resolvable.
DESCRIPTION

According to Edwards (1953) the mass was a well rounded monolith with the overall dimensions of 5 x 3.6 x 2.6 cm and weighed 210 g. The mass was slightly corroded but showed a regmaglypt and a distinct heat-affected rim zone.

Etched sections display a very fine structure, intermediate between Tazewell-Follinge and Freda. No continuous Widmanstätten lamellae are present, but kamacite spindles occur in profusion, generating a microscopic Widmanstätten pattern. The largest spindles are 10±2 μ wide and about 100 μ long, and smaller needles and plates occur in all sizes in varying concentrations. A considerable proportion of the alpha phase is developed as swathing kamacite around the numerous phosphide inclusions. Where the swathing kamacite attains widths of 10-25 μ Neumann bands are clearly visible, at least below a depth of 5-10 mm from the surface.

The plessitic matrix is bainitic-martensitic with the platelets distinctly parallel to the bulk Widmanstätten structure. Very fine precipitates, about 0.5 μ wide, occur as vermicular bodies, that may be carbides. Locally, unetched structureless patches indicate retained austenite into which martensitic platelets project from the sides.

Schreibersite is evenly dispersed and occurs with a frequency of about 4 per mm², in dimensions ranging from 20 μ to 400 x 50 μ. Many of the crystals have been nucleated by small blebs of troilite and chromite. Generally only 10-25 μ across. Many of the larger schreibersite crystals are rimmed with 2-5 μ wide carbide precipitates, and carbide also appears to be present as 1-10 μ blebs in some kamacite spindles. The schreibersite is enveloped in 10-50 μ wide swathing kamacite.

Troilite occurs as 25-100 μ nodules, often associated with the schreibersite. It is shock-melted to 1-2 μ fine polycrystalline aggregates which include 1-2 μ iron grains in a eutectic. Free gold was reported by Edwards (1953) as a 250 x 200 μ unetching patch near the edge of the specimen. The identification appears very insufficient, and could not be supported by this examination. He also reported cliftonite associated with troilite; it may be correct but is certainly not characteristic.

The heat-affected α₂ zone extends to a considerable, but somewhat variable, depth because of the curvature of the small mass; compare Follinge. It was observed to range from 4-7 mm in width, and micromelted rhabdites were found to be present to half these depths. The martensitic matrix and the taenite rim zones are, as usual, also affected in the α₂ zone. The taenite etches only with difficulty in the exterior parts, and the matrix is distinctly decomposed to a number of differently oriented grains.

Corrosion has selectively attacked the swathing kamacite, the fine iron grains of the shock-melted iron-sulfur eutectic, and the α-spindles near the surface.

Wedderburn is, in its structure and chemical composition, intermediate between Follinge and Freda and is, as these, a very small iron. While Follinge shows continuous but very narrow kamacite lamellae, Wedderburn and Freda have so much nickel that the lamellae are arrested in an early growth stage and are only present as pointed spindles.

Weekeroo Station, Mannahill, South Australia
32°16'S, 139°52'E

Polycrystalline coarse octahedrite with silicate inclusions. Bandwidth 2.5±0.5 mm, Neumann bands. HV 220±15.
Anomalous. 7.22% Ni, 0.45% Co, about 0.15% P, 29 ppm Ga, 66 ppm Ge, 2.8 ppm Ir.

HISTORY

A mass of 94.2 kg was found in 1924 by Mr. James Lane at Weekeroo Station, Mannahill, the coordinates of which are given above. It was discovered on the brow of a big hill resting on, and level with, the surface of a quartz reef. Hodge-Smith (1932) presented analytical results of the bulk material, and planimetric measurements of the troilite (?) and silicate inclusions. In addition he gave two photographs of the exterior and one of an etched section. A photograph of the meteorite seen from a different angle was given by Hodge-Smith (1939: plate 3), and another print of a different section was presented by Nininger & Nininger (1950: plate 11). About 1928 the mass was, with difficulty, cut in the Government Railway Workshops, and following this, large slices were exchanged.

The silicates of Weekeroo Station have been the object of numerous recent investigations. Olsen & Mueller (1964) identified nodules of sodic plagioclase, and clinopyroxene-orthopyroxene aggregates similar to those of Kodaikanal. Mason (1967a) discussed the silicate minerals and found them sufficiently uniform and closely related to chondritic minerals to suggest that they might represent inclusions of chondritic material which completely recrystallized during the cooling.
the slow cooling that resulted in the Widmanstätten structure. Bunch (1967) and Bunch & Olsen (1968) examined the feldspars with the microprobe and gave their detailed composition. Axon & Smith (1970a) examined the metal with the microprobe.

A detailed chemical analysis of the silicate portion was reported by Olsen & Jarosewich (1970) who found the composition significantly different from most chondrites.

This implied that the recrystallization of chondritic material could not have produced the observed aggregates. They considered the interesting possibility that olivine might have been fractionally removed from a chondritic composition, and that Weekeroo Station might be a residue silicate fraction. By adding an average amount, 50%, of olivine (85% forsterite, 15% fayalite) to the Weekeroo analysis they obtained a result which was close to the average chondrite analysis for all major elements.

**WEEKEROO STATION – SELECTED CHEMICAL ANALYSES**

Hodge-Smith (1932), when examining a section measuring 49 x 19 cm, found 324 inclusions of troilite and silicates. A Rosiwal analysis of the section gave 96.2% nickel-iron, 3% troilite and 0.77% silicates. While the total, 3.77 volume percent of inclusions appears to be a good value for sections through Weekeroo, it is very doubtful whether the troilite content is as high as reported by Hodge-Smith. The sections I have examined are all rich in silicate and poor in troilite, the ratio approaching 50:1. Hodge-Smith must have worked with sections atypically high in troilite, or perhaps mistaken several silicate nodules for troilite.

### I. Metal.

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<thead>
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<th>Ni</th>
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<th>Cr</th>
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<td>Wasson &amp; Kimberlin</td>
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### II. Analysis of 12 silicate inclusions (2 g). (Olsen & Jarosewich 1970).

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<td>10.67</td>
<td>P₂O₅</td>
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**Mode:**

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<th></th>
<th>54.1%</th>
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<td>Orthopyroxene</td>
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<td>Silica, tridymite</td>
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<td>K-feldspar</td>
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<td>Ilmenite</td>
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<td>Whitlockite</td>
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<td></td>
<td></td>
<td>Chromite</td>
<td>3.1%</td>
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<tr>
<td></td>
<td></td>
<td>Graphite</td>
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Wasserburg et al. (1965) and Burnett & Wasserburg (1967a) isolated a feldspar fraction and proved the feasibility of using the $^{87}\text{Sr}/^{87}\text{Rb}$ method to determine the age of silicate inclusions in iron meteorites. A least squares line drawn through nine data points was found to correspond to a formation age of $4.37 \times 10^9$ years. The authors also discussed the discrepancies between the Sr/Rb method and the $^{40}\text{K}/^{40}\text{Ar}$ method, which consistently yielded higher ages by a factor of 1.5-2 (Rancitelli et al. 1967). The high K-Ar ages have later been explained on the grounds of a formation age of 4.37 x $10^9$ years.

The individual austenite grains have decomposed to a coarse Widmanstätten structure of straight, bulky (W) ~ 5-10) kamacite lamellae with a width of 2.5±0.5 mm. Locally, late growth has created irregular kamacite units up to 20 x 16 mm in size. If it were not for the presence of filamentary silicates along many austenite grain boundaries, the poly crystalline nature of the metal phase would only be indistinctly revealed by the alternating Widmanstätten patterns.

The kamacite has numerous subboundaries decorated by 1-2 μ taenite particles, occasionally increasing in size to 10 μ. A very fine-meshed net of cell boundaries is also present, and the cell walls are often arranged in subparallel bundles with mutual distances of 5-15 μ.

There are two generations of Neumann bands. The older, conspicuous one is heavily decorated by 1-3 μ taenite particles, occasionally increasing in size to 10 μ. These resemble rhabdites, but most are, in fact, nickel-rich taenite particles as proved by examination under the electron microprobe. The decorated bands must reflect some early cosmic plastic deformation and were later able to act as nucleation sites for taenite and phosphides. The younger generation is a set of normal, undecorated bands which offset the old ones; they are particularly frequent along the grain boundary fissures. It appears that the new Neumann bands formed when the meteorite violently decelerated in the atmosphere and, thereby, cracked along grain boundaries and inclusions. The hardness of the kamacite is 220±15, corresponding to slightly cold-worked material.

In the interior of the kamacite there are numerous densely spaced particles, generally 0.5-1 μ wide and often

**Figure 1912.** Weekeroo (U.S.N.M. no. 835). The edge of a complex silicate showing multiple twinning in plagioclase. Along the edge irregular pockets of deformed troilite are located (light). Polished. Scale bar 100 μ.

**Figure 1913.** Weekeroo (U.S.N.M. no. 835). Three kamacite grains meet at a brecciated schreibersite crystal. Previous Neumann bands are partially annealed out, partially decorated along both sides by minute taenite particles. Etched. Scale bar 50 μ.
displaying branching. They may easily be mistaken for minute rhabdites, but a check with the microprobe disclosed that the majority are in fact high-nickel taenite with 40-50% Ni. The particles apparently represent a variety of the isothermal taenite reported by Brentnall & Axon (1962) in artificial heating experiments and by Buchwald (1967a) in Seelägen and other irons.

Taenite and plessite cover 1-2% by area. A few comb plessite fields are larger than 4 x 3 mm in size, most are about 1 x 1 mm. The taenite lamellae stain blue-brown upon etching and display hardnesses of 340±25, probably due to cold working caused by the same event that hardened the kamacite. Larger taenite wedges show slightly decomposed interiors of, e.g., martensitic-bainitic transformation products (HV 360±30) developed parallel to {111} of the bulk Widmanstätten structure. Pearlitic and spheroidal developments are absent. Due to the late kamacite grain growth, many of the plessite and taenite fields are no longer situated at grain boundaries but are engulfed by a single kamacite grain.

Schreibersite is common as 30-100 μ wide grain boundary precipitates and as 10-60 μ discontinuous rims on the silicates. Rhabdites are common. The bulk phosphorus content of the metal in Weekeroo is estimated to be 0.15±0.03%.

Troilite is not present in the form of large nodules but occurs mainly as fillings and rims, associated with the silicates. The troilite rims are typically 0.5-1 mm long and 0.05-0.2 mm thick. They are monocrystalline but, because of plastic deformation, they are somewhat shattered and display undulatory extinction. The troilite forms sharp boundaries against the metal matrix but is frequently serrated against the silicates. Some tiny (5-15 μ) irregular troilite particles may frequently be identified in an exterior 100-200 μ wide zone of the shock-melted silicates.

Graphite has tentatively been reported in an analysis by Olsen & Jarosewich (1970), but I have not seen it in polished sections. It is certainly not common. Carbides were not detected.

The silicates have been well examined by various workers so the following is mainly a summary of the previously quoted papers. Orthopyroxene of bronzite composition constitutes about 50%, plagioclase of oligoclase composition about 20%, and clinopyroxenes about 15%. In addition there are magnesian chromite, chlorapatite, whitlockite, ilmenite and rutile. Thin lath-shaped crystals,
typically 100 x 10 μ in size, of K-feldspar and of tridymite are found at the interface silicate-metal, frequently protruding distinctly into the metallic matrix. The K-feldspar laths and exsolution lamellae were too small for X-ray identification, but could be analyzed with the microprobe. Clear and isotropic maskelynite, with internal cleavage traces and grain boundaries retained, was also identified (Bunch & Olsen 1968). Troilite and schreibersite are mainly found along the interfaces between silicates and metal.

The pyroxene crystals are usually concentrated in the interior of the silicate assemblages, while the chromite crystals are clustered near the interface with enclosing metal. The clinopyroxenes are mainly large (0.5-3 mm) euhedral chromian augite crystals with exsolved lamellae of Ca-poor pyroxene. Much of the oligoclase has been fused, presumably by shock, and has cooled rapidly into a complex spherulitic mixture of oligoclase and tridymite. Where these shock-fused minerals are in contact with troilite, discrete blebs of troilite have become dispersed within the silicate melt in a narrow zone. Olsen & Jarosewich (1970) noted that about one percent of the silicate nodules exhibited features suggesting that two immiscible silicate liquids had been present within them. Meniscus-like interfaces, which separated feldspar-rich and pyroxene-rich portions, were described. Such textures could possibly be the result of shock melting and rapid solidification.

The meteorite displays many deformation features due to plastic cold working. The Neumann bands are slightly bent and distorted near grain boundaries and inclusions, and in places there are lenticular deformation bands. The microhardness increases in such places to about 250. Numerous grain boundaries are in fact open fissures, and the cracks continue through taenite, schreibersite and silicates. Even the massive kamacite lamellae display internal narrow cleavage cracks along the cube planes. The schreibersite crystals are severely brecciated and may be displaced along a number of shear planes, in steps of 1-10 μ. Some of these sheared crystals are afterwards healed by diffusion.

It appears that we have two different events that strained the mass significantly. The early event shattered the nonmetallic inclusions, introduced Neumann bands, shock-melted the oligoclase and slightly dispersed the troilite in it. Subsequently, mild annealing allowed for some healing, and decoration of the first Neumann band generation occurred simultaneously. This event may be a remote cosmic shock event.

The second event formed fresh Neumann bands, fissured the minerals and developed cubic cleavage cracks in the kamacite. The relative displacement of neighboring grains along common boundaries distorted the Neumann bands, until finally some grain boundaries fissured completely. It appears that this event could have been the violent deceleration when the meteorite entered our atmosphere.

The meteorite has quite a weathered interior, mainly because so many open lanes had been produced by the...
shock events discussed above, Corrosion forms 20-100 \( \mu \) wide limonitic veinlets along grain boundaries and also penetrates the shattered schreibersite and silicates, which often occur recemented as disordered angular breccias. Some corrosion also follows the decorated Neumann bands. The troilite is veined by pentlandite. Terrrestrial weathering may have reduced out the minute quantities of free copper reported by Bunch & Olsen (1968).

Weekeroo Station is an anomalous meteorite. The polycrystalline nature of its metallic part might indicate a relationship with such group I irons as Campo del Cielo (El Taco), Woodbine, Four Corners and Copiapó. Since the nickel content — and presumably the cooling rate — of Weekeroo deviates from these, the kamacite bandwidths are different. Also, the typical microstructural elements of the group I irons are absent in Weekeroo. Moreover, the trace element content of the Weekeroo metal is quite different from that of Campo del Cielo, etc. and approaches that of some pallasites (Marjalahti), Barranca Blanca and group IIIA. Finally, olivine is absent in Weekeroo and free silica occurs as tridymite, as opposed to Campo del Cielo, etc. It, therefore, appears that Weekeroo Station is unrelated to the various group I irons with silicate inclusions.

In its metal-silicate assemblage Weekeroo Station is related to Colomera, Kodaiakanal, Elga and Netschaev. Particularly close associations appear to exist with the first two mentioned; common to these is, e.g., the potassium feldspar which otherwise is rare in meteorites.

Bunch (1967) suggested a close genetic relationship to the siderophyre Steinbach. Although pyroxenes and tridymite are indeed common to Steinbach and Weekeroo Station, I find so many other differences — mainly in the metallic texture and composition, both with respect to major and minor elements — that I believe the two meteorites are unrelated. Steinbach belongs rather to the resolved chemical group IVA, as discussed by Schaudy et al. (1972).

Weekeroo has been described as a brecciated octahedrite by Hodge-Smith (1932), Hey (1966) and Mason (1967a). It appears, however, that Weekeroo is not the result of true brecciation, but rather a polycrystalline aggregate of austenite grains where the grain boundaries are distinguished by high silicate concentrations. Such aggregates might be the result of mechanical mixing of metallic particles and silicate particles, and subsequent compression and sintering at 1100-1200° C. Any troilite present would migrate to the grain boundaries and, as a liquid, probably promote sintering and grain growth by making diffusion easier through the liquid films. Upon cooling, each austenite grain would develop its independent Widmanstätten pattern. Still later, various shock events would have altered the structural details.

In preliminary, unpublished experiments with this sequence in mind, I mixed powders (5-10 \( \mu \) grain size) of iron, nickel, phosphide and porcelain, compressed them to briquets, and heated them. Within 24 hours at 1100° C, the briquets sintered into massive tablets with an austenitic grain size as large as 1 mm. The silicates, which were not examined in detail, were found as filaments in the grain boundaries and as spherules in the grain interiors. The whole assemblage resembled, indeed, Weekeroo Station very much en miniature.

Specimens in the U.S. National Museum in Washington:
11.6 kg slice on exhibit (no. 835, about 40 x 17 x 3 cm)
About 200 g as minor part-slices and mounted sections.

Welland, Ontario, Canada
43°1'N, 79°13'W

Medium octahedrite, Om. Bandwidth 1.20±0.15 mm. e-structure. HV 335±20.
Group IIIA, 8.66% Ni, about 0.25% P, 0.06% C, 21 ppm Ga, 47 ppm Ge, 0.29 ppm Ir.
HISTORY
A mass of about 8 kg was plowed up in April 1888 by Mr. W. Caughell, on land owned by Mr. Shannon, about 2 km north of Welland. The finder detached, with great difficulty, a piece of about 140 g and threw the main mass aside. When it was later realized that the iron was of meteoritic origin, the original mass was finally rediscovered in a pile of old iron inside a disused stove (Howell 1890). Howell produced a woodcut of the exterior shape, while Ward (1904a: plate I) gave a photomacrograph of an etched section. Davison (1891) analyzed the individual components of kamacite (6.69 Ni, 0.25 Co, 0.02 C) and taenite (24.32 Ni, 0.33 Co, 0.50 C) which had become separated due to weathering. The analyses are remarkably good for their day, and what is interesting is the high proportion of carbon present in the taenite. Brezina (1896: 284) observed the marked weathering which in one place had produced a loose octahedron 9 cm in diameter. He reported numerous cohenite crystals centrally in the kamacite lamellae. This observation is, however, incorrect since the precipitates are actually schreibersite crystals.

COLLECTIONS
Vienna (1.2 kg), Chicago (926 g), Toronto (about 600 g), Tallinn (515 g), London (466 g), Ottawa (308 g), New York (261 g), Washington (210 g), Ann Arbor (200 g), Harvard (138 g), Prague (135 g), Strasbourg (73 g), Vatican (65 g), Yale (57 g), Bonn (49 g), Philadelphia (49 g), Helsinki (45 g), Berlin (44 g), Rome (41 g), Sarajevo (41 g), Copenhagen (35 g), Tempe (1 g. Hey (1966) had stated 1 kg.)

Figure 1920. Welland (Pra gue no. 73). A medium octahedrite of group IIIA. Note the small schreibersite crystals (black) along the center lines of many kamacite lamellae. Deep-etched. Scale bar 22 mm.

Figure 1921. Welland (C openh age n no. 1891, 55) A large comb plessite field with edges of cloudy taenite and unresolvable black taenite. Shock-hatched kamacite everywhere. Etched. Scale bar 300 μ.

WELLAND – SELECTED CHEMICAL ANALYSES

<table>
<thead>
<tr>
<th>References</th>
<th>Ni</th>
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<th>Cr</th>
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The black-etching taenite islands are surrounded by kamacite, rich in decorated slipplanes (HV 300±20). The precipitates are ultramicroscopic and may be either phosphides or carbides. The reason for their presence seems to be a late shear-transformation (<400°C) in the taenite, whereby the accompanying increase in volume strained the surrounding kamacite. In due time the numerous dislocations became decorated with precipitates on a submicroscopic scale. Compare Thule, Trenton and others.

Schreibersite is conspicuous as 2 x 0.2, 1.5 x 0.1, 0.8 x 0.6 mm or smaller angular inclusions which frequently are aligned in the α-bands. The crystals are monocrystalline but brecciated because of the shock that created the hatched kamacite. Schreibersite is also common as 30-70μ wide grain boundary veinlets and as 2-20μ blebs inside the plessite fields. Rhabdites proper are absent, but a number of fine precipitates (<0.5μ) in the kamacite are probably submicroscopic rhabdites. The bulk phosphorus content is estimated to be about 0.25%.

Troilite was not observed in any of the available sections. A small amount of carlsbergite in the form of 1-2μ blebs is present in the kamacite phase.

The heat-affected α2 zone has been removed by terrestrial corrosion. There is, however, a hardness gradient from the interior of the mass to the surface. Within the last 1-2 mm, the hardness drops from 330 to about 275, indicating that corrosion has removed about 6-8 mm (hardness curve type I, where the α2 zone and 3/4 of the ascending leg is lacking).

Welland is a medium octahedrite, which for structural reasons alone seems to belong to the chemical group III. It is closely related to Aggie Creek, Veliko-Nikolaevskij Priisk, Gundaring, Lenarto and Orange River and a trace-element analysis will probably show that it, with these, is transitional between group IIIA and IIIB. The meteorite has not been artificially reheated; the fact that it was found in a disused oven appears to be coincidental.

Figure 1922. Welland (Copenhagen no. 1891, 55). Plessite field typical of Welland, showing comb and net varieties and, along the upper edge, acicular development. Subboundaries in kamacite. Etched. Scale bar 200 μ.

Figure 1923. Welland (Copenhagen no. 1891, 55). Three kamacite lamellae showing different shades in the shock hatching, purely an effect from orientation shift across the boundaries. In the boundaries are cloudy taenite (T) and brecciated schreibersite. Etched. Scale bar 200 μ.

Figure 1924. Welland (Copenhagen no. 1891, 55). Detail of a plessite field showing the exterior yellow high-nickel taenite rim followed by cloudy taenite. This forms an irregular boundary to the interior martensitic transformation products. Etched. Scale bar 20 μ.

Figure 1925. Welland (Copenhagen no. 1891, 55). Detail of the hard shock-hatched kamacite. Etched. Scale bar 20 μ.
Specimens in the U.S. National Museum in Washington:
46 g part slice (no. 416)
36 g part slice (no. 1178, 5 x 2 x 0.5 cm)
45 g part slice (no. 3146, 5 x 3 x 0.5 cm)
40 g part slice (no. 3148, 5 x 1.8 x 0.5 cm)
30 g cuttings and a small piece (nos. 3147, 3384)

Western Arkansas, U.S.A.
Approximately 34°30'N, 93°30'W

Fine octahedrite, Of. Bandwidth 0.30±0.03 mm, α₂ structure, HV 180±10.
Group IVA. 7.62% Ni, about 0.03% P, 1.97 ppm Ga, 0.10 ppm Ge, 2.8 ppm Ir.
The microstructure indicates that the mass has been hammered and artificially reheated to about 800°C.

HISTORY
The history of this iron of 1.75 kg is virtually unknown. According to Merrill (1927b), the mass was part of the F.A. Canfield mineral collection bequeathed to the Smithsonian Institution in 1926. It was labeled in Canfield's hand "Meteor found in Arkansas, presented by I. Price Wetherill, (?) June, 1890" and on the obverse: "Mr. Wilkins said a native mountaineer brought the specimen to him in Joplin." In view of the indefinite locality of find, the coordinates above are those of Joplin, Montgomery County.

Merrill (1927b) only gave an incomplete description, accompanied by an erroneous analysis by Shannon (5.1% Ni), wherefore the meteorite has long been classified as a nickel-poor ataxite (Prior 1953; Hey 1966). Recently Wasson (1968, personal communication) found that, chemically, it was a member of group IVA, while I had found the primary structure to correspond to that of Charlotte and Gibeon. Jain & Lipschutz (1970) examined the microstructure and produced a photomicrograph; from the disordered mosaic structure they concluded that the meteorite had been cosmically reheated. The possibility of a different explanation will be accounted for below.

COLLECTIONS
Washington (1.5 kg), London (19 g), Tempe (17 g).

DESCRIPTION
The only specimen known measuring 8 x 6 x 6 cm, is in the Smithsonian Institution; from this, only very small slices have been detached for exchange and analysis. As it appears today, it is a somewhat rounded, triangular mass which looks as if it is only an endpiece of some larger unknown mass. There are numerous hammer and chisel marks on the surface, no doubt made by either the finder or the early owners in order to test the nature of the material and perhaps to separate it from a larger mass.

Etched sections reveal a fine Widmanstätten structure of slightly undulating, long (W ~ 30) kamacite lamellae with a width of 0.30±0.03 mm. There are numerous 50-200 μ wide shear zones that penetrate the sections from edge to edge, displacing kamacite and plessite in much the same way as in Puquios, Descubridora, Jamestown and Wood's Mountain. The deformation is so intensive that it must be due to some cosmic collision event. The deformation from hammering and chiseling has produced some additional effects, but mainly restricted to near-surface regions, tapering out below depths of 1-2 mm.

Talcite and plessite cover 40-45% by area but show little contrast on the dull lusterless surface. Comb, net and cellular plessite are common types, while martensitic-bainitic types are virtually absent. Duplex, unresolvable α + γ fields are also present. All talcite show somewhat diffuse boundaries as a result of a late reheating. Thorns protruding into the kamacite are not well developed, because the phosphorus content is too low.

Schreibersite and tiabrides are absent in any form, at least unresolvable using a 60x objective. The bulk phosphorus content is estimated to be 0.03±0.01%.

On a deep-etched section, a 2 x 1 mm troilite nodule was observed. It contained about 30% daubreelite, and both troilite and daubreelite were visibly faulted and sheardisplaced about 0.2 mm. Daubreelite also occurs as 5-50 μ irregular angular inclusions in the kamacite.

The macrostructure shows that Western Arkansas is a shocked, fine octahedrite related particularly to Gibeon, Jamestown and Wood's Mountain. Unfortunately, its microstructure has been destroyed by an artificial reheating:

The kamacite which originally may have shown hatched α-structure is now in a disordered state, decomposed to numerous serrated α₂ crystallites each 5-50 μ across. The hardness is 180±10 corresponding to values which are produced by air-cooling from about 800°C. In the hammered near-surface regions, the hardness increases to 230±20, because of superimposed cold-deformation. In the present state it is difficult to detect whether an ablation-heated α₂ zone from the atmospheric friction was present when the meteorite was discovered. The surface is corroded and worked too much for a conclusion.

The corrosion products have been heat-treated simultaneously with the meteorite, proving unambiguously that the peculiar microstructure of the kamacite in Western Arkansas is due to artificial reheating and not to any cosmic cause. The limonite is decomposed to magnetite and wüstite in which 1 μ precipitates of metallic beads are

WESTERN ARKANSAS - SELECTED CHEMICAL ANALYSES

<table>
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<tr>
<th>Reference</th>
<th>Ni percentage</th>
<th>Co</th>
<th>P</th>
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<th>Ge</th>
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<td>1.97</td>
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widely distributed. The corroded cracks are further lined with 5-30 μ wide laceworks of oxide and metal in a fashion which occurs only upon artificial reheating in the 700-800°C range. Finally, some intercrystalline, high temperature oxidation cracks occur in many places at the surface.

Western Arkansas is a shocked, fine octahedrite which chemically and structurally is closely related to Gibeon, Charlotte, Muonionalusta and Jamestown. The gross features of the structure, particularly the heavy faulting, are due to cosmic events. However, minor surface deformations from hammering are superimposed upon these. The present microstructure of \( \alpha_r \) indicates that the mass has been artificially reheated to about 800°C. Even if the mass should turn out to be a part of another meteorite, as the external shape and the chisel marks suggest, it does not appear to belong to any of the midwestern octahedrites on record, but rather to an unknown and probably lost mass.

Specimen in the U.S. National Museum in Washington:
1508 g endpiece (no. 794, 8 x 6 x 6 cm)

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**Wichita County, Texas, U.S.A.**

Approximately 34°N, 99°W

Coarse octahedrite, Og. Bandwidth 2.4±0.6 mm. Neumann bands. HV 177±10.
Group I. 6.76% Ni, about 0.2% P, 1.2% S, 84 ppm Ga, 344 ppm Ge, 2.1 ppm Ir.

See also pseudo Saint Francois County. Possibly a paired fall with Ballinger.

**HISTORY**

A mass of approximately 150 kg was discovered by the Spaniards who made several ineffectual attempts to remove it on pack mules. The Comanche Indians later endeavored to melt the mass by building large fires around it; then they attempted to break it into pieces, but failing this they came to consider it a powerful medicine stone. They regarded it with the highest veneration, and it was the custom of all who passed by to deposit upon it beads, arrowheads, tobacco, and other articles as offerings. In July 1836 the mass was taken to San Antonio and in 1859 it was forwarded to Austin (Shumard 1860). When the capitol building was destroyed by fire (1881) the meteorite fell into the basement where it was sheltered from the heat by masonry rubbish which accumulated over it. Removed from the ruins, it was turned over to the University of Texas in Austin where the main mass is still preserved in the Bureau of Economic Geology (Mallet 1884; Barnes 1939a). The exact locality of the original find is unknown; Barnes (1939a) speculated that the mass came from some other county, Baylor or Parker.

About a third of the mass has been offered for sale or exchange, mainly through Ward's Natural Science Establishment (see, e.g., The Ward-Coonley Collection of Meteorites, 1900 and 1904; and Price Lists, 1897 and 1931) and
through Foote Mineral Company (Price List, 1912). Brezina (1896: 285) gave a short description of the structure. Farrington (1915) reviewed the literature up to 1900. Perry (1944) described the microstructure on the basis of four photomicrographs. Several photomacrographs have been presented on various occasions, by Brezina (1855: plates 2 and 3), Meunier (1893a: 28), Ward (1904a: plate 2), Foote (1912: plate 10) and Mauroy (1913: plate 1).

Mallet (1884) and Merrill (1916a: 170) suggested that Wichita County might have been a part of the same fall as the Red River mass, found at another ill-defined place in Texas early in the nineteenth century. This is, however, out of the question since, structurally and chemically, the irons are as different as iron meteorites can be.

Olsen (1967) identified the amphibole richterite (soda tremolite) in small amounts in graphite nodules. No member of the amphibole group of silicates – which is quite prominent in terrestrial rocks – had hitherto been found in any meteorite. The largest grains were 0.6 x 0.2 mm, and the identification was performed optically, by electron microprobe work and by X-ray powder diffraction techniques. Adjacent to the amphibole were clear olivine grains, a little albite, roedderite and whitlockite. In the troilite nodules, small specks of sphalerite, diopside and orthorhombic enstatite were identified.

**Figure 1929.** Wichita County. Detail of Figure 1927 showing decorated subboundaries in the kamacite and a decomposing cohenite crystal (C). A taenite body (T) with interior martensite is also seen. Etched. Scale bar 300 μ.

**Figure 1930.** Wichita County (Copenhagen no. 1905, 1743). Detail of a decomposing cohenite crystal (C). Graphite forms an irregular plume and columnar ferrite grains (with 1-2% nickel) grow on both sides. Etched. Scale bar 30 μ.

WICHITA COUNTY – SELECTED CHEMICAL ANALYSES

Sjöström (in Cohen 1892) analyzed the cohenite-isolates with the following results: 90.80% Fe, 2.37% Ni, 0.16% Co, 6.67% C, a remarkable analysis. Reed (1969)

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<th>percentage</th>
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<th>ppm</th>
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<tr>
<td></td>
<td>Ni</td>
<td>Co</td>
<td>P</td>
</tr>
<tr>
<td>Manteuffel in Cohen</td>
<td>6.74</td>
<td>0.59</td>
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nODULES. When a neighboring section only displays a coarse octahedral structure with few visible inclusions. A 50 g slice in Copenhagen thus shows a very coarse structure and pronounced grain growth of the kamacite phase. Slices in Tempe and Washington, on the other hand, show a regular, coarse structure rich in cohenite precipitates. The following description is an attempt to describe the "average" specimen.

Etched sections display a coarse Widmanstätten structure of straight, bulky (W ~ 10) kamacite lamellae with a width of 2.450.6 mm. The kamacite is rich in Neumann bands. Subboundaries decorated with 1-2 μm rhabdites are common. The microhardness is 177±10, the same as that of a large number of other group I coarse octahedrites.

Taenite and plessite cover 2-4% by area. It is most common in association, and in contact, with cohenite crystals. It is developed as coarse pearlitic (1-2 μ γ-lamellae, microhardness 190±5) or fine pearlitic (< 0.5 μ γ-lamellae, HV 205±5) fields, and also as spheroidized fields with 2-20 μ globules of taenite. Taenite ribbons with a tarnished etch, 40 μ wide, have a hardness of 185±5, while the bainitic-martensitic interior of wider ribbons and wedges are significantly harder, 310±15. A rather unusual abrupt transition, from pearlitic to bainitic development, was observed at numerous places in the fields.

Schreibersite occurs as 10 x 1, 5 x 1 or 2 x 2 mm crystals, and as 20-80 μ wide grain boundary veinlets. The rims around the troilite nodules are irregular, up to 1 mm thick, and partly shattered and dispersed in the troilite. Rhabdites 5-20 μ across are common in the cohenite-poor specimens. They decrease in number and size (to ~ 0.5 μ) in the cohenite-rich specimens. The bulk phosphorus content is estimated to be 0.22±0.04%.

Cohenite is present in abundance in the form of smoothly rounded elongated crystals, typically 4 x 0.5 mm in size. As usual, they follow the Widmanstätten pattern and have often grown around retained austenite and fine schreibersite blebs, 20-100 μ across. Cohenite also forms the exterior 0.2-0.6 mm wide rim zone of the troilite nodules. The cohenite is monocristalline with a hardness of 1150±50.

All cohenite is under decomposition to graphite plus ferrite. The graphite is precipitated within the cohenite itself, apparently on both sides of preexisting fine fissures in the cohenite. The graphite now forms 3-15 μ wide, feathery lamellae which reach millimeter-lengths. Along their midribs limonitic products, which must come from late terrestrial corrosion, are frequently found.

The other product of the decomposition Fe₃C → 3 Fe + C, is in the form of rather unequilibrated, serrated ferrite grains, that may exhibit a columnar growth. The hardness is low (< 135), mainly because of the low nickel content (< 2.5%). Presumably the decomposition of the cohenite did not take place until after some cosmic collision had cracked the crystals and slightly reheated the

Figure 1931. Wichita County (Copenhagen no. 1905, 1743). One of the larger plessite fields showing crossing kamacite spindles. Cloudy taenite rims and annealed martensitic interior. Cohenite crystals (C) and Neumann bands in the kamacite. Etched. Scale bar 200 μ.

Figure 1932. Wichita County (Copenhagen no. 1905, 1743). Remnants of a comb plessite field. Taenite (T) and schreibersite (S) alternate. Neumann bands in the kamacite. Etched. Scale bar 300 μ.

Figure 1933. Wichita County (U.S.N.M. no. 802). An altered troilite-graphite nodule. Below polycrystalline troilite (light). Then a band of terrestrial limonite (colloform, black). Then a 0.5 mm wide band of brecciated, but almost pure graphite (gray). Finally a fine-grained mixture of troilite (light) and graphite. Polished. Scale bar 200 μ.
The reheating must have been rather mild (<400 °C), since recrystallization of α has not occurred. The softness of the γ-phase suggests, however, some recovery by slight reheating. It is out of the question that the structural changes are associated with the reported fires. First, the corrosion products have not participated in the reheating and second, several other iron meteorites, e.g., Dungannon, Oscuro Mountains and Deelfontein, show similar cosmic annealing effects.

The troilite-graphite nodules are 1-3 cm across, and the graphite is normally developed as an almost continuous 1-2 mm envelope around a core of troilite. To obtain a representative value for the sulfur content of the meteorite, a large slab of 26 x 16.5 cm was examined with a planimeter. Six troilite nodules occupied 79.2 cm² of the 348 cm² section, corresponding to about 1.2% S, having deducted the graphite part.

The troilite is severely shock-transformed. Rather passive blocks, 0.1-0.5 mm across, are separated by sheared and recrystallized channels 0.01-0.1 mm wide. Along phase boundaries, the troilite has been micromelted and is now in the form of iron-sulfur eutectics in which dispersed fragments of schreibersite and silicates are found. Also, the finely developed mixtures of irregular polycrystalline troilite grains and fractured graphite sheaves appear to be the result of dispersing preexisting solid graphite crystals in a rapidly melted and solidified troilite melt. The cause must have been a late shock and the associated local temperature peak.

Corrosion has removed the heat-affected α₂ zone from the atmospheric flight. Corrosion also penetrates several centimeters into the interior, particularly attacking the nickel-depleted zones near schreibersite and the nickel-poor ferrite around the graphite lamellae in cohenite.

Wichita County is a coarse octahedrite which in many respects resembles Ballinger, Canyon Diablo, Deelfontein and Youndegin. Chemically and structurally, it is a typical group I. Its detailed microstructure suggests a late, mild cosmic reheating, while the reported terrestrial fires apparently were of no consequence.

Concerning the possible pairing with another Texas iron meteorite, the reader is referred to the discussion of Ballinger.

Specimens in the U.S. National Museum in Washington:
- 20 g part slice (no. 20, 4 x 0.9 x 0.7 cm)
- 607 g and 1,365 g part slices (no. 802)
- 5 g weathered troilite nodule (no. 802, 25 x 11 x 6 mm)
- 212 g on two slices (no. 1181)
- 46 g part slice (no. 3152)

Wickenburg. See Canyon Diablo (Wickenburg)