A RESTUDY OF THE SOCIAL CIRCLE, GEORGIA, METEORITE

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ABSTRACT

A new analysis and density determination are reported for the Social Circle meteorite. This iron is evenly granulated throughout; this is believed to be due to reheating after the octahedral pattern formed, but before the meteorite entered our atmosphere.

This meteorite was found while plowing a field on the plantation of W. B. Spearman, near Social Circle, Walton County, Georgia, in 1926. The meteorite weighed 219 pounds and the length, breadth and thickness of it was given by S. W. McCallie[2] as fifteen, thirteen and nine inches, respectively, in the only published data on this meteorite.

This iron is believed to be an old fall because the outer surface is so weathered that no remnants of the original crust remained. Flight markings as well as the fusion crust, under average conditions, usually persist for a number of years. The surface of this meteorite, however, was so weathered that any shallow depressions or thumb marks which may have been present were completely obliterated. Hence the Social Circle iron must have fallen many years before it was found.

Shortly after the main mass was cut in the laboratories of the U. S. National Museum it was found to contain lawrencite, hence the alteration may have been somewhat accelerated by this agent. In places the weathering had penetrated about one centimeter below the present outside surface of the specimen.

When the preliminary investigation on this iron was made, probably for the purpose of identifying it as a meteorite, an unsightly notch was cut into the thin edge of the mass. This notch was about three inches deep, and as the two saw cuts did not meet there has been some speculation as to how the wedge-shaped piece of metal was removed.

Then, since the original analysis of this iron appeared to be inconsistent with the width of the granulated kamacite bands, and some speculation arose about the granulation extending evenly through the entire meteorite, these authors made an effort to obtain the main mass for restudy. Through the cooperation of Captain Garland Peyton, Director, and Dr. A. S. Furcron, Assistant Director, of the Georgia Department

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] Notes of Social Circle Meteorite, *Am. Jour. Sci.*, 5th ser., **13**, 360 (1927).

of Mines, Mining and Geology, the Social Circle meteorite was sent to the U. S. National Museum with permission to section it.

A new cut was made parallel to the long dimension of the meteorite and far enough into the specimen to remove the unsightly notch. Thus a large cross section was prepared and from this sizable mass a number of slices were cut at right angles to the large cross section.

The largest cross section through this iron measures seventeen by eight and one half inches and has approximately one hundred square inches of surface. This was polished and etched, as were all of the eight sections which were cut at right angles to the larger cross section. After examining all of these surfaces it was apparent that the entire meteorite has the same degree of granulation. This is believed to be a significant point.

TABLE 1. COMPOSITION OF THE SOCIAL CIRCLE, GEORGIA, METEORITE

	1	2	
Fe	94.07	91.83	
Ni	5.02	7.44	
Co	.38	.38	
Cu	trace	—	
Sn	.09	—	
P	.06	trace	Mol. Rat.
	99.62	99.65	$\frac{Fe}{Ni+Co} = 12.43$
Specific Gravity	7.42	7.81	
Specific Gravity		7.89	

1. Edgar Everhart analyst, *op. cit.*
2. E. P. Henderson, analyst.

The difference in specific gravities may be due to the fact that the original determination was made upon a piece of metal which was slightly oxidized.

This iron although granulated still shows outlines of the octahedral structure. The kamacite bands average between .3 and .5 millimeter in width, hence the Social Circle iron is a fine octahedrite. The kamacite bands are separated by long narrow taenite lamellae, but the kamacite is uniformly granulated. No appreciable difference in the degree of granulation was noted in any of the sections. Although the long taenite lamellae were not broken up, the plessite areas have been modified and their structure transformed to a granular texture.

Only a few inclusions of schreibersite and troilite were noted. The temperature required to produce any effect on either of these constituents is far above that which is necessary to granulate kamacite. To alter plessite would require still greater heating, because it takes higher temperatures to alter taenite bodies than it does either to diffuse phosphide or to granulate kamacite.

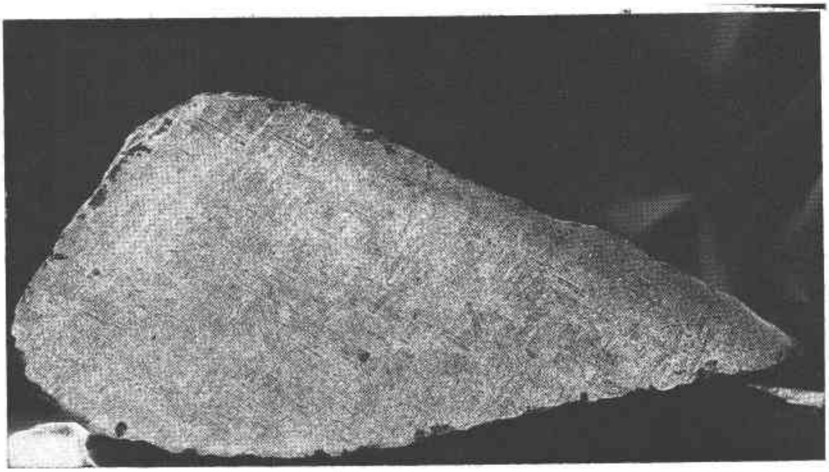

FIG. 1. Cross section of the Social Circle Meteorite showing that it is evenly granulated throughout. Weathering had removed all the original external features from this iron and the dark areas around the edge show the distance weathering had penetrated. This meteorite contains some lawrencite. $\frac{1}{4}$ natural size.

Farrington[3] published pictures of the Toluca iron showing its structure before and after heating to a temperature of 900° C for seven hours. The octahedral structure was all but completely destroyed. The temperature to which the Social Circle iron was reheated cannot be estimated because a prolonged heating at lower temperature, 600–700° C would probably be sufficient to produce the effect noted in this iron. Most likely it was gradually heated and the temperature to which it was raised must have been maintained long enough to heat it uniformly throughout. The degree and the duration of the heating of this iron were not enough to materially affect the taenite lamellae but were sufficient to alter the plessite fields.[4] The exact nature of that alteration is not clear to the authors. The appearance of the fields differs from that of similar fields of normal character. They present a darkened and confused pattern, the character of which is not clear even under high magnification. Conceivably minute particles of taenite in such a field might be affected by heating to a range that would not visibly affect lamellae of taenite. Or the field may

[3] Meteorites, p. 99, 1915. Published privately by the author.

[4] Perry, S. H., Metallography of Meteoric Iron: *U. S. Nat. Mus., Bull.* **184**, pl. 74 (1944).

have contained a dark gamma-alpha aggregate, common in such fields, which underwent alteration, but the original presence of which cannot now be affirmed.

Kamacite would be the first constituent to be affected by the heat because the solubility of the nickel in kamacite is reported to be gradually decreased as the temperature is raised above 400° C.[5] Kamacite at about 600° C will contain about 4 per cent of nickel and at 700° C the solubility of nickel is further reduced to about 2 per cent. Granulation could

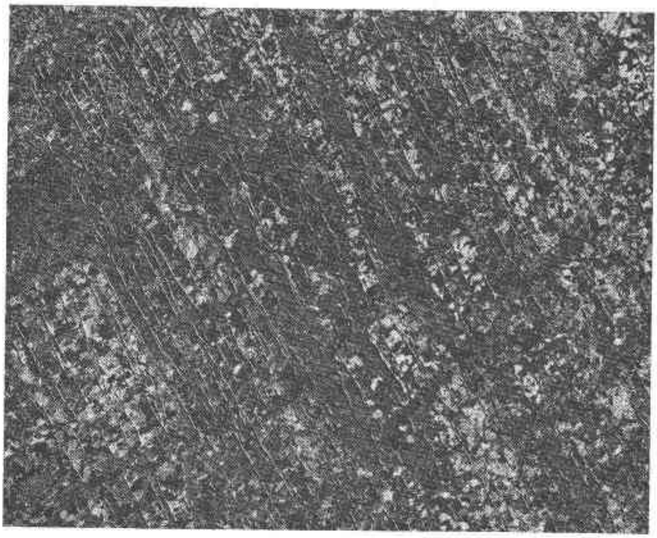

FIG. 2. The kamacite has been granulated by the reheating but the narrow taenite lines have not been affected. 5×

be attained, according to Tammann[6] by prolonged heating even at 400° C, but it would probably be a fine grained secondary granulation. It is estimated that the grain size of the kamacite in Social Circle meteorite was formed by heating to a much higher temperature. It is doubtful if a temperature of even 600–700° C would be high enough to alter the plessite fields unless it was sustained for a long time.

Many of the new boundaries of the granulated kamacite structure stop at taenite lamellae, and if they all did it certainly would be strong evidence that granulation was produced subsequent to the formation of the octahedral structure.

It is doubtful if granulation could be produced at temperatures of 400° C or less by even long and continued heating. At these low tempera-

[5] Owens and Sully: *Philos. Mag. Jour. of Science*, **27**, no. 184, p. 614 (1939).

[6] Gustav Tammann: Lehrbuch der Metallographie (1923).

tures it would require an unusual set of conditions which are difficult to reconcile with the supposed formation of meteoritic structures. The heat would have to be maintained for an extremely long time because any rearrangement in the iron at these low temperatures would be very sluggish. Therefore these authors feel justified in stating that the granulation or reheating of the Social Circle iron was in no way related to its flight through our atmosphere.

Meteorites are only in the earth's atmosphere for a short time, measured in seconds, hence there is not enough time for the heat generated during the fall to penetrate very far into the mass. Evidence can be found in a limited number of polished sections of meteorites that the heat which develops during their flight penetrates the mass in localized areas. Rarely will the structures be modified as far as one centimeter below the outer surface.

The granulation in the Social Circle meteorite is not the result of man's attempt to apply heat. A number of the meteorites discovered a long time ago were heated in the blacksmith's forge. Such heating would not produce an even temperature throughout, because the surface would be heated to a higher degree than the interior, hence, the granulation near the outside would be different from that in the center of the iron. The Social Circle iron certainly was never heated under controlled conditions such as would be possible in a laboratory.

Because the time needed to uniformly heat this meteorite to the temperature required to produce the granulation observed, these authors believe that it was reheated, after it originally cooled, and after the octahedral pattern formed. The present concept most generally favored is that iron meteorites represent the internal core of a planet. Thus the reheating or granulation may have taken place while this meteorite was a part of the core of some planet-like body.

If this is the case, the gradual rise in temperature was connected with some internal heating in the planetary mass. However, the evidence gained from this examination of the Social Circle iron suggests that it was not reheated at the time the planet disrupted, because the temperature necessary for this degree of granulation was not high enough to have an intimate relationship with that catastrophic event.

The other explanation for the reheating of this meteorite is that it occurred after the planet had broken up and before it fell through our atmosphere to this earth. The next logical possibility to consider is that the mass strayed in close enough to our sun and remained there long enough to be heated throughout to the necessary temperature.

However, most astronomers seem to have rejected this possibility and feel that meteorites belong to our system and that they have elliptical orbits like asteroids. Dr. Charles P. Olivier[7] has informed these authors "that some asteroids have orbits that take them inside of the orbits of Venus and one or two inside that of Mercury. Hence innumerable meteorites inevitably have the same orbits. Therefore, it is possible that this mass did have an elliptical orbit with a perihelion distance near enough to the sun to become heated. This meteor may have made several revisits near the sun before it finally crossed the earth's orbit at a time when we were in position to catch it."

Thus if its orbit could have taken it inside of Mercury it is most likely that the mass would have been heated long enough to produce the alteration in structure found in this meteorite.

The answer to the question as to where and how this meteorite was reheated is an astronomical problem and this point is being left to the astronomers.

The Social Circle iron when found weighed 219 pounds and no estimate is made of the amount of material that was lost through weathering. It must have been much larger before it entered our atmosphere because a great reduction in weight and considerable reduction in size occurs as a meteor passes through our atmosphere.

Since the original dimensions of the mass must have been greater than they are today, perhaps the original external portions were more granulated by reheating than the central core, but this material has been removed in the flight of the mass through our atmosphere. However, it seems reasonable to assume that an iron mass of several tons could be as uniformly heated, by the process mentioned above, as a smaller body.

Acknowledgments

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[7] Private communications.