METALLURGY

Destruction of the Widmanstatten Structure in Iron Meteorites by Laboratory Heat Treatment

A KNOWLEDGE of the response of iron meteorites to heat treatment is necessary for the understanding of such specimens as Kamkas[1] which appear to have suffered partial destruction of their Widmanstatten structures by cosmic heat treatment. Kasé[2] has published evidence to show that for the medium octahedrite Sacramento Mountains the nickel-rich tænite is still clearly visible after a heat treatment of 20 min at 1,000° C or 3 min at 1,200° C. Even after 4 min at 1,300° C there remains a faint trace of nickel enrichment which marks the previous location of a tænite area.

In the work recorded here more lengthy heat treatments were conducted on small ($0{\cdot}5 \times 0{\cdot}5 \times 1{\cdot}0$ cm) fragments taken from a specimen of Canyon Diablo which is known to contain cohenite. In each case duplicate specimens were sealed in evacuated silica capsules which were heated to the maximum temperature over a period of three days and afterwards cooled to room temperature over three days. The period of holding at maximum temperature was 2 days at 1,000° C and 3 days at 1,100° C or 1,180° C. Experiments with specimens of this size do not correctly reproduce the conditions in a massive meteorite since at 1,100° C and 1,180° C it was found that all the schreibersite melted to eutectic and exuded along the original kamacite phase boundaries to produce a layer of phosphide-rich liquid on the outer surface of the specimens. At 1,000° C exudation was incomplete and the resolidification of liquid veins within the specimen produced structures similar to that illustrated by Perry[3]. With increasing temperature the phosphide eutectic, which had left the solid by way of grain boundaries in the original structure, showed an increased tendency to re-enter the solid by way of the new γ-grain boundaries which were formed by heat treatment of the kamacite. Macro- and micro-scopic observations were made on etched sections at locations away from the regions of grain boundary penetration. Macroscopic examination of the etched sections with the aid of a hand-lens revealed the recognizable remains of tænite ribbons after all heat treatments. Microscopic examination showed that the original kamacite regions had changed to a duplex arrangement of ragged ferrite and small carbide crystals. It was possible to detect the boundaries of the γ-grains from which the ferrite-carbide aggregate formed on cooling. The microstructure of the tænite regions showed a greater variation with heat treatment temperature. After the 1,000° C heat treatment the tænite still maintained a distinct boundary and was at no place crossed by the new generation of γ-grain boundaries; suggesting that the tænite had maintained its complete integrity at the heat treatment temperature. The tænite itself was characterized by a fine precipitate of non-metallics at the centre and an indistinct acicular structure at the edge.

After the 1,100° C heat treatment the tænite boundary was less sharp and was demarked by acicular (bainitic) transformation product. No precipitate was observed within the tænite and the presence of new generation γ-grain boundaries within the tænite was rare.

The 1,180° C heat treatment resulted in a coarse pattern of acicular transformation product within which the pattern of new generation γ-grain boundaries was continuous with that in the kamacite, indicating that at 1,180° C the tænite had lost its physical identity as a separate crystal but had retained a sufficiently different chemical composition to reveal itself by the production of acicular transformation product on cooling.

Less detailed examination of carbide-free specimens heated to 1,000° C and 1,100° C revealed a 'watery' appearance in the tænite without acicular transformation product. The acicular product may thus be tentatively identified as a carbon containing bainite.

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[1] Axon, H. J., *The Metallurgist*, 322 (1961).
[2] Kasé, T., *Sci. Rep. Tôhoku Imp. Univ.*, 537 (1925).
[3] Perry, S. H., *U.S. Nat. Mus. Bull.*, 184, Plate 74, Fig. 4 (1944).

Topography of Kish Crystals and the Effect of Oxidation in Air

DETAILED studies have been reported recently on the production of etch pits in purified Ticonderoga natural graphite crystals as a result of oxidation in oxygen in the temperature range 700°–870° C[1,2]. Others have also been concerned with the effect of oxidation on the topography of natural graphite[3–6]. In this communication, the effect of oxidation on the topography of purified kish crystals is considered.

Kish is a waste product which forms on the surface of molten iron of high carbon content during the manufacture of steel. It is carbon which has been taken into solid solution with the iron and is afterwards evolved when the iron cools. Kish particles are large and flaky, resembling large particles of natural graphite. Walker and Imperial[7] have previously shown that purified kish has the same interlayer spacing as Ceylon natural graphite, indicative that it has a large crystallite size and essentially complete three-dimensional ordering.

The kish used in this investigation was purified by boiling alternately in hydrochloric acid and hydrofluoric acid (or in some cases just boiling in hydrochloric acid), followed by repeated washings in distilled water, and drying in a vacuum oven. Its structure has been further studied by transmission electron diffraction, using 50-kV electrons having a beam width of 10μ. The diffraction pattern (Fig. 1) is characteristic of a material of large crystallite size and a high degree of preferred crystallite orientation (essentially a mosaic single crystal).

The basal plane (000*l*) surfaces of the kish were studied by light microscopy. Typical micrographs of the unoxidized kish are shown in Figs. 2 and 3. In Fig. 2, the twin planes are readily distinguished as the striations running parallel to one another or intersecting at 60° (ref. 8). The presence of impurities on the basal plane, following treatment with hydrochloric acid only, is clearly in evidence. On a very significant portion of the surface, large hexag-

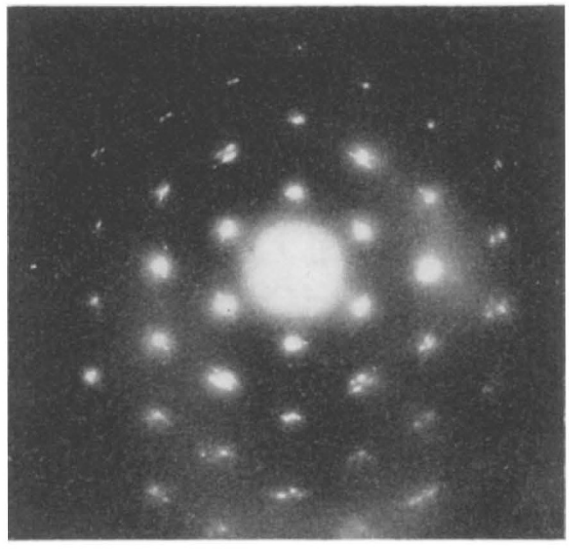

Fig. 1. Transmission electron diffraction pattern of purified kish