MINERALOGICAL MAGAZINE, SEPTEMBER 1984, VOL. 48, PP. 462–3

# Discontinuous precipitation from kamacite in the Sinai meteorite: first occurrence in an L-group chondrite

HITHERTO most discussion of metal structures in meteorites, and their development, has centred on the plane interface model of perpendicular diffusion-controlled growth. More recently Axon and Grokhovsky (1982) have described the development of metal structures in the Richardton (H5) chondrite by the process of discontinuous precipitation. This is a process by which cells of duplex $\alpha+\gamma$ structure grow from parent phase, $\alpha$ or $\gamma$, by virtue of a moving cell interface between the parent and duplex structures with atomic migration along or parallel to the length of the moving interface. The present report is intended to record the presence of discontinuous precipitation structures in the Sinai (L6) stone.

There is a complex interaction of effects whereby a late-stage shock veining episode imposes local change upon some of the metal. An attempt is made to separately identify these effects.

Prior (1923) described the stone as an intermediate [olivine] hypersthene chondrite containing 8–6 % metal. He observed a single Fe–Ni mass 4 mm square but reported that metal was 'mostly less than 1 mm in greatest dimension'. Maskelynite (a shock indicator) was found interstitial to ill-defined and fragmented chondrule material. Van Schmus and Wood (1967) classified the stone L6. There seems to be no easily available report on the condition of the metal.

The section surface on the main mass in the Manchester Museum is profusely veined and our study was conducted on 1.5 sq. cm of polished and etched surface prepared on a small chip from that mass. We encountered one small (10 $\mu$m) particle of copper, but most of the metal was kamacite ($\alpha$-FeNi), which ranged in size from *c.* 50 $\mu$m to *c.* 1 mm. All 'unmelted' FeNi was polycrystalline and appeared to be present in two size distributions; 50–100 $\mu$m or > 500 $\mu$m. Irrespective of size the metal also divided into three alternative classes: 'melted' globules and stringers of metal-sulphide material occupied the actual vein material; away from the veins, most of the FeNi showed no signs of deformation or shock reheating; in the vicinity of the veins metal occasionally showed a ghostly $\alpha_2$ structure suggestive of a local reheating episode superimposed upon the structure of the previous class. [Similar structures were observed in a few small FeNi grains that could not be tied to an observable vein in the plane of section, these are presumed to be related to veins above or below the section plane.]

Now considering the bimodal size distribution:

I. FeNi > 500 $\mu$m were usually composed of 'large' (90 $\mu$m) well annealed grains of $\alpha$ with occasional traces of clear, or slightly cloudy, $\gamma$. In a single instance one of these 'large' grained polycrystalline masses showed, at the metal–silicate interface, a development of smaller grains (*c.* 15 $\mu$m) with associated grain-boundary precipitation of $\gamma$. This is similar to the condition of discontinuous precipitation noted in Richardton (H5) by Axon and Grokhovsky (1982).

II. FeNi 50–100 $\mu$m were usually polycrystalline at the 'small' (*c.* 15 $\mu$m) size and with grain boundary precipitation. It seems reasonable to regard these as the product of discontinuous precipitation reactions that are more effectively triggered in small than in large masses of metal embedded in the silicate matrix.

As already noted, some of the metal masses, in either size range, showed the ghostly signs of shock reheating. Thus the veination arose subsequent to the discontinuous precipitation.

From the present observations a possible metallurgical history might emerge as follows.

An early episode of deformation fragmented the silicates and strained the $\alpha$-FeNi metal; annealing in the temperature range at or above 450 °C [maximum solid solubility temperature for Ni in $\alpha$-Fe] allowed the $\alpha$-FeNi to anneal to the 90 $\mu$m grain size. Subsequent deformation plus a lower temperature anneal, below 450 °C, induced a new generation of 'small' (*c.* 15 $\mu$m) $\alpha$ grains at the metal–silicate contacts, and these new $\alpha$ grains grew with the discontinuous precipitation of $\gamma$ at their boundaries.

Later shock events introduced macroscopic veining in the silicate with the mobilization of metal–sulphide material along the veins and the occasional superposition of local shock reheating

($\alpha_2$ production) upon some pre-existing metal structures.

## REFERENCES

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[*Manuscript received 1 August 1983; revised 19 October 1983*]



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