

AEM STUDY OF THE METAL PHASES IN METEORITES; C. -W. Yang, D. B. Williams, Dept. of Materials Science and Engineering, Lehigh University, Bethlehem, PA 18015, J. I. Goldstein, College of Engineering, University of Massachusetts, Amherst, MA 01003

Three sub-zones in the tetrataenite rim, which is the outermost region of the retained taenite, were observed in irons, mesosiderites, pallasites as well as chondrites. This sub-zone structure is due to the precipitates in the tetrataenite rim. The island phase in the cloudy zone also contains precipitates. The microstructure and chemical composition of the metallic phases were investigated using high resolution analytical and scanning electron microscopy.

Introduction The retained taenite of meteoritic metal consists of several structural regions: clear taenite I (CT I), cloudy zone (CZ), clear taenite II (CT II), and martensite (M) along the Ni concentration gradient [1]. Three sub-zones have been observed in the tetrataenite rim which corresponds to clear taenite I in chondrites [2] and mesosiderites [3]. It was originally argued that the three sub-zone structure was unique to the non-phosphorus containing metal particles found in the chondrites [1]. In examining the tetrataenite rim in irons and pallasites we observed a microstructure containing three sub-zones very similar to that in ordinary chondrites. We also observed that the island phase in the cloudy zone had a substructure within it. The purpose of this study is to investigate the microstructure and composition of the tetrataenite rim and the cloudy zone in the retained taenite using analytical electron microscopy (AEM) techniques.

Experiment A combination of electron optical instruments was employed including a JEOL 6300F field emission gun high resolution scanning electron microscope, a VG HB501 FEG-STEM, a Philips 400T AEM, and a JEOL 733 electron probe microanalyzer.

Results and Discussion Fig. 1 shows a transmission electron microscopy (TEM) bright field (BF) image of the boundary between the tetrataenite rim and the cloudy zone in the RKPA 79015 mesosiderite. The tetrataenite rim (TR) contains a number of precipitates (p). The density of the precipitates decreases with increasing local Ni content in the TR, and the precipitates are absent in the outermost part of the TR. By electron diffraction, the crystal structure of the precipitate was identified as bcc. The matrix was a L_{10} ordered FeNi tetrataenite. Fig. 2 shows a TEM BF image of the cloudy zone. The cloudy zone consists of the honeycomb phase (H) and the island phase (I) containing precipitates (p). By electron diffraction, the island phase was identified as a L_{10} ordered FeNi tetrataenite. The honeycomb phase and the precipitates have the same crystal structure, bcc. The chemical composition of each phase was measured with the VG HB501 FEG-STEM which has a high X-ray spatial resolution ($\sim 2\text{nm}$) [4]. Fig. 3) shows a Ni concentration profile across the kamacite /tetrataenite rim interface in the RKPA 79015 mesosiderite. The Ni content of 65.5 ± 3.3 wt.% is the highest reported to date, and was measured at the tetrataenite/kamacite interface. The kamacite at this interface contains 3.6 ± 0.2 wt.% Ni. The measured Ni content of the precipitates in the TR was 14.2 ± 1.0 wt.%. The Ni concentration of the ordered FeNi matrix was consistent throughout the TR except near ($< 500\text{ nm}$) the kamacite/tetrataenite interface, Fig. 3). The average Ni content measured was 51.8 ± 1.7 wt.%. Fig. 4) shows a Ni concentration profile across a precipitate in the cloudy zone. The measured Ni content of the precipitate is 14.7 ± 1.0 wt.%, the same as the Ni content of the precipitates in the TR. Fig. 5) is a Ni concentration profile across the island phase and the honeycomb phase in the CZ. The honeycomb phase at this and other areas contains 9.0 ± 1.0 wt.% Ni and the non precipitate regions in the island phase within the CZ contain 51.8 ± 1.7 wt.% Ni.

It is likely that the sub-zone structure is a general feature of the TR and CZ of metal in all types of meteorites. This structure is observed because the TR is composed of low Ni precipitates in a high Ni ordered FeNi matrix. The low Ni precipitates are easily etched away during the chemical treatment for microscopic observation resulting in dark etch pits. These low Ni precipitates form during the cooling of meteorites below 400°C .

References [1] Reuter K. B. et al. (1988) *Geochim. Cosmochim. Acta.* 52, 617 [2] Duffield C. E. et al. (1991) *Meteoritics*, 26, 97 [3] Yang C. W. et al. (1994) *LPSC XXV*, 1557 [4] Michael J. R. and Williams D. B. (1987) *JOM*, 147, 289

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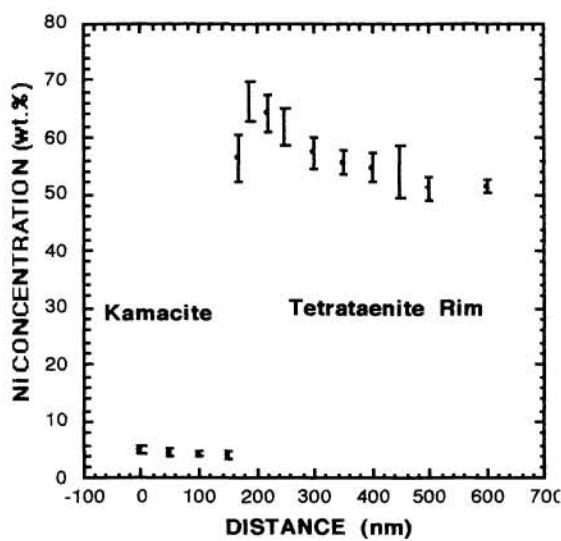
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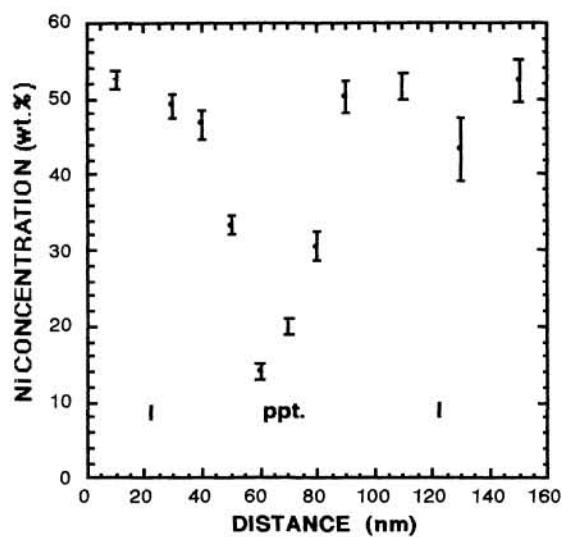
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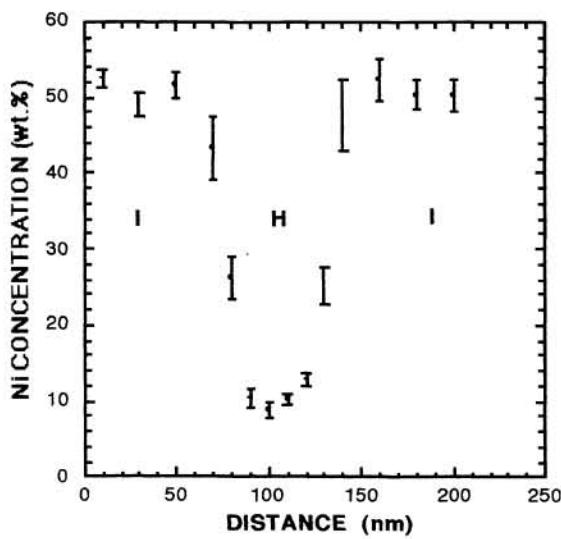


Fig. 1) A TEM bright field image of the RKPA 79015 mesosiderite showing the tetrataenite rim and the cloudy zone at the boundary between two structures, 2) A TEM bright field image of the cloudy zone, 3) A Ni concentration profile across the kamacite/tetrataenite rim interface obtained with the VG HB501 STEM, 4) A Ni concentration profile across a precipitate in the island phase of the cloudy zone obtained with the VG HB501 STEM, 5) A Ni concentration profile across the island phase and the honeycomb phase in the cloudy zone in the RKPA 79015 mesosiderite obtained with the VG HB501 STEM.