IRON METEORITES: PROFILES OF Ge, Ga, AND Cu USING μ-PIXE;
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The determination of metallographic cooling rates of iron meteorites are presently based on measurements and modelling of disequilibrium profiles of Ni in taenite lamellae [1,2,3,4]. Key elements of such models are the FeNiP phase diagram (in case of IAB's also the FeNiC phase diagram [5]) and the diffusivities of Ni in both kamacite and taenite. Until 1995 the data have been interpreted in terms of a linear cooling history yielding a constant cooling rate in the Widmanstätten pattern formation interval (~800-300°C). Rasmussen et al. (1995) [4] provide the first attempt to estimate a two-stage cooling history. Thus the obtained cooling rates only apply in a limited temperature interval. We have initiated a search for alternatives to Ni as a cooling rate indicator that could yield cooling rates of iron meteorites in different temperature intervals. The idea is that elements with a strong partition between taenite and kamacite and a diffusivity significantly different from that of Ni will become immobilized at different temperatures. Disequilibrium profiles of these elements may therefore provide cooling rate information for other temperature intervals. We have applied μ-PIXE analysis in the search for concentration profiles of Ge, Ga, and Cu in Toluca and Odessa (IAB), and Cape York (IIIAB).

The μ-PIXE analysis was performed on the Lund Nuclear Microprobe [6]. The data acquisition system consists of a Kevex X-ray detector, a Tennelec Amplifier (TC 244, Oxford Instruments Inc.), an ADC (Nuclear data system) and a VME bus system connected to a Micro VAX computer. The energy resolution of the X-ray detector, defined as full width at half maximum of Mn K_α (5.9 KeV) energy, is 150 eV. The sensitive area of the detector is 50 mm^2 and the detector is covered by a 5 μm thick Be window. The major elements, Fe and Ni, yield X-rays with high cross-sections in the PIXE analysis. Typically, a X-ray event takes about 10 to 100 μsec in signal processing; therefore the upper limit of the count rate is a few kilo counts per second. In order to avoid serious pile-up in the X-ray spectrum we use a set of customized filters (consisting of films of 20 μm Cr and 10 μm Ti). These filters provide strong absorption of the K-lines from Fe and Ni. The Cr film keeps a low transmission for the K-line from Fe (about 0.1%) and a high transmission for the X-rays from heavier elements, such as Ge, Ga, Ru, and Pd. The Ti filter absorbs the secondary X-rays from Cr, thereby further reducing the pile up. The 2.7 MeV proton beam is focused to about 3-5 μm by 15-10 μm. We have chosen a rectangular shape of the beam instead of square shape, in order to obtain higher beam current through the slit while maintaining a small beam size in the direction in which the beam is scanned across the taenite lamellae. In this way have we obtained line profiles of taenite lamellae with a typical beam current of 3-4 nA. The PIXE data were evaluated using the *GeoPIXE*-code ([7],[8]). The concentrations profiles of Ni, Ge, Ga, and Cu from Toluca in Fig. 1 are shown with error bars representing +/- one standard deviation yielding a confidence level of 66%. The relative size of an error bar is determined by the statistics of the peak, filter thickness error (a few percent); a typical value of the errorbar is 20%.

Germanium exhibits, in principle, the same kind of concentration profiles as Ni although the mid profile concentration of Ge in taenite is comparable to the Ge concentration in kamacite. The profile of Ga also shows the characteristic M-shape but here the mid profile concentration is significantly higher than typical kamacite Ga concentrations. Measurements of Cu have previously been reported [9], obtained by an electron microprobe, where the profiles were found to be very similar to Ni profiles. We find the levels of Cu in taenite to be similar to those obtained by Clarke and Jarosewich, although the statistics of our analyses are too poor to

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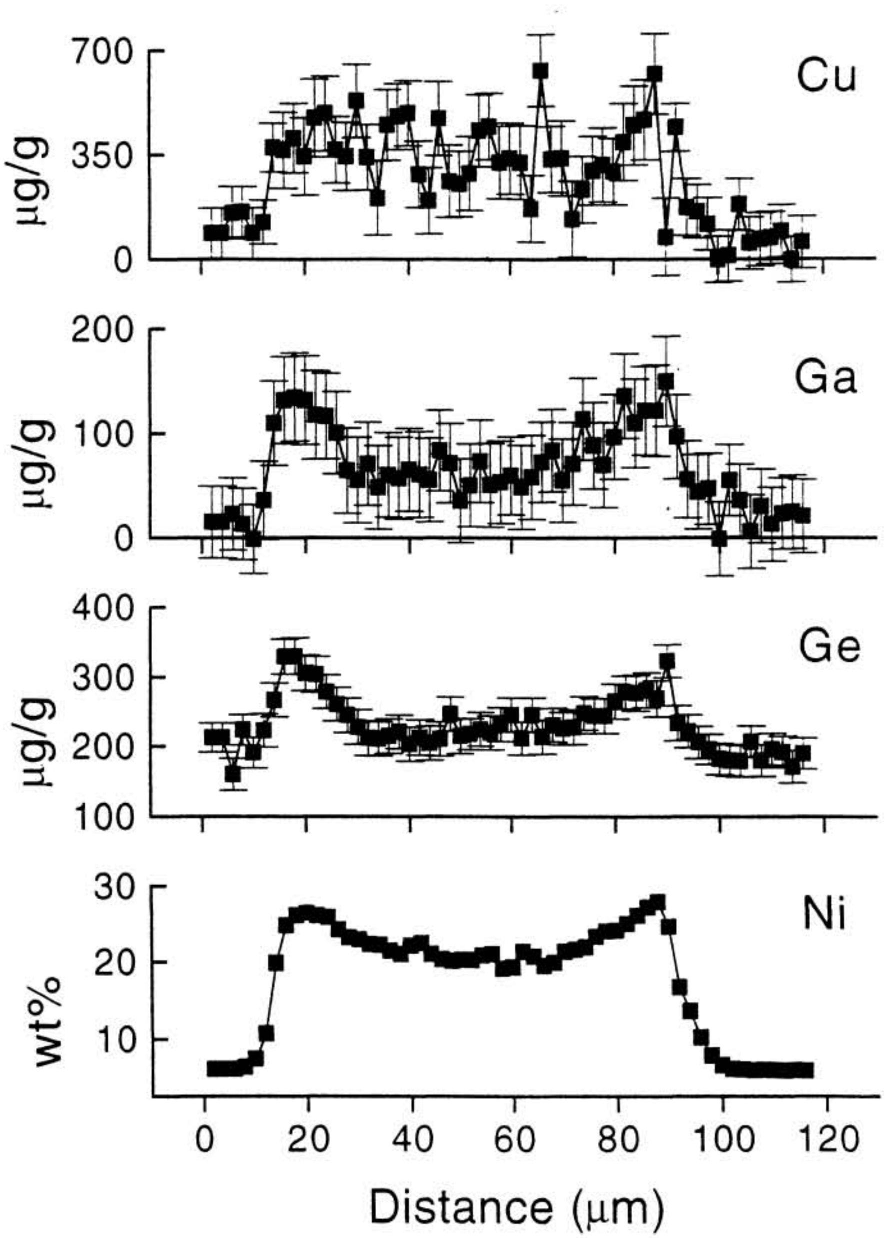

Figure 1. Profiles of Cu, Ga, Ge, and Ni in a Toluca (IAB) taenite lamella obtained by PIXE. Beamsize ca 4 by 12 μm^2, beam current 3-4 nA, and proton energy 2.7 MeV.