PARTITIONING OF Ni, P, Ir, Au AND Ge BETWEEN TAENITE AND P-RICH KAMACITE. P.E. Janney and J. H. Jones, NASA Johnson Space Center, Houston, TX 77058.

In iron meteorites, subsolidus fractionations of minor and trace elements can occur when Ni-poor kamacite ($\alpha$-iron) exsolves from Ni-rich taenite ($\gamma$-iron) (e.g., Rasmussen et al., 1988). These fractionations can be important in deciphering the thermal history of iron meteorites. For example, if cooling proceeds faster than diffusion, then zoning profiles develop and these can be modeled to yield cooling rates, provided diffusion rates and partitioning behaviors are known accurately.

Metallographic cooling rates for iron meteorites are determined in exactly this manner, using the zonation of Ni in taenite ("M-shaped profiles") as a guide (Wood, 1964). In principle, this same technique could be applied to other elements, but typically neither diffusion rates nor fractionations are known precisely. Here we present experimental data pertaining to the fractionation of Ni, P and several trace elements between kamacite and taenite. These data are compared to partitioning behaviors inferred from iron meteorites.

**Experimental.** Three charges were sealed in evacuated silica tubes and suspended together in a Deltech furnace at 1080°C for 22 days. The Fe-Ni-P charges were made up of powders of Fe, Ni and P with ~1-2 wt.% of a single tracer (Ge, Au or Ir). The Fe/Ni ratio of the charges was ~10:1. Upon quenching, the samples were mounted in epoxy, polished and analyzed with the electron microprobe using standard techniques.

**Results.** In all three cases, the charges crystallized kamacite, but the Ir-bearing charge also crystallized taenite. Significant zoning was observed only in the taenite of the Ir-bearing charge. Iridium in this phase decreased from 1.7 wt.% to 1.3 wt.%, core to rim. All other phases appeared homogeneous. Kamacite was distinguished from taenite in three ways: (1) unlike the "blebby", rounded taenite crystals grown in similar experiments, the kamacites were euhedral; (2) the kamacites appeared less resistant to etching by dilute nitric acid; and (3) the kamacite contained much lower Ni and somewhat higher P contents than taenite. Table 1 gives a summary of the Ni and P concentrations of the various phases in the three experiments. Also given in Table 1 are the results of the experimental study by Doan and Goldstein (1970) for the Fe-rich portion of the Fe-Ni-P system.

We see much larger differences in Ni contents between kamacite and taenite than did Doan and Goldstein, possibly because our samples were held at temperature for 22 days, while the Doan and Goldstein experiment only lasted 4-5 days. However, such a large difference in Ni concentration between kamacite and taenite at high temperatures is difficult to understand, although the difference appears reproducible. The differences between our measured P contents and those of Doan and Goldstein appear to be systematic, with our analyses always being ~25-35% lower. We do not presently understand this discrepancy, but we suspect that there is an electron microprobe standardization problem, although a standardization error of this magnitude seems rather large.

A summary of partition coefficients is given in Table 2, with some data for $D_{\gamma/liquid}$ extracted (or interpolated) from the work of Narayan and Goldstein (1982), Willis and Goldstein (1982), Jones and Drake (1983) and Malvin et al. (1986). In one case, that of Ge, the fractionation between kamacite and taenite is rather small. In most cases the fractionation is moderate (Ni, P and Au). However, in the case of Ir, the fractionation is extreme, with the kamacite having no detectable Ir. The senses of the fractionations are typically in agreement with those observed in iron meteorites (Rasmussen et al., 1988). However, Goldstein (1967) inferred from microprobe analyses of iron meteorites that Ge followed Ni and produced M-shaped profiles during kamacite exsolution from taenite. Conversely, our experiment indicates that Ge should show very little preference for either kamacite or taenite. We will discuss Ge zonation in iron meteorites more fully below.

**Application to iron meteorites.** Taken at face value, the data for Ir suggest that analysis of Ir zoning could yield more accurate cooling rates, as Ir appears to be excluded from kamacite most efficiently. However, even if analytical problems associated with documenting trace element zoning patterns are ignored, diffusion of Ir is likely to be extremely sluggish at low temperatures (Jones and Drake, 1983). Therefore, Ir profiles will probably be extremely sharp and difficult to model.

As alluded to above, the data for Ge appear to be at odds with the observation that Ge mimics Ni during kamacite exsolution. Interestingly, however, the cores of the exsolved kamacite lamellae in iron meteorites do not appear to be strongly depleted in Ge compared to either the bulk meteorite or to the cores of taenite crystals. Ge in kamacite is usually ~0.85 that of the whole rock and approximately equal to that in the cores of taenite crystals (Goldstein, 1967). This observation and our experimental results both suggest that kamacite does not strongly exclude Ge, compared to taenite. One possibility is that Ge is much more mobile than Ni at low temperatures and that Ge is then preferentially partitioned into ordered tetrataenite over either kamacite or taenite.

The experiments reported here were carried out by P.E.J., while a NASA Summer Intern at Johnson Space Center.

**Table 1**

| Experiment | Phase | Ni (wt.%) | P (wt.%) |
|---|---|---|---|
| 22(Au) | Kamacite | 3.2 | 1.8 |
| | Liquid | 8.3 | 7.8 |
| 23(Ge) | Kamacite | 2.0 | 1.5 |
| | Liquid | 7.5 | 8.0 |
| 24(Ir) | Kamacite | 3.3 | 1.9 |
| | Taenite | 6.8 | 0.9 |
| | Liquid | 7.8 | 8.0 |
| Doan and Goldstein (1970) -- 1080°C | | | |
| | Kamacite | 6.6 | 2.6 |
| | Taenite | 8.7 | 1.2 |
| | Liquid | 8.4 | 12.0 |

**Table 2**

| Element | $D_{(\alpha/liquid)}$* | $D_{(\gamma/liquid)}$* | $D_{(\alpha/\gamma)}$* | $D_{(\alpha/\gamma)}$** |
|---|---|---|---|---|
| Au | 0.52 | 0.77 | 0.68 | 0.20-0.02 |
| Ge | 2.17 | 1.83 | 1.19 | ~0.85 |
| Ir | BDL | 5.2 | <~0.1 | 0.23-0.04 |
| Ni | 0.27-0.39 | ~0.9 | ~0.4 | 0.33-0.14 |
| P | 0.19-0.23 | ~0.10 | ~2 | >1 |

*Experimentally determined; **From iron meteorites (Rasmussen et al., 1988), Goldstein (1967) and Clarke and Goldstein (1971).

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