COMPOSITIONAL DEPENDENCE OF AU DIFFUSION IN FE-NI ALLOYS: IMPLICATIONS FOR METEORITE COOLING RATE MODELS. K. J. Johanesen[1], H. C. Watson[2], and Y.Fei[2]. [1] Department of Geology, Beloit College, Beloit WI, 53511, USA (katy.johanesen@gmail.com) [2] Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd. NW Washington DC, 20016, USA (h.watson@gl.ciw.edu, y.fei@gl.ciw.edu)

Introduction: The Widmanstatten texture, composed of alternating lamellae of different FeNi alloys, is produced by diffusion-controlled exsolution of kamacite (low Ni, low temperature BCC alloy) from taenite (High Ni, High temperature, FCC alloy) during slow cooling of the parent body [1-3]. The development of this texture is largely determined by the thermal history of the parent body, which is in turn directly related to its size. The estimation of cooling rates in iron meteorites has traditionally been accomplished by modeling the diffusion-emplaced profiles of Ni in these phases [e.g. 4-6]. Trace elements, particularly siderophile elements can be used as geochemical tracers of parent body history. It has been suggested that the incorporation of trace element profiles into these models may be a benefit to their precision [7,8] In order to accurately include the trace element aspect into the cooling rate models, a thorough understanding of siderophile element diffusion at the relevant conditions must be achieved. This knowledge of siderophile element diffusion, coupled with forward modeling will be useful in attempts to better constrain cooling rates for meteorites and properties of the parent body, such as its size, and possibly collision events in the planetesimal's history

It has been shown that increased Ni content causes faster Ni diffusion in pure Fe-Ni alloy and calculated diffusion coefficients for Ni over a range of Ni concentrations from 0 to 50 atomic percent Ni and at 1 atm and 40 kbar [9]. Since siderophile trace elements like Au have similar properties to Ni, and behave similarly under many conditions [10] it is possible that the Ni content of a meteorite could have a substantial effect on the diffusion rates of these trace elements, which could in turn affect cooling rate models based on trace element diffusion.

Previous studies have measured the temperature dependence of trace element diffusion in Fe-Ni materials relevant to iron meteorites. Watson and Watson [10] studied the diffusion of siderophile trace elements, including Au (1 to 2 wt. %) in a 90% Fe, 10% Ni synthetic alloy. Righter et al. [11] conducted a similar study, but with pure iron rods stacked on actual meteorite samples containing ~5wt% Ni. The diffusion coefficients for Au and Pd in the latter study were substantially lower than those found in the former. The focus of our present work is on determining the effect of Ni concentration on the diffusion rates of these trace elements, an area still poorly studied. In order to determine if (and how) Ni content affects the diffusion rates of siderophile trace elements, we have experimentally determined diffusion coefficients for Au (a representative siderophile element) in Fe-Ni alloys of 0 wt. %, 20 wt. %, and 30 wt. % Ni at 1GPa and 1150^{o}C – 1400^{o}C.

Experimental Procedure: The experiment is modeled after Watson and Watson (2003) using a standard piston cylinder press. To synthesize materials, homogenous base mixes of pure powdered Fe, 80 wt. % Fe with 20 wt. % Ni, and 70 wt. % Fe with 30 wt. % Ni were prepared and portions of each were doped with 0.5 - 1 wt. % Au. These mixtures were then shaken for approximately 24 hours to homogenize. The grain sizes of all powders used were between 0.5 - 3mm. These doped and base mix samples were loaded into pre-drilled 6 mm deep holes in a MgO cylinder, then placed in a standard 3/4 inch piston cylinder assembly. In this assembly, the MgO capsule is contained between two MgO filler pieces, within a tapered graphite furnace capped by a graphite disc on the bottom end. The cylinder is fitted into a Pyrex^{TM} tube inside a talc cylinder to assist insulation and pressure conduction. This assembly was placed in a piston cylinder press and held at 1 GPa and 1400˚C for 60 h. Homogeneity was confirmed by electron microprobe analysis. The alloy rods were cut into 1 mm wafers and polished using SiC paper, then Al_2O_3 powder to a grain size of 0.3 mm. Doped and pure alloy wafers of the same base Fe-Ni composition were stacked in pairs to form semi-infinite diffusion couples and placed in an MgO cylinder in the assembly. One pair of each Ni composition was placed in each assembly, assuring that these experiments would be at exactly the same conditions. Each experiment was brought to 1 GPa and temperatures ranging from 1150˚C to 1400˚C and held at these conditions for times ranging from 3 h to 48 h, conditions consistent with the γ phase (FCC) iron stability field (Fig 2). The experiments were quenched and cooled within 30 seconds. Concentration was measured by electron microprobe at 3 to 15 micron spacing along transects perpendicular to the interface. Concentration profiles were fitted to the solution to the linear diffusion equation for an infinitely thick diffusion couple**.**

Results: As is evident in Figures. 1 and 2, D increases with temperature for each Ni concentration and also increases with Ni concentration at each temperature.

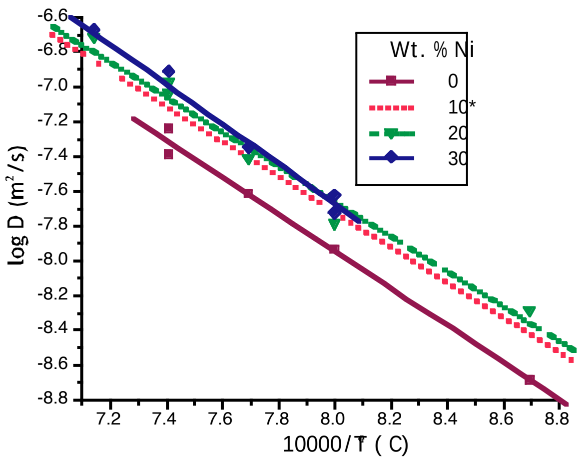

Figure 1: Arrhenius plot of Log D vs 10^4/T. Activation energies are similar for all concentrations, but the absolute diffusivities increase slightly with higher Ni content.

Figure 1 is an Arrhenius plot of the log of diffusivity versus 10^4/T. Each line represents a separate Ni concentration (wt%). The activation energies are very similar for all the concentrations. Figure 2is a plot of diffusivity versus wt.% Ni. Each line represents a different temperature condition of the experiment. The slopes of these lines represent the effect of Ni concentration on diffusivity.

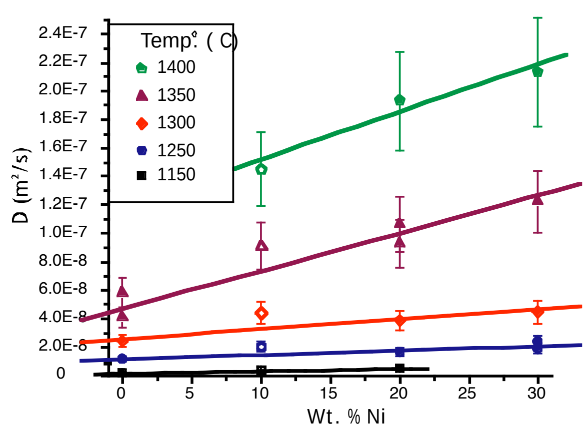

Figure 2: Plot of D vs wt% Ni. Each line represents adifferent temperature. The change in slope with higher temperature indicates a possible change in mechanism.

Discussion and Conclusions: As expected, the diffusivity increases with Ni concentration at each temperature, and also increases with temperature at each Ni concentration. This effect of concentration is consistent with the observed differences in previous experiments [10,11]. It is interesting to note, however, that the *effect* of Ni concentration on D increases with temperature, and implies a possible change in diffusion mechanism between 1250 ˚C and 1300 ˚C. More experiments will be needed to clarify the relationship between the compositional effect of Ni and temperature, and potentially identify the different mechanisms at work. As Ni content appears to have a negligible effect on diffusivity at lower temperatures (1250 ˚C and under), it may not need to be considered in modeling siderophile trace elements in iron meteorites. This would simplify the problem of developing a model significantly. Although Au can be considered representative of many siderophile elements, future work should involve similar experiments for other trace elements, such as Re, Mo, and Ga. Higher Ni concentrations like 40 wt. % to 60 wt. % Ni should also be tested to determine how far these trends continue.

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