N94-36147

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Preliminary Results of Sulfide Melt/Silicate Wetting Experiments in a Partially Melted Ordinary Chondrite.

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Recently, mechanisms for core formation in planetary bodies have received considerable attention. Most current theories emphasize the need for large degrees of silicate partial melting (40-50 vol.%) to facilitate the coalescence and sinking of sulfide-metal liquid blebs through a low strength semi-crystalline silicate mush, e.g. [1, 2]. This scenario is based upon observations that sulfide-metal liquid tends to form circular blebs in partially molten meteorites during laboratory experiments [3, 4]. However, recent experimental work by Herpfer and Larimer [5] indicates that for some sulfide-Fe liquids (particularly eutectic Fe-S liquid) have wetting angles at and slightly below 60° in an olivine aggregate, implying an interconnected melt structure at any melt fraction. Such melt interconnectivity provides a means for gravitational compaction and extraction of the majority of a sulfide liquid phase in small planetary bodies without invoking large degrees of silicate partial melting. Because of the important ramifications of these results, we conducted a series of experiments using H-chondrite starting material in order to evaluate sulfide-liquid/silicate wetting behavior in a more complex natural system.

Experimental: An ordinary H-chondrite was selected as a starting material for several reasons: 1) high metal and sulfur contents, 2) a simple mineralogy comprised predominantly of olivine and pyroxene, and 3) its common nature suggests that it is a likely starting material for many asteroids. A two gram sample of the Benld (H6) chondrite was obtained from the Chicago Field Museum of Natural History. Benld is a typical H6 chondrite composed of olivine, pyroxene, plagioclase and substantial metal and sulfide [6]. The sample was pulverized and then ground under acetone in an agate mortar to a very fine powder. The silicate and sulfide fractions have an estimated average grain size less than 10 microns while the Fe-Ni metal particles were approximately 100 microns. An extremely fine powder increases the surface area (and subsequently the surface energy) and lowers the diffusion distance that atoms must travel to get to a grain boundary, thus reducing the time needed to attain textural equilibrium [7].

The experiments were run in a piston cylinder apparatus at 10 kb pressure and temperatures of 1000°C, 1100°C, and 1150°C. Sample containers were made of either crushable MgO or fired pyrophyllite. A standard piston cylinder assembly was used with the thermocouple located 1mm from the top of the capsule. The temperature gradient over the sample is estimated to be no more than 10°C. Fourteen day run durations were used in an effort to approach textural equilibrium. After each run the charge was sectioned, mounted, and polished for analysis. Electron probe analyses were performed to check mineralogy, and high resolution SEM photographs were used for wetting angle measurements. Angle measurements were made from photographs using a very precise goniometer.

Results: The microstructure obtained from the 1000°C experiment is illustrated in Figure 1. As is apparent from the scale bar in the figure, even after two weeks at 1000°C the grain size of the silicate matrix was so small that it was very difficult to measure wetting angles with any degree of accuracy. However, 91 measurements were made from the photographs. Because of the difficultly in making these measurements, it was not possible to accurately separate the angles for different silicate phases. The angle measurements indicate that the median sulfide melt/silicate wetting angle from all phases is approximately 77°. However, examination of the frequency distribution for this experiment shows at least two potential peaks: one around 60 degrees and a second around 80 degrees. Given the complex mineralogy of the charge, multiple peaks are a possibility. The predominant silicate phases were determined to be olivine, two pyroxenes, and plagioclase. Silicate phases were categorized during angle measurements based on grey tone variations. This does not allow for accurate phase determinations (e.g. cpx vs. opx) and may be the primary cause for multiple peaks. However, it is also possible that the charge was not completely texturally equilibrated. The solid Fe-Ni metal in the charges remained as large grains and the silicate phases contacting them developed a rounded texture.

The 1000°C run was the only run made in a crushable MgO capsule. During the initial stages of the run, some of the sulfide liquid rapidly infiltrated the grain edge porosity of the capsule. This infiltrating behavior led to thermocouple contamination in the higher temperature runs, so fired pyrophyllite was subsequently used as the sample container.

The microstructure of the 1100°C experiment is illustrated in Figure 2. In contrast to the 1000°C run, the silicates in the 1100°C experiment underwent substantial grain growth. The larger grain size facilitated making angle measurements for specific phase contacts. However, the problem of determining mineralogy from grey tone variations on the photographs still leads to multiple or ill-defined angle peaks on the frequency distribution. Approximately 60 measurements each were made for olivine/sulfide-liquid, olivine/pyroxene/sulfide-liquid, and pyroxene/pyroxene/sulfide-liquid wetting angles. As in the previous experiment there appears to some tendency for multiple angle peaks. The olivine/olivine/sulfide contacts appear to have several angle peaks with a median angle around 78°. The pyroxene/olivine/sulfide angles show a broad peak with a median angle of 73° and the pyroxene/pyroxene/sulfide-liquid angles have a median of 65°. The Solid Fe-Ni metal decreased in abundance but texturally appeared similar to the previous experiment.

The 1150°C experiment was similar to the 1100°C experiment in general texture but the silicate grain size had increased still further. Between 30 and 60 angle measurements were made for each silicate phase/sulfide-liquid combination with the same phase determination problems. The apparent olivine/olivine/sulfide-liquid, olivine/pyroxene/sulfide-liquid, and pyroxene/pyroxene/sulfide-liquid median angles were 99°, 83°, and 82°, respectively.

Discussion: The important result from our experiments is that the sulfide-liquid wetting angles vary in a relatively small range between 60 and 100 degrees. Although the complex silicate mineralogy of our ordinary chondrite system prevents an accurate assigning of specific sulfide-liquid contact angles to silicate mineral combinations, this range of angles suggests that it is highly unlikely that complete sulfide melt interconnectivity could be maintained at liquid fractions below 1 or 2 vol. % [8]. Conversely, it also implies that there will be at least some sulfide liquid interconnectivity with only a few volume percent of melt. Such interconnectivity could provide a pathway for gravitational segregation of a least a portion of the sulfide metal liquid. However, the complete segregation of both metal and sulfide from a silicate matrix is a complex process in which wetting behavior is only one part.

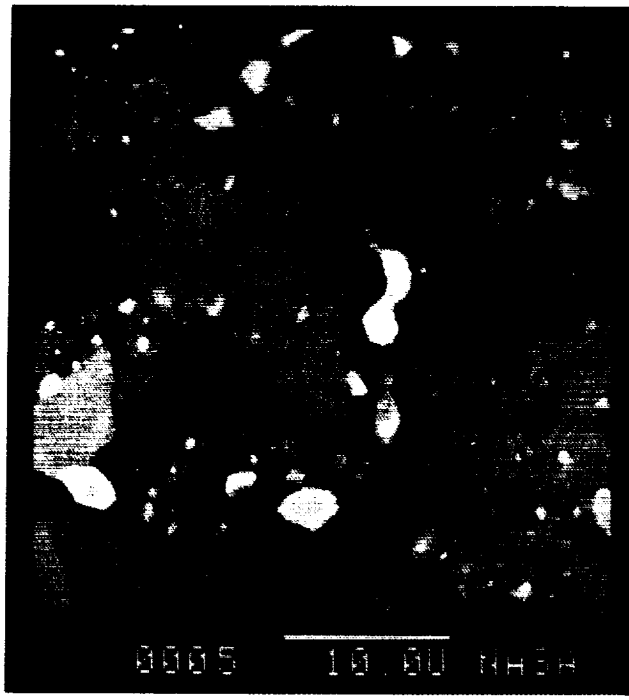

Fig. I

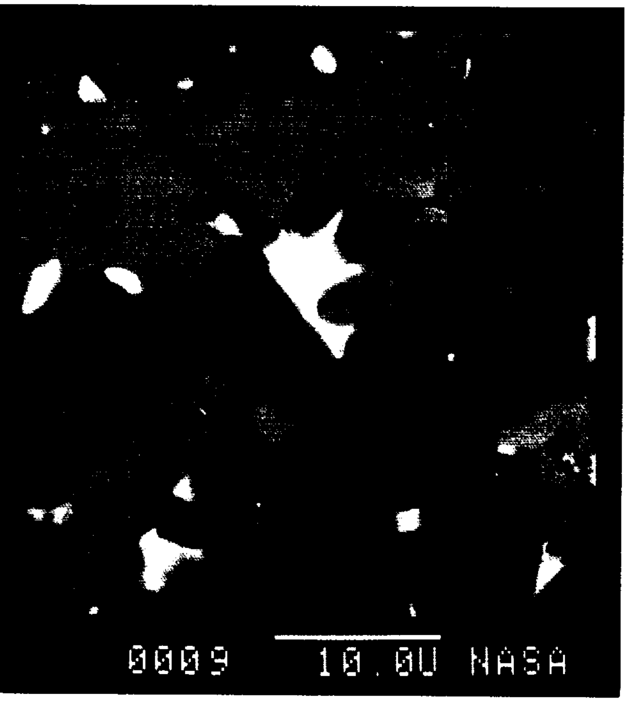

Fig. 2

References: [1] Stevenson D.J.(1990) In Origin of the Earth, 231-249. [2] Taylor G.J. (1992) *J. Geophys. Res.* **97**, 14717-14726. [3] Takahasi E. (1983) *Mem. Nal. Inst. Polar Res. Spec. Issue Jpn.* **30**, 168-180. [4] Walker D. and Agee C.B. (1988) *Meteoritics*, **23**, 81-91. [5] Herpfer M.A. and Larimer J.W. (1993) *Meteoritics* **28**, 362. [6] Mason B. (1963) *Geochim. et Cosmochim. Acta* **27**, 1011-1017. [7] Lifshitz I.M. and Slyozov V.V. (1961) *J. Phys. Chem. Solids*, **19**, 35-50 [8] von Bargen N. and Waff H. (1986) *J. Geophys. Res.* **91**, 9277-9282