EXPERIMENTAL QUANTIFICATION OF GRAIN GROWTH IN OLIVINE-METAL MIXTURES: APPLICATION TO SMALL PARENT BODIES DURING EARLY ACCRETION. J. Guignard[1], M. Bystricky[2], and M.J. Toplis[1]. [1]DTP-UMR5562, 14, Av. E. Belin, 31400, Toulouse, France (guignard@dtp.obs-mip.fr). [2]LMTG-UMR5563, 14, Av. E. Belin, 31400, Toulouse, France.

Introduction: The trace of processes which took place early in the history of the solar system has been largely wiped out on large planetary bodies such as the Earth or Mars. On the other hand, many of the meteorites which fall to Earth provide samples in which a direct record of these processes has been preserved. For example, variations in the relative proportion of metal and crystalline silicates in different classes of meteorite (e.g. chondrites, primitive achondrites, pallasites....), as well as variations in grain sizes and shapes, provide a potential window into the process of metal-silicate segregation on meteorite parent bodies. However, correct and quantitative interpretation of the observations requires independent experimental constraints. With this is mind we have undertaken a series of experiments to quantify the textural changes associated with metal-silicate equilibrium at high temperature.

Experimental procedures: Initial experiments have been performed on binary mixtures of pure forsterite and nickel. Four starting mixtures were studied with 5, 20, 70 and 90 volume% Ni, covering the range from isolated pockets of metal in an olivine matrix to isolated olivines in a metallic matrix. Synthesis of starting mixtures with reproducible grain size distributions and as little initial porosity as possible was a considerable challenge. First of all, the commercially available forsterite and Ni powders were found to have highly variable grain size and an additional grinding step was necessary to produce powders with a narrow size distribution. The final grain size of each powder is typically 1 and 3 microns. These powders were then mixed in the relevant proportions and sintered before formal experiments. For the two metal-rich mixtures, 5 hours at 1400°C at one bar in a pure nickel crucible and under a reducing atmosphere (four log units below the NiNiO buffer) were found to result in residual porosities on the order of 0.2%. On the other hand, olivine-rich mixtures with such low porosity could not be made in this way, and a technique called 'Spark Plasma Sintering' was employed. This involves passing a current of several hundred amps through a sample under uniaxial compression of 1kb for a duration of 3 minutes under 10^{-4} bar of Ar. These samples had residual porosity less than 1%. These starting materials were then annealed at 1440°C and 1 bar (just below the melting point of Ni) in a vertical drop quench furnace under a CO/CO_2 gas mixture corresponding to NNO-4, for times ranging from 1 to 10 days. The resulting charges were then cut and polished for analysis by SEM and electron microprobe.

Results and Discussion: Significant textural changes are observed as a function of time (Fig. 1). The circularity (perimeter/area) and distribution of grain size have been quantified for each experiment.

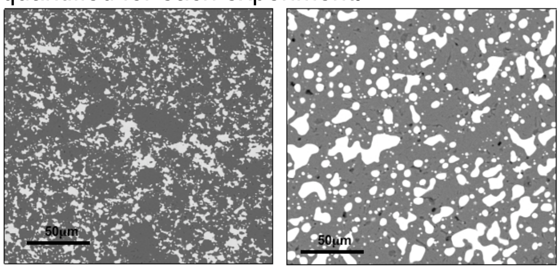

Fig. 1. SEM images of experiments with 20% Ni. The left hand image is the starting material, and the right hand image a sample annealed for 10 days.

Metal grains in an olivine matrix become approximately circular in less than two days, but continuous changes in the distribution of grain sizes are observed (Fig. 2), with elimination of smaller grains and growth of larger ones.

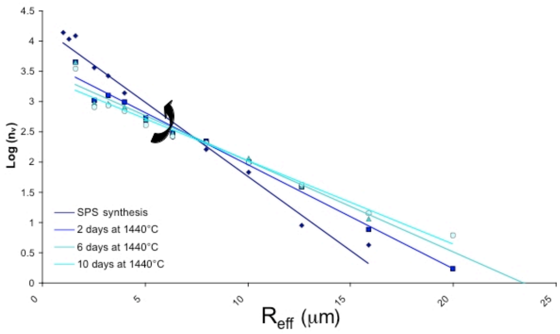

Fig. 2. Grain size distribuion of metal in experiments with 20% Ni as a function of time.

Further treatment of experimental charges to highlight grain boundaries is underway, with the aim of quantifying crystal growth rates and constraining the influence of a second phase on these rates. Other experiments are also in preparation to measure growth rate in the presence of a silicate melt.