Geophysical Research Abstracts
Vol. 13, EGU2011-7729, 2011
EGU General Assembly 2011

Grain Growth in Experimental Forsterite ± Metal ± Silicate Melt Systems: Analogues of Chondritic and Achondritic Parent Bodies.

Jeremy Guignard (1,2), Misha Bystricky (1,2), Mickael Toplis (1,2)

(1) Université de Toulouse; UPS-OMP; IRAP; Toulouse, France, (2) 2CNRS; IRAP; 14, avenue Edouard Belin, F-31400 Toulouse, France. (guignard@dtp.obs-mip.fr)

Introduction: Many meteorites provide evidence for the physical and chemical processes which occurred on small parent bodies accreted early in the history of the solar system. For instance, variations in phase proportions (e.g. metal, crystalline silicates, silicate melt), and/or grain shapes and sizes, can provide information relevant for constraining processes such as metal/silicate segregation. However, observations made in natural samples have to be constrained by experimental data. For this reason, we decided to perform experimental studies on the grain growth of metal and silicate grains using a simplified meteorite analogue system: olivine + metal ± silicate melt. In the framework of this study, grain growth laws have been established for each solid phase.

Experimental Procedure: Initial experiments have been performed on binary Forsterite (Fo)-Nickel (Ni) mixtures. Four compositions have been prepared, in which the proportion of Fo ranges from 10 to 95 vol%. In this way we investigated the influence of isolating and/or interconnecting grains. Dense starting aggregates (porosity < 1%) were obtained from ground powders (3-4 microns and narrow grain size distribution) sintered using the Spark Plasma Sintering (SPS) technique (100MPa, ∼1300°C, 3min, under vacuum; Guignard et al., in press) . These starting materials were then annealed at 1390 and 1440°C in a 1 bar vertical furnace under an atmosphere of CO/CO2 of oxygen fugacity 3.5 log units below the Ni-NiO buffer. Run durations varied from 2 hours to 21 days. A second set of experiments has been performed in the ternary system Fo + Ni + silicate melt. 5 and 20% melt has been added to a base binary mixture of Fo90Ni5. Five different liquids have been studied in the system An-Di-Fo, all in equilibrium with forsterite at 1400°C (with compositions varying from Fo36-An34-Di0 to Fo13-An0-Di87). Ternary mixtures were also prepared by SPS. Annealing experiments were then performed slightly above 1400°C for durations and fO2 conditions similar to those used for the binary mixtures.

Results and Discussion: In binary systems, important textural changes occur with time. In Fo-rich mixtures (respectively 95 and 80%), both Fo and Ni grow whereas in the Fo-poor ones (30 and 10%), Ni continues to grow but grain growth of Fo is limited and even non-existent when olivine is isolated. Where grain growth occurs, we observe that there is no evolution of the normalized grain size distribution with time, suggesting that grain growth is normal (NGG). Grain growth is thus described by the equation: $d^n - d_0^n = kt$ where n is the grain growth exponent, providing potential constraints on grain growth mechanisms. In our experiments, different mechanisms of grain growth occur as a function of the relative phase proportions, from grain boundary migration to coalescence of metal in response to growth of olivine. Preliminary results suggest that the presence of a silicate melt accelerates grain growth, and further analysis is underway to quantify these effects and the influence of melt composition. These data will then be used to model the textural consequences of heating small parent bodies early in the solar system.

Ref: Guignard, Bystricky & Béjina, Dense Fine-grained aggregates prepared by Spark Plasma Sintering (SPS), an original technique in experimental petrology, European Journal of Minerology, in press.