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Growth mechanism of Fe-FeS melts in the early melting stage of terrestrial planets

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In order to understand metal-silicate separation in early melting process of terrestrial planets, we carried out more than 60 experiments using piston-cylinder apparatus at the Magma Factory, Tokyo Institute of Technology. Starting materials were mixtures of Fe-metal (sponge or wire) and peridotite KLB-1 (Takahashi, 1986) with proportions of 30:70, 50:50 and 70:30 (in weight). In order to test the effect of sulfur on the grain growth mechanism, mixtures of Fe and FeS powder was used instead of pure Fe in some experiments. Pressure was kept constant at 1 GPa at preheating stage (1300C for 10 min), then temperatures were raised very quickly (in 5 to 60 sec) from 1300 to 1600C, hold and quenched. Heating duration at 1600C varied from 10 to1800 sec. In the recovered samples, degree of melting in peridotite matrix is approximately 50 vol% (only olivine residue) while Fe and Fe-FeS melts are totally molten. Graphite capsule was used for short experiments whereas MgO capsule was used in longer experiments (>60sec). Instantaneous growth of Fe-melt droplets up to 50 um was observed in all experiments even in shortest runs. In Fe-rich samples, up to millimeter scale very large Fe-grains were formed instantaneously. The instantaneous growth of Fe or Fe-FeS melt at the beginning of melting should be controlled by the amount of metal sulfide grains that are three-dimensionally connected prior to melting. Subsequent growth of Fe or Fe-FeS melt droplets dispersed in partially molten peridotite is controlled by Ostwald-ripening like mechanism as studied by Yoshino & Watson (2005). Using image analysis software, grain size distributions of Fe or Fe-FeS melt droplets were analyzed. Given same volume proportions of starting materials, amount of fine Fe melt droplets are much larger than fine Fe-FeS droplets in sulfur bearing runs, while difference is small in the amount of large melt droplets. The difference in grain size distribution can be explained by the difference in connectivity of Fe-FeS and Fe melts due to the drastic drop of surface energy from pure Fe to sulfur bearing melt. Based on these experiments, we discuss that size of the metal grains formed in each shock melting process in planet building stage may depends on the connectivity of Fe-metal phase in the source materials. Pallasite (stony-iron meteorite) may represent the products of local melt pockets formed after impacts.