Wetting ability of liquid Fe–S in solid core during planetesimal core crystallization

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Planetesimals and protoplanets were direct source of the terrestrial planets. It is widely known that some asteroids, such as Vesta, corresponding to remnants of planetesimals, are differentiated to metallic core and silicate mantle. In the differentiated planetesimals, the liquid core starts to crystallize after core–mantle differentiation and liquid-solid phase separation would occur in the core. Wetting ability controls whether liquid iron-alloys can migrate in solid iron-alloys grains during core crystallization. However, wetting behavior between solid and liquid iron-alloys are poorly known. In this study, we performed high pressure experiments at the conditions of planetesimal and protoplanet interiors to study wetting ability of liquid Fe–S alloys at grain boundaries of solid Fe. Wetting ability was evaluated from dihedral angle between solid Fe and liquid Fe–S. In particular, the effects of pressure and duration time on the dihedral angle were investigated.

Starting material was a mixed powder of Fe and FeS (Fe–2wt%S), and MgO, Al_2O_3, or BN capsules were used. High pressure experiments were conducted using the piston-cylinder apparatus at Institute for Planetary Materials. Experiments were performed at 0.5–3.0 GPa and 1323 K. Duration time of the experiments were varied from 15 minutes to 12 hours. Textual observation and quantitative chemical analysis of the recovered samples were carried out using the electron microprobe.

Measured dihedral angles between liquid Fe–S and solid Fe was approximately constant after 2 hours duration and tended to decrease with increasing pressure. The dihedral angles in this study were in the range of 30–48°, which was below the percolation threshold of 60° in all the present experimental conditions. Therefore, liquid Fe–S alloys can percolate through solid Fe during the core crystallization process in planetesimals and protoplanets.

Keywords: planetesimals, asteroids, core crystallization, wetting ability, planetary interior, iron-alloys