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Wetting property of Fe-Ni-N alloy melt in ringwoodite: Implications for nitrogen depletion in the bulk silicate Earth

KYUSEI TSUNO, DAMANVEER S GREWAL, VIRGINIA XU, LOGAN LEINBACH, KURT LEINENWEBER, AXEL WITTMANN AND SANG-HEON SHIM

Arizona State University

Presenting Author: ktsuno@asu.edu

Nitrogen (N) is one of the most important life-essential elements, along with carbon and water, but is more depleted than these volatiles in the present-day BSE (bulk silicate Earth) [1,2]. N depletion in the BSE is thought to have been established during the Earth's accretion [3,4]. However, due to the limited efficiency of alloy-silicate melt equilibrium during the final stages of Earth's growth [5,6] and the retention of substantial amount of N-bearing atmosphere [7,8], the solid mantle post magma ocean (MO) crystallization may not have been as N-poor as the BSE. Post-MO crystallization, a small portion of Fe-Ni alloy precipitated in the reduced mantle owing to charge disproportionation of iron in silicate phases [9]. Here we carried out multi-anvil experiments to measure dihedral angle of Fe-Ni-N alloy melt in ringwoodite at 20 GPa and 1673-2073 K to examine whether the Fe-Ni alloy melt can incorporate excess N and percolate through the solid mantle. Our experimental results show that the removal of excess N from the mantle by the percolation of Fe-Ni alloy melt into the Earth's core cannot be a viable mechanism to explain the present-day N-depletion in the BSE. Instead, if the alloy melt was stranded in the deep mantle in grain boundaries of silicate minerals, it could be a hidden N reservoir in the deep mantle [10] and the present-day BSE may not be as N-depleted as predicted.

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