Core freezing, chemical segregation and mushy magnetohydrodynamics

DAVID BERCOVICI* & ELVIRA MULYUKOVA

Deptartment of Geology & Geophysics, Yale University, PO Box 208109, New Haven CT 06520-8109, (*correspondence: david.bercovici@yale.edu)

The freezing of planetary and planetesimal cores and resultant compositional convection are likely important drivers for dynamo activity. The solidification of compositional mixtures, such as iron and sulfur, generates mush zones of partial melt at the freezing front, which can eject chemically buoyant or heavy liquid that then drives convection. Freezing in large planets can take billions of years, but small planets and planetesimals likely undergo complete freezing relatively rapidly, and their final stages of fluid motion during crystallization are probably dominated by mushy convection, compaction and percolative flow. However, dynamo models usually treat the solid core as static and electrically conducting, while models of partial melt mush zones assume the medium is mobile but electrically insulating. The magneto-hydrodynamic behavior of the deformable mush zone imposes a different boundary condition on dynamo activity than would a conducting solid, and conversely magnetism can impose extra forces on the phase separation in the mush zone. We extend our new two-phase magneto-hydrodynamic theory (Bercovici & Mulyukova, 2019) for percolation and compaction of a mush zone to include bulk mass, chemical and energy exchange during crystallization. Our model indicates that core freezing, partial crystallization and continuous compaction of the mush layer generates a well-magnetized chemically enriched liquid phase that is ejected into the pure-melted portion of the core.

Reference

Bercovici D. and E. Mulyukova, Two-phase magnetohydrodynamics: Theory and applications to magnetocompaction and magnetoconvection in crystallizing planetary and planetesimal cores, submitted to *Phys. Earth Planet. Int.,* 2019.