CORE FORMATION IN OXIDISED PARENT BODIES: EXPERIMENTS USING THE KAROONDA METEORITE

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Introduction: Our understanding of core formation processes is well developed for parent bodies that contain metal and troilite [1, 2]. However, oxidized parent body chemistry can significantly alter the ability for planets which contain large quantities of ice to form metallic cores. Oxidized parent bodies, like that of the CK chondrites and potentially the icy moons of the gas giants, do not contain free metal, having oxidized all their metal to magnetite and spinel[3]. A question therefore remains as to the nature of core forming melts which could form within highly oxidized parent bodies.

Methods: We acquired a 5.9g sample of Karoonda from the South Australian Museum. Twelve pellets were melted at temperatures of 1300°C in a vertical tube furnace within a 1 bar Ar atmosphere, with further experiments planned for 950, 1000, 1050, 1100, 1150, 1200, and 1250°C.

Observations: At 1300°C, magnetite appears to be mostly recrystallized with some immiscible Fe-O melt coexisting with silicate melt and olivine. Sulfide devolatilised from the samples at high temperatures. Silicate glass wets magnetite and olivine, and more importantly, Fe-O melt wets olivine. Olivine became depleted in Fe relative to its starting composition.

Discussion: The observed wetting relationship between Fe-O melt and olivine is a significant departure from the previously observed non-wetting relationship between liquid FeNi metal and olivine. Bagdassarov [4] found conclusively that the non-wetting behavior of metallic melt effectively rules out the possibility that metallic cores formed via percolation. Our finding thus marks a significant departure in core formation behavior for oxidized parent bodies. The wetting behavior of Fe-O liquids allows for the development of an interconnected melt network, and the migration of that melt via percolation. Thus, cores would be expected to form rapidly via percolation in sufficiently oxidized planetesimals that formed early enough in the history of the solar system to have enough ^{26}Al to undergo widespread melting.

Most CK and R chondrites are of low petrographic type, and there appear to be no achondrites sufficiently oxidized to have magnetite as a stable peak metamorphic phase. This may be because the more water-rich, and thus eventually more oxidized, bodies formed further from the sun, and therefore accreted slightly later than the inner bodies. However, these experiments likely inform us of processes occurring in other solar systems where oxidized planetesimals may have accreted with sufficient material for widespread melting. The effect of sulfide liberation is uncertain at this point, and more experiments are required to examine whether Fe-S-O liquids can form under some conditions, and the wetting properties of these liquids, particularly close to the magnetite-FeS eutectic at 940°C.

References: [1] Wood, B.J., Walter, M.J. and Wade, J. 2006. Nature 441: 825-833. [2] Chabot, N.L., Draper, D.S. and Agee, C.B. 2005. Geochimica et Cosmochimica Acta, 69: 2141-2151. [3] Kallemeyn, G.W., Rubin, A.E. and Wasson J.T., Geochimica et Cosmochimica Acta, 1991. 55: 881-892. [4] Bagdassarov, N., Solferino, G., Golabek, G.J. Schmidt, M.W. 2009. Earth and Planetary Science Letters 288: 84–95.