

## DIFFERENTIATION OF RELATIVELY OXIDIZED PLANETESIMALS: EXPERIMENTAL PARTIAL MELTING OF ALLENDE AT IW+1

N. G. Lunning, T. J. McCoy, C. M. Corrigan, and L. E. Waters, Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0119, USA. (lunningn@si.edu)

**Introduction:** Our dominant paradigm of planetesimal differentiation produces bodies with basaltic crusts, olivine and orthopyroxene-rich mantles, and metallic iron-nickel cores [e.g., 1]. Models that include iron-nickel cores inherently correspond to relatively reduced bodies, in this abstract we use reduced to refer oxygen fugacities ( $fO_2$ ) below the iron-wüstite (IW) buffer. This paradigm does not neatly translate to oxidized meteorite parent bodies [2,3]. Partial melting—by extension differentiation—may follow a notably distinct path under relatively oxidizing conditions. If basaltic liquid and FeNi/FeNiS/FeNiSO liquid are cogenetically produced by partial melting of a chondritic precursor as our current understanding of planetesimal differentiation indicates [e.g., 1], then relatively oxidized bodies could generate core-forming liquids that may crystallize sulfides and oxides in place of metal. The composition of oxides that crystallize from partial melts may influence the petrologic structure of oxidized differentiated planetesimals, and potentially their thermal structure when the oxides are Al-bearing phases (e.g. hercynite) which could control the planetesimal-scale distribution of  $^{26}\text{Al}$ .

There are a handful of meteorite parent bodies on which differentiation may have occurred at  $fO_2 > \text{IW}$ . The angrites have experienced  $fO_2$  around IW+2 [4-6]. This  $fO_2 (> \text{IW})$  is potentially not consistent with these basaltic meteorites forming on a body with an FeNi metallic core. Additionally, it has been proposed that the CV and/or CK chondrites originate from a partially differentiated parent body [2,3]; however, given the calculated intrinsic oxygen fugacities of these chondrite groups, respectively  $> \text{IW}$  and  $> \text{FMQ}$  [7], it is difficult to imagine a CV and/or CK parent body would have a metallic iron-nickel core.

**Materials and Methods:** We performed preliminary partial melting experiments on samples of Allende (CV3<sub>oxa</sub> chondrite) using two different experimental setups. The first set was conducted over a range of temperatures (1050-1400 °C) and durations (1-24 h) in a 1-atm gas-mixing furnace and  $fO_2$  was fixed at IW+1 using CO-CO<sub>2</sub> gases. The second set of experiments was conducted in a vertically oriented cold-seal apparatus, where the pressure vessel is composed of a Mo-alloy with trace amounts of Hf and C (referred to henceforth as MHC), at 1150°C and 50 MPa for 24 h. The MHC experimental charge consisted of a double Pt-capsule setup with a WWO buffer pair that held the oxygen fugacity  $\sim \text{IW}+1$  [8-9]. Preliminary mineral chemistry data have been obtained via high-resolution energy dispersive x-ray (EDS) using the FEI Nova NanoSEM 600 at the Smithsonian Institution.

**Results and Discussion:** The MHC apparatus enables us to achieve the pressure conditions of the interior of planetesimals. Only a couple of studies have conducted similar experiments to investigate the petrologic evolution of planetesimals [10-11], and previous studies have not focused on relatively oxidized bodies. One of the most promising findings from our preliminary MHC experiment (at 50 MPa) was that it retained about half its initial sulfur content, whereas sulfur (S<sub>2</sub> gas) completely volatilized from otherwise similar experiments in the 1-atm furnace.

Retention of sulfur in the MHC experiments will enable us to test our preliminary hypothesis from the results of our 1-atm experiments that sulfur volatilization under oxidizing conditions may increase the FeO activity in the silicate liquid and feed crystallization of hercynite, var. picotite: (Fe,Mg)(Al,Cr)<sub>2</sub>O<sub>4</sub>. In our first MHC experiment a similar spinel, an Al-rich chromite, crystallized. Crystallization of hercynite and Al-rich chromite, which are dense relative to olivine and silicate liquid formed in our experiments, could retain  $^{26}\text{Al}$  in the deep interior of oxidized planetesimals. In differentiation models of more reduced planetesimals, such as Vesta/HED parent body ( $fO_2 \sim \text{IW}-2$ ), the Al and by extension  $^{26}\text{Al}$  is erupted to the exterior of the body in basalts [12]. Erupting the primary heat source ( $^{26}\text{Al}$ ) to the crust presents a challenge for the interior thermal structure of reduced planetesimals [1,13].

**Conclusion:** Crystallization of hercynite during differentiation may lead to development of notably different thermal structures on oxidized planetesimals compared to more reduced planetesimals with potentially widely reaching consequences for the evolution of these different groups of planetesimals. However, the evidence supporting our hypothesis is preliminary and more partial melting experiments under oxidizing conditions are underway to test the influence of sulfur volatilization/retention on the abundance and composition of hercynite.

**References:** [1] McCoy T J et al. 2006 *in* Meteorites and the Early Solar System II pp. 733 [2] Carporzen L et al. 2011 *PNAS* 108: 6386 [3] Elkins-Tanton L T et al. 2011 *EPSL* 305: [4] Jurewicz A. J. G. et al. 1991 *Science* 252: 695 [5] Jurewicz A J G et al. 1993 *GCA* 57: 2123 [6] Shearer C. K. et al. 2016 Abstract #1370 47<sup>th</sup> Lunar & Planetary Science Conference [7] Righter K and Neff K E 2007 *Polar Science* 1: 35 [8] O'Neill H S-C and Pownceby M I 1993 *Am Mineral* 114: 296 [9] Shofner G A et al. 2016 *Am Mineral* 101: 211 [10] Singletary S J and Grove T L 2003 *MAPS* 38: 95 [11] Bartels K S and Grove TL 1991 *Proc. of LPSC* 21: 351 [12] Yamaguchi A et al. 2009 *GCA* 73: 7162 [13] Neumann W. et al. 2014 *EPSL* 395: 267