THE ORIGIN OF HIGH-TI LUNAR PICRITIC GLASSES: PRELIMINARY RESULTS FROM AN EXPERIMENTAL STUDY ON PARTIAL MELTING OF A HYBRID LUNAR MANTLE.

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Introduction The origin of the most primitive, Ti-enriched lunar picritic melts, sampled as pyroclastic glass beads in the lunar soils, remains poorly constrained. Three different hypotheses have been proposed: I) Ascent of a primary, undifferentiated melt from the lunar interior and assimilation of clinopyroxene (Cpx) and ilmenite (Ilm) in the upper section of the not overturned lunar mantle [1]. II) Melting of a hybridized lunar mantle after lunar mantel overturn [2,3]. III) Reaction of sunken low-degree high-density melts of the hybrid magma ocean source with high Mg-cumulates in the deep interior of the lunar mantle and subsequent uprise [3,4,5]. This study re-investigates hypothesis II with the aim to assess whether melting of a heterogeneous lunar mantle can be responsible for the compositional variabilities of lunar high-Ti picritic melts.

Methods: Since olivine (Ol) and orthopyroxene (Opx) are the phases predicted to coexist with primitive lunar mantle melts at the multiple saturation point [3], a starting material composition should yield only Opx, Ol and melt in the experiments. Bulk compositions were calculated to yield this prerequisite by combining appropriate amounts of equilibrated Opx, Ol (harzburgite cumulate) and Ilm, Cpx (ilmenite bearing cumulate) and small amounts of plagioclase, which are the basic components of the bulk lunar mantle after cumulate overturn [6].

To investigate the composition and modal amounts of partial melts from several different starting materials, we conducted high-pressure high-temperature experiments in an endloaded Piston Cylinder apparatus at the University of Münster. All runs were conducted at a pressure of 1.5 GPa, whereas run temperatures were varied between 1300 and 1450 °C [1]. To control fO_2 and to minimize Fe-loss in the runs, we used graphite-lined Pt capsules [1,2].

Results: Our preliminary results show that partial melting of some starting materials yield high-Ti, picritic melt compositions that are very similar to yellow and red lunar glasses (**Fig 1**). In both experiments the melts are in equilibrium with Ol and Opx.

Preliminary characterization of our run products with scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDS) at 1300°C and 1400°C indicate a degree of melting between 22 and 35%, respectively. Melt fractions were determined using the ImageJ free software [7].

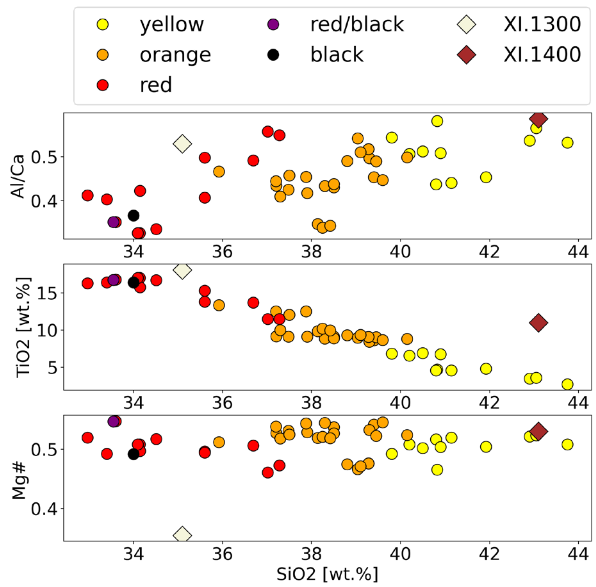

Figure 1: Preliminary melt compositions of lunar picritic glasses (yellow, orange, red, black) from [8,9] and our experimental melts from starting material XI. Beige and brown diamonds correspond to the experiment at 1300 °C with 22% and 1400 °C with 35% melt, respectively. Plots show the molar ratio Al/Ca, TiO_2 in wt.% and Mg# plotted against SiO_2 in wt.%.

Discussion: Our preliminary data shows, that the melting of a heterogeneous lunar mantle produced by the overturn of lunar stratification after the solidification of the lunar magma ocean can produce high-Ti picritic melts at temperatures that agree with the temperatures and depth of origin predicted by previous experimental studies [1,4]. Partial melting of this cumulate-bearing mantle can produce melts similar to the yellow and red glasses. This may be a viable and simple alternative to the currently accepted complex melting model. [3,4] Nevertheless, the origin of heat required to remelt lunar cumulates remains unclear. It seems unlikely, that radioactive heating alone, which is favored by many researchers as the source of secondary melting in the lunar mantle [e.g. 5], could have caused enough heat to create the amount of melt needed, i.e. 22-35%. Alternatively, we propose that heat was produced by impacts, as suggested by [10]. They argue that crater excavation and in-situ depressurization or long lived isostatically provoked convection caused adiabatic melting, which persists up to 350 Ma after the impact itself. This can explain the origin of lunar picritic melts by simple melting of a heterogeneous cumulate-bearing lunar mantle in the temporal context of late heavy bombardment and lunar mare magmatism which lasted at least from 3.9 to 3.5 Ga [4,11].

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References: [1] Wagner T. P. and Grove T. L. (1997) *Geochim Cosmochim Ac, 61, 6,* 1315–1327. [2] Krawczynski M. J. and Grove T. L. (2012) *Geochim Cosmochim Ac, 79,* 1-19. [3] Singletary G. H. and Grove T. L. (2008) *Earth Planet Sc Lett, 208,* 182–189. [4] Elkins-Tanton L. T., van Orman J. A. et al. (2002) *Earth Planet Sc Lett, 196,* 239-249. [5] Hess P. C. and Parmentier E. M. (1995) *Earth Planet Sc Lett 134,* 501-514 [6] Elkins L. T., Fernandes V. A. et al. (2000) *Geochim Cosmochim Ac, 64.13,* 2339–2350. [7] Schindelin J., Arganda-Carreras I. et al. (2012) *Nat Methods, 9*, 676-682 [8] Delano (1986) *J Geophys Res-Solid 91,* B4 201-213 [9] Shearer C. K. and Papike J. J. (1993) *Geochim Cosmochim Ac, 57, 19,* 4785-4812 [10] Elkins-Tanton L. T., Hager B. H. et al. (2004) *Earth Planet Sc Lett, 22,* 17-27. [11] Shearer C. K., Hess P. C. et al. (2006) *Rev Mineral Geochem, 60, 1,* 365–518.