Extrusive history of martian meteorite Yamato 980459: An experimental study

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The compositional characteristics that have made Y-98 the optimal choice for martian mantle-melting studies [1-3] also distinguish it as an ideal starting composition for crystallization experiments investigating the extrusive history of the magma. The whole rock is Mg-rich and in Fe-Mg equilibrium with olivine phenocryst cores, suggesting it is a liquid composition [4,5]. Here, we present a suite of dynamic cooling experiments on a synthetic bulk Y-98 composition, in which we attempt to replicate both textural and compositional features of the natural meteorite.

Results indicate that at least two cooling stages are required to produce the porphyritic texture of the natural meteorite, consistent with previous works [5-7]. However, the presence of groundmass olivine dendrites at all experimental cooling rates precludes the extreme final cooling rate inferred in [6]. Additional textural constraints indicate that an early cooling rate <1 °C h^{-1} is required to produce the faceted, infilled olivine megacrysts in Y-98, and a final cooling rate of ~100 °C h^{-1} is required to suppress plagioclase formation without inhibiting olivine dendrites or groundmass pyroxene crystallization.

Quantitative crystal shape analyses [8] track the effects of variable cooling rate on pyroxene populations, and close compositional matches between experimental and natural phases confirm the plausibility of our experimental cooling paths. The best-match cooling scenario suggests crystallization occurred in a progression from magma source to lava flow field/front and is inconsistent with exceptional physical conditions (e.g. thin flow, rapid emplacement [5,6,9]).

[1] Musselwhite et al (2006), *MAPS* **41**, 1271-1290. [2] Rapp, Draper & Mercer (2013), *MAPS* **48**, 1780-1799. [3] Usui et al. (2012), *EPSL* **357-358**, 119-129. [4] Filiberto & Dasgupta (2011), *EPSL* **304**, 527-537. [5] Usui, McSween & Floss (2008), *GCA* **72**, 1711-1730. [6] Greshake, Fritz & Stoffler (2004), *GCA* **68**, 2359-2377. [7] Lentz & McSween (2005), *Ant. Met. Res.* **18**, 66-82. [8] Hammer (2009), *MAPS* **44**, 141-154. [9] McSween (2008), in *The Martian Surface*, 383-395.