An experimental study of partial melting and fractional crystallization on the HED parent body

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The Howardite-Eucrite-Diogenite (HED) suite is a suite of basalts, gabbros, orthopyroxenites, harzburgites and impact breccias believed to originate from Vesta. The two main models proposed for their formation are through magma ocean crystallization ([1], [2]) and serial magmatism (e.g. [3]). As Vesta is the only known intact differentiated protoplanet, the HEDs provide an invaluable snapshot into the early conditions and planetary forming processes occuring in the early solar system. We performed a series of one-atmosphere experiments between 1150 – 1650 ºC, at an appropriate fO_2 on synthetic HED compositions in order to investigate the phase relations and the major and trace element geochemistry of the main rock forming phases (olivine, orthopyroxene and feldspar) during partial melting and fractional crystallisation paths. The experimental results were combined with MELTS models, testing the applicability of the MELTS algorithm to the Fe-rich, reduced, low pressure HED system. The MELTS algorithm is good at predicting the crystallization sequence and phase compositions observed experimentally, but overestimates the temperature at which orthopyroxene starts to crystallize. The error between models and experiments is similar to those observed for terrestrial and martian systems. Two-stage models of equilibrium crystallization or partial melting followed by melt extraction and fractional crystallization are capable of producing eucrite and diogenite compositions experimentally. Further investigation using MELTS to investigate the range of starting compositions capable of producing the HED meteorites suggests that the mantle of the HED body needs a Mg# (= 100*(Mg/Mg+Fe), atomic) between 75 -80 and greater than 43 wt. % SiO_2.

[1] Righter and Drake (1997), *Meteoritics and Planetary Science* **32(6),** 929-944. [2] Mandler and Elkins-Tanton (2013), *Meteoritics and Planetary Science* **48(11),** 2333-2349. [3] Beck and McSween (2010), *Meteoritics and Planetary Science* **45(5),** 850-872.