TIMING AND MECHANISMS OF THE EVOLUTION OF THE MAGMA OCEAN ON THE HED PARENT BODY

M. Schiller[1,2], J. A. Baker[2], M. Bizzarro[1], J. Creech[2] and A. J. Irving[3]. [1]Centre for Star and Planet Formation, University of Copenhagen, Øster Voldgade 5-7, DK-1350, Denmark. E-mail: Schiller@snm.ku.dk. [2]School of Geography, Environment and Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand. [3]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195.

Introduction: Diogenites are ultramafic pyroxene and olivine rocks that are presumed to be cumulates that resulted from magmatic differentiation on the howardite-eucrite-diogenite (HED) parent body. There are, however, no precise and independent age constraints on the formation of diogenites and, in particular, their age relationships with the basaltic eucrites. We report a mineralogical (major and trace elements) and high-precision Mg isotope study of 24 diogenite meteorites that cover the known range of orthopyroxene and olivine compositions (En = 65.4 - 85.3 and Fo = 70.1 - 91.0) present in this meteorite group.

Methods: Major and trace elements of minerals were measured using an electron probe microanalyzer and a laser ablation system coupled to an inductively coupled plasma mass spectrometer, respectively. Mg isotopes were determined on Mg chemically purified from whole rock samples using a multiple collector inductively coupled plasma mass spectrometer in pseudo-high resolution mode.

Results: Fe, Ca and incompatible trace elements are negatively correlated with the Mg concentrations in orthopyroxene. Despite having significantly sub-chondritic $^{27}Al/^{24}Mg$, the diogenites exhibit significant variations in the mass-independent abundance of ^{26}Mg ($\delta^{26}Mg^*$) from -0.0108 ± 0.0018 to +0.0128 ± 0.0018‰ and $\delta^{26}Mg^*$ generally correlates with orthopyroxene/olivine major and trace element chemistry.

Discussion: The observed range of $\delta^{26}Mg^*$ and its correlation with major and trace element chemistry can only be explained through decay of live ^{26}Al ($t_{1/2}$ = 0.73 Myr) throughout the formation history of the diogenites. This suggest that large scale magmatic differentiation driven by decay of ^{26}Al on the HED parent body during the lifetime of ^{26}Al resulted in the cumulate minerals capturing the chemical and isotopic evolution of large scale magma bodies or a magma ocean on the HED parent body. Calculated $^{27}Al/^{24}Mg$ ratios of the diogenite parent melts inverted from orthopyroxene major element chemistry positively correlate with increasing $\delta^{26}Mg^*$ and suggest an initial degree of melting of 20 to 25%. The largest $\delta^{26}Mg^*$ deficits appear to date the onset of diogenite formation to just 0.7 to 1.3 Myr after CAIs considering the uncertainty in the initial $(^{26}Al/^{27}Al)_0$ abundance of the HED parent body. Thus diogenite formation significantly pre-dates the formation of basaltic eucrites. The period of magmatic differentiation responsible for forming the full suite of diogenites might have been as short as ca. 0.2 Myr, but could have lasted longer depending on the initial $(^{26}Al/^{27}Al)_0$ of the HED parent body and uncertainties in the model calculations. The increase in heavy REE concentrations from the oldest to the youngest diogenites produced in this interval require up to 85 to 90% fractional crystallization of a common parent magma.