TRACE AND MINOR ELEMENT CHEMISTRY IN AUGITE FROM THE NAKHLITES AS A PROXI FOR EARLY SUBTERRANEAN BASALTIC ACTIVITY.

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Introduction: The nakhlites are fragments of a young Martian basaltic crust about 1.3 Ga old that were excavated and ejected into space by one or two impacts of meteorite a few Ma ago [1, 2]. Each nakhlites represent a distinct meteorite fall but because they have very similar bulk and mineral compositions, mineral paragenesis and radiogenic isotope compositions they are thought to represent the solidified products of the same parent magma [3].

The nakhlites are all medium-grained pyroxenites likely formed by fractional crystallization of basaltic magma [3, 4]. The porphyritic texture of the rocks indicates a two-stage history probably with stagnation of the parent magma in a slowly cooling magma chamber where the large homogeneous cores of augite crystallized prior to final emplacement of the crystal-bearing magma possibly as a single lava flow or shallow intrusion [4]. Textural analyses of augite phenocrysts in different nakhlites indicate that they grew over similar timescales [5]. Upon emplacement, the magma experienced crystal accumulation, differentiation and sub-solidus re-equilibration processes that have partially erased the original chemistry of the liquidus phases. Variations in correlated petrographic characteristics (augite and olivine rim composition, modal proportion, mesostasis texture, etc.) between the nakhlites are believed to reflect the internal structure (or depth profile) of the cumulate body [6].

Augite is an important mineral phase in the nakhlites. It is the first-formed crystal in all nakhlites, so it has crystallized from the most 'primitive' parent melt. In addition augite has a complex crystalline chemistry and structure which means that it has not only the capacity to accommodate many incompatible elements but also that its chemical composition varies with the physico-chemical conditions that prevailed during its formation [7]. Here we report selected trace and minor element composition of cumulus augite from different nakhlites to better constrain the early petrogenetic processes that operated in the hypabyssal basaltic plumbing system.

Results and discussion: The concentration of selected trace and minor elements in augite phenocrysts from six nakhlites (North West Africa (NWA0 5790, NWA 817, Yamato (Y) 000593, Y 000749, Nakhla and NWA 998) were measured by LA ICP-MS at Durham University. As previously recognized by [8], cumulus augites are extensively zoned in many augite-incompatible trace elements (Ti, Y, Zr, Hf, etc.) within individual nakhlites while elemental abundances within single nakhlites form overlapping trends between the meteorites. Incompatible trace element patterns of the large cores of cumulus augite are very similar between the different nakhlites. Positive correlation between different incompatible elements (Ti *vs.* Y, Zr or Sr) suggests that their zoning is of primary origin. The core of cumulus augite from Y 000593, Y 000749 and Nakhla have the lowest incompatible element abundances while NWA 5790 and NWA 817 are consistently and similarly enriched in all of the incompatible elements that were analysed. The two latter nakhlites have incompatible trace element compositions similar to those of the augite rims of the other studied nakhlites. However, at apparently similar degrees of differentiation (i.e. similar incompatible element concentration, e.g. Ti), NWA 5790 and NWA 817 display different minor augite-compatible element compositions (Cr, Co, Ni, etc.). Cumulus augites from these nakhlites are believed to have remained unaffected by sub-solidus diffusional re-equilibration [9]. If correct, then cumulus augite from both meteorites crystallized under different physical and/or chemical conditions. Variations in trace and minor element abundances in the nakhlites indicate that their parent magma(s) experienced various degrees of fractionation prior to augite crystallization while the different fractionated products have largely remained unmixed during and after final emplacement.

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