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Trace and minor element variations in lunar granulites: Insights into lunar metamorphic conditions.

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Metamorphic rocks on the Moon are an important yet under-studied suite of lunar lithologies that have been identified in the Apollo and lunar meteorite collections [1]. These rocks, with granoblastic textures, are generally referred to as granulites; however, unlike their terrestrial counterparts, they are considered to represent the products of only high-temperature (> 1000 ^{o}C) thermal metamorphism that completely re-crystallised their protolith(s). Lunar granulites are commonly sub-divided into two main compositional groups related to their protolith lithologies. The Fe-granulites, found at most Apollo landing sites, are generally accepted to derive from metamorphosed plagioclase-rich igneous cumulates, termed the ferroan anorthosite (FAN) suite. The FAN suite are important lithologies as they represent products of the primary lunar crust. The Mg-granulites are found mostly at the Apollo 16 landing site and within lunar meteorite samples; the protolith(s) of this latter group is not well understood [2]. Early studies have linked the protolith to secondary magmatic intrusions into the primary anorthositic crust (termed the Mg-suite); however, recent studies have tentatively connected the protolith to a Mg-rich variation of the primary crustal plagioclase cumulates (termed the MAN suite). The occurrence of MANs is controversial, it is unclear how the MAN suite fits into canonical lunar crustal formation models [3]. To investigate the protoliths of the granulite suites, we report in situ trace- and minor-element abundances for olivine and pyroxene grains within Fe- and Mg-granulites, determined by LA-ICP-MS and EPMA respectively. Trace-element data presented here indicate that the Mg-granulites are compositionally similar to the MAN suite. Furthermore, by comparing plagioclase trace-element data with peak metamorphic temperatures (calculated using two-pyroxene thermometers [4]), we find no relationship between metamorphic temperature and diagnostic trace-element signatures suggesting that both granulite suites experienced similar thermal metamorphic conditions. Additionally, we estimate the duration of metamorphic heating using experimentally derived diffusion rates of minor elements in minerals, (such as Ca in olivine [5]). Both the calculated cooling rates and peak metamorphic temperatures can set constraints on the metamorphic heat source responsible for thermally annealing the Fe- and Mg-granulites. Specifically, we are able to assess whether the granulites formed as a result of shallow (<1 km) burial of the protolith by impact melt sheets or hot, impact-generated fall-back breccias [6]; or deep (> 1km) contact metamorphism of the protolith due to the emplacement of magma chambers or upwelling plutons within the lunar crust [7].

[1] Lindstrom & Lindstrom, 1986, JGR, 91(B4), 263-276 [2] Treiman et al. 2010. MaPS, 45, 163-180. [3] Gross et al. 2014, EPSL, 388, 318-328. [4] Brey & Köhler, 1990, J Pet, 31, 1353-1378. [5] Dohmen et al, 2007, PCM, 34, 389-407. [6] Cushing et al. 1999, MaPS, 34, 185-195. [7] Hudgins et al. 2011, Am Min, 96, 1673-1685.