DID FELDSPAR-RICH CUMULATE FORM DURING CRYSTALLIZATION OF GABBRO FROM THE NORTHWEST AFRICA 773 CLAN LUNAR METEORITES? HINTS FROM A TERRESTRIAL SILL

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Introduction: The Northwest Africa 773 (NWA 773) clan of lunar meteorites is dominated by mafic lithologies, including a distinct olivine cumulate gabbro (OCG) [1-3] (Fig. 1). Many lithologies within the NWA 773 clan are considered to be co-magmatic, or at least closely related by igneous processes, with the OCG as a rock that formed at an early stage of igneous crystallization [1,2]. Most isotopic ages derived from the NWA 773 clan cluster near 3.1 Ga, supporting the interpretation of a common origin of rocks included in the clan [4,5 and references therein].

In this project, we compare the NWA 773 clan with a gabbroic sill from Murotomisaki, Japan, where a crystallization sequence has been determined based on whole-rock geochemistry, petrology and field relations [e.g., 6-9]. The Murotomisaki gabbroic sill (MGS) crystallized from chilled margins inward; olivine gabbros occur inward from the chilled margins and the middle zone of the sill consists of a coarse-grained gabbro dominated by augite and plagioclase feldspar. The lower olivine gabbro was divided by [7] into two subunits: a stratigraphically lower unit with fine-grained olivine and an overlying unit with coarser olivine. Hoshide et al [7] inferred that the fine olivine horizon was dominated by gravitational settling, whereas crystal growth was a more important mechanism for the coarse olivine subunit. An additional complication is prompted by plagioclase-rich segregations in the sill, with bulbous-upward margins suggesting diapiric rise during crystallization of the sill (Fig. 1; see [7,8]).

Samples and Methods: Field observations and collection of samples of the MGS were guided by a field report provided by T. Hoshide. Polished thin sections of samples from the MGS and NWA 773 clan were studied using petrographic microscopes, a scanning electron microscope (SEM, Hitachi 3-3400) and electron probe micro-analyzer (EPMA, JEOL JXA-8900) at Waseda University (WU). Whole-rock analyses of several MGS samples were conducted by X-ray fluorescence (XRF, Rigaku ZSX Primus II) at WU. Analyses reported by [6] were combined with our XRF results to evaluate whole rock chemical evolution in the MGS.

Results and Discussion: Subtle variations in texture and Fe# (FeO/[FeO+MgO]) of olivine indicate that the NWA 773 clan OCG consists of at least two subunits: an earlier unit with lower Fe# and textures indicating a crystallization sequence olivine → low-Ca pyroxene → high Ca-pyroxene; a later unit with higher Fe# and more ambiguous textures. The distinct varieties of OCG may reflect a change somewhat analogous to the settling vs. crystal growth zones of olivine gabbro in the MGS [7]. In any case, crystallization of OCG in the NWA 773 magmatic system led to Mg-depletion in residual liquid, and consequently higher Fe# in later lithologies, including feldspar-pyroxene gabbros (Fig. 1) and later ferroan olivine-bearing gabbros [1,2]. Feldspathic glass inclusions in NWA 773 fayalite formed by immiscibility from Mg-depleted mafic liquid. Similar zoning to Mg-depleted compositions of pyroxene and late-stage glass can be observed in MGS. However, whole rock variations in Fe# of the MGS are not as extreme as might be expected from mineral zoning. Instead, whole rock CaO and FeO vs. MgO contents in the MGS, combined with field evidence of feldspar segregation and mobility (Fig. 1), indicate that plagioclase accumulation affected compositional evolution of the sill. Feldspar-rich gabbros have been identified in the NWA 773 clan (note the anorthositic gabbro lithology of [2]), suggesting that some mechanism for feldspar enrichment (diapiric rise?) occurred in the NWA 773 magmatic system. We note further that if only thin section scale observations were available for the MGS, the importance of feldspar segregation during formation of MGS might be overlooked. Hand sample and global scale data are available for the Moon; intermediate spatial scale observations should be prioritized as plans for renewed exploration of the Moon are considered.

References: [1] Fagan et al (2014) *GCA* 133:97-127. [2] Valencia S.N. et al (2019) *MaPS* 54: 2083-2115. [3] Korotev R.L. & Irving A.J. (2021) MaPS 56: 206-240. [4] Merle R.E. et al (2020) MaPS 55: 1808-1832. [5] Moromoto N. et al (2023) Mass Spectrometry A0115. [6] Akatsuka T. et al (1999) J. Geol. Soc. Japan 105: 771-788. [7] Hoshide T. et al (2006) J. Min. Pet. Sci. 101: 223-239. [8] Hoshide T. et al (2006) J. Min. Pet. Sci. 101: 334-339. [9] Hoshide T. & Obata M. (2009) Trans. Royal Soc. Edinburgh 100: 235-249.

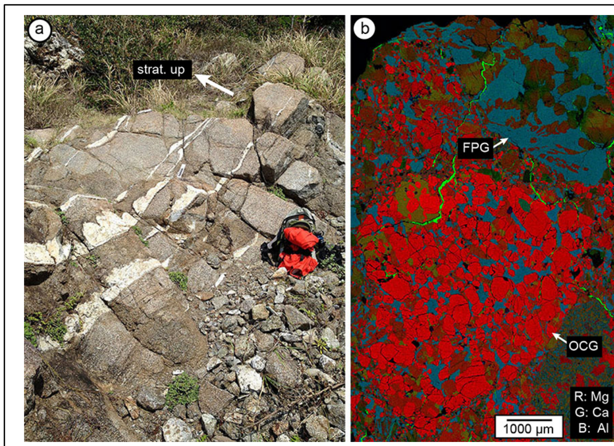

Fig. 1. (a) Feldspar-rich layers (white) in the MGS. Backpack for scale at right is approx. 0.5 m tall. Arrow points toward stratigraphic top. (b) Elemental map (red:Mg, green:Ca, blue:Al) of clasts of OCG and feldspar-pyroxene gabbro (FPG) in NWA 2727. $CaCO_3$-rich veins (bright green) are due to terrestrial weathering.