NORTHWEST AFRICA 773 CLAN OLIVINE CUMULATE GABBROS: CRYSTALLIZATION TRENDS COMPARED WITH A GABBROIC SILL FROM MUROTOMISAKI, JAPAN

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Introduction: Olivine cumulate gabbro (OC) is a distinctive clast type that is common and abundant in the Northwest Africa 773 (NWA 773) clan of lunar meteorites [1-4]. The petrologic significance of the OC stems from, among other reasons, the interpretation of the OC as an early stage lithology during crystallization of a co-magmatic sequence, now preserved by several clasts in the NWA 773 clan [5]. This interpretation depends on spatial variations in Ti# vs. Fe# zoning in pyroxene (Fig. 1a). One problem, however, is that zoning within the OC shows a wide range of Ti# at fixed Fe#, whereas an evolution toward late-stage magmatic clasts requires increases in both Ti# and Fe# (Fig. 1a). Is it reasonable to infer that the OC represents an early stage of magmatic evolution, even though zoning within the OC pyroxene does not show the increase in Fe# needed to produce late-stage lithologies?

In this project, we compare pyroxene zoning trends of the NWA 773 clan OC with those of a gabbroic sill from Murotomisaki, Japan [6]. Samples from the Murotomisaki gabbroic sill (MGS) are known to be co-magmatic and the sequence of crystallization can be derived from field constraints.

Methods: Samples of the MGS, which is in the Muroto Misaki Geopark [7], were collected in August 2014. From early to later stages of crystallization, the three samples of this study are Muro-7, Muro-4 and Muro-14 (Fig. 1c). Polished thin sections were prepared and examined using petrographic microscopes. Images and quantitative analyses of minerals were collected using a JEOL JXA-8900 electron probe micro-analyzer at Waseda University.

Results and Discussion: An early-stage zoning trend of increasing Ti# at constant Fe# in pyroxene was identified in Muro-7 and Muro-14 (Fig. 1b). The Muro-4 pyroxene analyzed at present has constant Ti# and Fe# at an inflection point, where zoning in Muro-14 changes from increasing Ti# to increasing Fe# (Fig. 1b). The latest stage pyroxene in Muro-14 exhibits increasing Fe# at constant Ti# to values that are high in both Ti# and Fe# (Fig. 1b).

Thus, early stage pyroxene from the MGS has increasing Ti# at constant Fe#, similar to zoning in NWA 773 clan OC (Figs. 1a,b; see "titanian-KREEP-enrichment" trend of [5]). Late stage pyroxene from the MGS has high values for both Ti# and Fe#, similar to late-stage NWA 773 clasts inferred to be co-magmatic with the OC [5]. We infer that the MGS and NWA 773 OC magmatic system both evolved toward higher Ti# at early stages and higher Fe# later; however, the paths from early to latest stages of the two magmatic systems differed. In the MGS, Ti# increase was followed by Fe# increase at ~ constant Ti# (Fig. 1b). In the NWA 773 system, Ti# increased in trapped pockets of the OC, and the main body of liquid evolved by simultaneous increases in both Ti# and Fe# (Fig. 1a).

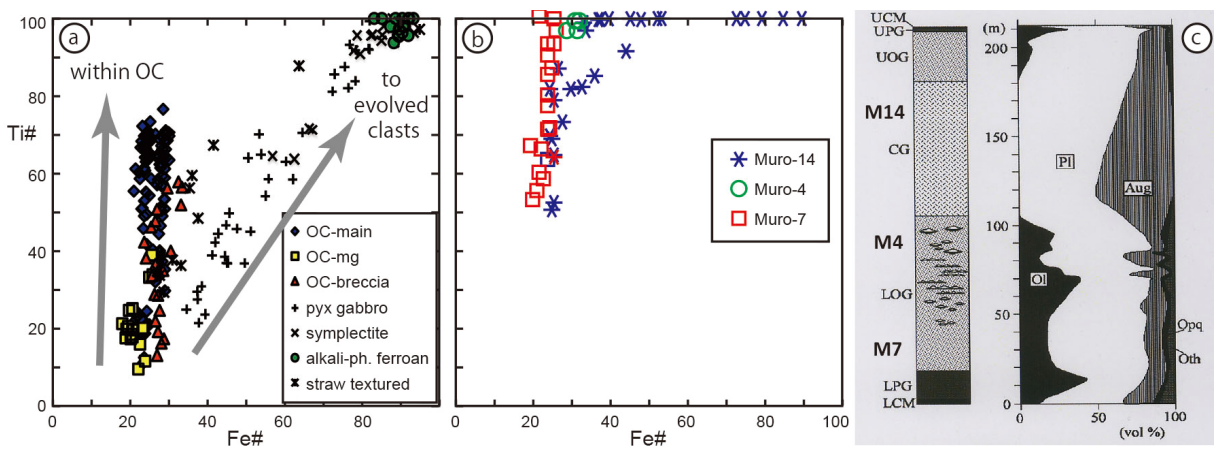

Figure 1. Pyroxene Ti# (Ti/[Ti+Cr]x100) vs. Fe# (Fe/[Fe+Mg]x100) for clasts in NWA 773 (a, from [5]) and from the Murotomisaki gabbroic sill (MGS) (b); and cross-section of the MGS (c, from [6]), showing stratigraphic levels of samples Muro-7, Muro-4 and Muro-14. Abbreviations in (c): L = lower; U = upper; CM = chilled margin; PG = picritic gabbro; OG = olivine gabbro; CG = coarse gabbro; Ol = olivine; Pl = plagioclase; Aug = augite; Opq = opaques; Oth = others. Arrows in (a) show zoning trends in OC and pyroxene gabbro of the NWA 773 clan.

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