STAGES OF CRYSTALLIZATION IN A BASALTIC BODY FROM THE MOON REVEALED BY DIFFERENT TYPES OF OLIVINE CUMULATE GABBRO FROM NWA 773 GROUP METEORITES.

T.J. Fagan[1], Y. Hori[1], M. Sasaki[1] and H. Nagaoka[2], [1]Department of Earth Sciences, Waseda University, Tokyo (fagan@waseda.jp), [2]Research Institute for Science and Engineering, Waseda University, Tokyo.

Introduction: Lunar meteorites of the Northwest Africa 773 (NWA 773) clan preserve a record of igneous crystallization of a magmatic body on the Moon [1-3]. Diverse rocks occur in the NWA 773 clan [4], but several lithologies can be linked together representing an igneous body that underwent Fe-enrichment during progressive crystallization from (1) olivine cumulate gabbro (OCG), to (2) pyroxene gabbro, to (3) symplectites and alkali-rich phase ferroan rocks [5]. In this study, we show that distinct phases of the OCG occur--one enriched in pyroxene and the other with more olivine and feldspar--representing distinct processes during early stages of crystallization of the OCG magmatic body.

Methods: NWA 2977 and NWA 6950 are members of the NWA 773 clan and consist entirely of OCG [3,6]. One polished thin section (pts) of NWA 2977 and one of NWA 6950 were examined. Thin-section scale images of back-scattered electrons (BSE) and Kα X-rays of several elements were prepared using a JEOL JXA-8900 electron microprobe-analyzer (EPMA) at Waseda University (WU). Approximate boundaries between pyroxene-rich vs. olivine-feldspar-rich domains of the OCG were drawn based on the BSE and elemental maps (Fig. 1). Grids were overlain on the elemental maps; the mineral at each grid node was identified based on composition; modes were determined for both OCG types for both pts. Quantitative analyses of olivine, low-Ca pyroxene, high-Ca pyroxene and plagioclase feldspar were collected by EPMA at WU.

Results: Two distinct types of OCG can be recognized based simply on modes. For both NWA 2977 and NWA 6950, the pyroxene-rich OCG has >60 mode% pyroxene (combining low-Ca and high-Ca pyroxene), <35% olivine and <10% feldspar; whereas the olivine-rich OCG has <30% pyroxene, >50% olivine and >10% feldspar (Fig. 1). Plagioclase feldspar has similar compositions in the two OCG types (~An_{90}), but mafic silicates have different compositions and zoning trends. The Fe#'s (molar FeO/[MgO+FeO]) are slightly lower in the pyroxene-rich OCG (olivine Fa_{31} vs. Fa_{30}; pyroxene Fe# = 24 vs. Fe# = 26 for the olivine-rich OCG). Pyroxene Ti#'s (molar Ti/[Ti+Cr]) are more variable in the olivine-rich OCG, reflecting zoned pyroxene crystals with Ti# increasing toward K-feldspar rich incompatible pockets [see 5]. The K-rich pockets are characteristic of the olivine-rich OCG, but were not identified in the pyroxene-rich OCG. The pyroxene-rich OCG represents an earlier stage of crystallization where residual, incompatible element-rich liquids were expelled efficiently. In contrast, residual liquids were trapped in pockets in the olivine-rich OCG. The OCG types may reflect a change from crystal growth to crystal accumulation during cooling of the parental magmatic body.

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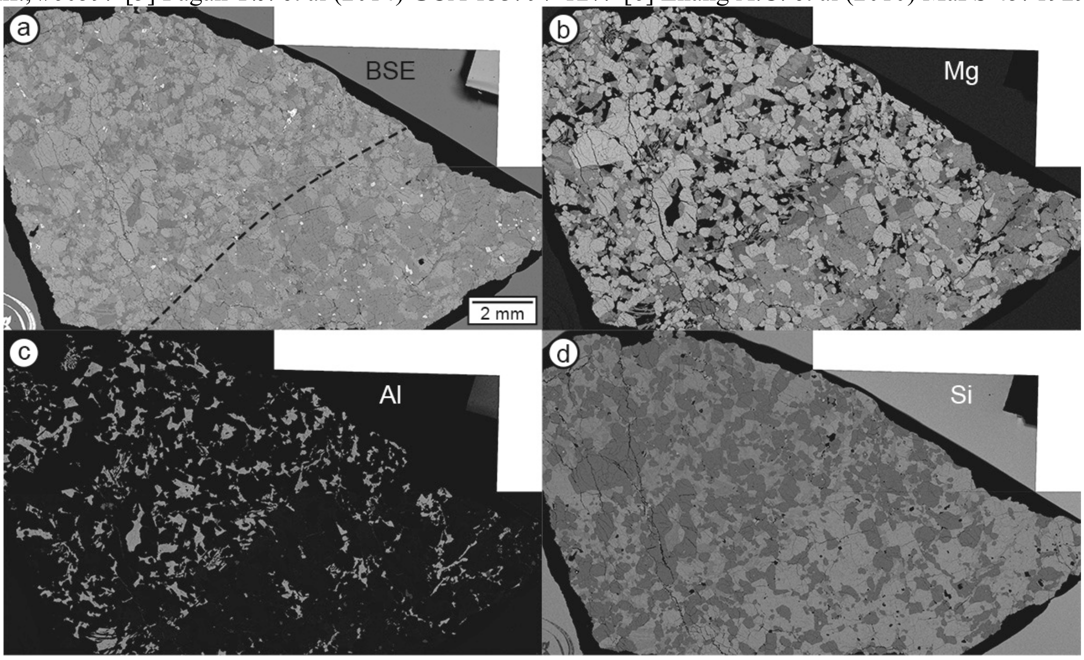

Fig. 1. Olivine cumulate gabbro (OCG) in a polished thin section of NWA 2977, shown in BSE (a), and Kα X-ray elemental maps of Mg (b), Al (c) and Si (d). Dashed line in (a) shows approximate boundary between olivine-rich (upper left) vs. pyroxene-rich (lower right) domains of OCG.