MINERALOGICAL AND PETROLOGICAL STUDY OF NORTHWEST AFRICA 14127 SHERGOTTITE: IMPLICATIONS FOR MINERALOGICAL DIVERSITY OF POIKILITIC SHERGOTTITES.

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Introduction: Shergottites record recent igneous activity of Mars and analyzing these samples can allow us to understand magmatic compositions and crystallization processes near the Martian surface. Shergottites are generally classified into three subgroups based on their petrological characteristics: basaltic (diabasic), olivine-phyric and poikilitic, reflecting distinct crystallization processes. It is also known that shergottites originated from a few (several?) distinct mantle reservoirs regardless of petrological grouping [e.g., 1-3]. Among three petrological subgroups, poikilitic shergottites showed similar petrology within the subgroup dominated by pyroxene oikocrysts enclosing olivine chadacrysts and petrological difference was not significant among samples known before mid-2000s [e.g., 4]. However, textural variation of poikilitic shergottites has become evident since the finding of more evolved samples with less abundance of pyroxene oikocrysts (e.g., RBT 04262) [e.g., 5]. In this study we focus on a new shergottite NWA 14127 found in 2021 which contains a small amount of poikilitic areas, but is distinct from known samples of poikilitic shergottites and rather shows a textural affinity to olivine-phyric shergottites. We compare its mineral compositions and petrological characteristics with those of some other poikilitic shergottites to discuss the mineralogical diversity within this subgroup and petrogenetic relationships between poikilitic and other shergottite subgroups.

Samples and Methods: We studied thin sections of NWA 14127, ALH 77005, NWA 4468, NWA 13366, NWA 13369, NWA 12241 and NWA 13227. Elemental maps were obtained using a JEOL JXA-8900 electron probe microanalyzer (EPMA) at the University of Tokyo (15 kV acceleration voltage and 80 nA beam current). The elemental maps were then used for quantitative analysis to decide the analysis points of olivine, pyroxene and spinel minerals in both poikilitic and non-poikilitic lithologies. The quantitative analysis was set up at acceleration voltage of 15 kV and beam current of 12 nA.

Results: All shergottites studied contain both poikilitic and non-poikilitic lithologies although their abundances widely vary. Most olivines in NWA 14127 are euhedral coarse grains (~2 mm) in non-poikilitic lithologies and olivine chadacrysts (~0.3 mm) enclosed by pyroxene oikocrysts are minor (Fig. 1). Most other samples similarly contain only small amounts of pyroxene oikocrysts except ALH 77005, NWA 12241 and NWA 13369 that include large (>5 mm) pyroxene oikocrysts. When the size of pyroxene oikocryst is smaller, the abundance and size of olivine chadacrysts correspondingly smaller. The Fo# (molar Mg/(Mg+Fe)) of olivine in each sample is shown in Fig. 2. It is obvious that the Fo# range of olivine in NWA 14127 is larger than those of other samples and extends to more Fe-rich compositions. Also, it is remarkable that non-poikilitic olivine in NWA 14127 is as Mg-rich (or even more Mg-rich) as olivine chadacrysts that are considered to have first crystallized from magma. Similar compositional relationship between non-poikilitic olivine and olivine chadacryst can be seen in NWA 13366, NWA 12241 and NWA 13227 (Fig. 2).

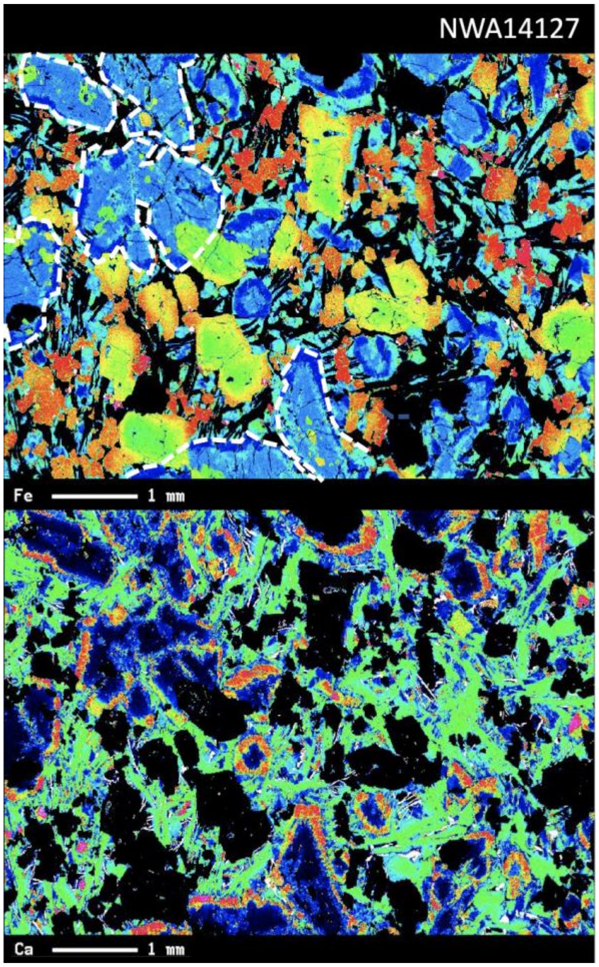

Fig. 1. Fe and Ca X-ray maps of NWA 14127. Olivine is green~yellow~red color in the Mg map. Pyroxene is mostly blue. White dashed lines show pyroxene oikocrysts enclosing olivine chadacrysts. Ca map shows the presence of non-poikilitic pyroxenes with clear augite mantles (red in color).

Most pyroxene oikocrysts in poikilitic shergottites studied have augite rims. Pyroxene oikocrysts in NWA 14127 have similar augite rims, but there are non-poikilitic pyroxenes having augite mantles and Fe-rich low-Ca pyroxene rims similar to QUE 94201, EET 79001 and LAR 06319 [e.g., 4,6,7] (Fig. 1). Such obvious non-poikilitic pyroxenes are absent in other samples. Because Al-Ti systematics of pyroxene are used to estimate the depth of their formation places [e.g., 8,9], we plotted Al and Ti abundances in the core and rim of pyroxene in both poikilitic and non-poikilitic areas (Fig. 3). It is evident that the Ca-poor core and Ca-rich rim of the pyroxene oikocrysts have lower Ti/Al ratios compared to those in non-poikilitic pyroxenes.

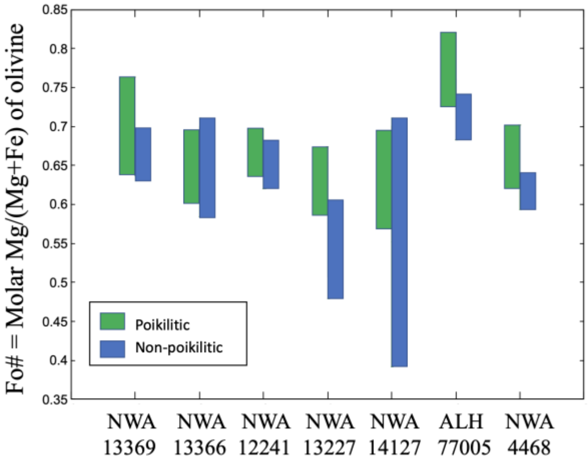

Fig. 2. Fo# of NWA 14127 and six samples of poikilitic shergottites. NWA 14127 has the widest range of Fo# compared with those of other poikilitic shergottites.

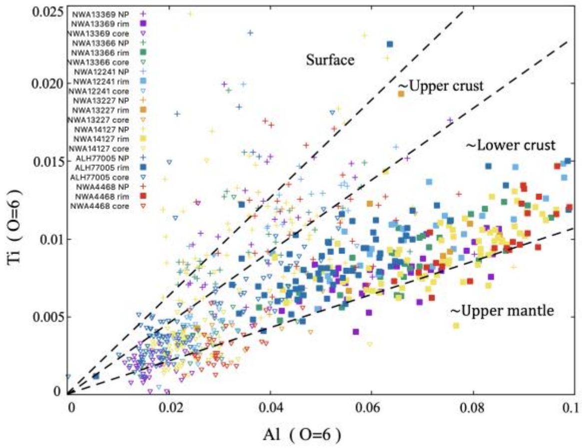

Fig. 3. Al *vs.* Ti of pyroxenes in seven poikilitic shergottites. The Ca-poor core and Ca-rich rim of pyroxene oikocryst represent triangle and square, respectively. Cross symbol represents non-poikilitic (NP) pyroxenes.

Discussion and Conclusion: This study demonstrates a larger textural and mineralogical variation of poikilitic shergottites than previously known. Interestingly, the texture and mineralogy of NWA 14127 are rather similar to those of olivine-phyric shergottites although NWA 14127 contains poikilitic areas. The presence of core-mantle-rim textures of non-poikilitic pyroxenes are unlike other poikilitic shergottites and similar to QUE 94201, EET 79001 and LAR 06319, suggesting crystallization by undercooling of magma [4,6,7]. Such a disequilibrium condition during cooling is consistent with a large variation of olivine composition of NWA 14127 extending to an Fe-enriched composition compared to other samples. The Al-Ti systematics of pyroxene in all samples analyzed plot two distinct regions between poikilitic and non-poikilitic textures (Fig. 3). The Ca-poor core and Ca-rich rim of the oikocrystic pyroxene were presumably formed in the region of the upper mantle to the lower crust while non-poikilitic pyroxenes formed in the region from the upper crust to the surface [8,9]. This is consistent with textural evidence that pyroxene oikocrysts are early formed cumulates and non-poikilitic areas subsequently formed from interstitial melt. Perhaps, the formation history of poikilitic shergottites includes early crystallization at depth forming poikilitic textures followed by near-surface crystallization of non-poikilitic areas, but the degrees of accumulation of early minerals and undercooling of magma differ among samples. In this respect, NWA 14127 would have resided only for a short time at depth after the formation of minor poikilitic texture compared to other samples and the accumulation did not largely take place. The NWA 14127 magma was then immediately relocated to near the surface and rapidly cooled under an undercooling condition. NWA 13227 is most similar to NWA 14127 among the samples studied as it contains abundant non-poikilitic areas and a large compositional range of olivine (Fig. 2). Thus, the degree of accumulation of early minerals and undercooling of magma controlled the mineralogical diversity of poikilitic shergottites. When such an accumulation was not significant, a rock similar to olivine-phyric shergottites would have formed.

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