Chemical characteristics of an olivine-phyric shergottites, Yamato 980459. N. Shirai and M. Ebihara, Department of Chemistry, Tokyo Metropolitan University, Hachioji, Tokyo 192-0397.

Introduction: Among Martian meteorites, shergottites are predominant in number of specimens. Shergottites were further classified into two subgroups, basaltic shergottites and lherzolitic shergottites. Following the recent finding of a lot of meteorites in hot desert, the third class of shergottites, namely olivine-phyric shergottites has been recognized [1]. According to petrographic features, Yamato (Y) 980459 discovered by the 1997-1999 Japanese Antarctic Expedition Team are classified as an olivine-phyric shergottite, to which EETA 79001A, DaG 476, SaU 005, Dho 019, NWA 1068 and NWA 1195 also belong.

Many worker (e.g., [2, 3]) suggest that shergottites enriched in light rare earth elements (LREEs) were derived either from LREEs-enriched mantle sources or by the assimilation of LREEs-enriched components to their parental magmas. If so, LREEs-depleted shergottites were to be derived from LREE-depleted mantle sources and scarcely affected by the assimilation of LREEs-enriched crust components. In this study, we test whether a mixing model is valid in explaining chemical compositions of Y 980459.

Analytical procedures: Lump specimens (Y 980459, 80) weighing 2.585g were carefully ground in a clean agate mortar at the National Institute of Polar Research. An aliquot of the powdered sample weighing 248mg was allocated for this study. Bulk major, minor and trace element composition were measured by using prompt gamma ray analysis (PGA), instrument neutron activation analysis (INAA) and inductively coupled plasma mass spectrometry (ICP-MS). About 100mg and 33mg of the sample were used for PGA and INAA, respectively. REEs, Th and U were determined by ICP-MS.

Results: Major elemental abundances with respect to Mg, Ca, Al and Cr are different among Martian meteorites as shown in Fig.1, where Ca/Si ratios are plotted against Mg/Si ratios. This figure effectively characterizes Martian meteorite into several groups [4]. Shergottites are spread along a line joining a point with high Ca/Si and low Mg/Si ratios and a point with low Ca/Si and high Mg/Si ratios, on which each group of shergottites is localized. Olivine-phyric shergottites are located between basaltic shergottites and lherzolitic shergottites groups. It is apparent that the Mg/Si vs. Ca/Si plot is usable for the subclassification of shergottites. Apparently Y 980459 exists in the olivine-phyric shergottites area.

Y 980459 is compared with other olivine-phyric shergottites in terms of mg# (a molar ratio of Mg relative to (Fe+Mg)). A mg# for Y 980459 (0.66) is close to those for DaG 476 (0.68) and SaU 005 (0.67). These values are closed to but systematically smaller than those for lherzolitic shergottites (0.70-0.72). According to mg#, olivine-phyric shergottites could be divided into two groups; high mg# and low mg# shergottites, which are close to lherzolitic shergottites and basaltic shergottites (mg# =0.2-0.52) respectively. Such differences are obvious when incompatible elements such as REEs are taken into account (Fig. 2). LREEs in Y 980459 are strongly depleted. A REE abundance pattern of Y 980459 is very similar to those for two other olivine-phyric shergottites, DaG 476 and SaU 005, suggesting a close genetic linkage among these three meteorites. Other olivine-phyric shergottites have higher REE abundances, especially for LREEs. It may be noted that REE abundances patterns for Y 980459, DaG 476 and SaU 005 are similar to that for basaltic shergottites QUE 94201. According to its mg# (0.38), QUE 94201 represents a more evolved magma than olivine-phyric shergottites.

Using a mass balance model, Norman [4] estimated the Mars crustal thickness of 20-30 km as an optimum value and determined REE abundances of the crust component in Shergotty by assuming that it represents a mixture of a mantle-derived magma similar in composition to EETA 79001A and a LREE-enriched crust component. As previously pointed out, REE abundances of Y 980459 are similar to those of DaG 476 and SaU 005 and their LREEs are more depleted than those for EETA 79001A. Wadhwa et al. [5] discussed that DaG 476 was generated from a more LREEs-depleted source in the Mars mantle than that of basaltic shergottites or less affected by assimilation of the LREEs-enriched component. Antarctic meteorites are well acknowledged to be better candidates for whole rock geochemical studies than hot desert meteorites [6]. Considering that Y 980459 has the least abundant LREEs among shergottites and is the only olivine-phyric shergottites collected on Antarctica (and, hence, least altered by terrestrial weathering), we adopted Y 980459 as the LREEs-depleted magma. Following to Norman [4], it was assumed that Shergotty represents a mixture of a mantle-derived magma similar in composition to Y 980459 and a LREEs-enriched crust component. REE abundanced of the crust component in Shergotty are determined by subtracting LREEs-depleted parental magma composition similar to Y 980459 from the REE composition of Shergotty [7]. With the Martian crustal thickness of 20-30 km, neodymium concentration in crust is calculated to be 14.3 ppm [4]. If this value is assumed for the Martian crust, fractional ratio of the crust component in Shergotty is calculated to be about 0.25, which can be compared with 0.20 derived by Norman [4]. By using this ratio, we then confirm whether LREEs-enriched shergottites are produced by mixing the magma having REE abundances similar to those for Y 980459 and the Mars crust calculated from Shergotty and Y 980459. Our calculated results are shown in Fig.3. In this figure, LREEs-enriched shergottites (mostly basaltic shergottites) are located in high (La/Sm)n and high (La/Lu)n area. In contrast, LREEs-depleted shergottites (Y 980459, DaG 476, SaU 005 and QUE 94201) are located in low (La/Sm)n and low (La/Lu)n area. Thus, mixing model is successful in producing LREE-enriched shergottites. Some basaltic shergottites (Los Angeles and NWA 480) and an olivine-phyric shergottite (NWA 1068) are apparently located off the line, suggesting that these shergottites experienced different genetic processes from other shergottites on the mixing line.

References: [1] C. A. Goodrich. (2002) MAPS 37, B31. [2] J. H. Jones. (1989) Proc. 19th LPSC 465. [3] M. Wadhwa et al. (1994) GCA, 58, 4213. [4] Y. Oura et al. (2003) AMR 16, 80. [4] M. D. Norman. (1999) MAPS 34, 439. [5] M. Wadhwa et al. (2001) MAPS 36, 195. [6] G. Crozaz and M. Wadhwa. (2001) GCA 65, 971. [7] J. C. Laul et al. (1986) GCA 50, 909.

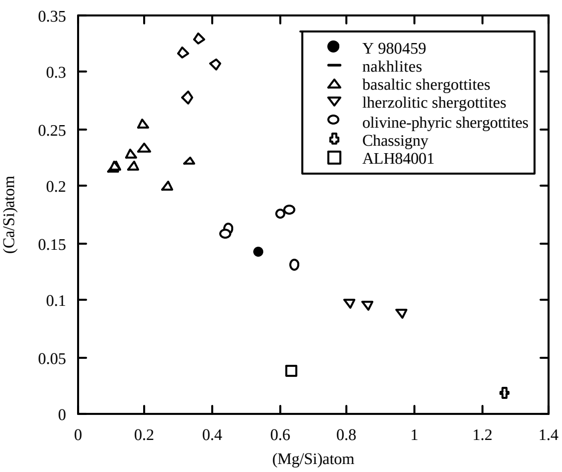

Fig. 1. Mg/Si versus Ca/Si ratios for Martian meteorites.

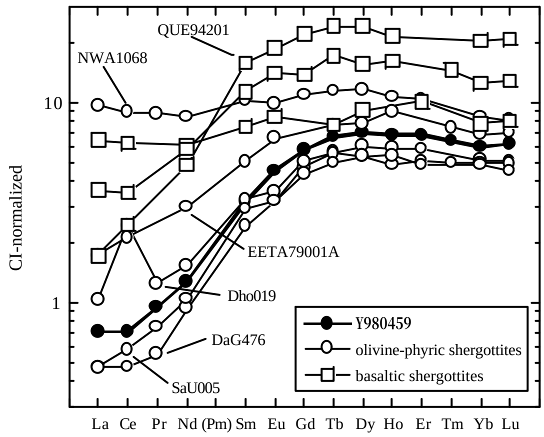

Fig. 2. CI chondrite-normalized REE abundance patterns for Martian meteorites.

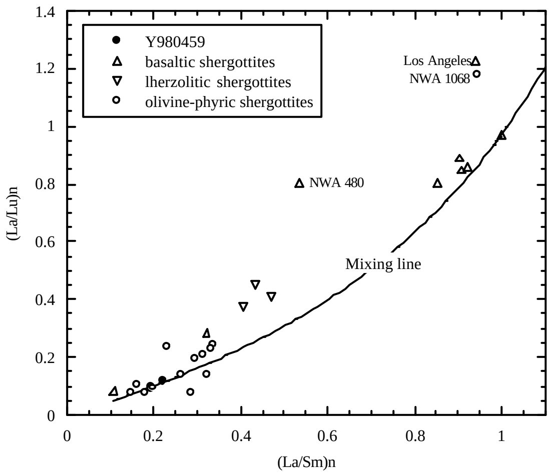

Fig. 3. (La/Sm)n vs. (La/Lu)n diagram for shergottites. The line is designated for mixing the parent magma similar to Y980459 in composition which is not affected by assimilation of Mars crust and the Mars crust component calculated.