OLIVINE CHEMICAL FEATURES AND O-Cr-Ti ISOTOPIC COMPOSITIONS OF NORTHWEST AFRICA 7312 UNIQUE DIFFERENTIATED METEORITE: COMPARING TO OTHER METEORITE GROUPS.

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Introduction: Differentiated meteorites enable us to better understand the early evolution of molten asteroids. NWA 7312 is an ultramafic differentiated meteorite consisting of Mg-rich silicates (olivine: Fo_{96}, ~40 vol%; orthopyroxene: En_{95}, ~60 vol%), with a well-developed petrofabric that implies ductile solid-state deformation in the parent body [1]. While the petrological features of NWA 7312 resemble lodranites, its O-isotopic composition is outside the range of the acapulcoite-lodranite clan, but within the range of CR chondrites. These results raise the possibility that NWA 7312 is derived from an unknown body. The minor element composition of olivine also provides a good indicator of formation history and relationship to other meteorite groups. O-Cr-Ti isotope systematics should help to demonstrate whether NWA 7312 is a carbonaceous or non-carbonaceous chondrite-related meteorite. We have investigated these features of NWA 7312 and compare the results with known meteorite groups.

Sample and Methods: We prepared three polished thin/thick sections for mineralogical study. The mineral chemical composition was obtained using an EPMA at NIPR. Cr isotope analyses were performed using a TIMS at the National Museum of Nature and Science, Japan. Ti isotope analyses were carried out using an MC-ICP-MS at the University of Tokyo. The Cr-Ti isotope analyses were performed following the procedures of [2, 3]. Oxygen isotope analysis of NWA 7312 was carried out by laser fluorination at the Open University following the procedures of [4].

Results and Discussion: The Fe/Mg-Fe/Mn systematics of olivine can be used to reveal formation processes and redox conditions [5]. Fe/Mg-Fe/Mn values for NWA 7312 fall within the subchondritic range (Fig. 1) and differ from chondrites and primitive achondrites that are within the chondritic range. These values also differ from all other known achondrites. We interpret NWA 7312 as a residual lithology that underwent more extensive melting than other primitive achondrites under reducing condition. This suggestion is consistent with the petrologic features of NWA 7312, which is a coarse-grained ultramafic rock. Alternatively, it could be a result of a metasomatic process that does not cause simple Fe loss/addition, although this process is poorly understood.

The CaO and Cr_2O_3 contents of olivine are distinguishable from those of ureilites, brachinites, and other achondrites, including lodranites. The olivine in NWA 7312 contains minor CaO (0.12-0.15 wt%) and Cr_2O_3 (0.18-0.29 wt%). The CaO and Cr_2O_3 contents of olivine in NWA 7312 are intermediate between ureilites and most other achondrites. These minor element contents are outside the range of any known meteorite group.

Ti and Cr isotopic compositions are shown in Fig. 2. NWA 7312 plots in the non-carbonaceous group. The composition of NWA 7312 resembles that of the ureilites and differs from the CR chondrites. NWA 7312 and the ureilites have distinct O-isotope compositions (Fig. 2).

Based on the mineralogical and isotopic evidence, we conclude that NWA 7312 is derived from an unknown differentiated asteroid that experienced extensive melting and later ductile solid-state deformation.

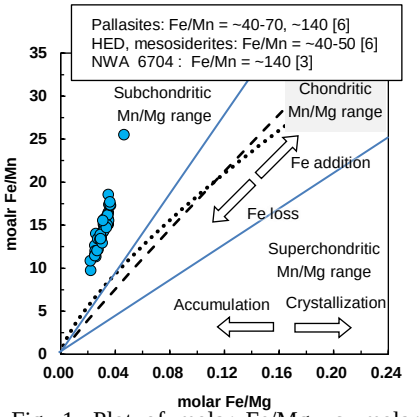

Fig. 1. Plot of molar Fe/Mg vs. molar Fe/Mn in olivine comparing NWA 7312 with regression curves for ureilites (broken curve) and lodranites (dotted curve) by [6].

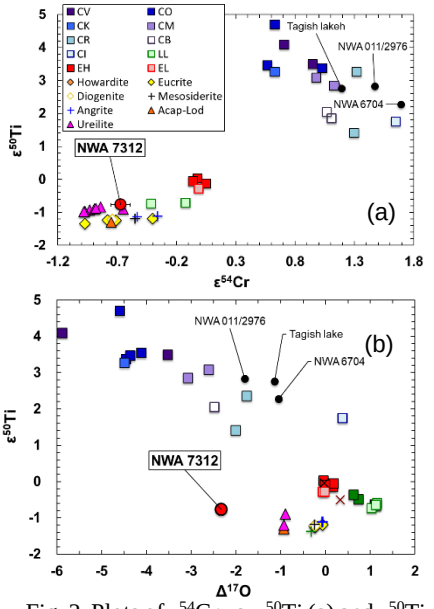

Fig. 2. Plots of $\varepsilon^{54}Cr$ vs. $\varepsilon^{50}Ti$ (a) and $\varepsilon^{50}Ti$ vs. $\Delta^{17}O$ (b) of NWA 7312. The data for other meteorite groups and some ungrouped meteorite are shown for comparison. The reference data of NWA 6704 is from [3] and other references therein. The errors of $\varepsilon^{50}Ti$ and $\Delta^{17}O$ are within the symbol.

References: [1] Yasutake M. et al. (2019) *50th LPSC*, Abstract #1796. [2] Hibiya Y. et al. (2019) *Geostandards and Geoanalytical Research*, 43:133-145 [3] Hibiya Y. et al. (2019) *Geochimica et Cosmochimica Acta* 245:597-627. [4] Greenwood R. C. et al. (2017) *Chemie der Erde*, 77:1-43. [5] Goodrich C. A. and Delaney. et al. (2000) *Geochimica et Cosmochimica Acta*, 64:149-160. [6] Goodrich C. A. and Righter K. (2000) *Meteoritics & Planetary Science*, 35:521-535.