UNIQUE DIFFERENTIATED METEORITE NORTHWEST AFRICA 7312. M. Yasutake[1], A. Yamaguchi[2], R. C. Greenwood[3], Y. Hibiya[4], T. Iizuka[4], I. Franchi[3], [1]Div. Earth and Planetary Science, Kyoto University (yasutake.masahiro.4n@kyoto-u.ac.jp), [2] National Institute of Polar Research, Japan, [3]Planetary and Space Sciences, The Open University, UK; [4] Dept. Earth and Planetary Sci., The University of Tokyo

Introduction: Differentiated meteorites provide critical evidence concerning the earliest stages of planetary evolution. While differentiated meteorites have been extensively studied from the perspective of early Solar System igneous activity, deformation processes, especially ductile solid-state deformation, remain poorly understood. Recent studies propose that mantle convection could have occurred in a meteorite parent body and result in ductile deformation [1,2]. It is well known that ductile solid-state deformation can lead to the development of a fabric [3]. Petrofabric analysis using SEM-EBSD is an important technique in understanding the conditions of deformation. As a consequence, we have investigated the petrology, mineralogy, petrofabric, and isotopic composition of a unique differentiated meteorite, Northwest Africa (NWA) 7312.

Methods: Three sections of NWA 7312 (#1, #2, #2-1) were studied under an optical microscope and an FE-SEM at NIPR, Japan. The modal abundances of sections were estimated from X-ray mapping images obtained by using a SEM-EDS. Mineral chemical compositions were obtained using an EPMA at NIPR. Petrofabric of the section was investigated by using a SEM-EBSD system at NIPR.

Another slab (#3) was used for isotopic investigations. Oxygen isotope analysis was carried out by infrared laser-assisted fluorination at the Open University following the procedure by [4]. Titanium-Chromium isotope analysis will be performed using a MC-ICP-MS at the University of Tokyo following the procedure by [5].

Results and Discussion: NWA 7312 has a coarse-grained texture (up to ~1.8 mm, ~300 µm in average) with abundant 120° triple junctions. It consists predominantly of Mg-rich olivine (Fo97, ~35-40 vol%) and orthopyroxene (Opx: Wo1.8En95, ~55-60 vol%) (Fig. 1). Plagioclase and augite were absent in the sections studied. Minor oxidized iron that may be a weathering product of kamacite occurs as small grains and veins along silicate grain boundaries. The abundance this Fe-rich phase is <10 vol%. Silicate grains include tiny metal and sulfide blebs (<50 µm) along grain boundaries and cracks.

These petrological and mineralogical features are similar to those of Mg-rich lodranites, such as Gibson (Fo96) and Willcox Playa 010 (Fo97) [6]. The Mg-rich composition of silicates and the presence of metal blebs indicate that NWA 7312 formed under reducing condition, that was probably similar to the acapulcoite-

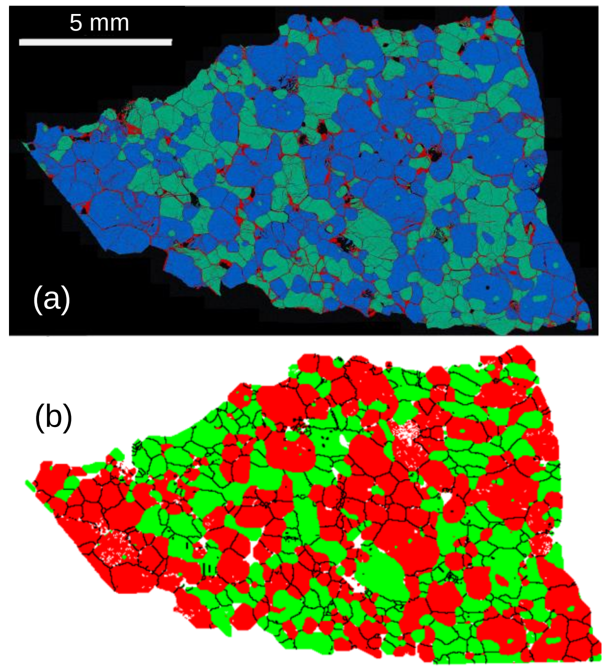

Fig. 1. (a) Elemental mapping of section #2-1. Red = Fe-rich phase, green = olivine, blue = Opx. (b) EBSD-phase map of #2-1. Olivine crystals weakly align to the upper-left to lower right. Green = olivine, red = Opx. Black lines show grain boundaries.

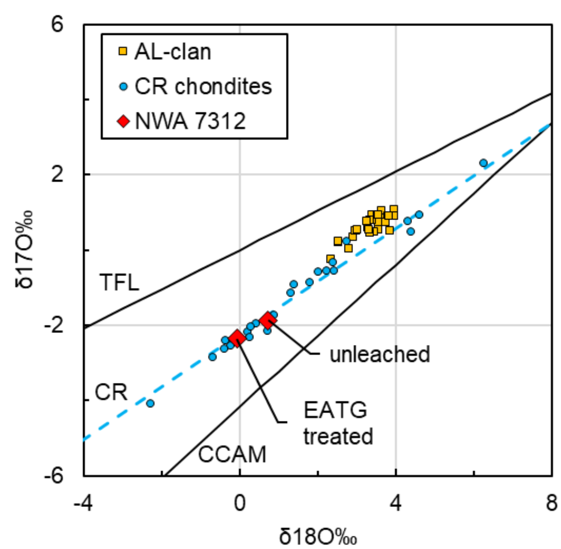

Fig. 2. Oxygen isotope composition of NWA 7312 with those of AL-clan and CR chondrites. TFL: terrestrial fractionation line, CR: CR chondrite mixing line, CCAM: carbonaceous chondrite anhydrous mineral line.

lodranite clan (AL-clan) and winonaites (ΔFMQ = –6) [7]. The lack of plagioclase and augite implies that NWA 7312 suffered heating, at least, above the silicate solidus of chondritic rocks ~1050 °C and experienced partial melting and loss of a plagioclase and augite-rich melt, in a similar manner to the lodranites [6].

On the other hand, the oxygen isotope composition shows that NWA 7312 has a unique origin. The composition of untreated and EATG-leached NWA 7312 are shown in Fig. 2 relative to the AL-clan and CR chondrites [4, 8, 9, 10]. The oxygen isotope composition is outside the known range of the AL-clan and any known differentiated meteorite. The composition of NWA 7312 is within the range of CR chondrite. This fact raises the possibility that NWA 7312 is a rare, differentiated meteorite related to the CR chondrites.

A petrofabric is well developed in all the sections of NWA 7312. The patterns of the observed fabric are nearly the same in all the sections studied. Olivine grain shape preferred orientations (SPO) were weakly developed in sections #1 and #2-1 (Fig. 1). Olivine lattice preferred orientations (LPO) were very clear and characterized concentration of [100] and [010] and a girdle of [010] on the plane normal to [100] point maxima (Fig. 3).

The observed olivine LPO pattern is similar to A-/D-type fabric found in terrestrial deformed harzburgite [11]. This type of fabric is formed by dislocation creep with {0*kl*}[100] and (010)[100] slip system [3]. These slip systems are activated at high temperature and medium to high stress (strain rate). Therefore, these facts indicate that the NWA 7312 parent body certainly suffered ductile solid-state deformation at temperatures in excess of 1000 °C.

Opx does not show clear SPO in all the sections. On the other hand, Opx LPO is well developed in all the sections. The LPO patterns are characterized by

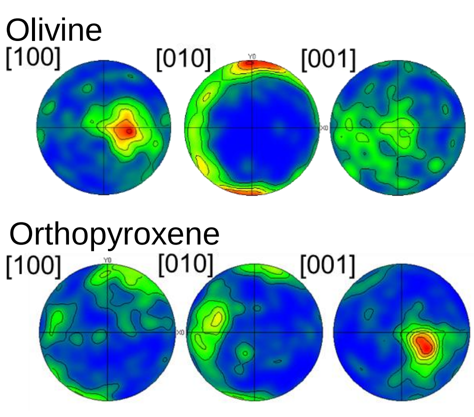

Fig. 3. LPO for olivine and Opx of #2-1. Lower hemisphere, equal area projection, contours at intervals of 1.0 multiples of a uniform distribution.

point maxima of [001] with a very strong concentration and distribution of other axes on the plane normal to [001] point maxima (Fig. 3). It is consistent with the pattern formed by deformation with {*hk*0}[001] slip system [3].

A big question is what event caused the deformation. There are two main possibilities. The first is mantle convection. Mantle convection is a common event that causes ductile solid-state deformation on the Earth, and possibly also on small bodies [1, 2]. Modeling studies showed that mantle convection starts when a body suffered heating over a critical temperature ~1350 °C [1, 12]. Therefore, mantle convection is a plausible scenario for NWA 7312.

Alternatively, a planetary-scale collision could cause solid-state deformation. Collisional events are likely to have been common during planetary evolution. However, this scenario is less likely for the development of a fabric. At first, if we consider a supersonic collision, the strain rate is supposed to be too fast ($>10^{-2}$) [13]. The deformation at such a high strain rate causes brittle failure [13]. Secondly, activated slip system of olivine is supposed to be {110}[001] at high strain rate [3]. This is not consistent with the fabric observed in NWA 7312. On the other hand, a gentle and low-speed collision might cause adequate stress deep inside a body, although it is not certain that it develops the petrofabric.

Conclusion: We propose that NWA 7312 is a unique differentiated meteorite that is possibly related to CR chondrites. Its parent body experienced differentiation above the silicate solidus and ductile solid-state deformation. Mantle convection is the most likely process to have caused the observed deformation. Alternatively, a collision scenario is not ruled out. Further studies are needed to resolve this matter.

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