IRON VALENCE STATES OF PLAGIOCLASE IN SOME LUNAR METEORITES. N. Yokoi, A. Takenouchi and T. Mikouchi, Dept. of Earth and Planet. Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan (E-mail: nina@eps.s.u-tokyo.ac.jp).

Introduction: Since the Apollo and Luna lunar missions in the 1960s and 1970s, various studies to reveal the water contents in lunar samples have been conducted, but it has been thought that most of the water and volatile components inside the moon have already been lost. However, in the 2000s, water contents in lunar samples have attracted attention again as traces of the presence of water were found in the lunar volcanic glass [e.g., 1]. The origins of lunar interior water are not clear yet and include various opinions such as solar wind origin and cometary origins [e.g., 2]. The water abundance is different among different lunar rock types and it is known that mare basalts contain less water compared to highland rocks [e.g., 3]. There is a possibility that the water content in the lunar samples is related to the redox states, but few studies have focused on such points so far. In previous studies, we clarified thz $Fe^{3+}/\Sigma Fe$ ratio in plagioclase well reflects the redox state when the rock was formed [4]. Therefore, in this study, by measuring the Fe valence states of plagioclase contained in lunar meteorites of different rock types, we tried to investigate the redox state at the timing of crystallization of the minerals and clarify the relationship with water contents.

Samples: The analyzed samples are plagioclase grains in three lunar meteorites: Dhofar 307, LAP 02205 and NWA 2727. Dhofar 307 is a breccia paired with Dhofar 489 that is mainly from highlands and includes several anorthosite and troctlite rock fragments [5]. LAP 02205 is a crystalline (non-brecciated) mare basalt consisting of olivine, pyroxene and plagioclase [6]. Almost all plagioclase grains are converted to maskelynite by impact. We analyzed relatively coarse grains among them. NWA 2727 is a breccia paired with NWA 773 [7]. Most of its components are the fragments of mare basalt and we analyzed plagioclase in such fragments.

Analytical Methods: We first observed polished thin sections with polarization optical microscope. Then, we analyzed mineral compositions by electron microprobe (JEOL JXA 8530F at Univ. of Tokyo). The Fe valence states of plagioclase were estimated using synchrotron radiation Fe-XANES (BL-4A, PF, KEK in Tsukuba, Japan). The beam size of synchrotron X-ray was about 5 μm. The analytical conditions and calculation procedures to estimate $Fe^{3+}/\Sigma Fe$ from XANES data were mainly based on [8].

Result: Table 1 summarizes the types of rocks including plagioclase analyzed in each sample and their chemical compositions. We analyzed several plagioclase grains in both anorthosite and troctolite lithologies of Dhofar 307 (Fig.1). The size of anorthosite fragment is 1.6 x 1.3 mm and plagioclase is 0.3 mm. The troctolite fragment (1.4 x 0.7 mm) mainly consists of plagioclase (~0.3 mm) and olivine (~0.1 mm). In LAP 02205, three points of maskelynite were analyzed (Fig. 2). The size of maskelynite was about 0.7 mm. In NWA 2727 we analyzed plagioclase grains contained in rock fragments of several different mare basalts (Fig. 3). The plagioclase size varies from 0.3 mm to 1.6 mm. The result of Fe-XANES measurement is summarized in Fig. 4. The horizontal axis is the positions of the centroid peak (Fe K absorption pre-edge) and the vertical axis shows estimated $Fe^{3+}/\Sigma Fe$ ratios. The proportion of Fe^{3+} tends to decrease in the order of anorthosite, troctolite, LAP 02205 and NWA 2727

Discussion and Conclusion: From the above results, it can be seen that the lunar mare basalt was formed under more reducing environment than highland rocks. This is consistent with the expectation that mare basalt with a relatively low water content is more reducing than the anorthosite [3]. When mare basalts are compared with each other, anorthosite converted into a maskelynite by impact metamorphism has a higher proportion of Fe^{3+} compared to crystalline plagioclase. However, it is known that the formation of maskelynite does not affect the valence of Fe [4].

Both of mare basalt in LAP 02205 and NWA 2727 belong to very low titanium (VLT) group and have very young crystallizations ages (NWA 2727: 2.99 ± 0.03 Ga [9] and LAP 02205: 2.95 ± 0.02 Ga [6]). It is considered that later mare volcanism contained less water in magma, which resulted in more reducing crystallization conditions. If this is the case, lower Fe^{3+} ratio of plagioclase in LAP 02205 and NWA 2727 compared to earlier formed highland rocks can be readily explained.

In order to further clarify the relationship between water contents and redox states, it is necessary to analyze more samples. Also, estimating redox states using a different approach (e.g., oxybarometers using compositions of Fe-Ti oxides and olivine-pyroxene-spinel) is also required.

References: [1] Saal A. E. et al. (2008) *Nature, 454,* 192-195. [2] Greenwood J. P. et al. (2011) *Nature Geosci., 4,* 79-82. [3] Anand M. et al. (2014) *Phil. Trans. R.Soc. A372*:20130254 [4] Satake W. et al. (2014) *Geochem. Jour., 48,* 85-98. [5] Takeda H. et al. (2006)

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Table1. Summary of analyzed plagioclase.

Sample	Analyzed point		An %	FeO(wt%)
Dhofar307	001,004,005	Anorthosie	95.0	0.16
	002,003	Troctolite	96.7	0.19
LAP02205	001~003	Mare basalt	90.4	0.71
NWA2727	001~006	Mare basalt	91.0	0.67

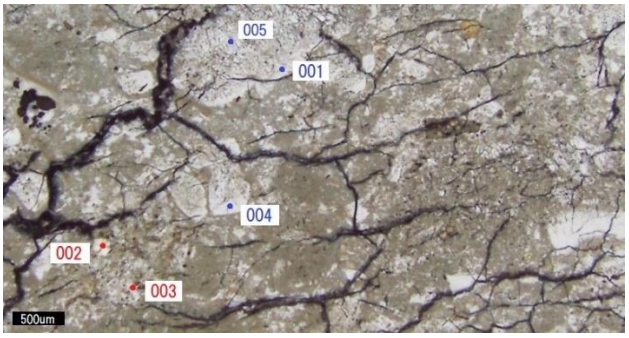

Fig. 1. Optical photomicrograph of Dhofar 307 (open nicol). The analyzed points are indicated (001~005). 001, 004 and 005 are plagioclase grains in anorthosites fragments. is 6.1 mm.

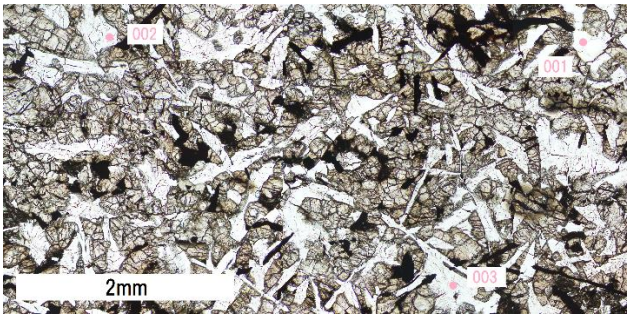

Fig. 2. Optical photomicrograph of LAP 02205 (open nicol). The analyzed points are indicated (001~003). The width of the image is 5.7 mm.

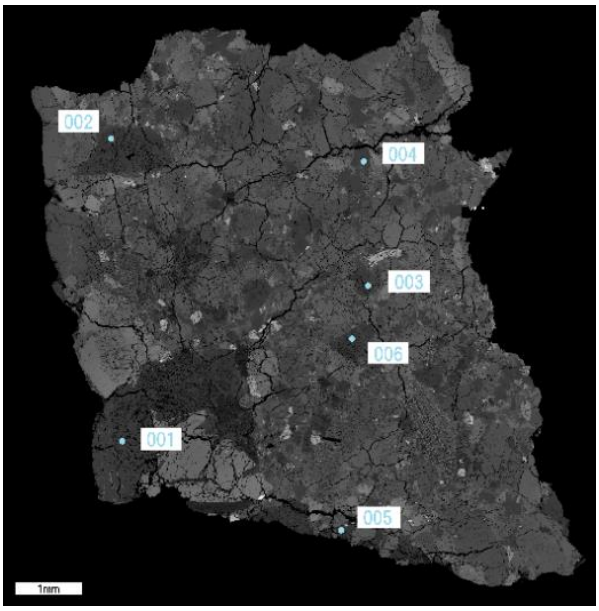

Fig. 3. Back-scattered electron (BSE) image of NWA 2727. The analyzed points are indicated (001~006).

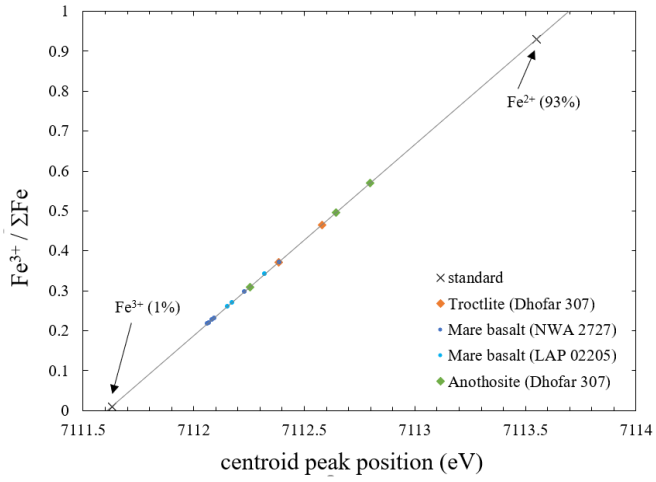

Fig. 4. Relationship between centroid peak positions of pre-edge peaks of Fe K edge of plagioclase and estimated $Fe^{3+}/\Sigma Fe$ ratios.