Redox states of lunar mare basalts as inferred from micro Fe-XANES analysis of plagioclase/maskelynite

T. MIKOUCHI[1]*, N.YOKOI[1] AND T. ARAI[2]

[1]University Museum, University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan, mikouchi@um.u-tokyo.ac.jp
[2]Planetary Exploration Research Center, Chiba Inst. of Technology, Tsudanuma, Chiba 275-0016, Japan

Introduction: Fe-XANES analysis of plagioclase in extraterrestrial samples provides a promising indicator of oxygen fugacity (fO_2) during their magmatic formation [e.g., 1]. We applied this method to plagioclase/maskelynite in lunar mare basalts to see the relationship between the obtained redox states and reported water contents [e.g., 2].

Samples and Methods: We newly analyzed 3 Antarctic unbrecciated lunar meteorites (LAP 02205, Y-793169 and Asuka-881757) and compared results with our earlier studies on 5 returned mare basalts (Apollo: 10019 (HT), 12010 (LT), 14321 (LT), 15459 (LT), and Luna: 24088 (VLT)) [3]. The Fe-XANES analysis was performed at BL-4A, Photon Factory, KEK, Japan [e.g., 1] and Fe valence states ($Fe^{3+}/\Sigma Fe$) were estimated using a procedure in [3].

Results and Discussions: The analyzed lunar meteorites are LT/VLT [e.g., 4] and the obtained $Fe^{3+}/\Sigma Fe$ of plagioclase/maskelynite are 3-4% for LAP 02205, 2% for Y-793169 and 2% for Asuka-881757. Y-793169/Asuka-881757 show slightly lower $Fe^{3+}/\Sigma Fe$ indicative of lower fO_2 and may be consistent with primitive nature with only little KREEP components [4]. However, all of these ratios are similarly low and close to those of Apollo/Luna HT (2-3%), LT (2-5%) and VLT (3-4%) basalts [3], suggesting formation under reducing conditions (perhaps $\log fO_2$~IW-1) consistent with earlier works [e.g., 5]. It should be noted that micro XANES analysis is more relevant to the early magmatic fO_2 because plagioclase is one of early crystallizing phases from basaltic magma and can avoid the influence by Fe-rich inclusions due to ~5 μm beam size. The reported water contents of apatite are higher in the order of VLT, LT and HT [e.g., 2], but the $Fe^{3+}/\Sigma Fe$ ratios of plagioclase/maskelynite are not related. This is probably because some other factors (e.g., degree of degassing) were involved and the relationship between redox states and water abundance is not straightforward.

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