Viscosity measurements of FeO-rich silicate melts and its implication for the lunar crust formation

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The anorthite crust of the Moon has been thought to be the product of large-scale differentiation in the cooling lunar magma ocean, and the bulk composition of the Moon has been estimated to be richer in FeO than the bulk silicate Earth (e.g. [1]). The FeO content is a critical parameter for density and viscosity of silicate melt, and precise determination of those parameters is important for quantitative evaluation of the lunar curst. Contrary to the density, viscosity of silicate melts show complicated dependence on pressure and composition. Hence, experimental determination of viscosity of FeO-rich silicate melts is important. We have carried out viscosity measurements with the falling sphere method for silicate melts suitable for the lunar magma ocean.

The starting materials are glasses with three different compositions, which are fractionated in terms of mantle minerals to the first appearance of anorthite from the bulk silicate Earth with FeO-enrichment with various degrees.

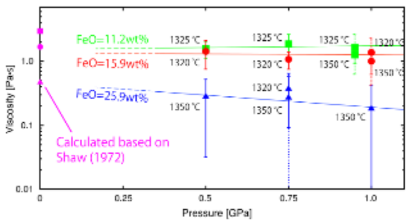

Figure 1: Viscosity of silicate melts responsible for differentiation of the Moon.

The results are shown in Figure 1, which shows weak (or slightly negative) dependence of viscosity on pressure and clear negative dependence on the FeO contents.

Figure 1 suggests little pressure dependence of viscosity for the lunar magma ocean melt at least to P>1GPa (~ 100km). The little or weak negative pressure dependence of the melt of the magma ocean in addition to high density due to high FeO contents result in effective flotation of anorthite, that is, effective formation of the anorthite crust. Our quantitative model predicts that the initial FeO content of the Moon that finally generated the anorthosite crust with the thickness of 45km was 10 - 13 wt%, which is more than the bulk silicate Earth.

[1] Khan *et al*. (2006) *Jour. Geophys. Res.* **111**, E05005, doi: 10.1029/2005/JE002608. [2] Sakai *et al*. (2011) *Lunar Planet. Sci*. **XXXXII**, abstract #1636.

Behavior of biological and terrigenous elements during the late Cenozoic in the Bering Sea: Paleoceanographic constraints of the IODP Exp. 323 sediments by high resolution non-destructive TATSCAN scanning

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Continuous marine sediment cores during 5 myrs in the Bowers Ridge (Sites U1340 and U1341) and continental slope of the Aleutian Basin (Sites U1341, U1343, and U1344) of the Bering sea obtained by the IODP expedition 323 in 2009. Age models of the drilled cores are constructed using oxygen isotope stratigraphy, bio- and magneto-stratigraphy with astronomical calibration of non-destructive XRF core measurements (TATSCAN-F2). Estimated sedimentation rates during interglacials are two to three times higher than that of glacials.

Marine primary productivity, Si/Al ratio measured using TATSCAN-F2 representing biogenic silica content, exhibits large glacial-interglacial cycles during the Plio-Pleistocene. and. The productivity is relatively high, similar to that of today's 'green-belt', during the interglacial periods with increasing glacial-interglacial variability after NHG, and even larger amplitude variations during last 500 kyrs. Changes of biological productivily were closely related to terrigenosu inputs representing by K/Al and Fe/Al ratio that those elements derived from the Alaskan large rivers during the past 5 myrs.