A ~4.3 Ga U-Pb age from lunar meteorite SaU169 and the chondritic Sm/Nd of the Moon

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A remarkably consistent set of $^{142}Nd/^{144}Nd$ and $^{143}Nd/^{144}Nd$ data of lunar rocks reported by Rankenburg *et al*. (2006) provides evidence for a chondritic Sm/Nd ratio of the Moon. An apparent minor inconsistency is present for the most fractionated lunar rock in their data set, the Imbrian high-KREEP lunar meteorite SaU169, which yielded a subchondritic initial ε_{142Nd} value if this parameter was calculated for its reported SIMS zircon date of 3909 ± 13 Ma (Gnos *et al*., 2004). The zircons dated were skeletal grains that crystallized from the impact melt.

We have carried out a leaching experiment on a 2 mg heavy mineral concentrate from the same impact melt, containing zircon and some merrilite, as follows. Step 1: 4N HNO_3, 25°c, 15 min. Step 2: 4N HNO_3, 100°C, 8 hrs. Step 3: Inverse aqua regia, 100°C, 16 hrs. Step 4: HF + 4N HNO_3, 150°C, 3 days. Isotope ratios of the ^{235}U + ^{202}Pb spiked leaches were measured on a Nu Instruments® MC-ICP-MS.

The final HF+HNO_3 step has $^{208}Pb/^{206}Pb$ = 0.37 and $^{206}Pb/^{204}Pb$ = 440 and dominantly reflects zircon. It yields a near-concordant U-Pb date of 4290 ± 30 Ma. This is robust, but significantly older than the SIMS dates of 3909 ± 13 Ma reported by Gnos *et al*. (2004), which give the age of the Imbrium impact melt. We suggest that our older age reflects a mixture of zircons crystallized from the impact melt, such as dated by Gnos *et al*. (2004), and much smaller, but collectively dominant crystals that might have survived impact melting and had a lunar crustal or KREEP source origin, with ages of 4300 Ma or older (Papike *et al*., 1998).

If the $^{142}Nd/^{144}Nd$ ratio of Rankenburg *et al.* (2006) for SaU169 is extrapolated back to the age of 4.3 Ga suggested by our result, the initial ε_{142Nd} value plots precisely on the chondritic evolution curve, consistent with their models. This further strengthens the case for a chondritic Sm/Nd ratio of the Moon and therefore, terrestrial fractionation after the Giant Impact.

References

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Sr-isotopes and trace elements in feldspar and clinopyroxene: Tracer of magma mixing in gabbros from Uralian-Alaskan-type complexes in the Ural Mountains, Russia

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We applied LA-ICPMS techniques to determine Sr isotopes and trace element concentrations of rock forming minerals in gabbroic rocks from zoned mafic-ultramafic complexes (Nizhnii Tagil and Kytlym) in the Ural Mountains in Russia.

These gabbros have porphyric textures with clinopyroxene phenocrysts in a matrix of olivine, clinopyroxene and spinel ± phlogopite. Based on the composition of additional matrix minerals two types of gabbro can be distinguished. One is silica saturated, contains plagioclase (An56-97) and in places orthopyroxene as matrix phases (bytownite gabbro). The second gabbro type is silica undersaturated and contains in the matrix plagioclase (An26-41) and pseudoleucite, a intergrowth of nepheline and K-feldspar (Or53-93).

Clinopyroxene of gabbros from Nizhnii Tagil and the western part of the Kytlym Complex is enriched in $LREE_N$ (4.4-33.6) relative to $HREE_N$ (1.4-8.4) and has high Sr concentrations (130-470 ppm). Phenocryst cores from silica undersaturated gabbros tend to have higher La/Lu (30-35) than those of silicate-saturated gabbros (La/Lu: 17-30). Towards the phenocryst rims the La/Lu increases up to 55 in the silica undersaturated gabbros monitoring the trend of a RFC magma chamber process. However, the large and continuous increase of La/Lu from silica-saturated to silica-undersaturated gabbro cannot be explained by this process.

The Sr isotopic composition of plagiclase in the silica undersaturated gabbros from Kytlym and Nizhnii Tagil ($^{87}Sr/^{86}Sr$ 0.70407-0.70454 ±0.00004) is similar. Thus despite their spatial separation and very different magmatic lineage the parental magmas of the silica undersaturated gabbros appear to sample a homogenous mantle source.

In the silica undersaturated gabbro from the Kytlym Complex plagioclase has generally higher Sr concentrations (>2000 ppm) and $^{87}Sr/^{86}Sr$ (0.70410-0.70434 ±0.00002) than in that in silica undersaturated gabbros (Sr 700-1200 ppm; $^{87}Sr/^{86}Sr$ 0.70384-0.70405 ±0.00004). These features imply that silica saturated and undersaturated gabbros are derived from distinct parental magmas. The continuous increase of La/Lu and $^{87}Sr/^{86}Sr$ from silica-saturated to silica-undersaturated gabbro monitors the mixing of these two different parental magmas, even on thin section scale.