Effect of impact-related processes on anorthosites: a lunar analog study at Mistastin Lake Crater, Labrador

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The origin of the Moon is a fundamental question in planetary science. It is generally thought that the Moon was derived when a giant Mars-sized object struck the Earth. Geochemical evidence, such as indistinguishable $\Delta^{17}O$, $\delta^{30}Si$ and $^{182}W/^{184}W$ signatures between the silicate Earth and Moon, provide evidence in support of the giant impact theory. It is generally assumed the Earth and Moon also share initial Pb isotopic compositions, yet the radiogenic nature of primary Pb in lunar rocks ($\mu > 35$) is in sharp contrast to Pb in the terrestrial mantle (μ ~8 to 10). An excess of unsupported radiogenic Pb is common in most lunar samples, including some of the oldest Ferroan Anorhosites (FAN; > 4.36 Ga). Attempts to explain the excess radiogenic Pb in FAN have included early (> 4.36 Ga) development of a high-μ, KREEP-like reservoir within the lunar upper mantle/lower crust and volatile mobilization of radiogenic Pb from KREEP-rich reservoirs during 3.9 Ga basin-forming impacts.

The Mistastin Lake impact structure, Labrador, Canada is an unique lunar analogue site, being the only known terrestrial crater to produce impact melt largely from an anorthositic source. In addition to anorthosite, the crystalline target rocks at Mistastin consist of mangerite and granodiorite, which can be used as proxies for the more radiogenic KREEP-like compositions identified in lunar rocks. In order to assess the effect of impact processes on the Pb isotope systematics of lunar rocks, we have investigated the elemental and Pb isotope ratios of well-preserved plagioclase, shocked plagioclase and maskelynite fom anorthosites, and well-preserved plagioclase from the mangerite at Mistastin using LA-ICPMS/LA-MC-ICPMS. Results show similar elemental and Pb isotope compositions for all plagioclase and maskelynite analyzed, suggesting the impact at Mistastin did not result in the modification of the Pb isotope systematics of these components. If the unsupported radiogenic Pb found in ancient lunar samples is the result of volatilization and mobilization of Pb due to impact, this may reflect the more intense impacting of the lunar crust and/or a more intimate relationship between the ancient lunar crust and a radiogenic source.