Crystal chemical effects on $\Delta'^{17}O$ of silicate minerals: Examples from lunar and terrestrial anorthosites

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Recently-published triple-oxygen isotope data from lunar basalts have improved constraints on plausible scenarios for the Moon forming event [1,2]. Lunar anorthosites have $\delta^{18}O$ values not far removed from those of their basaltic counterparts but more negative $\Delta'^{17}O$ values. These $\Delta'^{17}O$ depletions in anorthosites require fractionation exponents (three-isotope "slopes") far lower than one would expect for igneous processes.

Here we present new data from a larger suite of lunar anorthosites (and anorthositic-troctolites), terrestrial anorthosites, and terrestrial plagioclase separates. These data suggest that rocks dominated by plagioclase, on average, are measurably lower in $\Delta'^{17}O$ than genetically related mafic rocks and minerals. The new measurements of lunar anorthosites reported here have an average $\Delta'^{17}O$ of -0.0097‰ +/- 0.002 (1S.E.), or −10 +/− 2 ppm. Plagioclase separates from the Bushveld igneous complex with $\delta'^{18}O$ values of 6.7 and 7.3‰ have $\Delta'^{17}O$ values of −12 and −17 +/- 3 ppm, respectively. Lake County plagioclase has a $\delta'^{18}O$ of 5.6‰ and a $\Delta'^{17}O$ of −11 +/− 3 ppm. A sample of quartz from our laboratory with a $\delta'^{18}O$ of 10.2‰ has a similarly low $\Delta'^{17}O$ of −21 +/− 4 ppm.

We propose that tectosilicates exhibit systematically low $\Delta'^{17}O$ values relative to mafic silicates (e.g., olivine) as a result of a purely crystal chemical effect independent of temperature. We investigated the likelihood that our measured differences derive solely from a mass fractionation "slope" effect using *ab-initio* models for fractionation exponents. These calculations are unable to reproduce the negative $\Delta'^{17}O$ values measured in our felsic minerals. However, we find a good correlation between $\Delta'^{17}O$ values and crystal chemical parameters, including bulk moduli and Grüneisen parameters.

References: [1] E. D. Young, I. E. Kohl, P. H. Warren, D. C. Rubie, S A. Jacobson, and A. Morbidelli. (2015) *Science,* 351, p. 493 [2] D. Herwartz, A. Pack, B. Friedrichs, A. Bischoff (2014) *Science,* 344, p.1146.