

On lithium isotope systematics and abundances in lunar mare basalts

T. MAGNA^{1*}, C.R. NEAL², P.B. TOMASCAK³,
B. BOURDON⁴, F. OBERLI⁴ AND J.M.D. DAY⁵

¹Univ. Münster, Germany

(*correspondence, tomas.magna@uni-muenster.de)

²Univ. Notre Dame, USA (neal.1@nd.edu)

³SUNY Oswego, USA (tomascak@oswego.edu)

⁴ETH Zürich, Switzerland (bourdon@erdw.ethz.ch,
oberli@erdw.ethz.ch)

⁵Univ. Maryland, USA (jamesday@geol.umd.edu)

Recent studies of lunar mare basalts and volcanic glasses [1,2] have revealed resolvable $\delta^7\text{Li}$ differences between the melt products of low-Ti olivine-orthopyroxene-rich cumulates and high-Ti clinopyroxene-dominated lithologies formed after extensive crystallization of the lunar magma ocean (LMO), where the high-Ti basalts carry a higher $\delta^7\text{Li}$ signature. To more rigorously assess $\delta^7\text{Li}$ variations in the Moon, we have analyzed a variety of lunar low- and high-Ti mare basalts from the Apollo 11, 12, 14, 15 and 17 sites for their Li abundances and isotope compositions. The new data indicate broad $\delta^7\text{Li}$ homogeneity for the suite as a whole, with a few subtypes clearly deviating from the main field, and only subtle differences between low- and high-Ti basalts. High-K A-type basalts from the A11 site show a significant imprint of Li-rich material, likely consistent with addition of a KREEP component [3]. This is further corroborated by our new estimate of KREEP $\delta^7\text{Li}$ and Li abundances derived from KREEP basalt 15386 and impact melt 14310. C-type basalts from the A17 site have consistently higher $\delta^7\text{Li}$ than all other mare basalts, which may relate to metasomatic overprint by alkali-rich fluids [4], rather than the effect of clinopyroxene accumulation [1]. The $\delta^7\text{Li}$ variability of A17 high-Ti mare basalts provides further evidence for their origin from heterogeneous mantle sources [5]. Subtle $\delta^7\text{Li}$ fluctuations within individual A12 flows (olivine, pigeonite and ilmenite basalts) can be explained by fractional crystallization of olivine (\pm pigeonite). Our new results for olivine-normative A15 basalts (ONBs) further underscore their differences with A15 quartz-normative basalts (QNBs) [1], possibly indicating gradual evolution of their common source via accumulation of olivine in ONBs and plagioclase accumulation in QNBs [6].

[1] Magna *et al.* (2006) *Earth Planet. Sci. Lett.* **243**, 336; [2] Day *et al.* (2008) *Lunar Planet. Sci. Conf.* **XXXIX**, #1072; [3] Jerde *et al.* (1994) *Geochim. Cosmochim. Acta* **58**, 515; [4] Neal *et al.* (1990) *Lunar Planet. Sci. Conf.* **XXI**, 855; [5] Rhodes *et al.* (1976) *Lunar Planet. Sci. Conf.* **7th**, 1467; [6] Schnare *et al.* (2008) *Geochim. Cosmochim. Acta* **72**, 2556.

Why weathering rates differ between the laboratory and the field

KATE MAHER¹, CARL I. STEEFEL²
AND ART F. WHITE³

¹School of Earth Sciences, Stanford University

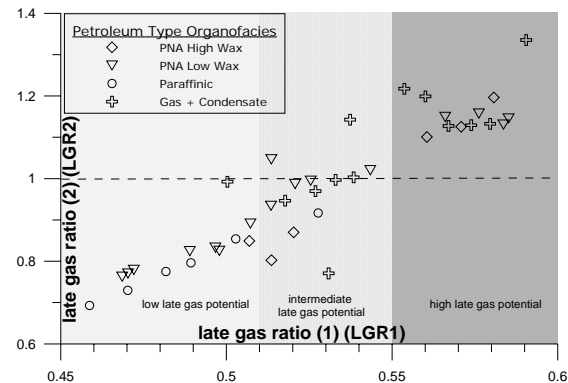
(*correspondence: kmaher@stanford.edu)

²Earth Sciences Division, Berkeley National Laboratory
(CISteeffel@lbl.gov)

³U.S. Geological Survey, Menlo Park, CA
(afwhite@usgs.gov)

In order to understand how experimentally-determined rate constants and kinetic rate laws can be extrapolated to capture the overall rates and chemical evolution of natural systems, a reactive transport model was used to fit the aqueous chemistry, mineral saturation state and solid elemental and mineral abundances

from a well-studied chronosequence at Santa Cruz, CA. Rate constants were initially calculated for the primary dissolving minerals (albite and K-feldspar) and the dominant precipitating mineral (kaolinite) using a simple linear TST approach. The intrinsic rate constant for the linear TST model was found to be 2 orders of magnitude smaller than the experimentally determined laboratory rate constant, even though the effect of kaolinite precipitation on the fluid saturation state was accounted for. The ability of the linear reference model to match the available data was compared to simulations that used experimentally-derived rate constants and rate laws with a non-linear dependence on the approach to equilibrium. When a non-linear dependence on the approach to equilibrium was considered using alternative rate law formulations, we found that the calculated rate constants were within error of experimental rate constants for the same fit to the data. These results suggest that the discrepancy between experimentally and field-calculated rates is not purely a result of close-to-equilibrium dissolution in natural systems, but depends on the particular form of the rate law as reaction rates approach equilibrium and on the identity and solubility of precipitating minerals.



precipitating mineral (kaolinite) using a simple linear TST approach. The intrinsic rate constant for the linear TST model was found to be 2 orders of magnitude smaller than the experimentally determined laboratory rate constant, even though the effect of kaolinite precipitation on the fluid saturation state was accounted for. The ability of the linear reference model to match the available data was compared to simulations that used experimentally-derived rate constants and rate laws with a non-linear dependence on the approach to equilibrium. When a non-linear dependence on the approach to equilibrium was considered using alternative rate law formulations, we found that the calculated rate constants were within error of experimental rate constants for the same fit to the data. These results suggest that the discrepancy between experimentally and field-calculated rates is not purely a result of close-to-equilibrium dissolution in natural systems, but depends on the particular form of the rate law as reaction rates approach equilibrium and on the identity and solubility of precipitating minerals.