Constraints on lunar surface temperatures from production and diffusion of cosmogenic ^{38}Ar and radiogenic ^{40}Ar

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The simultaneous diffusion of both cosmogenic ^{38}Ar and radiogenic ^{40}Ar is controlled by the thermal conditions of rocks while residing near planetary surfaces. In particular, combined observations of ^{38}Ar/^{37}Ar and ^{40}Ar/^{39}Ar ratios during sequential degassing analyses of neutron-irradiated Apollo samples can be used to distinguish between diffusive loss of Ar due to solar heating of the rocks and that associated with elevated temperatures during or following impact events; the data provide quantitative constraints on the durations and temperatures of each process. From the ^{38}Ar/^{37}Ar ratios can be calculated a spectrum of apparent ^{38}Ar exposure ages versus the cumulative release fraction of ^{37}Ar, which is particularly sensitive to conditions at the lunar surface typically over ~10^6-10^8 year timescales. Due to variable proportions of K- and Ca-bearing glass, plagioclase and pyroxene, with variability in the grain sizes of these phases, each sample will have distinct sensitivity to, and therefore different resolving power on, past near-surface thermal conditions. We will discuss the underlying assumptions, and the analytical and numerical methods used to quantify the Ar diffusion kinetics in multi-phase whole-rock analyses that provide these constraints. We will then present applications of this method using new data from whole-rock analyses of Apollo 15 basalts and recently published[a,b] data from Apollo 11 basalts. The open system behavior in both a radiogenic and a cosmogenic nuclide provides internal consistency tests on best-fitting solutions of time-integrated thermal conditions of rocks collected from planetary surfaces.

[1] Shea E., Weiss B.P., Cassata W.S., Shuster D.L., Tikoo S.M., Gattacceca J., Grove T.L., Fuller M.D. (2012), A long-lived lunar core dynamo, *Science*, **335** (6067), 453-456. [2] Suavet C, Weiss B.P, Cassata W.S., Shuster D.L., Gattacceca J., Chan L., Garrick-Bethell I., Head, J.W., Grove T.L., and Fuller M.D. (2013) Persistence of the Lunar Core Dynamo, *Proceedings of the National Academy of Sciences*, **110** (21), 8453-8458.