Constraining paleotemperatures of planetary surfaces with cosmogenic neon in feldspars

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Cosmogenic noble gases often exhibit open system behavior at planetary surface temperatures in common rock-forming minerals like feldspars. This open system behavior can be exploited to reconstruct the paleotemperatures of planetary surfaces, provided that the production and diffusion systematics of a particular cosmogenic noble gas–mineral pair are understood. Paleotemperatures on the moon have been reconstructed from cosmogenic and radiogenic isotopes of argon measured in multiple solid phases [1]. Here, we test whether cosmogenic neon isotopes in feldspar minerals can also be used to quantify lunar surface paleotemperatures using anorthite from lunar troctolite 76535. Measurements of cosmogenic 39Ar in 76535 indicate that this sample has a minimum exposure age of 142 Ma and did not experience temperatures greater than 170 °C during its exposure. Argon isotope measurements in other lunar samples indicate that effective diffusion temperatures (EDTs) of the lunar surface are ~70–80 °C [1].

We quantified the diffusion kinetics of neon in 76535 anorthite through step-degassing experiments on neutron-irradiated anorthite fragments. Linear behavior in an Arrhenius plot was observed for 98% of 22Ne released, indicating an activation energy (E_a) of 116 ± 3 kJ/mol and a pre-exponential factor (ln(D_0/a^2)) = 9.5 ± 0.5 ln(s^-1). Given these diffusion kinetics and lunar EDTs of ~70–80 °C, we predict that cosmogenic neon concentrations will have reached a steady state between production and diffusion during the 142 Ma exposure duration of 76535. Forthcoming measurements of the cosmogenic neon present in 76535 anorthite grains will provide a direct test of this prediction allow us to assess the viability of cosmogenic neon-in-feldspar paleothermometry on the moon and other planetary bodies.