Dating Mars with ID-KArD: Further Advances for a Future Mission

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Absolute ages of rocks outcropping on Mars are crucial for understanding the formation and evolution of the planet's surface, and can only be obtained in-situ or by sample return. The first Mars in-situ K-Ar age of 4.21 ± 0.35 Ga was recently obtained by the Curiosity Rover [1]. The ~ 8% uncertainty on this age, which arises equally from uncertainties in the Ar and K concentration measurements, is not really adequate to document the chronology of early Mars: Such an effort demands age uncertainties of < ~2%.

Here, we report the latest developments of our double isotope spiked technique ID-KArD (**I**sotope **D**ilution **K**-**Ar** **D**ating), for high precision in-situ dating on planetary bodies such as Mars [2-3]. Crucially, ID-KArD resolves two key challenges for in-situ dating: 1) A flux agent reduces the sample fusion temperature to < 1000 °C; 2) A doubly-spiked (^{41}K, ^{39}Ar) glass tracer negates the need for mass measurement, allowing for a K-Ar age determination using isotope ratios alone. For implementation on a rover, we have designed and built a unique prototype instrument capable of both K and Ar analysis on a single sample aliquot. The instrument includes two ion sources for separate analysis of Ar (electron-impact) and K (thermal ionisation) isotopic ratios by quadrupole mass spectrometry. Ar is released directly from a flux-melted sample (e.g. basalt), and the $^{40}Ar^*/^{39}Ar$ ratio measured, while K is volatilised simultaneously on to a filament. In a later step, this filament becomes a themal ionisation source, allowing measurement of the $^{39}K/^{41}K$ ratio. Early results demonstrate better than 2% precision on the K isotope ratio of spiked basalts analysed this way, and Ar isotope ratio measurements have comparable precision. On a 4 Ga basalt, the resulting age uncertainty would be about 1%. Isobaric interferences from HCl and hydrocarbons are currently our biggest challenge.

[1] Farley, K.A *et al* (2014) *Science* **343** (6169). [2] Farley, K. *et al* (2013), *GCA* **110**:1-12. [3] Cartwright, J.A. *et al* (2013) *LPSC XLIV*, (#1744).