Mass-dependent isotopic fractionation of argon in natural systems: Implications to $^{40}Ar/^{39}Ar$ dating

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Like all radiometric dating methods, in order to obtain accurate ages from the K-Ar radioisotope chronometer system, an accurate assessment and correction of the initial concentration of the daughter isotope (often referred to as either the "initial" or "trapped" component) ^{40}Ar is required. Generally it is assumed that the total amount of ^{40}Ar is composed of radiogenic $^{40}Ar^*$ derived from the decay of ^{40}K and a trapped $^{40}Ar_{trp}$ component derived from the atmosphere, incorporated into the system in proportion the atmospheric $^{40}Ar/^{36}Ar$ ratio 298.56 [1,2]. If this assumption is false, then the resultant calculated ages are incorrect. For the most part this assumption seems to hold true. However, evidence of non-atmospheric $^{40}Ar/^{36}Ar$ isotopic ratios that are enriched in ^{36}Ar are common in young volcanic rocks [3,4,5,6,7,8]. In $^{38}Ar/^{36}Ar$ vs $^{40}Ar/^{36}Ar$ space these ^{36}Ar samples lie on the kenetic mass dependent fractionation trend. Results from analyses reported here support Renne [9] that "kinetic fractionation of Ar isotopes is common, if not ubiquitous, in volcanic rocks".

To address this issue, we present an analytical protocol that identifies, and corrects for kenetic mass dependent fractionation that can be be applied to the $^{40}Ar/^{39}Ar$ dating method. Our protocol further accounts for temporal variaions in the Terrestrial atmosphereic $^{40}Ar/^{36}Ar$ ratio [10,11,12].

[1] Lee et al. (2006) *Geochim Cosmochim Atca* **70**, 4507-4512. [2] Valkiers et al. (2010) *Intl. Jour. Mass Spectrometry* **291**, 41-47. [3] Dalrymple (1969) EPSL **6**, 47-55. [4] Krummenacher (1970) *EPSL* **8**, 109-117. [5] Kaneoka (1980) *EPSL* **48**, 284-292. [6] Massumoto et al. (1989) *Mass Spectroscopy* **37**, 353-363. [7] Massumoto & Kobayashi (1995) *Chem. Geology* **125**, 123-135. [8] Ozawa et al. (2006) *Rev. Min. & Geochem* **47**, 411–480. Renne et al. (2009) Quat. Geochron. **4** 288–298. Cadogan PH (1977) *Nature* **268** 38-41Bender et al. (2008) Proc. *Natl. Acad Sci.* **105**, 8232–8237. Pujol et al. (2013) *Nature* **498**, 97-90