Taking the pulse of Mars via $^{40}Ar/^{39}Ar$ dating of a plume-fed volcano

BENJAMIN E. COHEN[1,2*], DARREN F. MARK[1,3], WILLIAM S. CASSATA[4], MARTIN R. LEE[2], TIM TOMKINSON[2], CAROLINE L. SMITH[5]

[1]Scottish Universities Environmental Research Centre, East Kilbride, UK.
[2]School of Geographical and Earth Sciences, University of Glasgow, UK
[3]Department of Earth & Environmental Science, University of St Andrews, UK
[4]Lawrence Livermore National Laboratory, USA
[5]The Natural History Musem, London, UK
*correspondence: ben.cohen@glasgow.ac.uk

Mars hosts the solar system's largest volcanoes [1]. Although their size and cratering density indicates individual volcanoes were active over billions of years, their formation rates are poorly understood [2]. Here we have quantified the growth rate of a Martian volcano by $^{40}Ar/^{39}Ar$ dating of six nakhlites, meteorites that were ejected from Mars by a single impact event [3]. We find that the nakhlites sample a stratigraphically layered volcanic sequence, and temporally constrain at least four discrete eruptive events spanning 93 ± 11 Ma (1,416 ± 7 Ma to 1,322 ± 9 Ma [2σ]). The meteorites contain a non-radiogenic trapped $^{40}Ar/^{36}Ar$ value of 1560 ± 110 (2σ), thus providing a constraint for the composition of Martian atmosphere at the time of nakhlite formation. Via analysis of cosmogenic-derived ^{38}Ar from unirradiated fragments of the nakhlites, we have also constrained that the nakhlites were ejected from the surface of Mars at 10.7 ± 0.8 Ma. Allowing for the maximum meteorite spallation depth from prospective source craters enables calculation of a growth rate of ca. 0.4-0.7 m/Ma – three orders of magnitude slower than comparable volcanoes on Earth. This remarkably slow rate in the mid-Amazonian necessitates that Mars was far more volcanically active earlier in its history.

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