**Text S1. Detailed 40Ar/39Ar Methods**

For 40Ar/39Ar analysis, hornblende, biotite, and potassium feldspar separates were submitted to the Geochronology Laboratory at the University of Alaska Fairbanks. The monitor mineral MMhb-1 (Samson and Alexander, 1987) with an age of 513.9 Ma (Lanphere and Dalrymple, 2000) was used to monitor neutron flux (and calculate the irradiation parameter, J). The samples and standards were wrapped in aluminum foil and loaded into aluminum cans of 2.5 cm diameter and 6 cm height. The samples were irradiated in position 5c of the uranium-enriched research reactor of McMaster University in Hamilton, Ontario, Canada for 20 megawatt-hours.

Upon their return from the reactor, the samples and monitors were loaded into 2 mm diameter holes in a copper tray that was then loaded in an ultra-high vacuum extraction line. The monitors were fused, and samples heated, using a 6-watt argon-ion laser following the technique described in York et al. (1981), Layer et al. (1987) and Benowitz (2013). Argon purification was achieved using a liquid nitrogen cold trap and a SAES Zr-Al getter at 400 °C. The samples were analyzed in a VG-3600 mass spectrometer at the Geophysical Institute, University of Alaska Fairbanks. The argon isotopes measured were corrected for system blank and mass discrimination, as well as calcium, potassium and chlorine interference reactions following procedures outlined in McDougall and Harrison (1999). Typical full-system 8 min laser blank values (in moles) were generally 2 × 10-16 mol 40Ar, 3 × 10218 mol 39Ar, 9 × 10-18 mol 38Ar and 2 × 10-18 mol 36Ar, which are 10–50 times smaller than the sample/standard volume fractions. Correction factors for nucleogenic interferences during irradiation were determined from irradiated CaF2 and K2SO4 as follows: (39Ar/37Ar)Ca = 7.06 × 10-4, (36Ar/37Ar)Ca = 2.79 × 10-4 and (40Ar/39Ar)K = 0.0297. Mass discrimination was monitored by running calibrated air shots. The mass discrimination during these experiments was 0.8% per mass unit. While doing our experiments, calibration measurements were made on a weekly– monthly basis to check for changes in mass discrimination with no significant variation seen during these intervals.

A summary of all the 40Ar/39Ar results is given in Tables 1 and 2, with all ages quoted to the ± 1 sigma level and calculated using the constants of Renne et al. (2010). Detailed step-heat data and single grains isotopic discrete isotopic measurement data following the recommendations of Renne et al., (2009) are provided in the GSA Data Repository Tables DR1 and DR2. The integrated age is the age given by the total gas measured and is equivalent to a potassium-argon (K-Ar) age. The spectrum provides a plateau age if three or more consecutive gas fractions represent at least 50% of the total gas release and are within two standard deviations of each other (Mean Square Weighted Deviation less than 2.5).

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