**NOTE:** Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

**Description of 40Ar/39Ar analytical methods**

Sample 201-SM025 was crushed, ultrasonicated, and sieved to 250 to 355 μm. Groundmass was separated from phenocryst phases using a LB-1 Barrier Frantz magnetic separator and careful handpicking under a binocular microscope. Sample 1912-SM167 was crushed, ultrasonicated, and sieved to 500 to 1000 μm. Sanidine grains were separated from groundmass and other phenocryst phases using a Frantz magnetic separator. Approximately 40 sanidine grains were hand-picked under a binocular microscope. Prior to irradiation, the sanidine crystals were leached using 8% HF to remove any adhering glass then rinsed thoroughly in deionized water. Sanidine grains were inspected under a binocular microscope after HF leaching to ensure no fluoride compounds were deposited on the grains. Sanidine from sample 1912-SM167 and ~100 mg of groundmass from sample 201-SM025 were packaged in Al foil along with Bodie Hills sanidine monitor minerals (9.7946 ± 0.0031 Ma; Fleck et al., 2019) and encapsulated in quartz vials. The quartz vials were wrapped in 0.5 mm thick Cd foil to shield samples from thermal neutrons during irradiation. Sample 1912-SM167 was irradiated for 2 hours and sample 201-SM025 was irradiated for 1 hour in the central thimble of the U.S. Geological Survey TRIGA reactor in Denver, CO (Dalrymple et al., 1981) at a power level of 1 MW.

Following irradiation, monitor minerals and sanidine from sample 1912-SM167 were analyzed by total fusion using a MIR10 CO2 laser and a NGX-600 mass spectrometer at the U.S. Geological Survey in Menlo Park, California. Groundmass samples were removed from their Al package and rewrapped in degassed Ta foil prior to analysis. For incremental heating analysis of the groundmass separate, the argon was extracted in discrete temperature steps using a diode laser attached to an Isotopx NGX-600 mass spectrometer. Temperatures were monitored using an optical pyrometer. Prior to measurement of Ar isotopic composition, the groundmass separate was degassed at 400°C.

The U.S. Geological Survey NGX-600 mass spectrometer is a 10-collector instrument outfitted with nine Faraday detectors and one electron multiplier, which allows for simultaneous measurement of all Ar isotopes and half-mass baselines. This system is fitted with an ATONA amplifier that significantly reduces amplifier noise and improves baseline and calibration stability, which allows for reproducible measurements of small quantities of Ar. Measurement of monitor minerals and unknowns were made using Faraday detectors for 40Ar, 39Ar, 38Ar, and 37Ar, whereas 36Ar was measured on the electron multiplier. For analysis of sanidine, extracted Ar was exposed to a 125K cold finger and two SAES ST-175 getters (one operated at 300oC and one at room temperature) to remove active gasses. For analysis of groundmass, extracted Ar was exposed to a 125K cold finger, two SAES ST-175 getters (both operated at 300oC), and a SAES Z-100 getter to remove active gasses. Instrumental mass discrimination was calculated by repeated measurement of atmospheric argon, assuming 40Ar/36Aratmosphere = 298.56 ± 0.31 (Lee et al., 2006). Intercalibration of Faraday detectors with the electron multiplier was also performed using atmospheric argon. 40Ar/39Ar ages are calculated using the decay constants recommended by Steiger and Jäger (1977). Uncertainties in reported 40Ar/39Ar ages include propagated uncertainties in counting statistics and J values.

**Description of calcite U/Pb analytical methods**

Faults in the study area are commonly coated with synkinematic calcite, and we use laser ablation inductively-coupled mass spectrometry (LA-ICP-MS) U-Pb geochronology to determine the timing of this mineralization. Oriented samples collected from fault surfaces were cut into thin (30 µm) or thick (120 µm) sections and analyzed in-situ to preserve textural context. Using a petrographic microscope we identified textural generations of calcite, crosscutting relations between calcite growth and brittle deformation, and microscopic slip sense indicators. Analyses were performed at the UTChron laboratory at the University of Texas at Austin using a 110 µm laser spot size and the NIST 614 glass standard (Jochum et al., 2011) for Pb isotope normalization and calcite standard WC-1 (Roberts et al., 2017) for U-Pb normalization. Some ablation spots exhibited down-hole isotopic differences and are presented with multiple integrations (Supplementary dataset 3; analyses with duplicate spot numbers indicate multiple integrations from the same analytical spot). Analyses are filtered for <1 207Pb/206Pb and <0.2 207Pb/206Pb 2σ error, which removes high-uncertainty analyses that may have ablated phases other than calcite. Dates are calculated from a Tera-Wasserburg discordia lower intercept and reported with 2σ uncertainty.

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