SUPPLEMENTARY INFORMATION #1 - ANALYTICAL METHODS

1. X-RAY FLUORESCENCE AND ICP-MS WHOLE ROCK GEOCHEMICAL ANALYTICAL METHODS

Slabs for geochemical analysis were prepared from rocks samples in the thin section lab in the Department of Earth and Planetary Sciences, UC Davis. The slabs were sent to the Peter Hooper GeoAnalytical Lab at Washington State University where they were prepared for analytical analysis:

X-ray Fluorescence Analysis: ThermoARL Advant'XP+ automated sequential wavelength spectrometer measures 29 major and trace elements (Si, Al, Ti, Fe, Mn, Ca, Mg, K, Na, P, Sc, V, Ni, Cr, Ba, Sr, Zr, Y, Rb, Nb, Ga, Cu, Zn, Pb, La, Ce, Th, Nd, U).

For further details see:

https://environment.wsu.edu/facilities/geoanalytical-lab/technical-notes/xrf-method/

ICP-MS Analysis: Agilent 7700 inductively coupled plasma mass spectrometer measures 27 elements (14 REEs & Ba, Th, Nb, Y, Hf, Ta, U, Pb, Rb, Cs, Sr, Sc, Zr) on bulk rocks or minerals.

For further details see:

https://environment.wsu.edu/facilities/geoanalytical-lab/technical-notes/icp-ms-method/

2. ^{40}Ar-^{39}Ar ANALYTICAL METHODS

The ^{40}Ar-^{39}Ar analyses were performed by Margarita López Martínez at the Geochronology Laboratory of the Departmento de Geologia, CICESE. The argon isotope experiments were conducted on sample fragments of whole rock, groundmass, plagioclase and hornblende concentrates. The experiments were performed with a Coherent Ar-ion Innova 330 laser extraction system on line with a VG5400 mass spectrometer. All the samples and irradiation monitors were irradiated in the U-enriched research reactor of McMaster University in Hamilton, Canada, at position 8C for 150 MWH. To block thermal neutrons, the capsule was covered with a cadmium liner during irradiation. As irradiation monitor, aliquots of sanidine FCT-2 (28.198 ± 0.044 Ma; Kuiper et al., 2008) were used. Upon irradiation sanidine FCT-2 aliquots were fused in one step while the samples were step-heated. The argon isotopes were corrected for blank, mass discrimination, radioactive decay of ^{37}Ar and ^{39}Ar and atmospheric contamination. For all the atmospheric argon corrections (^{40}Ar/^{36}Ar) = 295.5 was used. The parameters used to correct for neutron induced interference reactions were: $(^{39}Ar/^{37}Ar)_{Ca}$ = 6.50E-04; $(^{36}Ar/^{37}Ar)_{Ca}$ = 2.55E-04; $(^{40}Ar/^{39}Ar)_{K}$ = 0. Mass 36 was also corrected for chlorine-derived ^{36}Ar [$^{35}Cl(n, \gamma)\ ^{36}Cl \rightarrow\ ^{36}Ar + \beta^{-}$ with $t_{1/2}$ = 3.01E05 a]. The decay constants recommended by Steiger and Jäger (1977) were applied in the data processing. The equations reported by York et al. (2004) were used in all the straight line fitting routines of the argon data reduction. For several samples two experiments were performed. The plateau age was calculated from the weighted mean of at least three consecutive fractions that represent more than 30% of the ^{39}Ar released and their ages are

in agreement within 1σ error. The age is identified as W_m weighted mean when the criteria for plateau age calculation is no fulfilled, that is the case of groundmass sample SR 12-2 because the three fractions used to calculate the weighted mean represent less than 30% of the ^{39}Ar released. For the t_p and W_m ages, the percentage of ^{39}Ar released and the mean square of weighted deviates (MSWD) is reported. The error in the plateau, integrated and isochron ages include the error in the irradiation monitors. The analytical precision is reported as one standard deviation (1 σ). The isochron ages were calculated in the correlation $^{36}Ar/^{40}Ar$ versus $^{39}Ar/^{40}Ar$ diagram, from the best straight line described by the fractions that define the plateau segment. Additionally the error of the isochron age includes the goodness of fit when the MSWD value exceeded 1.

A summary table of the ^{40}Ar-^{39}Ar results and relevant ^{40}Ar-^{39}Ar data for all the experiments is given in supplementary information #3.

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3. ZIRCON ISOTOPE METHODS

Performed on sample SR 15-6 (field number CB15-6): pumices from tuff of El Morro. Sample described in Table 1 of text.

Zircon grains were separated at California State University Bakersfield by Sarah Brown. Rocks were processed through a BICO jaw-crusher and disk-mill to generate a sand-sized powder that was run through a Wilfley Gravity Table to concentrate zircon and other dense minerals. Zircon was concentrated further by density separation using methylene iodide.

U-Pb geochronology - Ion Microprobe (University of California Los Angeles)

U–Pb zircon geochronology was carried out by Graham Andrews in a single analytical session on the CAMECA ims 1270 ion microprobe at the University of California Los Angeles (UCLA), using established protocols for the analysis of Cenozoic zircon (Schmitt et al., 2003). Primary beam intensities for mass-filtered $^{16}O^-$ were ~20 and ~40 nA with a spot size of ~20–30 μm with depths after analysis being approximately one-tenth of the crater diameter. Oxygen flooding was used at the saturation pressure to enhance sensitivity for Pb. A ^{204}Pb-based common Pb correction was used for reference zircon, whereas ^{207}Pb was used as a proxy for common Pb for unknowns. Reproducibility of $^{206}Pb^*/^{238}U$ ages for AS3 (1099 Ma; Paces and Miller, 1993) used as a primary reference for the UO^+/U^+ versus U–Pb relative sensitivity calibration was ~2–3% (rel.), and accuracy of the weighted average $^{206}Pb^*/^{238}U$ ages based on comparison with replicate analyses (n = 10 each) on 91500 reference zircon was −1.5 % (relative deviation from reported age of 1065 Ma; Wiedenbeck et al., 1995).Th/U in unknown zircon was determined from measured $^{232}Th^+/^{238}U^+$ using a relative sensitivity factor calibrated on

measured $^{208}Pb^*/^{206}Pb^*$ of AS3 reference zircon. Uranium abundances were estimated from $U+/^{94}Zr_2O^+$ in relation to 91500 zircon with 81 ppm U (Wiedenback et al., 2004).

Analyses were corrected in IsoplotR (Vermeescg, 2018) for common Pb based on measured ^{207}Pb, assuming $^{207}Pb/^{206}Pb = 0.8283$ (Sañudo-Wilhelmy and Flega, 1994) and disequilibrium based on $\Delta Th/U = 0.17$ (Blundy and Wood, 2003). IsoplotR was used to calculate mean ages and to plot Tera-Wasserberg concordia.

Lu-Hf Isotopic Analysis - Laser Ablation ICPMS (University of Arizona)

Hf isotopic analyses were conducted by Graham Andrews on grains already dated at UCLA using a Nu Instruments HR multi-collector ICPMS connected to a Photon Machines Analyte G2 excimer laser at the Arizona Laser Center at the University of Arizona, following established analytical protocols described in Gehrels and Pecha (2014). Instrument settings were optimized for laser ablation analysis, and in-run analyses of seven different natural zircon standards (Mud Tank, Temora, FC52, R33, Temora, Plesovice, and Sri Lanka) were analysed and monitored every 15–20 unknowns. Ablation with a laser beam diameter of 40 μm targeted zircon domains directly over the earlier U–Pb analysis craters. All measurements were made in static mode using Faraday collectors equipped with 3×10^{11} Ω resistors. Each acquisition consisted of one 40-s integration for backgrounds (on peak with laser idle) followed by 60 one-s integrations with the laser firing. A 30 s delay between laser analyses provided adequate time to ensure the previous sample was completely purged from the collector block. The laser was run in constant energy mode at with an output of 7.5 mJ (fluence ~8 J/cm^2) and a pulse rate of 7 Hz. Isotope fractionation (β) was accounted for by incorporating the

method of Woodhead et al. (2004) with βHf determined from the measured $^{179}Hf/^{177}Hf$, and βYb from the measured $^{173}Yb/^{171}Yb$ (except for very low Yb signals); βLu is assumed to be the same as βYb; and an exponential formula is used for fractionation correction. Yb and Lu interferences are corrected by measurement of $^{176}Yb/^{171}Yb$ and $^{176}Lu/^{175}Lu$ (respectively), as advocated by Woodhead et al. (2004). Isotope ratios of $^{179}Hf/^{177}Hf$ = 0.73250 (Patchett and Tatsumoto, 1981); $^{173}Yb/^{171}Yb$ = 1.132338 (Vervoort et al., 2004); $^{176}Yb/^{171}Yb$ = 0.901691is, 2005) (Vervoort et al., 2004; Amelin and Davis, 2005); $^{176}Lu/^{175}Lu$ = 0.02653 (Patchett, 1983) were used and all corrections are done line-by-line. Data reduction protocols account for all standards and unknowns analysed during an entire session, and the βHf and βYb cut-offs were determined by monitoring the average offset of the standards from their known values resulting in a final standard offset of 0.0000001. $^{176}Hf/^{177}Hf$ uncertainty on the standard analyses for the entire session was determined to be 0.000037 (2σ).

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