

Supplementary Text S1: Ar-Ar and Re-Os Geochronology

⁴⁰Ar/³⁹Ar geochronology

Samples analyzed by the ⁴⁰Ar/³⁹Ar method at the University of Nevada Las Vegas were wrapped in Al foil and stacked in 6 mm inside diameter sealed fused silica tubes. Individual packets averaged 2 mm thick and neutron fluence monitors (FC-2, Fish Canyon Tuff sanidine) were placed every 5-10 mm along the tube. Synthetic K-glass and optical grade CaF₂ were included in the irradiation packages to monitor neutron induced argon interferences from K and Ca. Loaded tubes were packed in an Al container for irradiation. Samples irradiated at the Oregon State TRIGA Reactor, Corvallis, OR were in-core for 9.1 hours in the F-12 position, In-Core Irradiation Tube (ICIT) of the 1 MW TRIGA type reactor. Correction factors for interfering neutron reactions on K and Ca were determined by repeated analysis of K-glass and CaF₂ fragments. Measured (⁴⁰Ar/³⁹Ar)_K values were $1.32 (\pm 4.62\%) \times 10^{-1}$. Ca correction factors were (³⁶Ar/³⁷Ar)_{Ca} = $2.11 (\pm 0.78\%) \times 10^{-4}$ and (³⁹Ar/³⁷Ar)_{Ca} = $6.32 (\pm 0.57\%) \times 10^{-4}$. J factors were determined by fusion of 6-10 individual crystals of neutron fluence monitors which gave reproducibility's of 0.09% to 0.11% at each standard position. Variation in neutron fluence along the 100 mm length of the irradiation tubes was <4%. Matlab curve fit was used to determine J and uncertainty in J at each standard position. No significant neutron fluence gradients were present within individual packets of crystals as indicated by the excellent reproducibility of the single crystal fluence monitor fusions.

Irradiated FC-2 sanidine standards together with CaF₂ and K-glass fragments were placed in a Cu sample tray in a high vacuum extraction line and were fused using a 20 W CO₂ laser. Sample viewing during laser fusion was by a video camera system and positioning was via a motorized sample stage. Samples analyzed by the furnace step heating method utilized a double

vacuum resistance furnace similar to the Staudacher et al. (1978) design. Reactive gases were removed by three GP-50 SAES getters prior to being admitted to a MAP 215-50 mass spectrometer by expansion. The relative volumes of the extraction line and mass spectrometer allow 80% of the gas to be admitted to the mass spectrometer for laser fusion analyses and 76% for furnace heating analyses. Peak intensities were measured using a Balzers electron multiplier by peak hopping through 7 cycles; initial peak heights were determined by linear regression to the time of gas admission. Mass spectrometer discrimination and sensitivity was monitored by repeated analysis of atmospheric argon aliquots from an on-line pipette system. Measured $^{40}\text{Ar}/^{36}\text{Ar}$ ratios were $378.16 \pm 0.09\%$ during this work, thus a discrimination correction of 0.7814 (4 AMU) was applied to measured isotope ratios. The sensitivity of the mass spectrometer was $\sim 6 \times 10^{-17} \text{ mol mV}^{-1}$ with the multiplier operated at a gain of 36 over the Faraday. Line blanks averaged 1.40 mV for mass 40 and 0.01 mV for mass 36 for laser fusion analyses and 6.29 mV for mass 40 and 0.02 mV for mass 36 for furnace heating analyses. Discrimination, sensitivity, and blanks were relatively constant over the period of data collection. Computer automated operation of the sample stage, laser, extraction line and mass spectrometer as well as final data reduction and age calculations were done using LabSPEC software written by B. Idleman (Lehigh University). An age of 28.02 Ma (Renne et al., 1998) was used for the Fish Canyon Tuff sanidine fluence monitor in calculating ages for samples.

For $^{40}\text{Ar}/^{39}\text{Ar}$ analyses a plateau segment consists of 3 or more contiguous gas fractions having analytically indistinguishable ages (i.e. all plateau steps overlap in age at $\pm 2\sigma$ analytical error) and comprising a significant portion of the total gas released (typically >50%). Total gas (integrated) ages are calculated by weighting by the amount of ^{39}Ar released, whereas plateau ages are weighted by the inverse of the variance. For each sample inverse isochron diagrams are

examined to check for the effects of excess argon. Reliable isochrons are based on the MSWD criteria of Wendt and Carl (1991) and, as for plateaus, must comprise contiguous steps and a significant fraction of the total gas released. All analytical data are reported at the confidence level of 1σ (standard deviation) in **Table S1**.

Re-Os in molybdenite geochronology:

Two samples of molybdenite-bearing hydrothermal veins were collected from drillcore at the Kelly zone (Klaza) and from the Flex zone (Brown-McDade) in 2020 were submitted to the Re-Os Crustal Geochronology Laboratory at the University of Alberta with the employed methods for Re-Os analysis described in detail by Selby and Creaser (2004). Areas of each sample with visible molybdenite were removed, and preparation of a molybdenite mineral separate made by metal-free crushing and sieving followed by magnetic and gravity concentration methods. The ^{187}Re and ^{187}Os concentrations in molybdenite were determined by isotope dilution mass spectrometry using Carius-tube, solvent extraction, anion chromatography and negative thermal ionization mass spectrometry techniques. For this work, a mixed double spike containing known amounts of isotopically enriched ^{185}Re , ^{190}Os , and ^{188}Os analysis was used (Markey et al., 2007). Isotopic analysis used a ThermoScientific Triton mass spectrometer by Faraday collector. Total procedural blanks for Re and Os are less than <3 picograms and 2 picograms, respectively, which are insignificant in comparison to the Re and Os concentrations in molybdenite. The Reference Material 8599 Henderson molybdenite (Markey et al., 2007) is routinely analyzed as a standard, and during the past 6 years returned an average Re-Os date of 27.78 ± 0.07 Ma ($n=28$), indistinguishable from the Reference Age Value of 27.66 ± 0.1 Ma (Wise and Watters, 2011). The ^{187}Re decay constant used is 1.666e-11.a-1 (Smoliar et al, 1996).

References:

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