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Supplemental Material

S1. Mica $^{40}\text{Ar}/^{39}\text{Ar}$ method

Figure S1. Microstructures and mineral compositions of the samples for $^{40}\text{Ar}/^{39}\text{Ar}$ conventional step-heating technique dating in the DCS ranges in the Diancangshan antiform, Yunnan, China.

Table S1. Microstructures of the dated mylonites in the DCS massif in the Diancangshan antiform, Yunnan, China.

S2. Analytical method of AHe

Figure S2. Correlations of AHe dates and effective uranium concentration (eU) for all samples of the Diancangshan antiform in Yunnan, China.

S3. Apatite fission-track (AFT) methods

S1. MICA $^{40}\text{Ar}/^{39}\text{Ar}$ METHOD

We have dated muscovite, employing the $^{40}\text{Ar}/^{39}\text{Ar}$ conventional step-heating technique to determine the ages of the mylonitic rocks of the DCS dome. The sample locations are shown in Figure 3; their mineral assemblages, weighted mean plateau ages (WMPA), normal isochron ages (NIA), inverse isochron ages (IA), total fusion age (TFA) and J -factors are listed in Table S1.

Rock samples were crushed and then sieved. The required muscovite separates were carefully handpicked and checked under a binocular microscope, and only fresh mineral concentrates of 20–40-mesh grain-size were selected. These muscovite grains were ultrasonically cleaned in distilled water and dried.

All aliquots of samples (10 mg) were wrapped in aluminum foil to form wafers, and stacked in quartz vials with the international standard YBCs (29.286 ± 0.045 Ma, Wang et al., 2014). Neutron irradiation was carried out in position H8 of 49–2 Nuclear Reactor (49–2 NR), Beijing (China), with a flux of $\sim 6.5 \times 10^{12} \text{ n (cm}^2\text{s)}^{-1}$ for 24 h. CO_2 laser fusion technique was used for $^{40}\text{Ar}/^{39}\text{Ar}$ analyses. Isotopic measurements were made on the Noblesse mass spectrometer housed at the Institute of Geology and Geophysics, the Chinese Academy of Sciences (IGGCAS), Beijing. Ca and K correction factors are $[^{36}\text{Ar}/^{37}\text{Ar}]_{\text{Ca}} = 0.000261 \pm 0.0000142$, $[^{39}\text{Ar}/^{37}\text{Ar}]_{\text{Ca}} = 0.000724 \pm 0.0000281$, $[^{40}\text{Ar}/^{39}\text{Ar}]_{\text{K}} = 0.00088 \pm 0.000023$. Ages were calculated using the decay constant ($5.543 \times 10^{-10} \text{ yr}^{-1}$) listed by Steiger and Jäger (1977) and all errors were quoted at the 2σ level.

The criteria commonly adopted for defining a “plateau age” are the following (e.g., McDougall and Harrison, 1999): (1) containing at least 70% of total ^{39}Ar released; (2) there are at least three successive step-heating fractions in the plateau; (3) the integrated age of the plateau (weighted average of apparent ages of individual fractions comprising the plateau) should agree with each apparent age of the plateau within 2σ error. In this study, plateau ages were determined from three or more contiguous steps, comprising $>50\%$ of the ^{39}Ar released, revealing concordant ages at the 95% confidence level. Because no assumption was made regarding the trapped component, the preferred ages is isochron age, calculated from the results of plateau steps using the *York* regression algorithm (York, 1969).

The age errors reported here are internal errors, including analytical error and errors on blank, interaction factor, mass-discrimination and J -value; the error on the total decay constant is not propagated into the age error. Uncertainties on all data reported herein are at the 95% confidence level (2σ). The data were processed by using ArArCALC (Koppers, 2002). All data are given in supplementary Table S1. The age spectra and summary of data are shown in the text.

feldspar (Kfs)/plagioclase (Pl) porphyroclasts. The thick neo-crystallized muscovite-dominated layers present minor grains of feldspar limbed/mantled by oriented biotite, muscovite (Bi) and chlorite (Chl) fibers. Some prophyroclastic single muscovite grains of these samples are generally well elongated, rotated parallel to the shearing foliation. Quartz grains are characterized by subgrain rotation recrystallization (SGR). (E)-(F) Microstructures and kinematics of the top-to-the-southeast extensional deformation zone from the SE tip of the dome, sampling sites at DCS-GL-076 DCS-GL-104. The fine, neo-crystallized mica fragments (generally < 100 μm in size) or aggregates developed at or around the expense of biotite and feldspars resemble porphyroclasts. They are commonly parallel to or at slightly variable angles to the main shearing foliation. A small amount of segmented and sheared coarse muscovite grains (resemble prophyroclasts) are orientated to parallel to the neo-crystallized mica layers. Fine albite grains commonly develop to surround K-feldspar porphyroclasts. Extensively stretched quartz grains are characterized by undulose extinction and irregular grain boundaries, formed in response to bulging (BG) and subgrain rotation recrystallization (SGR).

Table S1. Microstructures of the dated mylonites in the DCS massif

No.	Sample No.	Microstructure		Estimated Temperature (°C) by Microstructures
		Quartz	K-Feldspar/Plagioclase	
DCS-GL-069 protomylonite	Protomylonite	SGR+BG	BG+SGR and Elongated	>500
DCS-GL-090	Mylonite	BG+SGR+G BMM	BG+SGR+MM	450–500
DCS-GL-049	Mylonite	BG+SGR+G BM	BG+SGR+CM	400–500
DCS-GL-050	Protomylonite	BG+SGR+G BM	BG+SGR+MM+CM and Elongated	400–450
DCS-GL-076	ProtoMylonite	BG+SGR	BG+SGR and Elongated	400–450
DCS-GL-104	Protomylonite	BG+SGR+G BM	BG+SGR+CM and Elongated	400–450

GBM: Grain boundary migration; BG: Bulging; SGR: Subgrain rotation; CM: Core and mantle structure; MM: Myrmekite

S2. ANALYTICAL METHOD OF AHE

Helium degassing and U-Th analyses of apatite were conducted at the University of Arizona Radiogenic Helium Dating Laboratory (ARHDL). Single crystals of apatite were selected for morphology, clarity, and lack of inclusions using a binocular microscope with crossed polars. Individual crystals were imaged, length and width dimensions checked on two sides, and loaded into Nb packets. Apatite grains were laser heated to 1000 °C for three minutes. Extracted He gas was spiked with ^3He , purified using cryogenic and gettering methods, and analyzed on a quadrupole mass spectrometer. The degassed apatites were retrieved, spiked with a ^{233}U - ^{229}Th - ^{147}Nd - ^{42}Ca tracer, dissolved in HNO_3 at $\sim 90^\circ\text{C}$ for 1 h, and analyzed on an Element 2 ICP-MS. The apatite mass was computed in two ways: 1) as the dimensional mass from the apatite radius and length measurements; 2) from the isotope-dilution measurements of Ca, combined with an assumed fluorapatite stoichiometry. This Ca-based mass was used to calculate the apatite U, Th and Sm concentrations. Fragments of the Durango apatite were used as a standard. Apatites were assumed to be unzoned in U, Th and Sm, and a hexagonal prism morphology with pinacoidal terminations was used for the apatite alpha-ejection correction (Farley et al., 1996), using individual corrections for each parent nuclide (Reiners et al., 2017).

Figure S2. Correlations of AHe dates and effective uranium concentration (eU) for all samples of the DCS dome.

S3. APATITE FISSION-TRACK (AFT) METHODS

Apatite grains were mounted in epoxy resin, alumina and diamond polished, and spontaneous fission tracks revealed by etching with 5.5M HNO₃ at 20 °C for 20 seconds. Samples were analyzed by applying the external detector methods using very low uranium, annealed muscovite mica detectors, and irradiated at the Oregon State University Triga Reactor, Corvallis, USA. The neutron fluence was monitored using European Institute for Reference Materials and Measurements (IRMM) uranium-dosed glasses IRMM 540R. After irradiation, mica detectors were etched in 40% HF for 45 min at 21 °C. Fission track analyses were performed under an Olympus microscope (1600x, dry) with reflected and transmitted light equipped with drawing tube located above a digitizing tablet and a Kinetek computer-controlled stage driven by the FT-Stage system. In general, at least 15 grains were analyzed per sample. Fission-track ages were calculated using the ξ -calibration approach and are reported as central ages with $\pm 2\sigma$ errors (95% confidence interval). We use the χ^2 test to quantify age homogeneity; if $P(\chi^2) > 5\%$, fission-track samples represent a single age population (Galbraith and Green, 1990; Galbraith and Laslett, 1993). All samples pass χ^2 test and yield high $P(\chi^2)$ values. Ages were calculated by the zeta method (351.6 ± 30.9 A.F.) for dosimeter glass (Hurford and Green, 1983; Hurford, 1990). Due to low spontaneous track densities in most apatite samples, measurement of track-length distributions and kinetic parameters of Dpar values could not be allowed.

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