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$^{40}\text{Ar}/^{39}\text{Ar}$ Geochronology Results from the Sierra Nevada Fault Project

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Introduction

In an effort to determine the age of faulting, seven samples from a greenschist facies fault zone in the Sierra Nevada Mountains of California were submitted by Matthew Pachell of Utah State University. There was concern that older micas and chlorite intergrown with the sericite that grew in the fault could result in ambiguous results. After reviewing the thin sections, sample 1957 was considered the best candidate for dating. Microprobe analysis revealed multiple sizes of muscovite (up to 200 μm) and minor chlorite intergrown within the sericite (Appendix 1). It is noted that all sizes of muscovite appeared compositionally similar.

$^{40}\text{Ar}/^{39}\text{Ar}$ Analytical Methods and Results

The sericite was analyzed by the furnace incremental heating age spectrum method. Abbreviated analytical methods for the dated samples are given in Table 1, and details of the overall operation of the New Mexico Geochronology Research Laboratory are provided in the Appendix. The argon isotopic results for the sericite is listed in Table 2.

The sericite from sample 1957 yielded a well-behaved age spectrum (Figure 1). The first ~10% of the ^{39}Ar released displays old apparent ages and low radiogenic yields. The remainder of the age spectrum has been used to calculate a weighted mean age of 79.90 ± 0.16 Ma. This weighted mean age has an acceptable MSWD value of 2.4 (cf. Mahon, 1996). The data has also been evaluated with the inverse isochron technique. It was found to have a $^{40}\text{Ar}/^{36}\text{Ar}$ ratio (291 ± 27) within error of the atmospheric value of 295.5. The isochron age (79.92 ± 0.69 Ma) agrees within error to the weighted mean age calculated from the age spectrum.

Discussion

The preferred age for sample 1957 is the weighted mean age of 79.70 ± 0.16 Ma assigned to steps E-I of the age spectrum. We can not state conclusively that this represents the age of faulting, as microprobe analysis revealed coarser mica intergrown with finer grained material. The analyzed sericite separate may, therefore, have contained two ages of mica. It has been shown that samples containing two populations of white mica result in disturbed age spectra as the different phases are to some extent thermally distinct and dominate different portions of the age spectra

(Wijbrans and McDougall, 1986). The nearly concordant age spectra of sample 1957 suggests the analyzed separate contained one age of mica. With the care taken during mineral separation to separate only the finest mica, it is unlikely that the separate was only coarse pre-fault mica. We tentatively suggest that the assigned age of 79.70 ± 0.16 Ma represents the age of faulting.

References Cited

- Deino, A., and Potts, R., 1990. Single-Crystal $^{40}\text{Ar}/^{39}\text{Ar}$ dating of the Olorgesailie Formation, Southern Kenya Rift, *J. Geophys. Res.*, 95, 8453-8470.
- Mahon, K.I., 1996. The New "York" regression: Application of an improved statistical method to geochemistry, *International Geology Review*, 38, 293-303.
- McDougall, I., and Harrison, T.M., 1999, *Geochronology and thermochronology by the $^{40}\text{Ar}/^{39}\text{Ar}$ method*: New York, Oxford University Press, xii, 269 p.
- Samson, S.D., and Alexander, E.C., Jr., 1987. Calibration of the interlaboratory $^{40}\text{Ar}/^{39}\text{Ar}$ dating standard, Mmhb-1, *Chem. Geol.*, 66, 27-34.
- Steiger, R.H., and Jäger, E., 1977. Subcommittee on geochronology: Convention on the use of decay constants in geo- and cosmochronology. *Earth and Planet. Sci. Lett.*, 36, 359-362.
- Taylor, J.R., 1982. *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements*. Univ. Sci. Books, Mill Valley, Calif., 270 p.
- Wijbrans, J.R., and McDougall, I., 1986. $^{40}\text{Ar}/^{39}\text{Ar}$ dating of white micas from an Alpine high-pressure metamorphic belt on Naxos (Greece): The resetting of the argon isotopic system. *Contrib. Mineral. Petrol.*, 93, 187-194.
- York, D., 1969. Least squares fitting of a straight line with correlated errors, *Earth and Planet. Sci. Lett.*, 5, 320-324.

Table 1. Summary of $^{40}\text{Ar}/^{39}\text{Ar}$ results and analytical methods

Sample	Lab #	Irradiation	mineral	Age	$\pm 2\sigma$	comments
1957	51528	NM-128	muscovite/sericite	79.70	0.16	

Sample preparation and irradiation:

The muscovite separate was prepared using standard hand-picking techniques.

The sample was loaded into a machined Al disc and irradiated for 100 hours in L-67 position, Ford Memorial Reactor, U of Mich. Neutron flux monitor Fish Canyon Tuff sanidine (FC-1). Assigned age = 27.84 Ma (Deino and Potts, 1990) relative to Mmhb-1 at 520.4 Ma (Samson and Alexander, 1987).

Instrumentation:

Mass Analyzer Products 215-50 mass spectrometer on line with automated all-metal extraction system.

Muscovite was step-heated in Mo double-vacuum resistance furnace. Heating duration 7 minutes.

Reactive gases removed by reaction with 3 SAES GP-50 getters, 2 operated at $\sim 450^\circ\text{C}$ and 1 at 20°C . Gas also exposed to a W filament operated at $\sim 2000^\circ\text{C}$.

Analytical parameters:

Electron multiplier sensitivity averaged 3.10×10^{-16} moles/pA.

Total system blank and background for the laser averaged 721, 1.6, 0.9, 0.7, 3.3×10^{-18} moles at masses 40, 39, 38, 37, and 36, respectively.

J-factors determined to a precision of $\pm 0.1\%$ by CO_2 laser-fusion of 4 single crystals from each of 3 radial positions around the irradiation tray.

Correction factors for interfering nuclear reactions were determined using K-glass and CaF_2 and are as follows:

$$(^{40}\text{Ar}/^{39}\text{Ar})_{\text{K}} = 0.02495 \pm 0.00025; (^{36}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 0.000277 \pm 0.000002; \text{ and } (^{39}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 0.0007 \pm 0.00005.$$

Age calculations:

Total gas age and error calculated by weighting individual steps by the fraction of ^{39}Ar released.

Plateau age or preferred age calculated for the indicated steps by weighting each step by the inverse of the variance.

Plateau age error calculated using the method of (Taylor, 1982).

MSWD values are calculated for n-1 degrees of freedom for plateau age.

Isochron ages, $^{40}\text{Ar}/^{36}\text{Ar}_i$ and MSWD values calculated from regression results obtained by the methods of York (1969).

Decay constants and isotopic abundances after Steiger and Jäger (1977).

All final errors reported at $\pm 2\sigma$, unless otherwise noted.

Table 2. Argon isotopic data for furnace step-heating results.

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10 ⁻³)	³⁹ Ar _K (x 10 ⁻¹⁶ mol)	K/Ca	⁴⁰ Ar* (%)	³⁹ Ar (%)	Age (Ma)	±1 (Ma)
1957, C1:128, 1.32 mg muscovite, J=0.0163498, NM-128, Lab#=51528-01										
A	625	35.79	0.1086	117.0	1.55	4.7	3.4	0.1	35.9	16.7
B	700	3.733	0.0321	2.668	14.7	15.9	79.2	1.4	84.6	1.3
C	750	2.925	0.0081	0.2894	33.2	62.9	97.2	4.1	81.28	0.56
D	800	2.861	0.0045	0.0617	73.4	113.7	99.4	10.2	81.29	0.27
E	875	2.862	0.0047	0.2463	36.9	107.5	97.5	13.3	79.78	0.42
F	975	2.812	0.0031	0.0665	414.0	162.0	99.3	47.6	79.84	0.13
G	1075	2.799	0.0049	0.0702	441.3	104.2	99.3	84.2	79.46	0.13
H	1250	2.921	0.0191	0.5442	105.3	26.8	96.0	93.0	80.16	0.24
I	1650	3.179	0.0477	1.374	84.9	10.7	87.3	100.0	79.42	0.29
total gas age			n=9		1205.3	109.0			79.83	0.38*
plateau		MSWD = 2.4	n=5	steps E-I	1082.3	111.6		89.8	79.70	0.16*

Notes:

Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions.

Individual analyses show analytical error only; plateau and total gas age errors include error in J and irradiation parameters.

n= number of heating steps

K/Ca = molar ratio calculated from reactor produced ³⁹Ar_K and ³⁷Ar_{Ca}.

* 2 error

1a. 1957 sericite

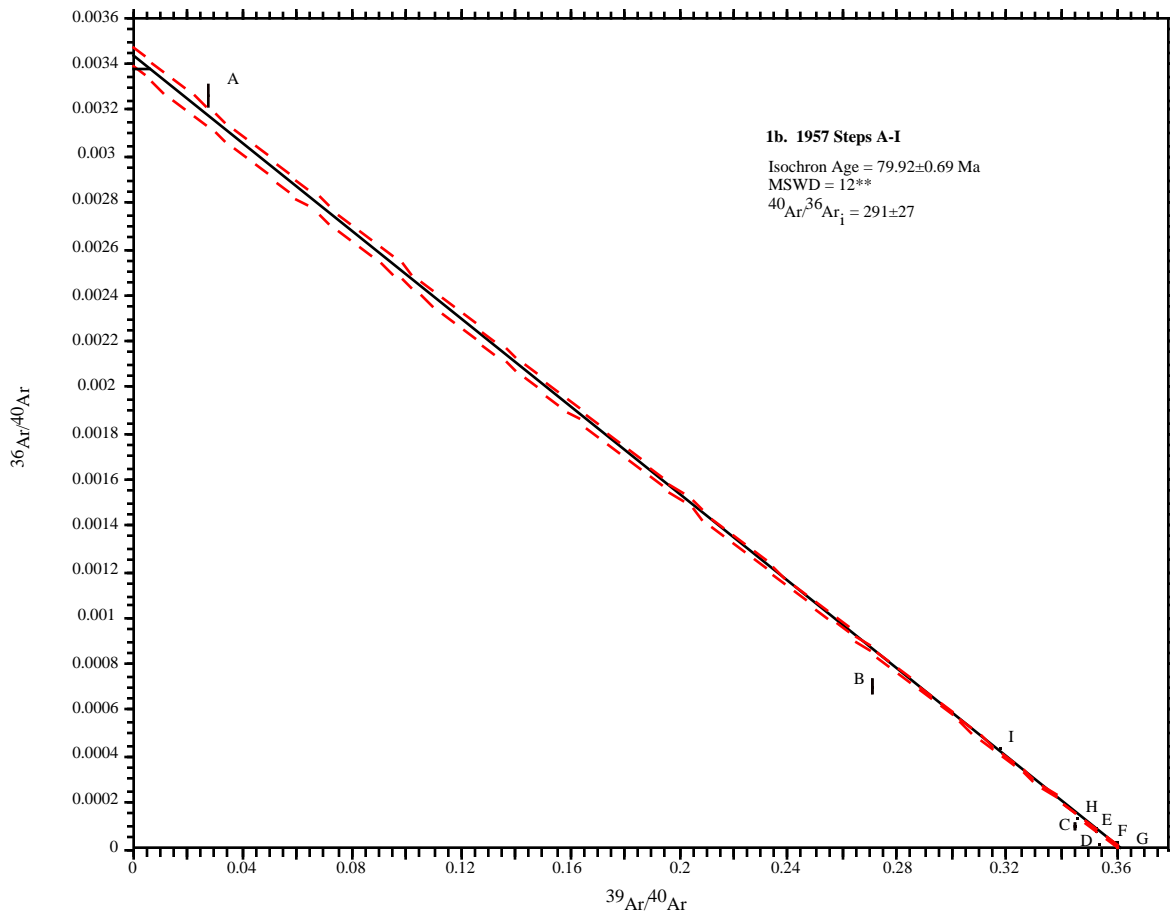
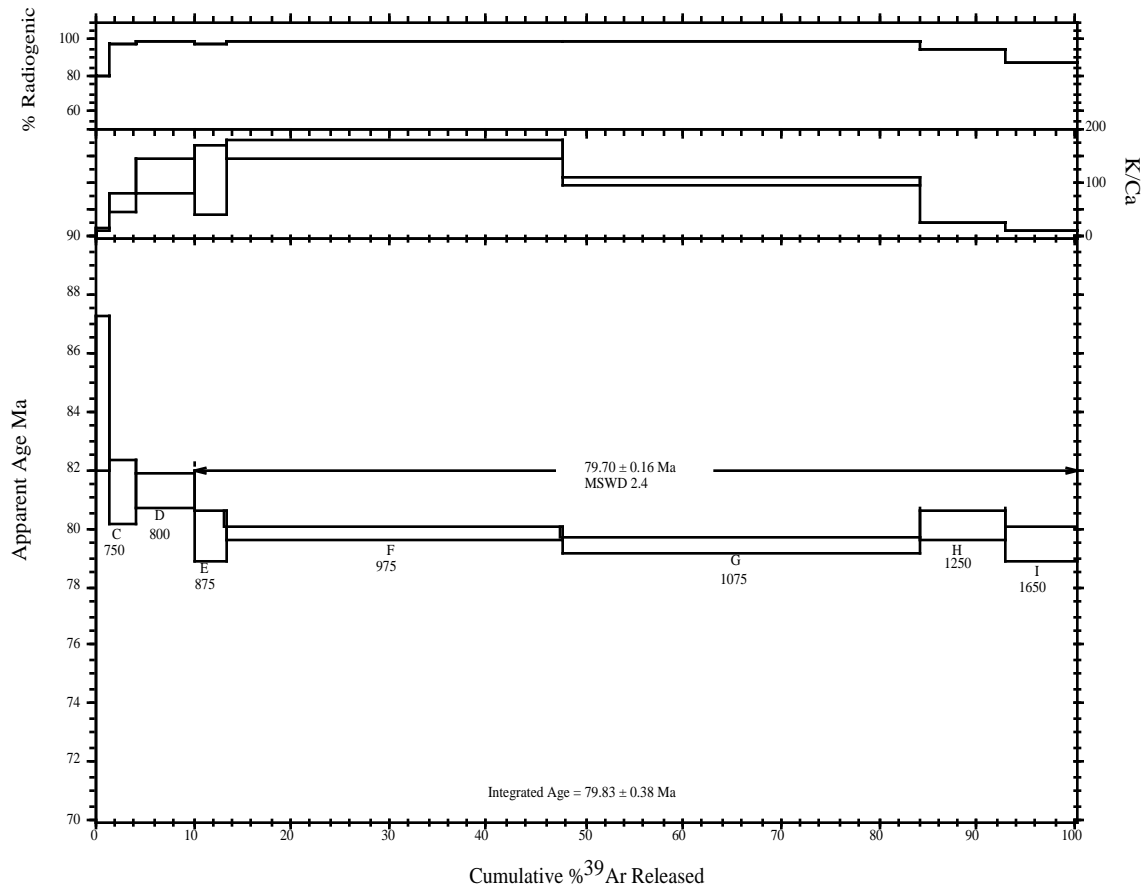


Figure 1. Age spectra (1a) and isochron (1b) for sample 1957 sericite.