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Geologic and Taphonomic Context of El Bosque Petrificado Piedra Chamana (Cajamarca, Peru)

We dated three feldspar separates from two samples from El Bosque Petrificado Piedra Chamana using $^{40}Ar/^{39}Ar$ methods. Single crystal laser-fusion analyses were performed at the New Mexico Geochronology Laboratory using a MAP 215-50 mass spectrometer on line with an all-metal automated CO_2 laser extraction line. Results are summarized in Table 1 and detailed in Table 2 and Figure 1. Table 2 footnotes include details of the instrumentation and analytical parameters.

Sanidine from sample SX-050, a welded ignimbrite underlying the fossiliferous deposit, provided the highest quality age determination. Twenty-eight single crystals yielded ages ranging from 38.76 ±0.09 Ma to 39.89 ± 0.08 Ma. A probability plot of these data (Fig. 1a, Table 2) suggests a unimodal Gaussian distribution, although the scatter in the data (MSWD = 10.9) is somewhat higher that would be expected from analytical uncertainty alone. Excluding results from the youngest crystal, the weighted mean age of twenty-seven crystals is 39.52 ± 0.11 Ma (2 sigma error). We interpret this as an accurate determination of the eruption age of the ignimbrite.

Plagioclase grains from SX-050 and SX-010 were too small for precise single-crystal analyses. Aliquots of 10 to 30 crystals were analyzed by two-step laser-incremental heating. The initial laser-heating step for each analysis was used to remove atmospheric argon. Data from these initial steps have very low precision and are not included in Table 2 or Figure 1.

The four aliquots of crystals plagioclase from the SX-050 yielded a weighted mean age of 39.17 ± 0.21 Ma (Fig. 2b, Table 2), which is analytically indistinguishable from the sanidine result described above.

Dating of plagioclase from sample SX-010 of the fossil-bearing ash-fall deposit was complicated by pervasive clay-alteration of the crystals. No sanidine was found in this unit. Data from five aliquots of plagioclase crystals produced reasonably precise ages (Table 2), which are bimodally distributed (Fig. 2c, Table 2). The ages of three aliquots overlap and yield a weighted mean age of 39.35 ± 0.21 Ma, which we interpret as the eruption age of this unit. The apparent ages of the other two aliquots are younger, near 38.2 Ma. We interpret these anomalously young ages as being due to alteration. Analysis of additional crystals might facilitate more confident interpretation of this apparent bimodal age distribution.

Table 1. Summary of $^{40}Ar/^{39}Ar$ results from Sexi, Peru samples.

Sample	Unit	Location	L#	Irrad	min	Mean Age						
						analysis	n	MSWD	K/Ca	± 2s	Age(Ma)	± 2s
SX-050	welded ignimbrite	S6 31.834 W79 02.874	56307	NM-196M	Sanidine	Mean	27	10.9	58.7	± 45.1	39.52	± 0.11
SX-050	welded ignimbrite	S6 31.834 W79 02.874	56311	NM-196N	Plagioclase	Mean	4	2.6	0.6	± 0.1	39.17	± 0.21
SX-010	white ash above paleosol	S6 34.188 W79 02.048	56310	NM-196N	Plagioclase	Mean	3	0.4	0.2	± 0.0	39.35	± 0.21

Table 2. $^{40}Ar/^{39}Ar$ analytical data.

	ID	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-15} mol)	K/Ca	$^{40}Ar^*$ (%)	Age (Ma)	±1σ (Ma)
	SX-050, Sanidine, J=0.0009108±0.05%, D=1.002±0.001, NM-196M, Lab#=56307								
x	06	24.25	0.0179	1.385	4.412	28.6	98.3	38.764	0.089
	01	24.27	0.0057	0.9105	5.727	89.2	98.9	39.005	0.075
	04	24.26	0.0092	0.8310	3.307	55.7	99.0	39.032	0.088
	27	24.18	0.0275	0.2959	6.365	18.6	99.6	39.162	0.068
	10	24.29	0.0136	0.5668	5.422	37.6	99.3	39.208	0.067
	13	24.31	0.0057	0.5477	2.217	89.7	99.3	39.24	0.10
	20	24.27	0.0324	0.3378	5.182	15.7	99.6	39.287	0.084
	16	24.34	0.0113	0.5595	3.550	45.2	99.3	39.295	0.089
	11	24.41	0.0055	0.6774	5.954	92.0	99.2	39.348	0.073
	17	24.33	0.0067	0.3533	3.987	75.9	99.6	39.378	0.088
	24	24.38	0.0067	0.4547	2.258	76.4	99.5	39.41	0.11
	15	24.51	0.0122	0.7904	7.942	41.7	99.1	39.454	0.068
	23	24.44	0.0129	0.5545	8.156	39.4	99.3	39.464	0.067
	09	25.02	0.0065	2.327	4.099	78.9	97.3	39.546	0.080
	12	24.47	0.0085	0.4781	5.912	59.9	99.4	39.547	0.068
	07	24.55	0.0076	0.7070	5.442	66.8	99.2	39.561	0.083
	05	24.53	0.0065	0.5101	2.150	78.5	99.4	39.61	0.12
	08	24.47	0.0410	0.2647	7.354	12.5	99.7	39.649	0.066
	18	24.46	0.0106	0.2003	4.565	47.9	99.8	39.651	0.078
	19	24.49	0.0082	0.2360	4.082	62.2	99.7	39.681	0.080
	21	24.47	0.0175	0.1149	4.750	29.2	99.9	39.721	0.088
	14	24.48	0.0089	0.1404	3.762	57.2	99.8	39.721	0.073
	02	24.50	0.0073	0.1738	2.279	69.7	99.8	39.74	0.10
	28	24.58	0.0067	0.3795	7.319	75.9	99.5	39.766	0.069
	26	24.57	0.0068	0.2138	6.876	74.7	99.7	39.830	0.062
	25	24.63	0.0086	0.3939	4.980	59.6	99.5	39.841	0.079
	03	24.65	0.0072	0.3857	5.031	71.0	99.5	39.870	0.077
	22	24.95	0.0079	1.372	3.369	64.8	98.4	39.889	0.081
	Mean age ± 2σ	n=27		MSWD=10.92		58.7 ±45.1		39.52	0.11
	SX-050, Plagioclase, J=0.000918±0.11%, D=1.002±0.001, NM-196N, Lab#=56311								
	03B	24.92	1.035	4.311	1.834	0.49	95.2	38.90	0.13
	04B	24.52	0.9491	2.353	2.180	0.54	97.5	39.19	0.11
	02B	24.43	0.9718	1.988	2.753	0.52	97.9	39.209	0.099
	05B	24.98	0.7859	3.333	1.468	0.65	96.3	39.43	0.15
x	01B	25.77	1.047	4.931	2.610	0.49	94.7	39.99	0.11
	Mean age ± 2σ	n=4		MSWD=2.58		0.55 ±0.14		39.17	0.21
	SX-010, Plagioclase, J=0.0009167±0.11%, D=1.002±0.001, NM-196N, Lab#=56310								
x	03B	23.63	2.764	2.035	2.123	0.18	98.4	38.12	0.12
x	01B	25.79	3.059	9.047	1.935	0.17	90.6	38.31	0.15
	02B	24.20	2.763	1.512	1.668	0.18	99.1	39.29	0.14
	05B	24.28	3.318	1.900	1.275	0.15	98.8	39.34	0.18
	04B	24.76	3.152	3.093	0.841	0.16	97.4	39.52	0.21
	Mean age ± 2σ	n=3		MSWD=0.38		0.17 ±0.03		39.35	0.21

Notes:

Age calculations:

x symbol preceding sample ID denotes analyses excluded from mean age calculations.

Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard (28.02 Ma, Renne et al, 1998).

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

Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties.

Mean age is weighted mean age of Taylor (1982). Mean age error is weighted error of the mean (Taylor, 1982), multiplied by the root of the MSWD where MSWD>1, and also incorporates uncertainty in J factors and irradiation correction uncertainties.

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

All weighted-mean age errors reported at $\pm 2\sigma$.

Sample preparation and irradiation:

Feldspar separates prepared using crushing, dilute HCl acid treatment, Franz magnetic separator, and hand-picking techniques.

Samples were loaded into machined Al discs and irradiated in one batch (NM-196) for 9 hours in the D-3 position, Nuclear Science Center, College Station, TX.

Neutron flux monitor Fish Canyon Tuff sanidine (FC-1).

Instrumentation:

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

Samples were fused or heated in two steps usung a Synra]d 50 watt CO2 laser (heating duration 30 seconds).

Reactive gases removed during furnace analysis by reaction with 2 SAES GP-50 getters, 1 operated at ~450°C and 1 at 20°C. Gas also exposed to a W filament operated at ~2000°C.

Analytical parameters:

Electron multiplier sensitivity averaged 4.7 x 10-17 moles/pA for the furnace extraction system.

Total system blank and background for the furnace averaged 224,3.7,1.5,2.9,6.3 x 10^{-18} moles.

J-factors determined to a precision of ± 0.1% by CO_2 laser-fusion of 6 single crystals from each of 6 radial positions around the irradiation tray.

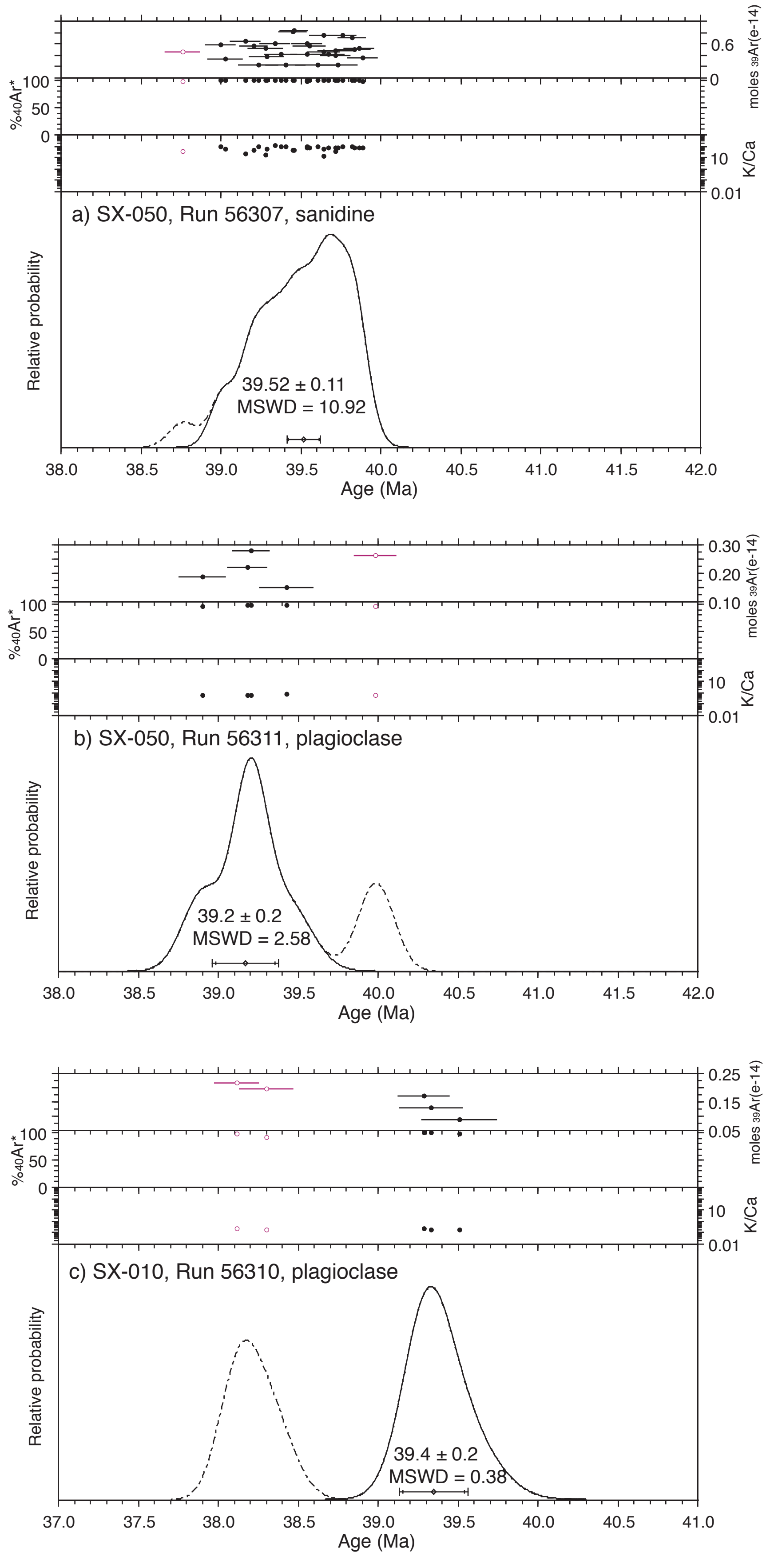
Correction factors for interfering nuclear reactions were determined using K-glass and CaF_2 and are as follows:

$(^{39}Ar/^{37}Ar)_{Ca} = 0.000676 \pm 4e\text{-}06$

$(^{36}Ar/^{37}Ar)_{Ca} = 0.000277 \pm 2e\text{-}06$

$(^{38}Ar/^{39}Ar)_{K} = 0.0126$

$(^{40}Ar/^{39}Ar)_{K} = 0 \pm 0.0004$



Appendix Figure 1. Probability distribution plots (Deino and Potts, 1992) for 40Ar/39Ar laser-fusion anlyses of El Bosque Petrificiado Piedra Chamana samples. a) sanidine from welded ignimbrite, b) plagioclase from welded ignimbrite, c) plagioclase from white ash above paleosol.

References for Data Repository

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