

Appendix 1. Summary of analytical methods and instrumentation.

**Summary**

Sample	L#	mat	Plateau					Isochron						
			Age	±	MSWD	% <sup>39</sup> Ar	n	Age	±	<sup>40</sup> Ar/ <sup>36</sup> Ar <sub>i</sub>	±	MSWD	Steps	n
TRC-20h clast	65424	gm	4.54	0.02	2.94	34.8	7	4.490	0.030	308.0	10.0	3.23	G-M	7
								4.460	0.010					
16C-516 clast	65426	gm	5.13	0.02	5.13	27.9	7	5.060	0.030	319.0	5.0	1.22	G-M	7
								5.430	0.010					

L# = Lab number  
 mat = material dated. gm = groundmass concentrate  
 n = number of steps for plateau or isochron used for age calculation.  
 %<sup>39</sup>Ar = percentage of total <sup>39</sup>Ar comprising the plateau steps.  
 All errors at 1σ  
 Age in box is preferred eruption age.

**Analytical Methods and Instrumentation**

**Sample preparation and irradiation:**

Groundmass prepared by crushing, cleaning in 5% HCl and hand-picking fragments devoid of phenocrysts. Samples were loaded into machined Al discs and irradiated for 8 hours, USGS TRIGA Reactor, Denver, CO Neutron flux monitor Fish Canyon Tuff sanidine (FC-2). Assigned age = 28.201 Ma (Kuiper et al., 2008).

**Instrumentation:**

Thermo-Fisher Scientific Helix MC Plus mass spectrometer on line with automated all-metal extraction system.

System = Felix

Multi-collector configuration: 40Ar-H2, 39Ar-H1, 38Ar-Ax, 37Ar-L1, 36Ar-L2

Amplification: H2, H1, AX, L1 all 1E12 Ohm Faraday, L2 - CDD ion counter, deadtime 20 nS.

**Laser Step-heating:**

Samples step-heated with 50W Photon-Machines diode laser (40 second heating)

Reactive gases removed by 1 min reaction with a SAES GP-50 getter operated 450°C.

Gas also exposed to cold finger operated at -140°C..

**Analytical parameters:**

Mass spectrometer sensitivity = 2.5E-16 mol/fA

Total system blank and background: 1±5%, 0.1±65%, 0.05±75%, 0.01±200%, 0.004±10%, x 10<sup>-17</sup> moles for masses 40, 39, 38, 37, 36, respectively.

J-factors determined to a precision of ~± 0.02% by CO<sub>2</sub> laser-fusion of 6 single crystals from each of 8 radial positions around the irradiation tray.

ID	Power (Watts)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ ( $\times 10^{-3}$ )	$^{39}\text{Ar}_k$ ( $\times 10^{-15}$ mol)	K/Ca	$^{40}\text{Ar}^*$ (%)	$^{39}\text{Ar}$ (%)	Age (Ma)	$\pm 1\sigma$ (Ma)
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**TRC-20h**, Groundmass, 12.53 mg, J=0.0018779 $\pm$ 0.02%, IC=0.9915652 $\pm$ 0.0030035, NM-288B, Lab#=65424-01

Xi A	0.5	13.51	0.9864	41.55	1.5	0.52	9.7	1.2	4.49	0.22
Xi B	0.8	3.610	0.5610	6.874	9.5	0.91	44.9	8.9	5.549	0.037
Xi C	1.3	1.717	0.3675	0.9379	32.2	1.4	85.5	35.0	5.019	0.008
Xi D	1.6	1.492	0.4015	0.4169	17.7	1.3	93.8	49.4	4.785	0.007
Xi E	1.9	1.458	0.4898	0.4182	11.3	1.0	94.1	58.6	4.692	0.010
Xi F	2.2	1.449	0.7340	0.5129	8.1	0.70	93.5	65.2	4.629	0.013
G	3.0	1.528	2.360	1.328	13.4	0.22	86.4	76.1	4.517	0.013
H	5.0	1.697	3.823	2.274	20.5	0.13	78.0	92.7	4.537	0.014
I	6.0	1.725	4.200	2.459	3.9	0.12	76.9	95.9	4.547	0.034
J	7.0	1.617	5.055	2.298	1.8	0.10	82.5	97.3	4.574	0.056
K	8.5	1.697	5.762	2.595	1.1	0.089	81.4	98.2	4.737	0.091
L	10.0	1.613	6.188	2.421	1.5	0.082	85.7	99.4	4.744	0.068
M	15.0	1.618	7.116	2.795	0.7	0.072	83.3	100.0	4.63	0.13
<b>Integrated age <math>\pm 1\sigma</math></b>			n=13		123.2		K2O=2.01%		4.799	0.006
<b>Plateau <math>\pm 1\sigma</math></b>	steps G-M		n=7	MSWD=2.94				34.8	4.535	0.016
<b>Isochron<math>\pm 1\sigma</math></b>	steps G-M		n=7	MSWD=3.23		$^{40}\text{Ar}/^{36}\text{Ar} =$	308.1 $\pm$ 9.8		4.493	0.034
<b>Isochron<math>\pm 1\sigma</math></b>	steps C-F		n=4	MSWD=30.3		$^{40}\text{Ar}/^{36}\text{Ar} =$	459.2 $\pm$ 7.6		4.556	0.014

ID	Power (Watts)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ ( $\times 10^{-3}$ )	$^{39}\text{Ar}_k$ ( $\times 10^{-15}$ mol)	K/Ca	$^{40}\text{Ar}^*$ (%)	$^{39}\text{Ar}$ (%)	Age (Ma)	$\pm 1\sigma$ (Ma)
<b>16C-516</b> , Groundmass, 13.91 mg, J=0.0018728 $\pm$ 0.02%, IC=0.9915652 $\pm$ 0.0030035, NM-288B, Lab#=65426-01										
Xi A	0.5	19.38	1.347	59.34	1.2	0.38	10.0	0.9	6.67	0.31
Xi B	0.8	7.147	0.8046	17.78	6.8	0.63	27.3	5.7	6.679	0.079
Xi C	1.3	2.097	0.4894	1.472	34.8	1.0	81.0	30.3	5.797	0.009
Xi D	1.6	1.679	0.4641	0.3150	31.6	1.1	96.6	52.6	5.532	0.005
Xi E	1.9	1.619	0.5472	0.2725	17.5	0.93	97.7	65.0	5.390	0.007
Xi F	2.2	1.599	0.7456	0.3578	10.1	0.68	97.0	72.1	5.290	0.011
G	3.0	1.595	2.408	0.9879	11.5	0.21	93.5	80.2	5.091	0.014
H	5.0	1.738	4.896	2.108	14.2	0.10	86.2	90.3	5.123	0.016
I	6.0	1.893	4.263	2.404	7.5	0.12	80.1	95.5	5.183	0.024
J	7.0	2.177	4.641	3.430	2.1	0.11	70.1	97.0	5.222	0.063
K	8.5	2.330	5.283	3.976	1.9	0.097	67.3	98.3	5.368	0.069
L	10.0	2.486	6.028	4.733	1.3	0.085	62.7	99.2	5.339	0.096
M	15.0	2.523	6.109	5.091	1.1	0.084	59.2	100.0	5.12	0.11
<b>Integrated age <math>\pm 1\sigma</math></b>		n=13		141.5		K <sub>2</sub> O=2.09%		5.520		0.006
<b>Plateau <math>\pm 1\sigma</math></b>		steps G-M	n=7	MSWD=5.25				27.9	5.126	0.021
<b>Isochron <math>\pm 1\sigma</math></b>		steps G-M	n=7	MSWD=1.22		$^{40}\text{Ar}/^{36}\text{Ar} =$	319.3 $\pm$ 5.0	5.063		0.016
<b>Isochron <math>\pm 1\sigma</math></b>		steps C-E	n=3	MSWD=134		$^{40}\text{Ar}/^{36}\text{Ar} =$	378.5 $\pm$ 3.0	5.432	0.006	

**Notes:**

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.

Integrated age calculated by summing isotopic measurements of all steps.

Integrated age error calculated by quadratically combining errors of isotopic measurements of all steps.

Plateau age is inverse-variance-weighted mean of selected steps.

Plateau age error is inverse-variance-weighted mean error (Taylor, 1982) times root MSWD > 1.

Plateau error is weighted error of Taylor (1982).

Isochron age and error following York (1969).

Isotopic abundances after Steiger and Jäger (1977).

X preceding sample ID denotes analyses excluded from plateau age calculations.

i preceding sample ID denotes analyses excluded from plateau age calculations.

IC = detector intercalibration: Measured  $^{40}\text{Ar}/^{36}\text{Ar}$  of air standard divided by 295.5

Weight percent K<sub>2</sub>O calculated from  $^{39}\text{Ar}$  signal, sample weight, and instrument sensitivity.

Ages calculated relative to FC-2 Fish Canyon Tuff sanidine standard at 28.201 Ma (Kuiper et al., 2008)

Decay Constant (LambdaK (total)) = 5.463e-10/a (Min et al., 2000)

Date highlighted in box is preferred eruption age

Correction factors:

$$(^{39}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 0.0006752 \pm 0.000002$$

$$(^{36}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 0.0002653 \pm 0.0000003$$

$$(^{40}\text{Ar}/^{39}\text{Ar})_k = 0.00697 \pm 0.0004$$