

**Appendix A.**

**$^{40}\text{Ar}/^{39}\text{Ar}$  analytical data**

**For:**

**Geochemical and geochronological characterization of Grand Mesa Volcanic Field,  
western Colorado**

REX COLE<sup>1</sup>, ALLEN STORK<sup>2</sup>, WILLIAM HOOD<sup>1</sup>, and MATT HEIZLER<sup>3</sup>

<sup>1</sup>Department of Physical and Environmental Sciences  
Colorado Mesa University  
1100 North Ave.  
Grand Junction, CO 81501  
[rcole@coloradomesa.edu](mailto:rcole@coloradomesa.edu)

<sup>2</sup>Department of Natural and Environmental Sciences  
Western State Colorado University  
600 North Adams Street  
Gunnison, CO 81231

<sup>3</sup>New Mexico Bureau of Geology  
New Mexico Institute of Mining and Technology  
801 Leroy Place  
Socorro, NM 87801

$^{40}\text{Ar}/^{39}\text{Ar}$  analyses were conducted on 20 groundmass samples from basalt flows and mafic dikes over the course of about 16 years at the New Mexico Geochronology Research Laboratory. All samples were step-heated to provide incremental heating age spectra. A summary of the age results is provided in Table A1 and analytical methods and detailed analytical data are given in Tables A2 and A3, respectively. Age spectra are plotted in Figures A1 and A2. All data are reported relative to Fish Canyon sanidine with an assigned age of 28.201 Ma (Kuiper et al., 2008) and a total  $^{40}\text{K}$  decay constant of  $5.463\text{e-}10$  /a (Min et al., 2000).

Age spectra are variable in shape and complexity, however a weighted mean age (plateau age) based on the inverse variance is calculated for 19 of the 20 samples. The number of steps chosen for the plateau segment is based on using consecutive steps that yielded an MSWD value less than 15. This is somewhat arbitrary, but because complexity of the spectra is likely related to a combination of factors such as minor excess argon and/or argon loss coupled with  $^{39}\text{Ar}$  recoil artifacts it was deemed prudent to include steps that did not always define a normal distribution. In general higher temperature steps were the most concordant and thus these steps dominate the plateau segments. Sample GM-1 (Figure A1(d)) was unusual with two semi-flat segments that have no unambiguous explanation and thus the integrated age was chosen as the preferred eruption age.

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- 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.

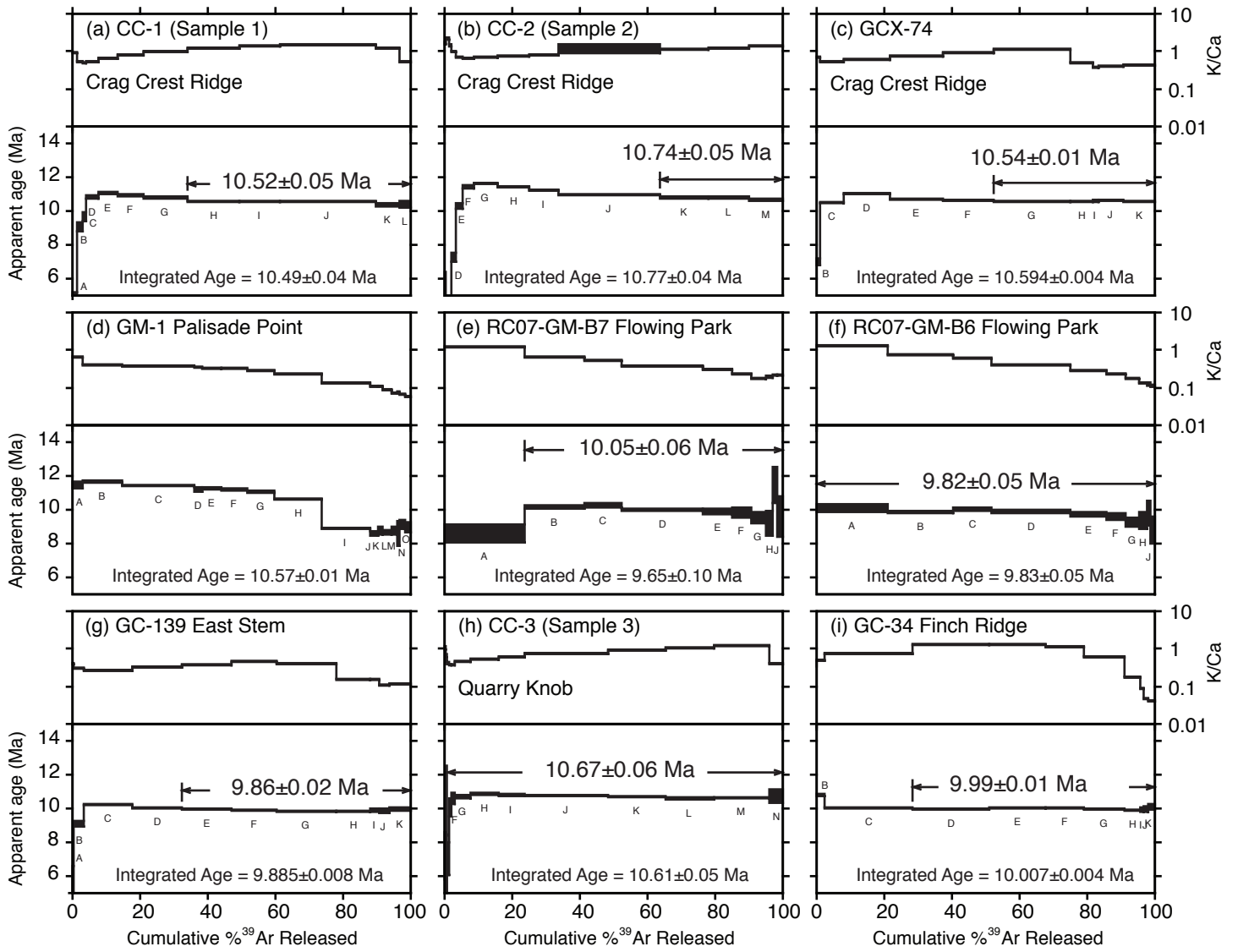


Figure A1. Age and K/Ca diagrams for Grand Mesa area basalt flows and dikes.

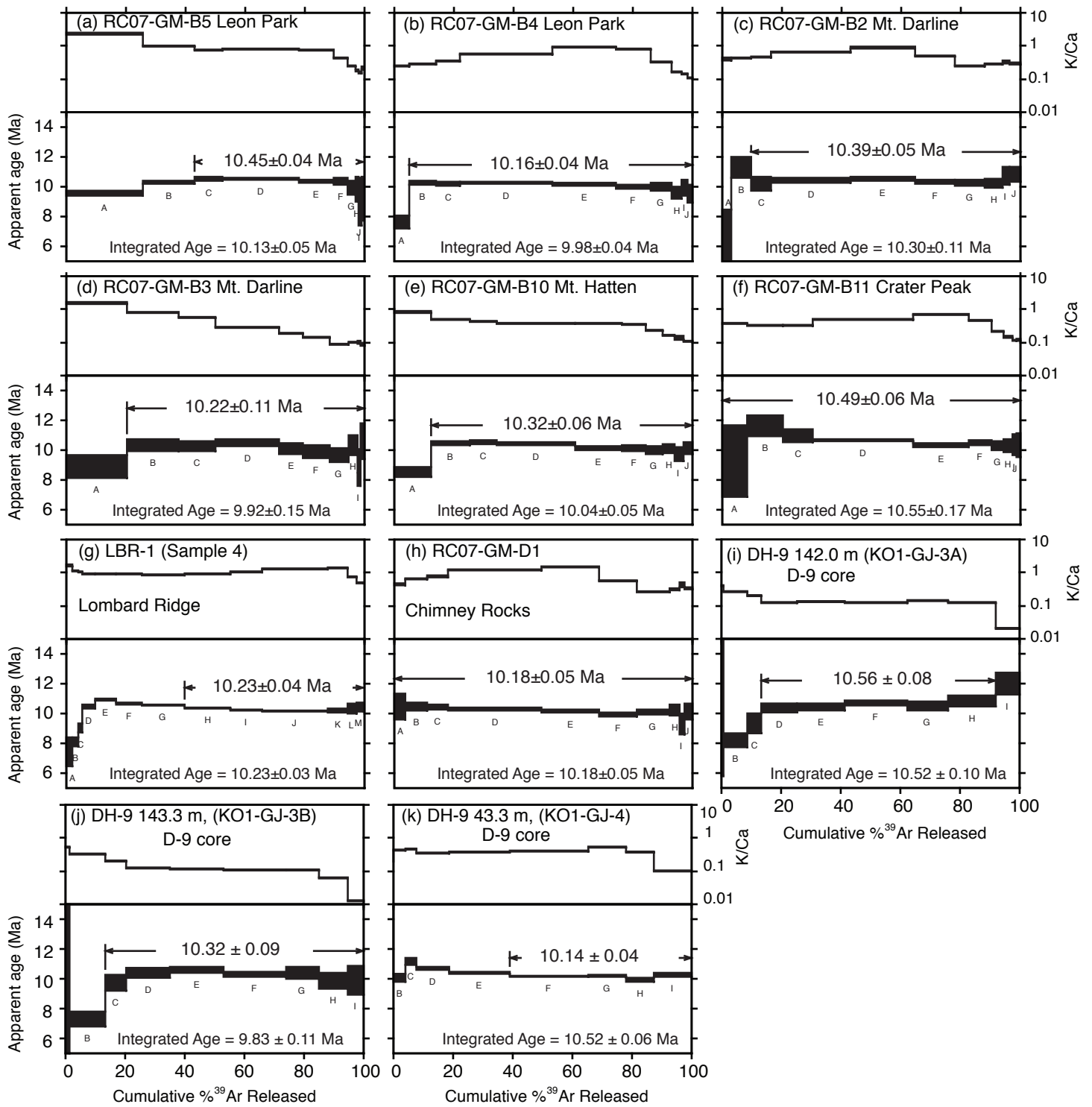


Figure A2. Age and K/Ca diagrams for Grand Mesa area basalt flows and dikes.

Table A1. Summary of geochronology data and supporting information.

Summary of  $^{40}\text{Ar}/^{39}\text{Ar}$  results

Sample	Lab Name	Location	L#	Irrad	Preferred Age					Integrated Age			MS	
					analysis	n	% $^{39}\text{Ar}$	MSWD	Age(Ma)	$\pm 1\sigma$	n	Age(Ma)		$\pm 1\sigma$
GM 1	GM 1	Palisade Point	61551-02	NM-256A	Integrated	16	100.0	na	10.57	$\pm 0.01$	16	10.42	$\pm 0.01$	O
RC07-GM-B2	RC07-GM-B2	Mt. Darline	58946-01	NM-224B	Plateau	8	90.3	1.9	10.39	$\pm 0.05$	10	10.30	$\pm 0.11$	M
RC07-GM-B7	RC07-GM-B7	Flowing Park	58947-01	NM-224B	Plateau	9	76.2	6.1	10.05	$\pm 0.06$	10	9.65	$\pm 0.08$	M
RC07-GM-B6	RC07-GM-B6	Flowing Park	58948-01	NM-224B	Plateau	10	100.0	5.9	9.82	$\pm 0.05$	10	9.83	$\pm 0.05$	M
RC07-GM-D1	RC07-GM-D1	Chimney Rocks	58949-01	NM-224B	Plateau	10	100.0	4.4	10.18	$\pm 0.05$	10	10.18	$\pm 0.05$	M
RC07-GM-B5	RC07-GM-B5	Leon Park	58950-01	NM-224B	Plateau	8	56.8	3.1	10.45	$\pm 0.04$	10	10.13	$\pm 0.05$	M
RC07-GM-B4	RC07-GM-B4	Leon Park	58951-01	NM-224B	Plateau	9	94.7	4.3	10.16	$\pm 0.04$	10	9.98	$\pm 0.04$	M
RC07-GM-B3	RC07-GM-B3	Mt. Darline	58952-01	NM-224C	Plateau	9	79.6	2.7	10.22	$\pm 0.11$	10	9.92	$\pm 0.14$	M
RC07-GM-B11	RC07-GM-B11	Crater Peak	58953-01	NM-224C	Plateau	10	100.0	4.5	10.49	$\pm 0.07$	10	10.55	$\pm 0.16$	M
RC07-GM-B10	RC07-GM-B10	Mt. Hatten	58954-01	NM-224C	Plateau	9	87.6	5.8	10.32	$\pm 0.06$	10	10.04	$\pm 0.05$	M
GCX-74	GCX-74	Crag Crest Ridge	65459-01	NM-288K	Plateau	5	47.5	5.6	10.54	$\pm 0.01$	11	10.59	$\pm 0.00$	F
GC-139	GC-139	East Stem	65460-01	NM-288K	Plateau	7	67.5	7.6	9.86	$\pm 0.02$	11	9.89	$\pm 0.01$	F
GC-34	GC-34	Finch Ridge	65461-01	NM-288K	Plateau	8	71.6	15.0	9.99	$\pm 0.01$	11	10.01	$\pm 0.00$	F
CC-1	Sample 1	Crag Crest Ridge	59635-01	NM-234A	Plateau	5	66.0	6.8	10.52	$\pm 0.05$	12	10.49	$\pm 0.04$	M
CC-2	Sample 2	Crag Crest Ridge	59636-01	NM-234A	Plateau	3	36.1	6.5	10.74	$\pm 0.05$	13	10.77	$\pm 0.04$	M
CC-3	Sample 3	Quarry Knob	59637-01	NM-234A	Plateau	11	99.1	12.8	10.67	$\pm 0.06$	14	10.61	$\pm 0.05$	M
LBR-1	Sample 4	Lombard Ridge	59638-01	NM-234A	Plateau	6	60.2	6.9	10.23	$\pm 0.06$	13	10.23	$\pm 0.05$	M
DH-9 (43.3 m)	K01-GJ-4	D-9 Core	52564-01	NM-141	Plateau	4	60.8	3.4	10.14	$\pm 0.04$	9	10.52	$\pm 0.06$	M
DH-9 (142.0 m)	K01-GJ-3A	D-9 Core	52562-01	NM-141	Plateau	5	78.6	2.2	10.56	$\pm 0.08$	9	10.52	$\pm 0.10$	M
DH-9 (143.3 m)	K01-GJ-3B	D-9 Core	52563-01	NM-141	Plateau	7	86.5	2.4	10.32	$\pm 0.09$	9	9.83	$\pm 0.11$	M

Notes

L# - Lab Identifier

All samples are Groundmass Concentrates

Irrad = Irradiation: NM-141 Texas A&M Reactor, 14 hours; NM-224 = USGS Denver, 5 hours; NM-234 = USGS Denver, 10 hours; NM-256 = USGS Denver, 20 hours;

NM-288 = USGS Denver, 8 hours

n - number of steps on the plateau or total number of steps

na - not applicable

MS - Mass spectrometer: O = Obama, ARGUS VI; M = MAP-215-50; F = Felix, Helix MC-plus

Correction Factors:

	$(^{40}\text{Ar}/^{39}\text{Ar})_k$	$\pm$	$(^{39}\text{Ar}/^{37}\text{Ar})_{ca}$	$\pm$	$(^{36}\text{Ar}/^{37}\text{Ar})_{ca}$	$\pm$
NM-141	0.0002	0.0003	0.0007	2.00E-05	0.00028	5.00E-06
NM-224	0.01	0.002	0.0007	2.00E-06	0.00028	0.00002
NM-234	0.01	0.002	0.0007	2.00E-06	0.00028	0.00002
NM-256	0.008068	0.000068	0.000698	7.80E-06	0.000273	2.00E-07
NM-288	0.00697	0.0004	0.0006752	1.76E-06	0.0002653	3.40E-07

Table A2. Analytical methods.

Methods
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**Sample preparation and irradiation:**

Groundmass concentrated by coarse crushing and picking fragments visibly free of phenocrysts.  
Samples were loaded into machined Al discs and irradiated in 5 separate batches (Table A1).  
Neutron flux monitor Fish Canyon Tuff sanidine (FC-2). Assigned age = 28.201 Ma; Kuiper et al. (2008).

**Instrumentation and analytical parameters:**

Mass Analyzer Products 215-50 mass spectrometer on line with automated all-metal extraction system.  
NM-141 samples. Step-heated using a Mo double vacuum resistance furnace.

MAP-215-50

Heating duration = 8 minutes

Gas exposed to a GP-50 Getter (450°C) during heating

Gas cleaned in 2<sup>nd</sup> stage after heating for 7 minutes with two SAES GP-50 getters. One operated at ~450°C and one at 20°C.

Gas also exposed to a W filament operated at ~2000°C while in 2<sup>nd</sup> stage.

Blank = 120, 0.8, 0.1, 1.9, 0.7 x 10<sup>-17</sup> moles for masses 40, 39, 38, 37, 36, respectively.

Sensitivity 1.5 x 10<sup>-16</sup> moles/pA.

NM-224 samples. Step-heated using a 50 W CO<sub>2</sub> laser.

MAP-215-50

Heating duration = 60 seconds

Reactive gases removed by a 3 minute exposure to two SAES GP-50 getters. One operated at ~450°C and one at 20°C.

Gas also exposed to a W filament operated at ~2000°C and a cold finger operated at -140°C.

Blank = 185, 1.2, 0.2, 1.8, 0.8 x 10<sup>-17</sup> moles for masses 40, 39, 38, 37, 36, respectively.

Sensitivity 5 x 10<sup>-17</sup> moles/pA.

NM-234 samples. Step-heated using a 50 W CO<sub>2</sub> laser.

MAP-215-50

Heating duration = 60 seconds

Reactive gases removed by a 4 minute exposure to two SAES GP-50 getters. One operated at ~450°C and one at 20°C.

Gas also exposed to a W filament operated at ~2000°C and a cold finger operated at -140°C.

Blank = 80, 0.7, 0.2, 0.7, 0.5 x 10<sup>-17</sup> moles for masses 40, 39, 38, 37, 36, respectively.

Sensitivity 5 x 10<sup>-17</sup> moles/pA.

NM-256 samples. Step-heated using a 75 W Diode laser.

ARGUS VI (Obama)

Heating duration = 60 seconds

Multi-collector configuration: 40Ar-H1, 39Ar-Ax, 38Ar-L1, 37Ar-L2, 36Ar-L3

Amplification: H1, L1, L2 1E12 Ohm Faraday, AX 1E13 Ohm Faraday, L3 - CDD ion counter, deadtime 18 nS.

Reactive gases removed by a 8 minute exposure to one SAES GP-50 getter operated ~450°C.

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

Blank = 50, 0.7, 0.4, 0.3, 0.2 x 10<sup>-17</sup> moles for masses 40, 39, 38, 37, 36, respectively.

Sensitivity 1 x 10<sup>-16</sup> moles/fA.

NM-288 samples. Step-heated using a 75 W Diode laser.

Helix MC-Plus (Felix)

Heating duration = 40 seconds

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

Amplification: H2, H1, Ax, L1, L2 1E12 Ohm Faraday, L3 - CDD ion counter, deadtime 20 nS.

Reactive gases removed by a 1.5 minute exposure to one SAES GP-50 getter operated ~450°C.

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

Blank = 15, 0.3, 0.2, 0.2, 0.06 x 10<sup>-17</sup> moles for masses 40, 39, 38, 37, 36, respectively.

Sensitivity 2.5 x 10<sup>-16</sup> moles/fA.

J-factors determined to variable precision (Table A3) with typically 6 FC-2 sanidine grains analyzed from at least 4 radial positions around the irradiation tray.

Table A3. <sup>40</sup>Ar/<sup>39</sup>Ar isotopic results for groundmass samples.

ID	Power/Temp (Watts/°C)	<sup>40</sup> Ar/ <sup>39</sup> Ar	<sup>37</sup> Ar/ <sup>39</sup> Ar	<sup>36</sup> Ar/ <sup>39</sup> Ar (x 10 <sup>-3</sup> )	<sup>39</sup> Ar <sub>K</sub> (x 10 <sup>-15</sup> mol)	K/Ca	<sup>40</sup> Ar* (%)	<sup>39</sup> Ar (%)	Age (Ma)	±1σ (Ma)
<b>GM 1, 7.45 mg, J=0.0047771±0.04%, IC=1.02298±0.00118, NM-256A, Lab#=61551-02</b>										
X A	17.5	2.764	0.7900	5.107	5.197	0.65	47.6	3.1	11.436	0.091
X B	18.0	1.474	1.304	0.8057	19.111	0.39	90.9	14.7	11.630	0.020
X C	18.5	1.374	1.396	0.5691	35.432	0.37	95.9	36.1	11.434	0.013
X D	19.0	1.332	1.421	0.5335	4.193	0.36	96.8	38.6	11.179	0.071
X E	19.5	1.333	1.515	0.5503	9.016	0.34	97.0	44.0	11.212	0.034
X F	20.0	1.324	1.582	0.5649	13.184	0.32	97.0	52.0	11.145	0.029
X G	20.5	1.316	1.782	0.6414	12.852	0.29	96.5	59.8	11.018	0.028
X H	20.5	1.291	2.192	0.8400	23.234	0.23	94.4	73.8	10.583	0.019
X I	22.0	1.127	3.759	1.393	23.567	0.14	90.4	88.0	8.842	0.020
X J	26.0	1.120	4.728	1.740	3.952	0.11	88.1	90.4	8.573	0.080
X K	28.0	1.151	4.728	1.787	2.469	0.11	87.2	91.9	8.72	0.12
X L	30.0	1.121	5.752	2.000	4.601	0.089	88.6	94.7	8.638	0.072
X M	35.0	1.181	7.298	2.592	2.507	0.070	84.9	96.2	8.74	0.13
X N	40.0	1.456	6.836	3.464	0.829	0.075	67.4	96.7	8.56	0.38
X O	45.0	1.585	7.868	3.981	2.746	0.065	65.7	98.3	9.08	0.13
X P	50.0	2.084	8.641	5.945	2.753	0.059	49.0	100.0	8.92	0.14
<b>Integrated age ± 1σ</b>			n=16		165.642	0.21	K2O=1.79%		10.573	0.010
<b>No Plateau</b>										
<b>RC07-GM-B2, 21.09 mg, J=0.0010712±0.06%, D=1.004±0.001, NM-224B, Lab#=58946-01</b>										
X A	3	134.9	1.318	447.1	2.92	0.39	2.2	3.1	5.7	1.4
X B	4	37.39	1.239	107.3	6.18	0.41	15.4	9.7	11.27	0.36
C	5	22.31	1.167	58.15	6.35	0.44	23.4	16.4	10.20	0.23
D	6	11.10	0.8159	19.74	25.1	0.63	48.0	43.2	10.421	0.080
E	8	8.379	0.5864	10.32	20.3	0.87	64.1	64.8	10.500	0.066
F	10	8.018	1.067	9.590	12.6	0.48	65.7	78.2	10.297	0.078
G	13	9.102	2.059	13.65	9.42	0.25	57.5	88.2	10.240	0.096
H	16	10.92	1.827	19.83	5.58	0.28	47.7	94.2	10.19	0.15
I	18	14.78	1.622	31.93	2.17	0.31	37.0	96.5	10.70	0.29
J	25	15.82	1.803	35.38	3.31	0.28	34.8	100.0	10.78	0.25
<b>Integrated age ± 1σ</b>			n=10		93.9	0.46	K2O=1.60%		10.15	0.11
<b>Plateau ± 1σ</b>	steps C-J		n=8	MSWD=1.88	84.8	0.56 ±0.22	90.3		10.385	0.050
<b>RC07-GM-B7, 18.66 mg, J=0.0010712±0.07%, D=1.004±0.001, NM-224B, Lab#=58947-01</b>										
X A	3	14.86	0.4394	35.60	20.2	1.2	29.4	23.8	8.56	0.26
B	4	6.277	0.8207	3.891	14.9	0.62	82.7	41.4	10.145	0.043
C	5	6.244	0.9799	3.696	9.5	0.52	83.8	52.6	10.220	0.057
D	6	6.149	1.389	3.957	20.3	0.37	82.8	76.5	9.953	0.042
E	8	7.882	1.700	10.02	7.48	0.30	64.2	85.3	9.894	0.085
F	10	10.48	2.349	19.12	4.73	0.22	47.9	90.9	9.82	0.15
G	13	11.03	3.043	21.71	3.66	0.17	44.1	95.2	9.51	0.17
H	16	16.68	2.718	41.36	1.78	0.19	28.1	97.3	9.17	0.36
I	18	25.94	2.393	68.62	1.01	0.21	22.6	98.5	11.45	0.53
J	25	30.02	2.365	85.69	1.27	0.22	16.3	100.0	9.58	0.61
<b>Integrated age ± 1σ</b>			n=10		84.7	0.42	K2O=1.63%		9.509	0.078
<b>Plateau ± 1σ</b>	steps B-J		n=9	MSWD=6.05	64.6	0.41 ±0.16	76.2		10.046	0.061

Table A3. 40Ar/39Ar isotopic results for groundmass samples.

ID	Power/Temp (Watts/°C)	<sup>40</sup> Ar/ <sup>39</sup> Ar	<sup>37</sup> Ar/ <sup>39</sup> Ar	<sup>36</sup> Ar/ <sup>39</sup> Ar (x 10 <sup>-3</sup> )	<sup>39</sup> Ar <sub>K</sub> (x 10 <sup>-15</sup> mol)	K/Ca	<sup>40</sup> Ar* (%)	<sup>39</sup> Ar (%)	Age (Ma)	±1σ (Ma)
<b>RC07-GM-B6, 21.88 mg, J=0.0010703±0.09%, D=1.004±0.001, NM-224B, Lab#=58948-01</b>										
A	3	14.94	0.4025	33.23	22.1	1.3	34.5	21.2	10.07	0.12
B	4	6.080	0.6706	3.678	20.2	0.76	83.0	40.7	9.850	0.038
C	5	6.051	0.8506	3.416	11.6	0.60	84.5	51.8	9.975	0.053
D	6	6.105	1.311	3.950	24.3	0.39	82.6	75.2	9.850	0.043
E	8	6.944	1.764	7.184	11.0	0.29	71.5	85.7	9.699	0.059
F	10	9.127	2.304	14.94	6.08	0.22	53.7	91.6	9.580	0.099
G	13	9.742	2.969	17.84	4.19	0.17	48.4	95.6	9.22	0.14
H	16	10.26	3.829	19.66	2.30	0.13	46.4	97.8	9.32	0.24
I	18	11.34	4.240	22.66	1.17	0.12	44.0	98.9	9.76	0.38
J	25	12.48	4.681	28.39	1.12	0.11	35.8	100.0	8.76	0.40
<b>Integrated age ± 1σ</b>		n=10			104.1	0.41	K2O=1.71%		9.686	0.047
<b>Plateau ± 1σ</b>		steps A-J	n=10	MSWD=5.91	104.1	0.63 ±0.37	100.0		9.822	0.053
<b>RC07-GM-D1, 17.67 mg, J=0.0010693±0.08%, D=1.004±0.001, NM-224B, Lab#=58949-01</b>										
A	3	34.92	1.153	100.4	4.16	0.44	15.3	4.0	10.43	0.42
B	4	12.15	0.7806	23.19	7.48	0.65	44.1	11.1	10.45	0.14
C	5	8.662	0.6777	11.49	7.54	0.75	61.4	18.3	10.372	0.085
D	6	6.794	0.4247	5.293	32.7	1.2	77.5	49.4	10.260	0.037
E	8	6.920	0.3506	5.906	20.3	1.5	75.2	68.7	10.140	0.047
F	10	7.756	0.9133	9.302	13.5	0.56	65.5	81.6	9.908	0.066
G	13	9.187	2.012	14.18	11.4	0.25	56.2	92.4	10.073	0.095
H	16	12.43	1.666	24.84	3.46	0.31	42.0	95.7	10.20	0.20
I	18	14.56	1.196	33.52	1.84	0.43	32.6	97.5	9.28	0.35
J	25	15.83	1.594	36.47	2.63	0.32	32.7	100.0	10.11	0.27
<b>Integrated age ± 1σ</b>		n=10			105.0	0.64	K2O=2.14%		10.030	0.051
<b>Plateau ± 1σ</b>		steps A-J	n=10	MSWD=4.41	105.0	0.90 ±0.40	100.0		10.180	0.051
<b>RC07-GM-B5, 16.38 mg, J=0.0010694±0.06%, D=1.004±0.001, NM-224B, Lab#=58950-01</b>										
X A	3	10.67	0.2240	19.62	33.8	2.3	45.8	25.8	9.537	0.081
X B	4	7.629	0.5314	8.149	22.8	0.96	69.0	43.2	10.264	0.049
C	5	6.929	0.6923	5.399	12.1	0.74	77.8	52.4	10.509	0.059
D	6	6.351	0.6434	3.474	33.7	0.79	84.7	78.1	10.482	0.029
E	8	7.144	0.7010	6.418	15.5	0.73	74.2	89.9	10.341	0.060
F	10	9.254	1.222	13.75	6.02	0.42	57.2	94.5	10.32	0.12
G	13	14.21	2.137	31.56	3.32	0.24	35.6	97.1	9.89	0.23
H	16	22.82	2.895	61.04	1.67	0.18	22.0	98.3	9.82	0.42
I	18	27.97	3.414	80.06	1.01	0.15	16.4	99.1	8.97	0.79
J	25	36.04	2.417	106.8	1.17	0.21	13.0	100.0	9.14	0.73
<b>Integrated age ± 1σ</b>		n=10			131.1	0.78	K2O=2.87%		9.986	0.045
<b>Plateau ± 1σ</b>		steps C-J	n=8	MSWD=3.07	74.5	0.7 ±0.3	56.8		10.45	0.04
<b>RC07-GM-B4, 18.97 mg, J=0.0010703±0.07%, D=1.004±0.001, NM-224B, Lab#=58951-01</b>										
X A	3	14.87	2.136	37.71	5.24	0.24	26.2	5.3	7.63	0.22
B	4	6.353	1.842	4.239	8.78	0.28	82.7	14.3	10.257	0.068
C	5	5.899	1.472	2.766	7.80	0.35	88.2	22.2	10.157	0.062
D	6	6.163	0.8858	3.328	30.5	0.58	85.2	53.2	10.249	0.033
E	8	6.990	0.5724	6.260	20.9	0.89	74.2	74.4	10.120	0.041
F	10	8.284	0.6585	10.89	11.5	0.77	61.8	86.1	9.989	0.070
G	13	9.608	1.582	15.68	7.02	0.32	53.1	93.2	9.97	0.12
H	16	10.96	3.181	21.41	3.24	0.16	44.6	96.5	9.57	0.19
I	18	11.52	3.751	22.92	1.89	0.14	43.9	98.4	9.90	0.27
J	25	13.21	4.782	29.62	1.56	0.11	36.7	100.0	9.50	0.29
<b>Integrated age ± 1σ</b>		n=10			98.4	0.41	K2O=1.86%		9.840	0.040
<b>Plateau ± 1σ</b>		steps B-J	n=9	MSWD=4.29	93.1	0.57 ±0.29	94.7		10.160	0.044



Table A3. 40Ar/39Ar isotopic results for groundmass samples.

ID	Power/Temp (Watts/°C)	<sup>40</sup> Ar/ <sup>39</sup> Ar	<sup>37</sup> Ar/ <sup>39</sup> Ar	<sup>36</sup> Ar/ <sup>39</sup> Ar (x 10 <sup>-3</sup> )	<sup>39</sup> Ar <sub>K</sub> (x 10 <sup>-15</sup> mol)	K/Ca	<sup>40</sup> Ar* (%)	<sup>39</sup> Ar (%)	Age (Ma)	±1σ (Ma)
<b>RC07-GM-B3, 17.45 mg, J=0.0010806±0.09%, D=1.004±0.001, NM-224C, Lab#=58952-01</b>										
X A	3	32.58	0.3417	95.17	12.7	1.5	13.8	20.4	8.84	0.38
B	4	18.53	0.6498	45.20	10.9	0.79	28.2	38.0	10.30	0.19
C	5	14.01	0.9171	30.09	7.54	0.56	37.1	50.1	10.24	0.17
D	6	11.21	1.776	20.44	13.4	0.29	47.4	71.6	10.48	0.11
E	8	11.09	2.816	21.09	5.03	0.18	45.9	79.6	10.05	0.18
F	10	13.80	3.572	30.78	5.48	0.14	36.2	88.5	9.87	0.21
G	13	13.03	5.868	29.22	3.87	0.087	37.4	94.7	9.64	0.24
H	16	12.66	5.149	26.61	1.87	0.099	41.2	97.7	10.33	0.33
I	18	13.03	5.327	30.55	0.758	0.096	34.1	98.9	8.78	0.62
J	25	15.77	5.948	36.97	0.682	0.086	33.8	100.0	10.56	0.61
<b>Integrated age ± 1σ</b>			n=10		62.2	0.27	K2O=1.27%		9.78	0.13
<b>Plateau ± 1σ</b>		steps B-J	n=9	MSWD=2.69	49.5	0.38 ±0.25	79.6		10.22	0.11
<b>RC07-GM-B11, 17.86 mg, J=0.0010802±0.09%, D=1.004±0.001, NM-224C, Lab#=58953-01</b>										
A	3	142.5	1.394	466.7	6.46	0.37	3.3	8.3	9.2	1.2
B	4	34.33	1.592	96.75	9.6	0.32	17.1	20.7	11.57	0.35
C	5	17.60	1.614	41.24	7.50	0.32	31.5	30.3	10.93	0.20
D	6	7.886	1.074	8.733	26.3	0.47	68.4	64.3	10.624	0.045
E	8	7.106	0.7785	6.588	14.3	0.66	73.5	82.7	10.286	0.058
F	10	7.561	1.137	7.954	5.96	0.45	70.1	90.4	10.448	0.078
G	13	7.787	2.417	9.392	3.27	0.21	66.9	94.6	10.27	0.15
H	16	7.979	3.516	10.37	2.23	0.15	65.2	97.5	10.27	0.20
I	18	8.471	4.497	12.22	1.07	0.11	61.7	98.9	10.33	0.35
J	25	9.458	4.491	15.61	0.884	0.11	55.1	100.0	10.30	0.39
<b>Integrated age ± 1σ</b>			n=10		77.5	0.37	K2O=1.54%		10.39	0.16
<b>Plateau ± 1σ</b>		steps A-J	n=10	MSWD=4.51	77.5	0.43 ±0.18	100.0		10.49	0.07
<b>RC07-GM-B10, 18.49 mg, J=0.0010796±0.08%, D=1.004±0.001, NM-224C, Lab#=58954-01</b>										
X A	3	14.65	0.6313	35.14	9.9	0.81	29.5	12.4	8.51	0.16
B	4	8.269	1.054	10.31	10.2	0.48	64.2	25.4	10.453	0.072
C	5	6.974	1.183	5.920	7.16	0.43	76.3	34.4	10.478	0.068
D	6	6.485	1.360	4.434	20.8	0.38	81.5	60.7	10.409	0.042
E	8	7.148	1.406	7.212	12.4	0.36	71.8	76.4	10.108	0.068
F	10	8.056	1.495	10.31	6.39	0.34	63.7	84.4	10.110	0.097
G	13	8.563	2.340	12.55	4.55	0.22	58.9	90.2	9.95	0.13
H	16	9.236	3.199	14.88	3.14	0.16	55.2	94.2	10.06	0.15
I	18	9.879	3.719	17.80	2.26	0.14	49.8	97.0	9.72	0.23
J	25	9.441	4.725	15.94	2.36	0.11	54.2	100.0	10.11	0.20
<b>Integrated age ± 1σ</b>			n=10		79.2	0.33	K2O=1.52%		9.899	0.049
<b>Plateau ± 1σ</b>		steps B-J	n=9	MSWD=5.75	69.3	0.35 ±0.14	87.6		10.315	0.064
<b>GCX-74, 16.77 mg, J=0.0018955±0.02%, IC=1.00771±0.00268, NM-288K, Lab#=65459-01</b>										
X A	0.5	27.48	0.6921	86.51	0.3	0.74	7.2	0.2	6.82	0.56
X B	0.8	7.165	0.7536	17.63	1.9	0.68	28.1	1.3	6.961	0.095
X C	1.3	3.382	0.9499	1.406	11.0	0.54	89.9	8.1	10.505	0.012
X D	1.6	3.275	0.8328	0.5252	21.9	0.61	97.3	21.7	11.001	0.006
X E	1.9	3.156	0.6912	0.3615	25.7	0.74	98.3	37.7	10.716	0.005
X F	2.2	3.122	0.5700	0.3315	24.0	0.90	98.3	52.5	10.597	0.005
G	3.0	3.165	0.4560	0.5064	36.6	1.1	96.4	75.2	10.536	0.005
H	5.0	3.433	1.053	1.583	10.5	0.48	88.8	81.7	10.526	0.013
I	7.0	3.590	1.323	2.145	3.1	0.39	85.2	83.7	10.573	0.030
J	10.0	3.550	1.277	1.974	11.4	0.40	86.4	90.7	10.595	0.014
K	15.0	3.519	1.213	1.881	15.0	0.42	86.9	100.0	10.567	0.012
<b>Integrated age ± 1σ</b>			n=11		161.4	0.65	K2O=1.95%		10.594	0.004
<b>Plateau ± 1σ</b>		steps G-K	n=5	MSWD=5.62	76.611		47.5		10.54	0.009

Table A3. 40Ar/39Ar isotopic results for groundmass samples.

ID	Power/Temp (Watts/°C)	<sup>40</sup> Ar/ <sup>39</sup> Ar	<sup>37</sup> Ar/ <sup>39</sup> Ar	<sup>36</sup> Ar/ <sup>39</sup> Ar (x 10 <sup>-3</sup> )	<sup>39</sup> Ar <sub>K</sub> (x 10 <sup>-15</sup> mol)	K/Ca	<sup>40</sup> Ar* (%)	<sup>39</sup> Ar (%)	Age (Ma)	±1σ (Ma)
<b>GC-139, 15.1 mg, J=0.0018954±0.02%, IC=1.00771±0.00268, NM-288K, Lab#=65460-01</b>										
X A	0.5	33.76	1.295	109.3	0.3	0.39	4.6	0.4	5.44	0.57
X B	0.8	6.705	1.637	14.25	2.2	0.31	39.0	3.3	9.060	0.082
X C	1.3	3.528	1.918	2.474	10.9	0.27	83.5	17.8	10.189	0.016
X D	1.6	3.215	1.599	1.491	11.1	0.32	90.2	32.5	10.021	0.012
E	1.9	3.202	1.323	1.472	11.1	0.39	89.6	47.3	9.917	0.012
F	2.2	3.308	1.136	1.832	10.0	0.45	86.3	60.5	9.864	0.015
G	3.0	3.513	1.307	2.644	13.4	0.39	80.6	78.3	9.794	0.015
H	5.0	4.005	3.313	4.832	7.4	0.15	70.8	88.2	9.813	0.026
I	7.0	4.052	3.253	4.895	2.0	0.16	70.5	90.9	9.895	0.052
J	10.0	4.607	4.846	7.259	2.1	0.11	61.6	93.7	9.841	0.058
K	15.0	4.653	4.385	7.210	4.7	0.12	61.5	100.0	9.923	0.042
<b>Integrated age ± 1σ</b>			n=11		75.3	0.26	K2O=1.01%		9.886	0.008
<b>Plateau ± 1σ</b>	steps E-K		n=7	MSWD=7.62	50.8			67.5	9.864	0.021
<b>GC-34, 15.98 mg, J=0.0018958±0.02%, IC=1.00771±0.00268, NM-288K, Lab#=65461-01</b>										
X A	0.5	10.72	1.576	26.50	0.2	0.32	28.1	0.2	10.41	0.38
X B	0.8	3.991	1.001	3.239	3.0	0.51	77.9	2.4	10.753	0.035
X C	1.3	2.992	0.6782	0.4858	35.0	0.75	97.0	28.4	10.023	0.004
D	1.6	2.948	0.3988	0.2942	30.7	1.3	98.1	51.2	9.987	0.004
E	1.9	2.945	0.3795	0.2732	22.5	1.3	98.3	67.8	9.993	0.005
F	2.2	2.957	0.4487	0.3173	15.4	1.1	98.0	79.2	10.010	0.006
G	3.0	3.008	0.8126	0.6548	16.0	0.63	95.7	91.1	9.942	0.007
H	5.0	3.255	2.907	2.138	6.5	0.18	87.6	96.0	9.863	0.019
I	7.0	3.721	5.773	4.453	1.4	0.088	76.8	97.0	9.904	0.063
J	10.0	4.729	10.80	9.193	1.4	0.047	60.4	98.0	9.946	0.083
K	15.0	5.893	12.28	13.40	2.7	0.042	49.1	100.0	10.079	0.077
<b>Integrated age ± 1σ</b>			n=11		134.8	0.48	K2O=1.71%		10.007	0.004
<b>Plateau ± 1σ</b>	steps D-K		n=8	MSWD=14.98	96.5			71.6	9.985	0.010
<b>CC-1 (Sample 1), 17.67 mg, J=0.0004686±0.32%, D=1.005±0.001, NM-234A, Lab#=59635-01</b>										
X A	3	102.1	0.5789	328.9	0.845	0.88	4.9	1.4	4.26	0.47
X B	4	16.24	0.9905	19.50	0.99	0.52	65.0	3.0	9.04	0.12
X C	5	15.09	1.070	13.19	0.740	0.48	74.7	4.3	9.65	0.14
X D	6	14.13	0.9593	5.421	2.05	0.53	89.2	7.7	10.779	0.053
X E	8	13.65	0.8093	2.804	3.55	0.63	94.4	13.6	11.021	0.035
X F	10	13.28	0.6554	1.933	4.59	0.78	96.1	21.2	10.908	0.027
X G	13	13.00	0.5184	1.554	7.76	0.98	96.8	34.0	10.756	0.022
H	16	12.88	0.4199	1.926	9.26	1.2	95.8	49.4	10.553	0.020
I	18	12.93	0.3683	2.193	7.33	1.4	95.2	61.5	10.526	0.024
J	30	14.14	0.3501	6.192	17.0	1.5	87.3	89.7	10.545	0.023
K	35	15.96	0.4320	13.30	4.34	1.2	75.6	96.9	10.315	0.045
L	45	19.15	0.9513	24.09	1.86	0.54	63.2	100.0	10.359	0.096
<b>Integrated age ± 1σ</b>			n=12		60.4	1.0	K2O=2.80%		10.489	0.040
<b>Plateau ± 1σ</b>	steps H-L		n=5	MSWD=6.83	39.8	1.3 ±0.4		66.0	10.523	0.046

Table A3. 40Ar/39Ar isotopic results for groundmass samples.

ID	Power/Temp (Watts/°C)	<sup>40</sup> Ar/ <sup>39</sup> Ar	<sup>37</sup> Ar/ <sup>39</sup> Ar	<sup>36</sup> Ar/ <sup>39</sup> Ar (x 10 <sup>-3</sup> )	<sup>39</sup> Ar <sub>K</sub> (x 10 <sup>-15</sup> mol)	K/Ca	<sup>40</sup> Ar* (%)	<sup>39</sup> Ar (%)	Age (Ma)	±1σ (Ma)
<b>CC-2 (Sample 2), 20.26 mg, J=0.00047±0.30%, D=1.005±0.001, NM-234A, Lab#=59636-01</b>										
X A	3	127.8	0.3167	413.4	0.348	1.6	4.4	0.6	4.87	0.74
X B	4	37.22	0.2469	114.6	0.600	2.1	9.1	1.6	2.90	0.28
X C	5	19.34	0.3593	50.84	0.402	1.4	22.5	2.2	3.73	0.33
X D	6	15.04	0.5355	22.45	0.791	0.95	56.2	3.6	7.25	0.13
X E	8	13.98	0.7459	7.036	1.21	0.68	85.6	5.6	10.262	0.088
X F	10	14.20	0.7742	3.323	1.99	0.66	93.5	8.9	11.392	0.050
X G	13	14.05	0.7123	1.966	4.29	0.72	96.3	16.0	11.601	0.031
X H	16	13.61	0.6687	1.293	5.60	0.76	97.6	25.3	11.394	0.026
X I	18	13.35	0.6446	1.166	5.10	0.79	97.8	33.8	11.194	0.026
X J	30	12.99	0.4302	0.9413	18.1	1.2	98.1	63.9	10.933	0.019
K	35	13.06	0.4602	1.798	8.60	1.1	96.2	78.1	10.773	0.022
L	45	14.71	0.4145	7.384	7.29	1.2	85.4	90.3	10.774	0.034
M	50	12.97	0.3687	1.953	5.86	1.4	95.8	100.0	10.652	0.028
<b>Integrated age ± 1σ</b>			n=13		60.2	1.0	K2O=2.43%		10.767	0.038
<b>Plateau ± 1σ</b>	steps K-M		n=3	MSWD=6.48	21.752	1.224±0.138	36.1		10.74	0.051
<b>CC-3 (Sample 3), 20.02 mg, J=0.0004706±0.39%, D=1.005±0.001, NM-234A, Lab#=59637-01</b>										
X A	3	80.98	0.4821	245.9	0.239	1.1	10.3	0.5	7.19	0.70
X B	4	41.30	0.8153	113.7	0.129	0.63	18.8	0.8	6.68	0.88
X C	5	23.52	1.110	75.53	0.092	0.46	5.4	0.9	1.1	1.0
D	6	18.76	1.261	36.19	0.197	0.40	43.5	1.3	7.02	0.49
E	8	15.64	1.415	13.85	0.357	0.36	74.6	2.1	10.03	0.27
F	10	14.19	1.385	6.834	0.615	0.37	86.6	3.3	10.56	0.16
G	13	13.65	1.146	4.538	2.19	0.45	90.9	7.8	10.652	0.053
H	16	13.27	0.9931	2.488	4.05	0.51	95.1	16.1	10.834	0.032
I	18	13.11	0.8603	2.175	3.80	0.59	95.6	23.9	10.772	0.035
J	30	12.95	0.6716	1.783	12.1	0.76	96.4	48.6	10.715	0.021
K	35	12.81	0.5447	1.495	8.28	0.94	96.9	65.5	10.662	0.024
L	45	12.91	0.4742	2.192	6.96	1.1	95.3	79.7	10.561	0.024
M	50	12.96	0.4130	2.175	8.11	1.2	95.3	96.3	10.607	0.025
N	50	48.00	1.314	120.6	1.81	0.39	26.0	100.0	10.72	0.20
<b>Integrated age ± 1σ</b>			n=14		48.9	0.75	K2O=2.00%		10.610	0.047
<b>Plateau ± 1σ</b>	steps D-N		n=11	MSWD=12.83	48.5	0.84 ±0.31	99.1		10.670	0.055
<b>LBR-1 (Sample 4), 16.35 mg, J=0.0004696±0.44%, D=1.005±0.001, NM-234A, Lab#=59638-01</b>										
X A	3	99.82	0.3169	308.7	1.00	1.6	8.6	2.1	7.40	0.49
X B	4	22.31	0.4513	43.86	0.96	1.1	42.1	4.1	8.04	0.16
X C	5	15.90	0.5046	18.40	0.725	1.0	66.1	5.6	9.01	0.16
X D	6	14.46	0.5492	7.890	2.06	0.93	84.2	9.9	10.430	0.064
X E	8	13.68	0.5607	3.454	3.25	0.91	92.9	16.7	10.885	0.040
X F	10	13.16	0.5669	2.640	4.15	0.90	94.4	25.4	10.651	0.033
X G	13	12.82	0.6043	1.961	6.88	0.84	95.9	39.8	10.528	0.025
H	16	12.66	0.5623	2.197	7.30	0.91	95.2	55.1	10.328	0.024
I	18	12.88	0.4933	3.457	5.11	1.0	92.4	65.8	10.198	0.029
J	30	14.10	0.3952	7.849	10.5	1.3	83.8	87.8	10.126	0.028
K	35	17.43	0.3722	18.97	3.15	1.4	68.0	94.4	10.161	0.059
L	45	33.37	0.7140	72.37	1.41	0.71	36.1	97.3	10.32	0.17
M	50	29.24	1.034	58.06	1.27	0.49	41.6	100.0	10.43	0.15
<b>Integrated age ± 1σ</b>			n=13		47.8	0.98	K2O=2.39%		10.233	0.054
<b>Plateau ± 1σ</b>	steps H-M		n=6	MSWD=6.94	28.8	1.1 ±0.3	60.2		10.227	0.060

Table A3. 40Ar/39Ar isotopic results for groundmass samples.

ID	Power/Temp (Watts/°C)	<sup>40</sup> Ar/ <sup>39</sup> Ar	<sup>37</sup> Ar/ <sup>39</sup> Ar	<sup>36</sup> Ar/ <sup>39</sup> Ar (x 10 <sup>-3</sup> )	<sup>39</sup> Ar <sub>K</sub> (x 10 <sup>-15</sup> mol)	K/Ca	<sup>40</sup> Ar* (%)	<sup>39</sup> Ar (%)	Age (Ma)	±1σ (Ma)
<b>DH-9 142.0 m, (KO1-GJ-3A), F1:141, 22.66 mg J=0.0014236±0.01%, D=1.00535±0.00031, NM-141, Lab#=52562-01</b>										
X A	625	769.5	1.298	2573	0.282	0.39	1.2	0.8	24.4	9.3
X B	700	7.754	1.937	16.17	2.91	0.26	40.4	8.8	8.17	0.24
X C	750	7.067	2.638	12.56	1.71	0.19	50.6	13.6	9.30	0.35
D	800	5.865	4.004	7.587	4.27	0.13	67.4	25.3	10.30	0.15
E	875	5.002	3.969	4.501	5.84	0.13	80.0	41.5	10.42	0.12
F	975	4.870	4.060	3.738	7.66	0.13	84.2	62.7	10.686	0.082
G	1075	5.803	3.496	7.037	4.84	0.15	69.2	76.0	10.45	0.15
H	1250	10.18	4.274	21.65	5.84	0.12	40.6	92.1	10.78	0.18
X I	1650	14.18	25.20	39.76	2.84	0.020	31.9	100.0	11.95	0.37
<b>Integrated age ± 1σ</b>			n=9		36.2	0.094	K2O=0.43%		10.52	0.10
<b>Plateau ± 1σ</b>			steps D-H	n=5	MSWD=2.15	28.4		78.6	10.556	0.079
<b>DH-9 143.3 m, (KO1-GJ-3B), F2:141, 23.32 mg J=0.0014221±0.01%, D=1.00535±0.00031, NM-141, Lab#=52563-01</b>										
X A	625	286.9	0.9581	961.6	0.525	0.53	1.0	1.6	7.3	5.2
X B	700	8.402	1.604	19.43	4.03	0.32	33.3	13.5	7.27	0.25
C	750	8.153	2.505	15.65	2.39	0.20	45.8	20.6	9.71	0.28
D	800	6.499	4.226	9.707	4.94	0.12	61.2	35.2	10.36	0.18
E	875	5.107	4.489	4.842	6.00	0.11	79.3	53.0	10.54	0.10
F	975	4.814	4.780	4.277	7.17	0.11	82.0	74.3	10.276	0.089
G	1075	5.555	4.659	6.663	3.68	0.11	71.5	85.2	10.34	0.20
H	1250	9.749	8.317	22.58	3.18	0.061	38.6	94.7	9.83	0.27
I	1650	13.92	39.35	45.62	1.79	0.013	26.6	100.0	9.87	0.50
<b>Integrated age ± 1σ</b>			n=9		33.7	0.082	K2O=0.39%		9.83	0.11
<b>Plateau ± 1σ</b>			steps C-I	n=7	MSWD=2.35	29.2		86.5	10.325	0.086
<b>DH-9 43.3 m, (KO1-GJ-4), F3:141, 23.54 mg J=0.0014231±0.01%, D=1.00535±0.00031, NM-141, Lab#=52564-01</b>										
X A	625	3241.7	2.864	10851	0.337	0.18	1.1	0.3	90	16
X B	700	5.563	1.202	6.100	4.47	0.42	69.4	4.2	10.03	0.15
X C	750	4.584	1.093	1.326	4.05	0.47	93.4	7.8	11.13	0.12
X D	800	4.265	1.505	0.9568	12.58	0.34	96.3	18.9	10.677	0.053
X E	875	4.116	1.403	0.8123	23.0	0.36	97.0	39.2	10.378	0.029
F	975	4.055	1.235	0.8555	29.8	0.41	96.3	65.5	10.151	0.023
G	1075	4.187	0.9762	1.219	14.33	0.52	93.3	78.2	10.157	0.044
H	1250	5.026	1.372	4.502	10.56	0.37	75.8	87.5	9.906	0.080
I	1650	5.526	5.112	6.854	14.12	0.100	71.0	100.0	10.228	0.080
<b>Integrated age ± 1σ</b>			n=9		113.2	0.29	K2O=1.30%		10.517	0.057
<b>Plateau ± 1σ</b>			steps F-I	n=4	MSWD=3.39	68.811		60.8	10.14	0.036

**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 where MSWD>1.

Plateau error is weighted error of Taylor (1982).

Isotopic abundances after Steiger and Jäger (1977).

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

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

Weight percent K<sub>2</sub>O calculated from <sup>39</sup>Ar signal, sample weight, and instrument sensitivity.

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

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

D = 1 amu mass discriminatin in favor of light isotopes

IC = Detector intercalibration; Measured 40Ar/36Ar of air standard divided by 295.5