$^{40}Ar/^{39}Ar$ Geochronology Results for the Bicknell and Greenwich Quadrangles, Utah

by

Utah Geological Survey and New Mexico Geochronology Research Laboratory

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INTRODUCTION

This Open-File Report makes available raw analytical data from laboratory procedures completed to determine the age of rock samples collected during geologic mapping funded or partially supported by the Utah Geological Survey (UGS). The reference listed in table 1 provides additional information regarding the geologic setting and significance or interpretation of the samples in the context of the area in which they were collected. This report was prepared by the New Mexico Geochronology Research Laboratory under contract to the UGS. These data are highly technical in nature and proper interpretation requires considerable training in the applicable geochronologic techniques.

Table 1. *Sample numbers and locations.*

Sample #	7.5' quadrangle	Easting UTM NAD83	Northing UTM NAD83	Reference
G100913-3	Greenwich	416680	4256828	Biek and others (2015)
G100913-7	Greenwich	414699	4261246	Biek and others (2015)
B100913-6	Bicknell	445809	4239973	Biek and others (2015)

DISCLAIMER

This open-file release is intended as a data repository for information gathered in support of various UGS projects. The data are presented as received from New Mexico Geochronology Research Laboratory and do not necessarily conform to UGS technical, editorial, or policy standards; this should be considered by an individual or group planning to take action based on the contents of this report. The Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding the suitability of this product for a particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to claims by users of this product.

REFERENCE

Biek, R.F., Eaton, J.G., Rowley, P.D., and Mattox, S.R., 2015, Interim geologic map of the west half of the Loa 30′ x 60′ quadrangle, Garfield, Iron, and Kane Counties, Utah: Utah Geological Survey Open-File Report 648, 20 p., 2 plates, scale 1:62,500.

$^{40}Ar/^{39}Ar$ Geochronology Results From the Marysvale Volcanic Field

By

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JANUARY 21, 2015

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Introduction

Four volcanic samples from the Marysvale volcanic field were submitted for dating by Bob Biek of the Utah Geological Survey (B100913-6, G100913-3, G100913-7 and S-1). These samples are all from the Marysvale volcanic field of southwest Utah. A groundmass concentrate was analyzed from the first three mentioned above. It was decided that S-1 was not suitable for Ar/Ar dating; the groundmass was very glassy and the plagioclase phenocrysts were x-rayed and found to be albitic in composition.

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

Groundmass concentrates were prepared by treating crushed material with dilute HCl and then removing the phenocrysts. The mineral separates and monitors (Fish Canyon tuff sanidine, 28.201, Kuiper et al., 2008) were loaded into aluminum discs and irradiated for 16 hours at the USGS TRIGA reactor in Denver Colorado.

The samples were step-heated with a Photon Machines Diode laser and analyzed with a Thermo Argus VI mass spectrometer. 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 is provided in the Appendix. The age results are summarized in Table 1 and the argon isotopic data are given in Table 2.

All three samples yielded similar age spectra, with decreasing apparent ages in the early heating steps that are correlated to increasing radiogenic yields. Weighted mean ages are calculated from the higher temperature and flatter portions of these age spectra (B100913-6-4.87±0.02 Ma, G100913-3-14.18±0.09 Ma, G100913-7-23.27±0.07 Ma). The data was analyzed with the inverse isochron technique and all three samples were found to have $^{40}Ar/^{36}Ar$ intercepts slightly above the atmospheric value of 295.5 (B100913-6-303±13, G100913-3-305±2 and G100913-7-338±13). The ages calculated from the inverse isochrons agree within error to those calculated from the age spectra

(B100913-6- 4.90±0.07 Ma, G100913-3-14.08±0.16 Ma and G100913-7-23.11±0.09 Ma).

Discussion

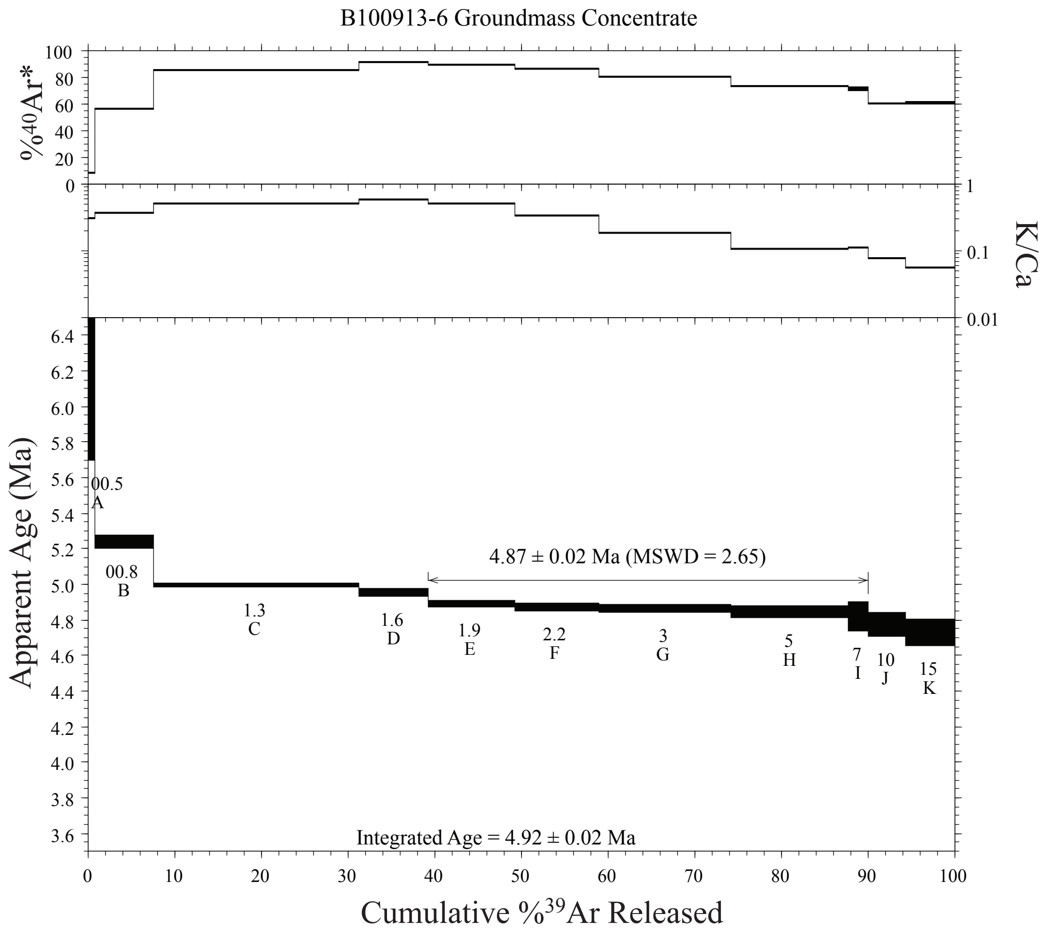
The $^{40}Ar/^{36}Ar$ intercepts calculated from the inverse isochrons for samples G100913-3 and G100913-7 are indicative of slight excess Ar. We have assigned the isochron ages of samples G100913-3 and G100913-7 (14.08±0.16 Ma and 23.11±0.09 Ma, respectively) as the preferred ages. These are interpreted as accurate eruption or emplacement ages. Although the $^{40}Ar/^{36}Ar$ intercept for sample B100913-6 is also above the atmospheric intercept (302.9±1.7), we have assigned the weighted mean age calculated from the age spectrum (4.87±0.02 Ma) as the preferred eruption age because the MSWD value (goodness of fit indicator) is so high (62). This high MSWD value for the isochron suggests that the discordance seen in the age spectrum is not simply the result of excess Ar. Recoil may be partly responsible for this discordance. It is noted that a case could be made to use either the weighted mean age calculated from the age spectrum, the integrated age or the isochron age but that all three ages are within error of each other. This age is thought to be an accurate, precise eruption age.

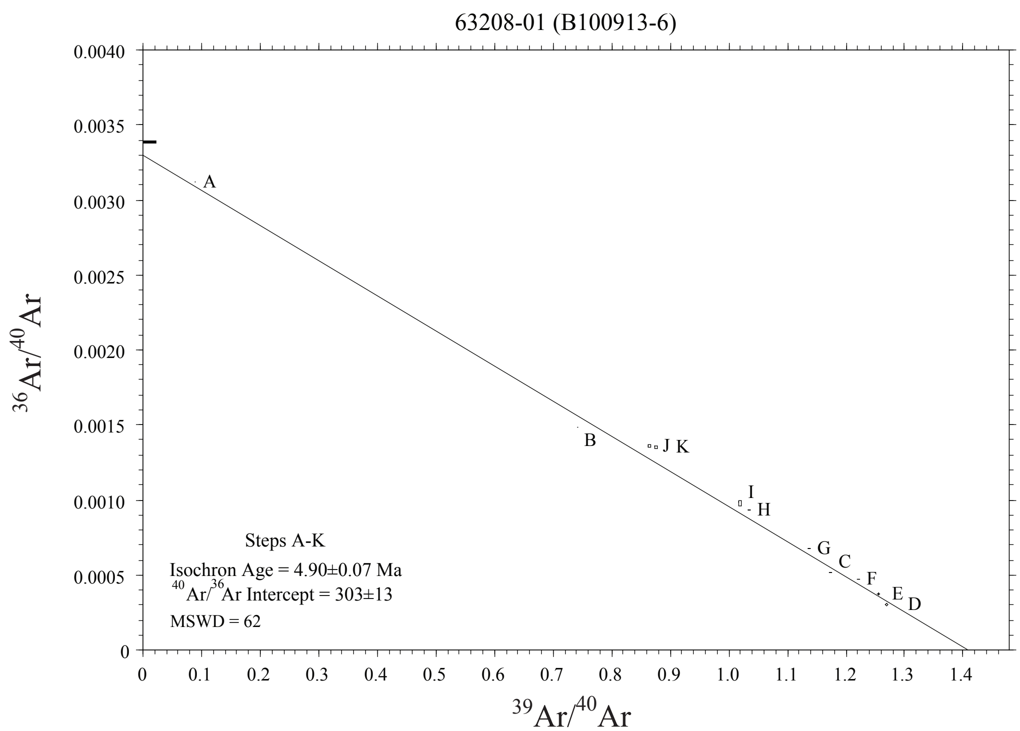
References Cited

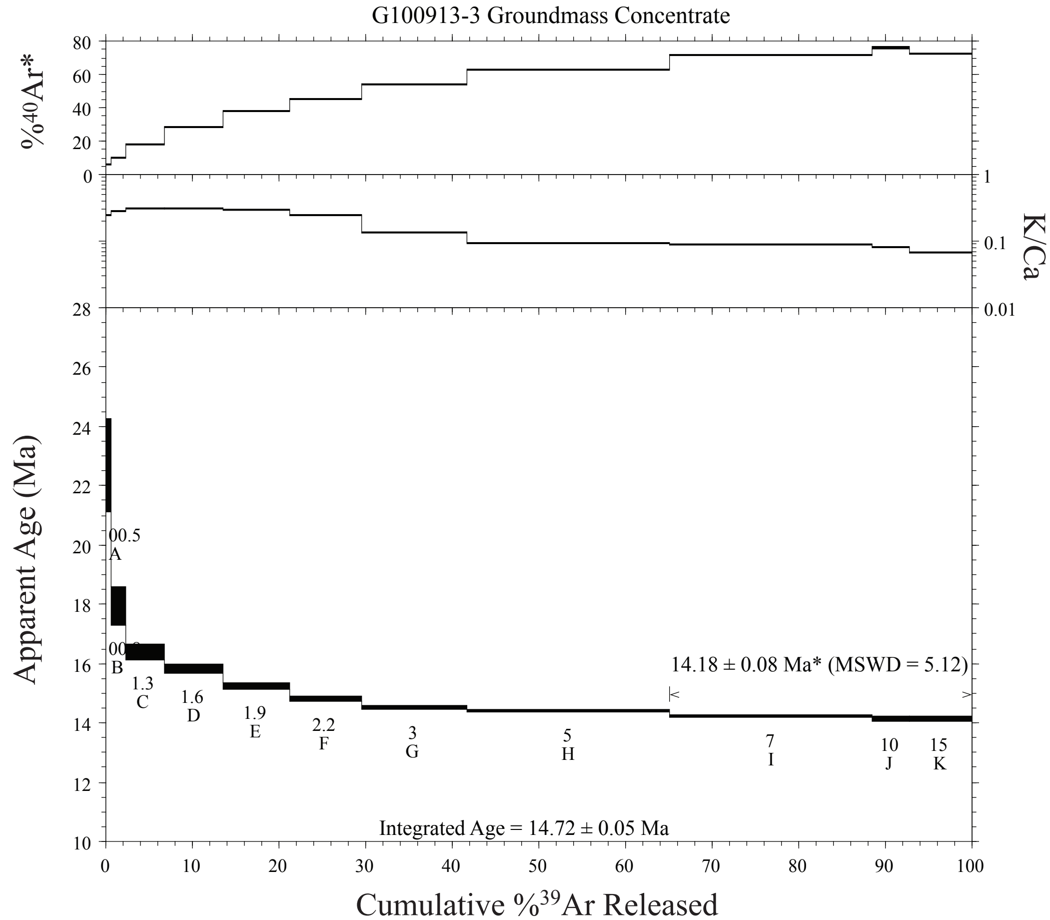
Kuiper, K. F., Deino, A., Hilgen, F. J., Krijgsman, W., Renne, P. R., and Wijbrans, J. R., 2008, Synchronizing rock clocks of earth history: Science, v. 320, p. 500-504.

Min, K., Mundil, R., Renne, P. L., and Ludwig, K.R., 2000, A test for systematic errors in $^{40}Ar/^{39}Ar$ geochronology through comparison with U/Pb analysis of a 1.1-Ga rhyolite: Geochimica et Cosmochimica Acta, v. 64, p. 73-98.

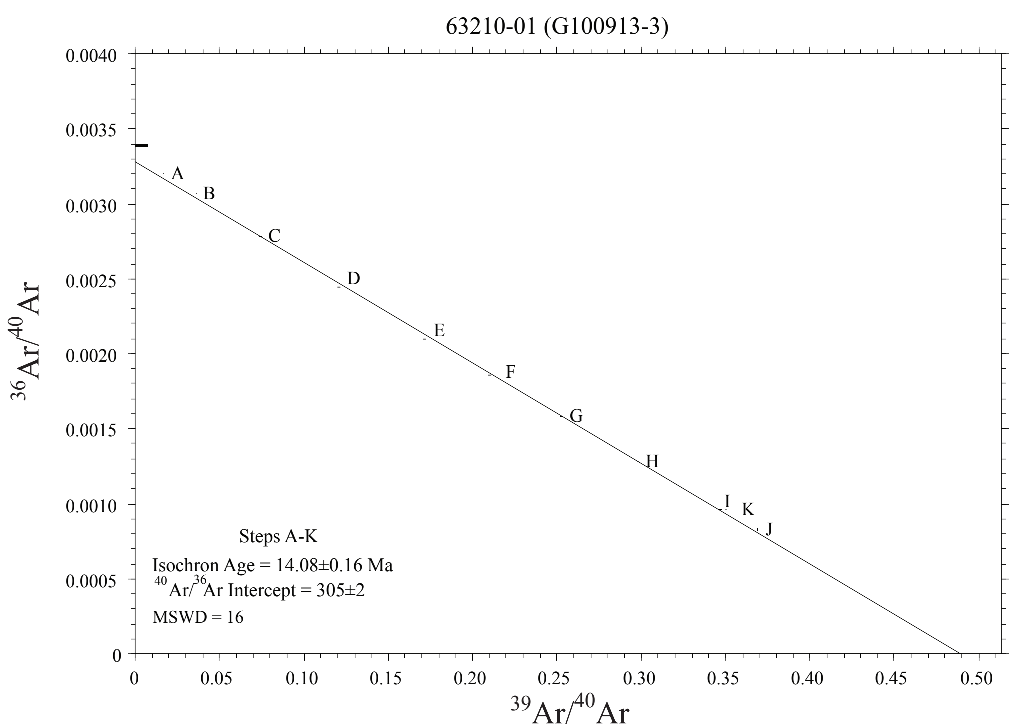
Taylor, J.R., 1982. An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements,. Univ. Sci. Books, Mill Valley, Calif., 270 p.


B100913-6 Groundmass Concentrate
%^{40}Ar*
K/Ca
Apparent Age (Ma)
00.5
A
00.8
B
1.3
C
1.6
D
1.9
E
2.2
F
3
G
5
H
7
I
10
J
15
K
4.87 ± 0.02 Ma (MSWD = 2.65)
Integrated Age = 4.92 ± 0.02 Ma
Cumulative %^{39}Ar Released

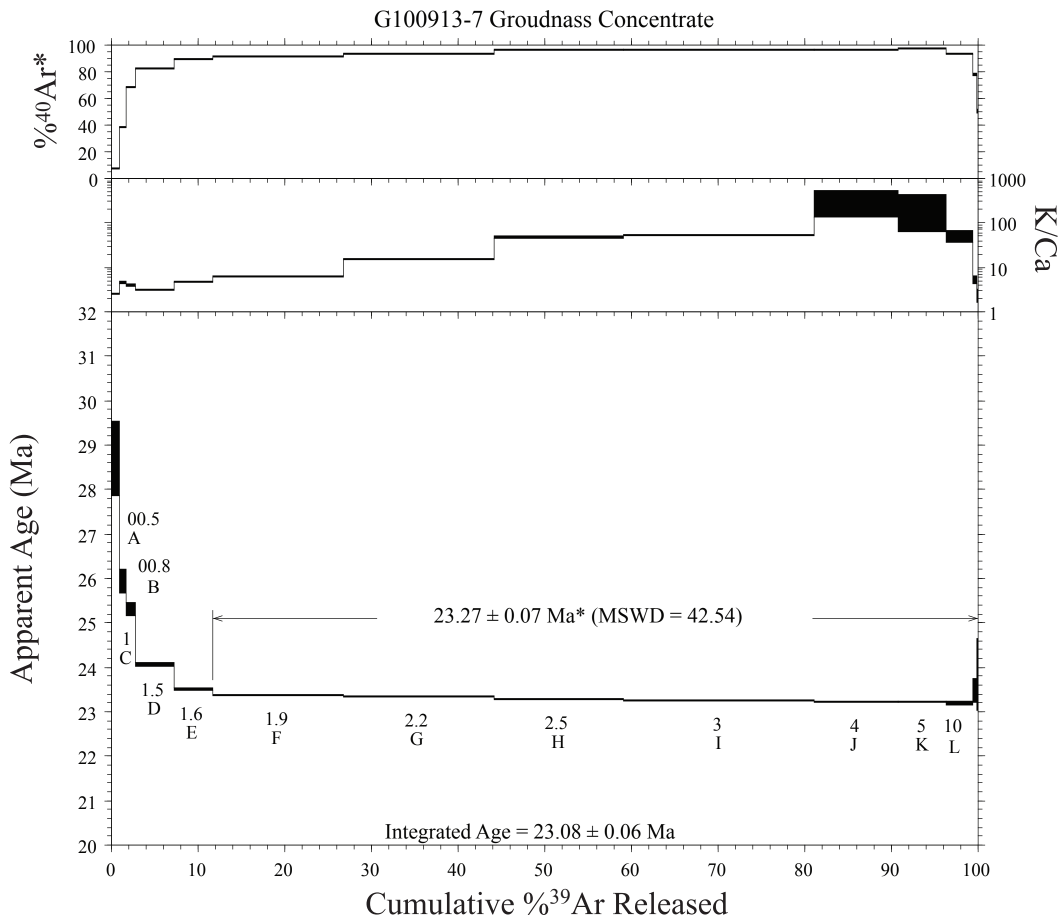

63208-01 (B100913-6)
^{36}Ar/^{40}Ar
^{39}Ar/^{40}Ar
Steps A-K
Isochron Age = 4.90±0.07 Ma
^{40}Ar/^{36}Ar Intercept = 303±13
MSWD = 62



G100913-3 Groundmass Concentrate
%40Ar*
K/Ca
Apparent Age (Ma)
Cumulative %39Ar Released
14.18 ± 0.08 Ma* (MSWD = 5.12)
Integrated Age = 14.72 ± 0.05 Ma



63210-01 (G100913-3)
36Ar/40Ar
39Ar/40Ar
Steps A-K
Isochron Age = 14.08±0.16 Ma
40Ar/36Ar Intercept = 305±2
MSWD = 16


G100913-7 Groudnass Concentrate
%40Ar*
K/Ca
Apparent Age (Ma)
00.5
A
00.8
B
1
C
1.5
D
1.6
E
1.9
F
2.2
G
2.5
H
3
I
4
J
5
K
10
L
23.27 ± 0.07 Ma* (MSWD = 42.54)
Integrated Age = 23.08 ± 0.06 Ma
Cumulative %39Ar Released

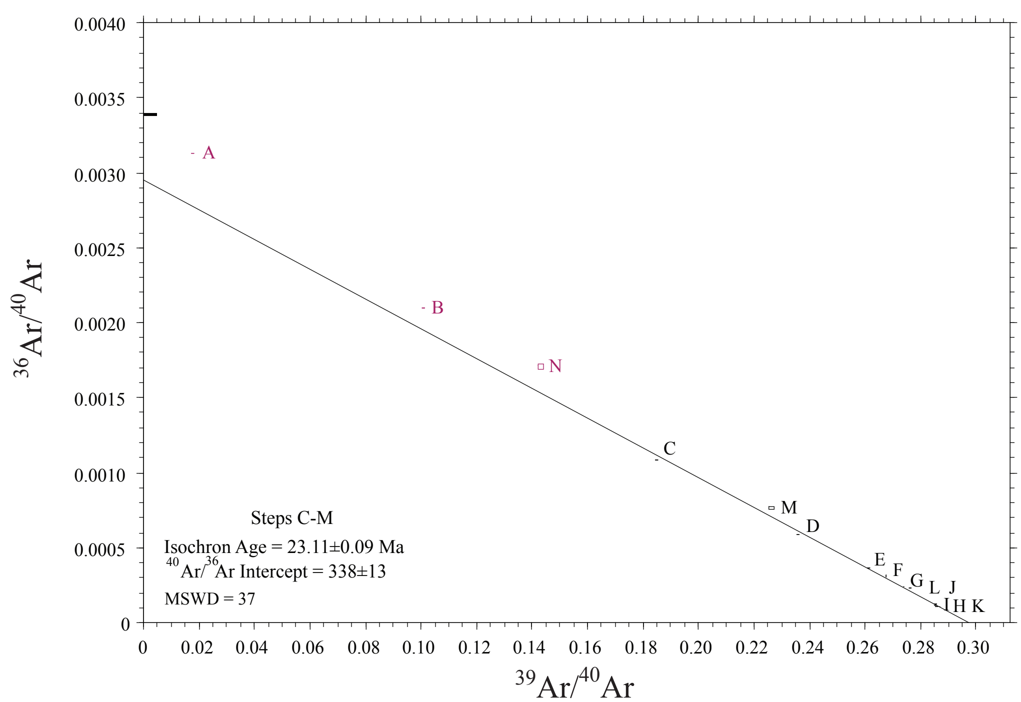

36Ar/40Ar
A
B
N
C
M
D
E
F
G
L
J
I
H
K
Steps C-M
Isochron Age = 23.11±0.09 Ma
40Ar/36Ar Intercept = 338±13
MSWD = 37
39Ar/40Ar

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

Sample	Lab #	Irradiation	mineral	age analysis	steps/analyses	Age	±2σ	MSWD	comments
B100913-6	63208	271	groundmass concentrate	bulk step-heat	5	4.87	0.02	2.65	
G100913-3	63210	271	groundmass concentrate	bulk step-heat	11	14.08	0.16	16.18	isochron
G100913-7	63212	271	groundmass concentrate	bulk step-heat	11	23.11	0.09	37.42	isochron

Sample preparation and irradiation:
Minerals separated with standard heavy liquid, Franz Magnetic and hand-picking techniques.
Samples in NM-271 irradiated in a machined Aluminum tray for 16 hours in C.T. position, USGS TRIGA, Denver, Colorado.
Neutron flux monitor Fish Canyon Tuff sanidine (FC-2). Assigned age = 28.201 Ma (Kuiper et al., 2008).

Instrumentation:
Total fusion analyses performed on a Argus VI mass spectrometer on line with automated all-metal extraction system. System = Jan
Step-heat analyses performed on a Argus VI mass spectrometer on line with automated all-metal extraction system. System = Obama
Multi-collector configuration: 40Ar-H1, 39Ar-Ax, 38Ar-L1, 37Ar-L2, 36Ar-CDD
Flux monitors fused with a Photon Machines Inc. CO_2 laser. Groundmass concentrate and glass step-heated with a Photon Machine Inc. Diode laser.

Analytical parameters:
Sensitivity for the Argus VI with the Diode laser (step-heated samples) is 9.84e-17 moles/fA.
Sensitivty for the Argus VI with the CO2 laser (fused monitors)is 4.62 e-17 moles/fA.
Typical system blank and background was 83.9, 1.32, 0.499, 0.382, 0.320 x 10^{-18} moles at masses 40, 39, 38, 37 and 36, respectively for the laser analyses.
J-factors determined by CO_2 laser-fusion of 6 single crystals from each of 8 radial positions around the irradiation tray.
Decay constants and isotopic abundances after Minn et al., (2000).

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

	ID	Power (Watts)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-15} mol)	K/Ca	$^{40}Ar^*$ (%)	^{39}Ar (%)	Age (Ma)	±1σ (Ma)
	B100913-6, gm, J=0.0037779±0.08%, D=1±0, NM-271D, Lab#=63208-01										
X	A	1	11.14	1.662	35.11	0.985	0.31	8.0	0.8	6.16	0.23
X	B	1	1.355	1.345	2.350	8.26	0.38	56.3	7.6	5.24	0.02
X	C	1	0.8582	0.9893	0.6952	28.7	0.52	84.9	31.3	4.99	0.01
X	D	2	0.7937	0.8513	0.4616	9.65	0.60	91.1	39.3	4.95	0.01
	E	2	0.8030	1.014	0.5648	12.22	0.50	89.0	49.3	4.89	0.01
	F	2	0.8247	1.490	0.7768	11.67	0.34	86.2	59.0	4.87	0.01
	G	3	0.8839	2.688	1.298	18.45	0.19	80.2	74.2	4.86	0.01
	H	5	0.9697	4.717	2.137	16.54	0.11	72.6	87.8	4.84	0.02
	I	7	0.9853	4.573	2.163	2.79	0.11	71.1	90.1	4.82	0.04
X	J	10	1.156	6.512	3.279	5.09	0.078	59.9	94.3	4.77	0.03
X	K	15	1.140	9.075	3.925	6.90	0.056	60.1	100.0	4.73	0.04
	Integrated age ± 2σ			n=11		121.3	0.20	K2O=0.48%		4.92	0.02
	Plateau ± 2σ	**steps E-I**		**n=5**	**MSWD=2.65**	**61.7**	**0.26 ±0.34**		**50.8**	**4.87**	**0.02**
	Isochron±2σ	steps A-K		n=11	MSWD=62.53		$^{40}Ar/^{36}Ar$=	303±13		4.90	0.07
	G100913-3, gm, J=0.0037774±0.12%, D=1±0, NM-271D, Lab#=63210-01										
X	A	1	59.27	2.141	190.0	0.500	0.24	5.6	0.6	22.68	0.79
X	B	1	27.39	1.807	84.35	1.390	0.28	9.5	2.4	17.91	0.33
X	C	1	13.36	1.672	37.59	3.60	0.31	17.8	6.8	16.38	0.13
X	D	2	8.242	1.620	20.55	5.43	0.31	27.8	13.6	15.79	0.08
X	E	2	5.808	1.720	12.61	6.17	0.30	38.1	21.3	15.23	0.05
X	F	2	4.743	2.108	9.331	6.75	0.24	45.3	29.7	14.78	0.05
X	G	3	3.944	3.767	7.209	9.76	0.14	53.4	41.8	14.51	0.03
X	H	5	3.352	5.482	5.716	18.72	0.093	62.3	65.1	14.40	0.03
	I	7	2.876	5.737	4.258	18.79	0.089	71.8	88.5	14.23	0.02
	J	10	2.705	6.244	3.881	3.57	0.082	75.6	92.9	14.10	0.04
	K	15	2.848	7.454	4.680	5.70	0.068	71.8	100.0	14.12	0.04
	Integrated age ± 2σ			n=11		80.4	0.12	K2O=0.35%		14.72	0.05
	Plateau ± 2σ	steps I-K		n=3	MSWD=5.12	28.062	0.084±0.021		34.9	14.18	0.09
	Isochron±2σ	**steps A-K**		**n=11**	**MSWD=16.18**		**$^{40}Ar/^{36}Ar$=**	**305±2**		**14.08**	**0.16**
	G100913-7, gm, J=0.0037783±0.14%, D=1±0, NM-271D, Lab#=63212-01										
Xi	A	1	54.88	0.2075	171.6	1.615	2.5	7.6	0.9	28.69	0.42
Xi	B	1	9.884	0.1167	20.68	1.497	4.4	38.2	1.8	25.93	0.13
X	C	1	5.409	0.1327	5.855	1.866	3.8	68.2	2.9	25.30	0.07
X	D	2	4.239	0.1626	2.525	7.57	3.1	82.7	7.3	24.04	0.02
X	E	2	3.831	0.1132	1.404	7.83	4.5	89.4	11.8	23.49	0.02
	F	2	3.744	0.0817	1.165	25.8	6.2	91.0	26.9	23.36	0.01
	G	2	3.659	0.0337	0.8768	29.8	15.1	93.0	44.2	23.33	0.01
	H	3	3.501	0.0111	0.3738	25.7	46.1	96.9	59.1	23.26	0.01
	I	3	3.509	0.0098	0.4049	37.8	52.2	96.6	81.1	23.25	0.00
	J	4	3.507	0.0016	0.4189	16.73	318.7	96.5	90.8	23.20	0.01
	K	5	3.493	0.0021	0.3624	9.56	240.3	96.9	96.4	23.22	0.01
	L	7	3.626	0.0102	0.8342	5.25	50.0	93.2	99.4	23.18	0.02
	M	10	4.418	0.0988	3.392	0.757	5.2	77.4	99.9	23.47	0.13
i	N	15	6.975	0.2150	11.91	0.220	2.4	49.7	100.0	23.82	0.41
	Integrated age ± 2σ			n=14			12.8	K2O=2.86%		23.08	0.06
	Plateau ± 2σ	steps F-N		n=9	MSWD=42.54	172.1	76.9 ±231.0		88.2	23.27	0.07
	Isochron±2σ	**steps C-M**		**n=11**	**MSWD=37.42**	151.7	**$^{40}Ar/^{36}Ar$=**	**338±13**		**23.11**	**0.09**

ID	Power (Watts)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ ($x 10^{-3}$)	$^{39}Ar_K$ ($x 10^{-15}$ mol)	K/Ca	$^{40}Ar^*$ (%)	^{39}Ar (%)	Age (Ma)	±1σ (Ma)

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).
Decay constants and isotopic abundances after Min et al. (2000).
X symbol preceding sample ID denotes analyses excluded from plateau age calculations.
Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.201 Ma
Decay Constant (LambdaK (total)) = 5.463e-10/a
Correction factors:
$(^{39}Ar/^{37}Ar)_{Ca}$ = 0.00066 ± 1e-05
$(^{36}Ar/^{37}Ar)_{Ca}$ = 0.000264 ± 1e-06
$(^{38}Ar/^{39}Ar)_{K}$ = 0.013
$(^{40}Ar/^{39}Ar)_{K}$ = 0.007619 ± 0.000105