$^{40}Ar/^{39}Ar$ Geochronology Results for the Burnt Peak and Phonolite Hill Quadrangles, Utah

by

Utah Geological Survey and New Mexico Geochronology Research Laboratory

Bibliographic citation for this data report:

Utah Geological Survey and New Mexico Geochronology Research Laboratory, 2019, $^{40}Ar/^{39}Ar$ geochronology results for the Burnt Peak and Phonolite Hill quadrangles, Utah: Utah Geological Survey Open-File Report 707, variously paginated, https://doi.org/10.34191/OFR-707.

OPEN-FILE REPORT 707
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2019

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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 such as 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
BP111213-2	Burnt Peak	362640	4209292	Rowley and others (2005)
PH042414-1	Phonolite Hill	407826	4229638	Rowley and others (2005)
PH042414-2	Phonolite Hill	405119	4226946	Rowley and others (2005)

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

Rowley, P.D., Vice, G.S., McDonald, R.E., Anderson, J.J., Machette, M.N., Maxwell, D.J., Ekren, E.B., Cunningham, C.G., Steven, T.A., and Wardlaw, B.R., 2005, Interim geologic map of the Beaver 30′ x 60′ quadrangle, Beaver, Piute, Iron, and Garfield Counties, Utah: Utah Geological Survey Open-File Report 454, 27 p., 1 plate, scale 1:100,000.

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

By

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JUNE 19, 2015

Prepared for
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Internal Report #: NMGRL-IR-878

Introduction

Bob Biek of the Utah Geological Survey submitted three samples from the Marysvale volcanic field for dating: BP111213-2 (monzonite porphyry), PHO42414-1 (Forshea Mountain rhyolite), and PHO42414-2 (Phonolite Hill rhyolite).

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

Mineral separates were prepared by crushing, treating with dilute HF, density separation in lithium metatungstate heavy liquid, and hand-picking. The mineral separates and monitors (Fish Canyon tuff sanidine, 28.201 Ma, Kuiper et al., 2008) were loaded into aluminum discs and irradiated for 8 hours at the USGS TRIGA reactor in Denver Colorado.

The samples were step-heated or fused with a Photon Machines Diode or CO_2 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 and 3.

Both biotite and hornblende were analyzed from sample BP111213-2. The biotite yielded a somewhat hump-shaped age spectrum. An increase in radiogenic yields (from 17% to 94%) is correlated to the increase in apparent ages (from 15.80 Ma to 27.11 Ma) over the initial ~24% of the ^{39}Ar released. After this initial increase, the radiogenic yields remain above 95% while the apparent ages decrease steadily to 25.12 Ma. A weighted mean age of 26.24±0.02 Ma is calculated from the final 37.8% of the ^{39}Ar released. We have not shown the isochron plot for this sample because the radiogenic yields of the higher temperature steps are uniformly high, resulting in a cluster of the points near the X-axis which do not form a well-defined linear array. The hornblende age spectrum is relatively flat after the initial 20.9% of ^{39}Ar release, and a weighted mean age of 26.22±0.04 Ma is calculated from this portion of the spectrum. Steps A-K were evaluated with the inverse isochron technique and found to have an isochron age of 26.21±0.13 Ma and a $^{40}Ar/^{39}Ar$ intercept of 299±3 (the atmospheric intercept is 295.5).

Feldspar was analyzed from samples PHO42414-1 and PHO42414-2. Fifteen single crystals of each were fused. Thirteen of the fifteen fused crystals of PHO42414-1 were used to calculate a weighted mean age of 7.89±0.12 Ma. The radiogenic yields for these crystals range from 76.7% to 92.6%. Normally, we would expect sanidine of this age to have radiogenic yields 90-100% range. There is no correlation between age and radiogenic yield, which we see in some cases where low yields are the result of alteration and Ar loss. We note that the K/Ca values for this sample (1.0-4.5) are indicative of anorthoclase rather than sanidine. The analyzed crystals of PHO42414-2 yielded apparent ages ranging from 4.2 Ma to 1522.4 Ma. Older crystals are interpreted as xenocrysts and are excluded from the mean-age calculation. A weighted mean age of 4.7±0.4 Ma is calculated from five of the younger crystals. The radiogenic yields of these crystals range from 45.1% to 87.1%. The K/Ca of these crystals (<1) is indicative of plagioclase rather than sanidine compositions.

Discussion

We have assigned the weighted mean age calculated from BP111213-2 hornblende (26.24±0.02 Ma) as the preferred age for the cooling of the monzonite porphyry through the closure temperature of hornblende (500-550°C). We note that while we have assigned the weighted mean age calculated from the hornblende as the preferred age, the weighted mean age calculated from the final 37.8% of the biotite age spectrum (26.24±0.02 Ma) does agree within error to the hornblende age, suggesting that this rock cooled quickly through the 550-300°C temperature range. The analyzed single crystals from both PHO42414-1 (Forshea Mountain Rhyolite) and PHO42414-2 (Phonolite Hill Rhyolite) reveal lower radiogenic yields than expected and for PHO42414-2 and to a lesser extent PHO42414-1 a greater spread in ages than usually seen. This is in part likely due to the low K_2O contents relative to typical sanidines, but may also reflect some alteration of the feldspars. Both of these samples also contain some anomalously old feldspar crystals apparently included during their emplacement.

We consider the weighted mean ages of the younger feldspar crystals from these two samples (PHO42414-1, 7.89±0.12 Ma, and PHO42414-2, 4.7±0.4 Ma), to be reasonably accurate if somewhat imprecise determinations of the emplacement ages of these two rhyolites.

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.

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

Sample	Lab #	Irradiation	mineral	age analysis	steps/analyses	Age	±2σ	MSWD	comments
BP111213-2	63509	275	bioitite	laser step-heat	5	26.24	0.02	3.61	
BP111213-2	**63510**	**275**	**hornblende**	**laser step-heat**	**6**	**26.22**	**0.04**	**0.63**	
PHO42414-1	63569	275	sanidine	laser fusion	12	7.89	0.12	26.61	
PHO42414-2	63571	275	sanidine/plagioclase	laser fusion	6	4.7	0.4	1.72	

Sample preparation and irradiation:
Minerals separated with standard heavy liquid, Franz Magnetic and hand-picking techniques.
Samples in NM-272 irradiated in a machined Aluminum tray for 8 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 monitor 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. Hornblende and biotite 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 128.0, 3.68, 0.147, -24.8, 0.394 x 10^{-18} moles at masses 40, 39, 38, 37 and 36, respectively for the diode laser analyses.
Typical system blank and background was 38.6, 0.109 0.374, 0.776, 0.138 x 10^{-18} moles at masses 40, 39, 38, 37 and 36, respectively for the CO_2 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)
	BP111213-2, Biotite, 3.28 mg, J=0.0019198±0.02%, D=1±0, NM-275B, Lab#=63509-01										
X	A	1	26.60	0.0545	74.72	3.82	9.4	17.0	3.8	15.80	0.14
X	B	2	8.958	0.0141	4.847	4.73	36.1	84.0	8.5	26.24	0.02
X	C	3	8.269	0.0153	1.660	15.47	33.4	94.1	23.9	27.11	0.01
X	D	3	7.954	0.0066	0.7361	11.30	77.1	97.3	35.2	26.96	0.01
X	E	4	7.869	0.0276	0.6592	9.44	18.5	97.6	44.6	26.76	0.01
X	F	4	7.807	0.0265	0.6807	7.99	19.2	97.5	52.5	26.52	0.01
X	G	5	7.776	0.0268	0.7037	9.56	19.1	97.4	62.0	26.39	0.01
	H	5	7.727	0.0453	0.6737	5.29	11.3	97.5	67.3	26.25	0.01
	I	5	7.731	0.0757	0.6828	3.61	6.7	97.5	70.9	26.27	0.02
	J	6	7.690	0.0219	0.5685	12.23	23.3	97.8	83.1	26.23	0.01
	K	8	7.681	0.0098	0.5162	15.64	51.9	98.0	98.6	26.25	0.01
	L	10	7.807	0.0332	1.046	1.172	15.3	96.1	99.8	26.15	0.04
X	M	15	8.841	-0.1886	5.490	0.191	-	81.5	100.0	25.12	0.25
	Integrated age ± 2σ			n=13		100.4	22.8		K2O=6.13%	26.14	0.02
	Plateau ± 2σ	**steps H-L**		**n=5**	**MSWD=3.61**	**37.936**	**1.575±35.856**		**37.8**	**26.24**	**0.02**
	BP111213-2, Hornblende, 4.31 mg, J=0.0019201±0.02%, D=1±0, NM-275B, Lab#=63510-01										
X	A	1	178.0	4.190	576.9	0.204	0.12	4.4	2.0	27.58	1.30
X	B	2	27.57	4.705	68.39	0.139	0.11	28.0	3.3	27.03	0.50
X	C	3	96.75	2.334	298.6	0.173	0.22	9.0	5.0	30.34	0.88
X	D	3	19.97	6.719	43.46	0.267	0.076	38.3	7.6	26.82	0.28
X	E	4	14.29	7.988	24.23	1.381	0.064	54.2	20.9	27.16	0.09
	F	4	9.061	8.136	7.487	3.42	0.063	82.6	53.9	26.24	0.03
	G	5	8.388	7.992	5.206	3.29	0.064	89.1	85.7	26.20	0.03
	H	5	8.046	6.729	3.639	0.647	0.076	93.2	92.0	26.25	0.08
	I	5	8.005	5.384	3.140	0.269	0.095	93.7	94.6	26.24	0.18
	J	6	8.233	7.988	4.738	0.256	0.064	90.6	97.0	26.15	0.19
	K	8	8.349	8.102	4.821	0.263	0.063	90.5	99.6	26.49	0.19
Xi	L	10	13.86	18.55	11.27	0.033	0.028	86.6	99.9	42.17	1.87
Xi	M	15	28.01	31.48	48.04	0.011	0.016	58.2	100.0	57.57	6.91
	Integrated age ± 2σ			n=13		10.36	0.066		K2O=0.48%	26.56	0.08
	Plateau ± 2σ	**steps F-K**		**n=6**	**MSWD=0.63**	**8.15**	**0.065±0.026**		**78.7**	**26.22**	**0.04**
	Isochron±2σ	steps A-K		n=11	MSWD=8.49		$^{40}Ar/^{36}Ar$=	299±3		26.21	0.13

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 Minn et al. (2000).
symbol preceding sample ID denotes analyses excluded from plateau age calculations.
Weight percent K_2O calculated from ^{39}Ar signal, sample weight, and instrument sensitivity.
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

$(^{36}Ar/^{37}Ar)_{Ca}$ = 0.000265 ± 1e-06

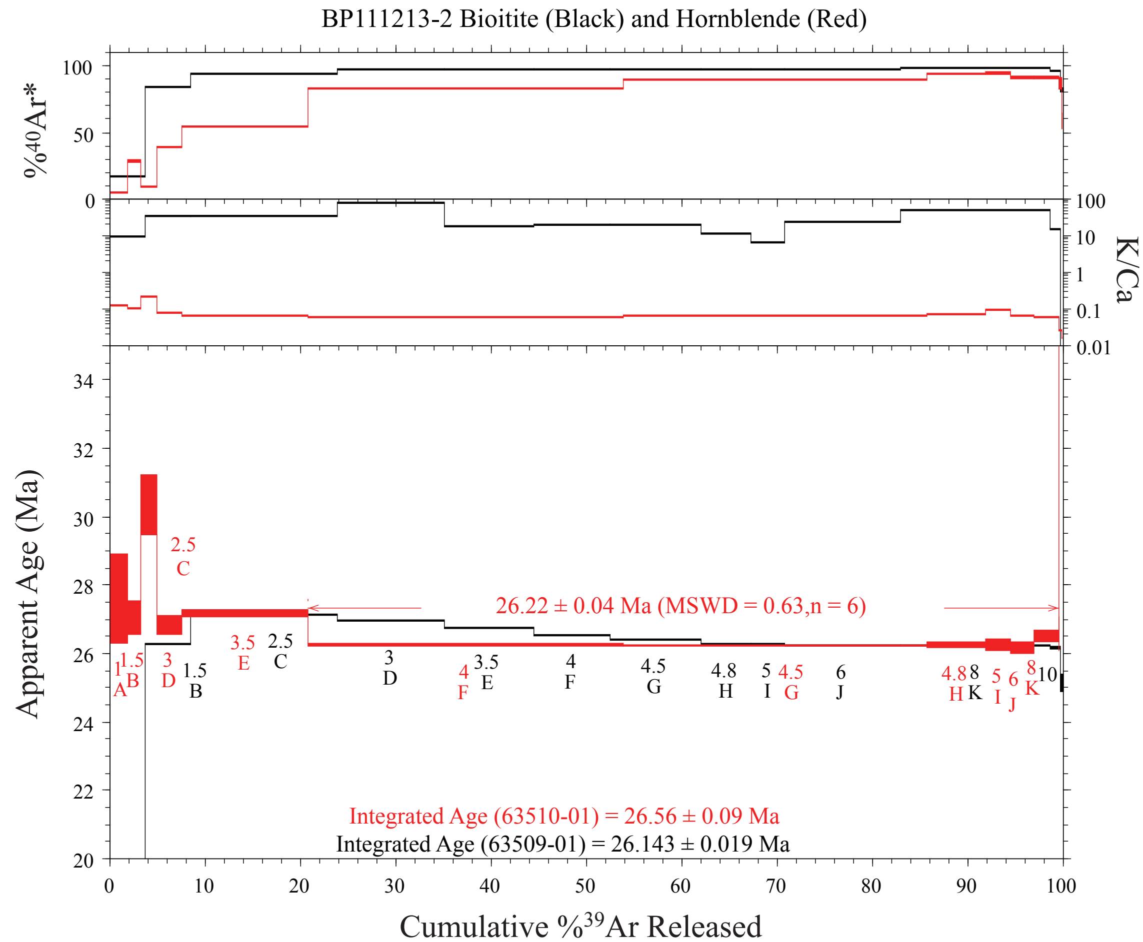
Table 3. $^{40}Ar/^{39}Ar$ analytical data.

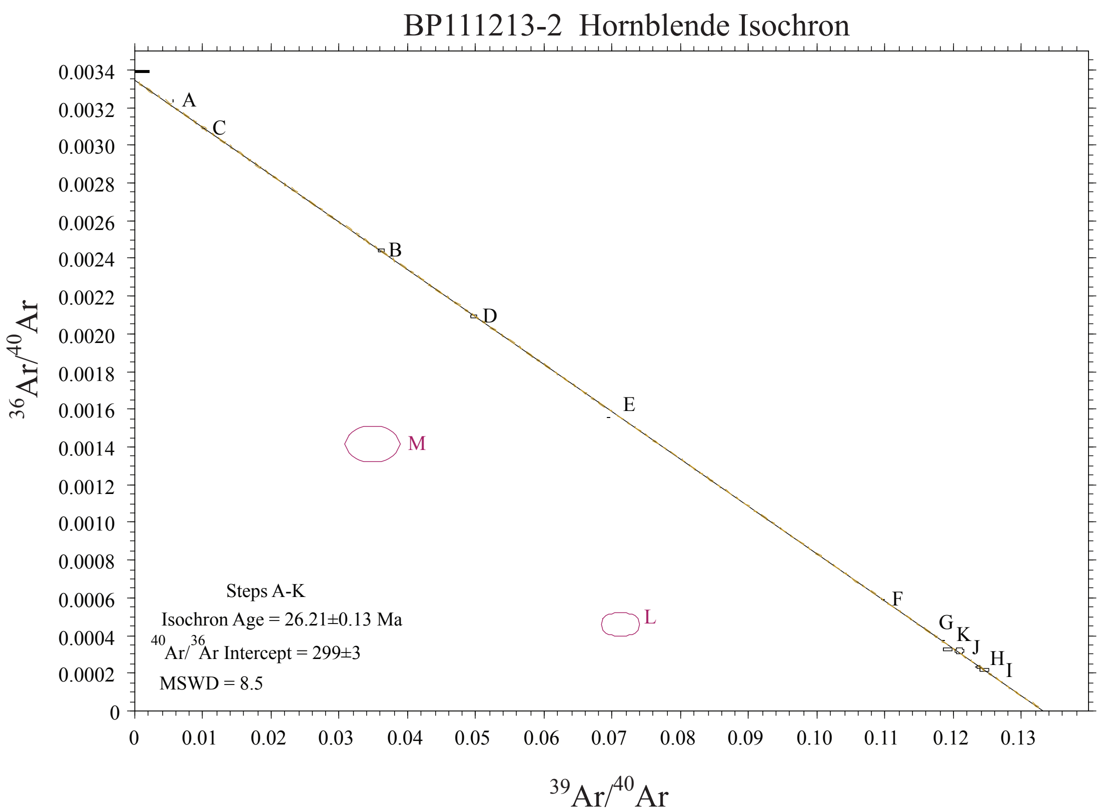
ID	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-15} mol)	K/Ca	$^{40}Ar^*$ (%)	Age (Ma)	±1σ (Ma)
PHO42414-2, san, J=0.001924±0.02%, D=1±0, NM-275E, Lab#=63571								
12	2.655	0.9788	5.215	0.009	0.52	45.1	4.2	1.7
04	1.432	0.4873	0.8536	0.075	1.0	85.1	4.26	0.23
14	2.709	1.349	5.101	0.020	0.38	47.8	4.55	0.81
03	1.593	0.8363	0.9064	0.042	0.61	87.1	4.86	0.36
02	2.147	0.7828	2.390	0.056	0.65	69.8	5.26	0.31
X 05	*2.722*	*1.654*	*1.184*	*0.051*	*0.31*	*91.9*	*8.78*	*0.32*
X 07	*4.864*	*0.6274*	*7.292*	*0.022*	*0.81*	*56.7*	*9.67*	*0.83*
X 06	*4.370*	*2.090*	*1.617*	*0.048*	*0.24*	*92.8*	*14.22*	*0.39*
X 15	*8.481*	*2.111*	*6.630*	*0.006*	*0.24*	*78.9*	*23.4*	*4.2*
X 10	*97.21*	*0.1450*	*1.558*	*0.096*	*3.5*	*99.5*	*312.5*	*2.5*
X 11	*197.7*	*0.0042*	*0.8832*	*0.596*	*122.9*	*99.9*	*589.30*	*0.70*
X 01	*675.8*	*0.1067*	*5.361*	*0.200*	*4.8*	*99.8*	*1522.4*	*4.2*
Mean age ± 2σ	**n=5**	**MSWD=1.72**			**0.6 ±0.5**		**4.7**	**0.4**
PHO42414-1, san, J=0.0019214±0.02%, D=1±0, NM-275E, Lab#=63569								
X 13	*2.099*	*0.4803*	*1.331*	*0.031*	*1.1*	*82.8*	*6.08*	*0.48*
X 12	*2.255*	*0.6320*	*1.215*	*0.121*	*0.81*	*86.2*	*6.80*	*0.15*
08	2.448	0.3475	1.254	0.143	1.5	85.9	7.36	0.13
06	2.836	0.3113	2.311	0.596	1.6	76.7	7.618	0.054
07	2.379	0.4906	0.7218	0.331	1.0	92.6	7.712	0.060
04	2.534	0.2658	1.154	0.558	1.9	87.3	7.746	0.049
11	2.292	0.0956	0.2731	0.907	5.3	96.8	7.761	0.021
05	2.451	0.2415	0.7444	0.740	2.1	91.8	7.869	0.030
10	2.678	0.1774	1.484	0.458	2.9	84.1	7.881	0.055
01	2.524	0.1131	0.8516	1.018	4.5	90.4	7.980	0.024
09	2.929	0.4742	2.227	0.327	1.1	78.7	8.076	0.073
02	2.615	0.2861	1.102	0.575	1.8	88.4	8.087	0.045
03	2.802	0.4080	1.496	0.397	1.3	85.3	8.371	0.057
14	2.682	0.1101	0.8066	0.274	4.6	91.4	8.580	0.076
X 15	*4.289*	*0.9080*	*2.270*	*0.024*	*0.56*	*85.8*	*12.89*	*0.77*
Mean age ± 2σ	**n=12**	**MSWD=26.61**			**2.5 ±3.0**		**7.89**	**0.12**

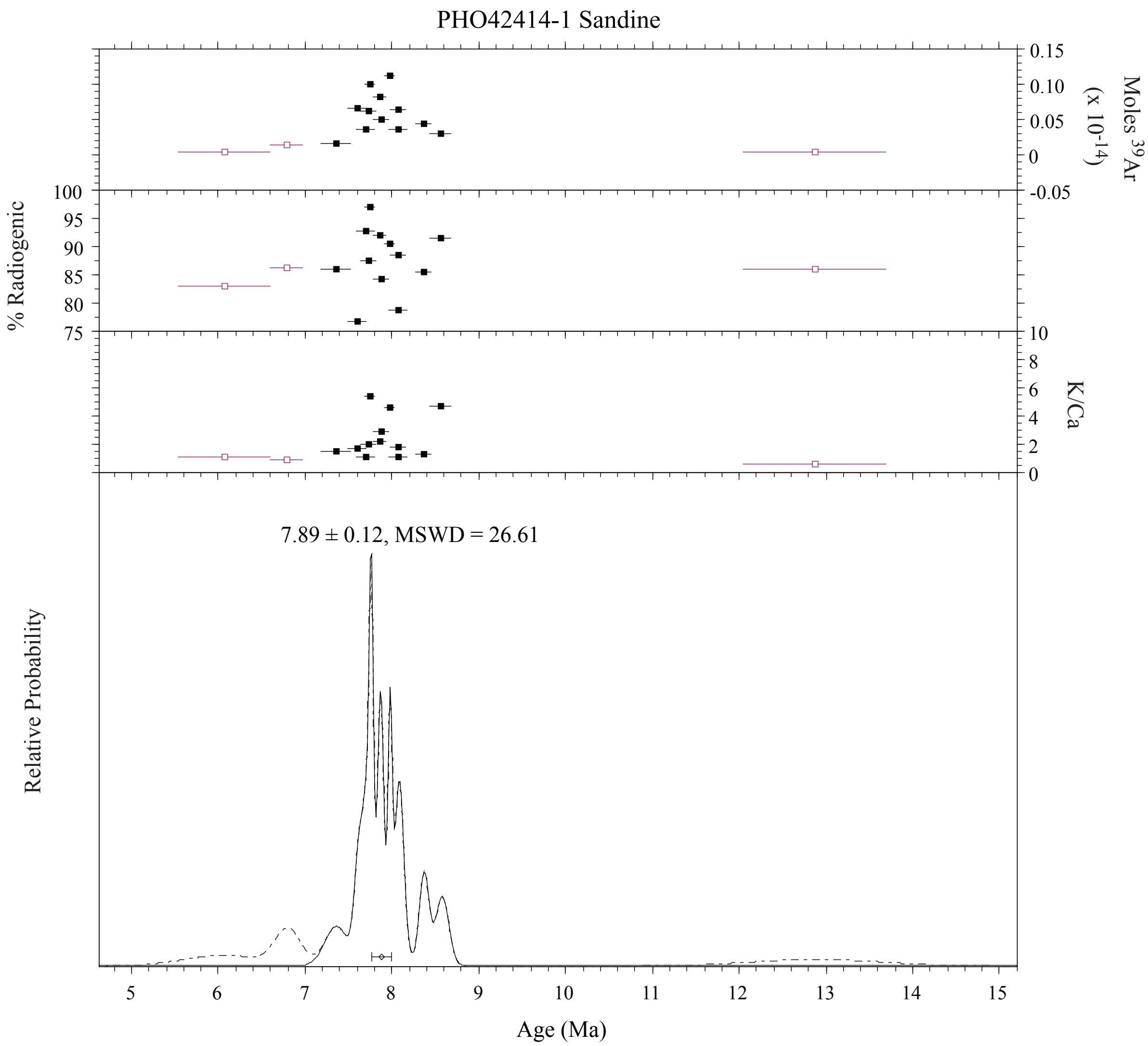
Notes:

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.
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 Minn et al. (2000).
symbol preceding sample ID denotes analyses excluded from mean age calculations.
Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.201Ma
Decay Constant (LambdaK (total)) = 5.543e-10/a
Correction factors:

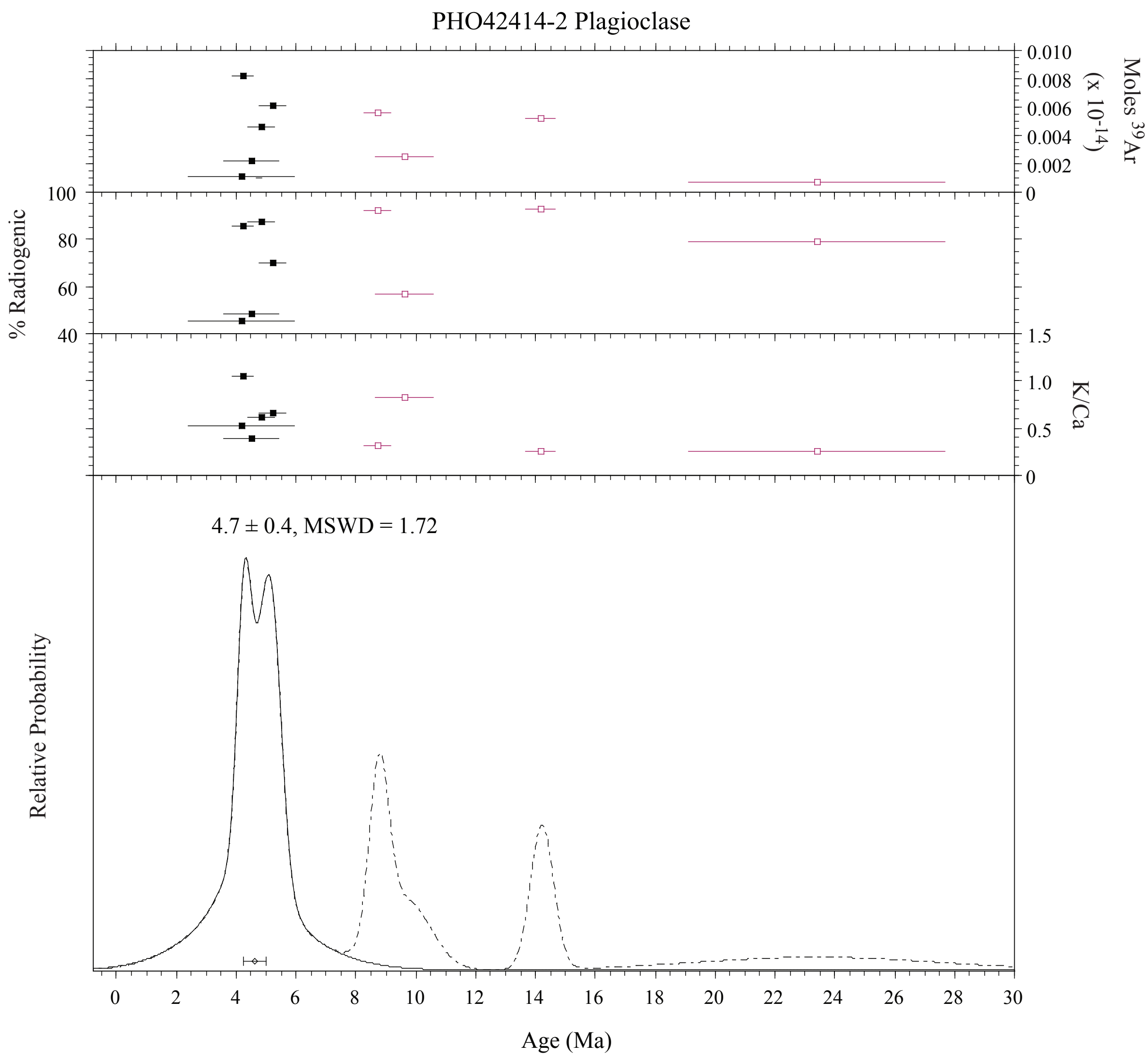
$(^{39}Ar/^{37}Ar)_{Ca}$ = 0.00066 ± 1e-05
$(^{36}Ar/^{37}Ar)_{Ca}$ = 0.000265 ± 1e-06
$(^{38}Ar/^{39}Ar)_{K}$ = 0.013
$(^{40}Ar/^{39}Ar)_{K}$ = 0.007614 ± 0.000105


BP111213-2 Bioitite (Black) and Hornblende (Red)
%40Ar*
K/Ca
Apparent Age (Ma)
26.22 ± 0.04 Ma (MSWD = 0.63,n = 6)
Integrated Age (63510-01) = 26.56 ± 0.09 Ma
Integrated Age (63509-01) = 26.143 ± 0.019 Ma
Cumulative %39Ar Released


BP111213-2 Hornblende Isochron
Steps A-K
Isochron Age = 26.21±0.13 Ma
40Ar/36Ar Intercept = 299±3
MSWD = 8.5
36Ar/40Ar
39Ar/40Ar



PHO42414-1 Sandine
Moles ^{39}Ar (x 10^{-14})
0.15
0.10
0.05
0
-0.05
% Radiogenic
100
95
90
85
80
75
K/Ca
10
8
6
4
2
0
Relative Probability
7.89 ± 0.12, MSWD = 26.61
5
6
7
8
9
10
11
12
13
14
15
Age (Ma)



PHO42414-2 Plagioclase
Moles ^{39}Ar (x 10^{-14})
0.010
0.008
0.006
0.004
0.002
0
% Radiogenic
100
80
60
40
K/Ca
1.5
1.0
0.5
0
4.7 ± 0.4, MSWD = 1.72
Relative Probability
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Age (Ma)