$^{40}Ar/^{39}Ar$ Geochronology Results From the Dog Valley Peak and Sage Valley Quadrangles, Utah

by

Utah Geological Survey and New Mexico Geochronology Research Laboratory

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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 references listed in table 1 report the age of the samples and provide additional information such as the sample location, 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.

Disclaimer

This Open-File release is intended as a data repository for technical analytical information gathered in support of various geologic mapping projects. The data are presented as received from the New Mexico Geochronology Research Laboratory and do not necessarily conform to UGS technical or editorial standards. Therefore, it may be premature for an individual or group to take actions based on the contents of this report.

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References to Geologic Reports that Cite or Explain Rock Units Analyzed in this Report

Clark, D.L., 2003, Geologic map of the Sage Valley quadrangle, Juab County, Utah: Utah Geological Survey Miscellaneous Publication 03-2, 57 p., 2 plates, scale 1:24,000.

Hintze, L.F., and Davis, F.D., 2003, Geology of Millard County, Utah: Utah Geological Survey Bulletin 133, 305 p.

Hintze, L.F., Davis, F.D., Rowley, P.D., Cunningham, C.G., Steven, T.A., and Willis, G.C., 2003, Geologic map of the Richfield 30'x60' quadrangle, southeast Millard County and parts of Beaver, Piute, and Sevier Counties, Utah: Utah Geological Survey Map 195, 2 plates, scale 1:100,000.

Hintze, L.F., Davis, F.D., Rowley, P.D., Cunningham, C.G., Steven, T.A., and Willis, G.C., 2008, Geologic map of the Richfield 30'x60' quadrangle, southeast Millard County and parts of Beaver, Piute, and Sevier Counties, Utah (digital GIS files): Utah Geological Survey Map 195DM, 2 plates, scale 1:100,000.

Corrections

The technical report introduction lists one of the sample numbers incorrectly. The correct sample is DV0011 (not DV001).

The "Richfield quadrangle" referred to in the technical report is the 30'x60' quadrangle – samples DV0011 and DV0012 are from the Dog Valley Peak 7.5' quadrangle within the Richfield 30'x60' quadrangle.

Notes

(also see discussion on reliability and preferred ages in technical report section)

SV21701-1 – Sample from the Chicken Creek Tuff Member of the Goldens Ranch Formation.

SV21701-2 – Sample from the tuff of Little Sage Valley, volcanic rocks of Sage Valley.

SV21701-4 – Sample from the Fernow Quartz Latite, volcanic rocks of Sage Valley.

DV0011 – Dog Valley Peak 7.5' quadrangle. From unit mapped as tuff of Dog Valley (Tdt) in Hintze and others (2003). Outcrop is resistant knob with volcanic foliation that dips about 20 degrees south. Sample is crystal-rich, with small phenocrysts of gray plagioclase, hornblende, and biotite, and with abundant pumice and lithic fragments.

DV0012 – From Dog Valley Peak 7.5' quadrangle. From unit mapped as Aurora Formation (Tau) (Hintze and others, 2003). Collected from very poorly preserved, long-abandoned road cut just south of rural dirt road. Sample is poorly lithified, weathered volcaniclastic clay or clayey mudstone.

Table 1.
Sample numbers and locations.

Sample #	**7.5' quadrangle**	**Latitude (N)**	**Longitude (W)**	**Reference**
SV021701-1	Sage Valley	39°35'36"	112°00'23"	Clark, 2003
SV021701-2	Sage Valley	39°36'25"	112°02'13"	Clark, 2003
SV021701-4	Sage Valley	39°37'07"	112°02'26"	Clark, 2003

Samples collected by R.F. Biek, UGS.

Latitude and longitude in NAD27.

Sample #	**7.5' quadrangle**	**Location**	**Reference**
DV0011	Dog Valley Peak	SW ¼ of SW ¼ of NE ¼ of section 7, T. 25 S., R. 6 W.	Hintze and Davis, 2003 Hintze and others, 2003
DV0012	Dog Valley Peak	NE ¼ of SW ¼ of NE ¼ of section 11, T. 25 S., R. 7 W.	Hintze and Davis, 2003 Hintze and others, 2003

Ar/ Ar Geochronology Results from the Sage Valley and Richfield Quadrangles Utah

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Introduction

Three samples (SV21701-1, SV21701-2, and SV21701-4) from the Sage Valley quadrangle, Utah and two samples (DV001 and DV0012) from the Richfield quadrangle, Utah were submitted for analysis by Bob Biek of the Utah Geological Survey. Biotite was separated from all five samples. Sanidine was also separated from SV21701-4.

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

The sanidine separate was analyzed by the single crystal total fusion method, while the biotite separates were analyzed both as single crystal and bulk separate by the incremental heating age spectrum method using a CO_2 laser equipped with an integrator lens. Abbreviated analytical methods for the dated samples are given in Table 1. The $^{40}Ar/^{39}Ar$ analytical results for the dated samples are given in Tables 2-4. Details of the overall operation of the New Mexico Geochronology Research Laboratory are provided in the Appendix. A summary of the $^{40}Ar/^{39}Ar$ results can be found in Table 1.

Of the sixteen crystals of SV21701-4 analyzed, 14 yielded K/Ca ratios indicative of sanidine (Table 2). A weighted mean age of 34.83±0.15 Ma is calculated from these 14 crystals (Figure 1). The MSWD value is outside the 95% confidence interval, the error on the weighted mean has been increased accordingly (Mahon, 1996).

Initially, the biotite was analyzed as single crystals to evaluate possible xenocrystic contamination of the separates (Table 3). Weighted mean ages were calculated from the more radiogenic and thus more precise B steps of these analyses (Table 4). The weighted mean age calculated for SV21701-1 (Figure 2), 38.73±0.22 Ma, has an acceptable MSWD (cf. Mahon, 1996). Those calculated for the other samples (DV00-11, 33.25±0.59 Ma; SV21701-4, 34.99±0.71 Ma; SV21701-2, 37.58±0.42 Ma; DV00-12, 38.42±0.82 Ma) have MSWD values that fall outside the 95% confidence interval (Table 4, cf. Mahon, 1996). Even though the MSWD values are outside the 95% confidence interval, all samples (except DV00-12) have age distributions that are suggestive of one population rather than multiple (Figures 3-6). The single crystal data for DV00-12 is divided into a younger and less radiogenic population and an older and more radiogenic one. The weighted mean age quoted for DV00-12 is calculated from the older population. It is noted that the radiogenic yields for these analyses are lower than expected for biotite of this age (prestine biotite of this age would have radiogenic yields ~90-100%).

A more detailed step-heating schedule (11 steps verses 2) with 4-5 mg multigrain aliquots of biotite was run on all samples in an effort to improve the precision and accuracy of the apparent ages (Table 5). The age spectra are disturbed in the first 10-20% of the ^{39}Ar released with the remaining portions being concordant or nearly so (Figures 7a-11a). The disturbed portions of the age spectra correlate with low radiogenic yields. Weighted mean ages are calculated from the last 80-90% of the age spectra. These apparent ages are shown plotted on the age probability distribution diagrams mentioned above, Figures 2-6. It is noted that, for all samples except sample DV100-12, the weighted mean ages calculated from the all b steps of the single crystal analyses agree within error to the ages calculated from the age spectra analyses. All were evaluated with the inverse isochron method and found to have $^{40}Ar/^{36}Ar$ intercepts that agree within error to the atmospheric intercept of 295.5 (Figures 7b-11b).

Discussion

Before discussing the apparent ages assigned to these samples, we would like to mention that caution should be used when comparing sanidine apparent ages with those of biotite. It has been found that when biotite and sanidine from the same sample are analyzed, the biotite often yields apparent ages up ~.5 Ma older than the sanidine apparent age.

The weighted mean age calculated from the single crystal sanidine analyses (34.83±0.15 Ma) is assigned as the preferred eruption age of SV21701-4. As the single crystal data revealed no xenocrystic contamination, we have assigned the more precise weighted mean ages calculated from the age spectra analyses as the preferred eruption ages of three of the four samples dated only with biotite (DV00-11, 33.56±0.10 Ma; SV21701-1, 38.61±0.13 Ma; SV21701-2, 37.43±0.18 Ma). The correlation between the disturbed early portions of the age spectra and low radiogenic yields suggests that the biotite has undergone alteration and Ar loss. It is noted that the weighted mean age assigned to sanidine from SV21701-4 (34.83±0.15 Ma) agrees within error to the weighted mean age assigned to bulk biotite analysis (34.93±0.20 Ma). This would suggest that there has been only minimal Ar loss to the other biotite samples (age spectra disturbed to a similar or lesser degree).

The single crystal analyses of DV00-12 fall in two distinct populations, with the younger population revealing lower radiogenic yields that increase with apparent age. This

suggests these crystals have undergone alteration and Ar loss. The weighted mean age calculated from the age spectrum falls between the ages of these two populations, We suggest that the bulk analysis has homogenized the single crystal data and that a weighted mean calculated from the oldest population, and presumably less altered, of the single crystal analyses(38.42±0.17 Ma) represents the most accurate age for this sample.

References Cited

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

Sample	Lab #	Irradiation	mineral	Age	±2σ	comments
DV00-11	52305	NM-138	biotite	33.25	0.59	single crystal
DV00-12	52306	NM-138	biotite	38.42	0.82	single crystal
SV21701-1	52309	NM-138	biotite	38.73	0.22	single crystal
SV21701-2	52325	NM-138	biotite	37.58	0.42	single crystal
SV21701-4	52324	NM-138	sanidine	34.83	0.15	single crystal

Sample preparation and irradiation:

Mineral separates were prepared using standard crushing, heavy liquid and hand-picking techniques.
The samples were loaded into a machined Al disc and irradiated for 7 hour in D-3 position, Nuclear Science Center, College Station, TX.
Neutron flux monitor Fish Canyon Tuff sanidine (FC-1). Assigned age = 27.84 Ma (Deino and Potts, 1990)
relative to Mmhb-1 at 520.4 Ma (Samson and Alexander, 1987).

Instrumentation:

Mass Analyzer Products 215-50 mass spectrometer on line with automated all-metal extraction system.
Biotite separates were step-heated by a 50 watt Synrad CO_2 laser equipped with an integrator lens.
Heating duration: 30 seconds, 2 step analysis; 40 seconds, 11 step analysis
Reactive gases removed by a 6 or 13.3 minute 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 and a cold finger operated at -140°C.
Single sanidine crystals were fused by a 50 watt Synrad CO_2 laser.
Reactive gases removed during a 2 minute 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 and a cold finger operated at -140°C.

Analytical parameters:

Electron multiplier sensitivity averaged 7.84 x 10^{-17} moles/pA.
Total system blank and background for the single crystal biotite analyses averaged 898, 2.1, 0.7, 0.7, 3.8 x 10^{-18} moles,
for the bulk biotite analyses averaged 1550, 8.3, 1.7, 1.4, 5.7, x 10^{-18} and for the single crystal sanidine analyses averaged 244, 1.9, 0.4, 1.5, 1.3 x 10^{-18}
at masses 40, 39, 38, 37, and 36, respectively.
J-factors determined to a precision of ± 0.1% by CO_2 laser-fusion of 4 single crystals from each of 4 radial positions around the irradiation tray.
Correction factors for interfering nuclear reactions were determined using K-glass and CaF_2 and are as follows:
$(^{40}Ar/^{39}Ar)_K = 0.00020\pm0.0003$; $(^{36}Ar/^{37}Ar)_{Ca} = 0.00028\pm0.000005$; and $(^{39}Ar/^{37}Ar)_{Ca} = 0.0007\pm0.00002$.

Age calculations:

Total gas age and error calculated by weighting individual steps by the fraction of ^{39}Ar released.
Plateau age or preferred age calculated for the indicated steps by weighting each step by the inverse of the variance.
Plateau age error calculated using the method of (Taylor, 1982).
MSWD values are calculated for n-1 degrees of freedom for plateau age.
Isochron ages, $^{40}Ar/^{36}Ar_i$ and MSWD values calculated from regression results obtained by the methods of York (1969).
Decay constants and isotopic abundances after Steiger and Jäger (1977).
All final errors reported at ±2σ, unless otherwise noted.

Table 2. Argon isotopic results for single crystal sanidine results.

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)	±1□ (Ma)
SV21701-4, single crystal sanidine, J=0.0007748, NM-138, Lab#=52307								
30	25.10	0.0111	0.3946	4.12	46.0	99.5	34.59	0.09
25	24.88	0.1551	-0.3441	2.82	3.3	100.5	34.60	0.11
22	25.11	0.0050	0.2769	8.82	102.6	99.7	34.65	0.08
31	25.12	0.0074	0.2601	5.93	69.3	99.7	34.67	0.07
32	25.24	0.0095	0.4767	4.38	53.6	99.4	34.75	0.08
20	25.17	0.0072	0.2188	11.7	70.4	99.7	34.76	0.08
29	25.14	0.0078	0.0592	10.2	65.6	99.9	34.78	0.07
33	25.03	0.0036	-0.4341	4.04	143.3	100.5	34.83	0.09
23	25.42	0.0024	0.8052	3.46	212.5	99.1	34.85	0.08
28	25.23	0.0042	0.1668	8.74	120.4	99.8	34.85	0.08
24	25.41	0.0047	0.4530	5.69	108.5	99.5	34.99	0.08
27	25.37	0.0060	0.2579	5.82	84.3	99.7	35.01	0.08
21	25.31	0.0026	0.0391	5.57	196.8	100.0	35.03	0.09
26	25.33	0.0076	0.0810	7.97	66.9	99.9	35.04	0.07
35	*25.20*	*3.764*	*0.6622*	*0.307*	*0.14*	*100.5*	*35.13*	*0.52*
34	*25.20*	*1.797*	*-0.7069*	*0.287*	*0.28*	*101.4*	*35.42*	*0.56*
weighted mean	MSWD = 3.5**	n=14		96.0 ±57.5			34.83	0.15*

Notes:
Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interferring reactions.
Individual analyses show analytical error only; plateau and total gas age errors include error in J and irradiation parameters.
n= number of heating steps
K/Ca = molar ratio calculated from reactor produced $^{39}Ar_K$ and $^{37}Ar_{Ca}$.

* 2□ error

** MSWD outside 95% confidence interval

Table 3. Argon isotopic results for single-crystal step-heating results.

ID	Power (watts)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-16} mol)	K/Ca	$^{40}Ar^*$ (%)	^{39}Ar (%)	Age (Ma)	±1σ (Ma)
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-06										
A	1	2356.6	0.0418	7936.7	4.84	12.2	0.5	10.2	15.8	7.7
B	10	61.39	0.0402	119.6	42.7	12.7	42.4	100.0	36.19	0.28
total gas age			n=2		47.5	12.7			34.1	1.0
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-07										
A	1	1921.8	0.0290	6504.7	1.52	17.6	0.0	8.9	-0.5	9.0
B	10	63.14	0.0251	124.2	15.6	20.4	41.9	100.0	36.74	0.45
total gas age			n=2		17.1	20.1			33.4	1.2
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-08										
A	1	1344.0	-0.0001	4459.5	0.967	-	2.0	17.6	36.4	8.6
B	10	73.95	0.0297	172.5	4.52	17.2	31.1	100.0	31.95	0.84
total gas age			n=2		5.48	17.2			32.7	2.2
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-09										
A	1	1056.7	-0.0193	3516.2	1.24	-	1.7	13.5	24.6	7.2
B	10	41.44	0.0595	58.49	7.90	8.6	58.3	100.0	33.59	0.36
total gas age			n=2		9.14	8.6			32.4	1.3
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-10										
A	1	3058.4	0.0101	10344.4	2.37	50.8	0.1	3.6	2	13
B	10	52.73	0.0605	94.74	63.0	8.4	46.9	100.0	34.37	0.21
total gas age			n=2		65.4	10.0			33.21	0.68
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-01										
A	1	7981.1	-0.0330	26682.2	2.49	-	1.2	4.6	131	21
B	10	134.4	0.0542	358.8	51.4	9.4	21.1	100.0	39.33	0.45
total gas age			n=2		53.9	9.4			43.5	1.4
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-02										
A	1	3574.9	0.0084	12031.2	1.27	60.9	0.6	10.6	27	13
B	10	128.4	0.0302	338.6	10.8	16.9	22.1	100.0	39.40	0.94
total gas age			n=2		12.0	21.6			38.1	2.2
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-03										
A	1	2047.3	0.0874	6815.3	0.746	5.8	1.6	5.0	46	11
B	10	44.63	0.0305	56.19	14.1	16.7	62.8	100.0	38.92	0.31
total gas age			n=2		14.8	16.2			39.29	0.86
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-04										
A	1	452.5	0.1196	1500.4	0.375	4.3	2.0	5.6	12.8	8.1
B	10	49.11	0.0239	71.44	6.36	21.4	57.0	100.0	38.88	0.50
total gas age			n=2		6.74	20.4			37.43	0.92
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-05										
A	1	916.4	0.0317	3053.1	1.90	16.1	1.6	4.9	19.9	5.8
B	10	42.02	0.0401	47.56	37.3	12.7	66.6	100.0	38.83	0.16
total gas age			n=2		39.2	12.9			37.92	0.43
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-06										
A	1	1360.2	0.0371	4528.3	0.994	13.8	1.6	5.8	30.8	9.6
B	10	60.89	0.0331	114.4	16.1	15.4	44.5	100.0	37.62	0.35
total gas age			n=2		17.1	15.3			37.22	0.88
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-07										
A	1	919.0	0.0950	3054.0	0.321	5.4	1.8	9.0	23	13
B	10	120.0	0.0168	313.4	3.23	30.3	22.8	100.0	38.0	1.2
total gas age			n=2		3.55	28.1			36.7	2.3
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-08										
A	1	4272.5	0.0842	14502.2	1.09	6.1	-0.3	11.1	-18	20
B	10	85.44	0.0220	193.8	8.69	23.2	33.0	100.0	39.12	0.62
total gas age			n=2		9.78	21.3			32.8	2.7

Table 3. Argon isotopic results for single-crystal step-heating results.

ID	Power (watts)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-16} mol)	K/Ca	$^{40}Ar^*$ (%)	^{39}Ar (%)	Age (Ma)	±1□ (Ma)
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-04										
A	1	281.1	-0.0117	866.6	1.17	-	8.9	13.4	34.5	4.0
B	10	85.66	0.0035	193.0	7.53	144.8	33.4	100.0	39.42	0.63
total gas age			n=2		8.70	144.8			38.8	1.1
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-05										
A	1	249.5	0.0077	774.7	3.46	66.3	8.2	28.9	28.4	1.6
B	10	96.96	0.0201	237.0	8.52	25.3	27.8	100.0	37.08	0.78
total gas age			n=2		12.0	37.2			34.6	1.0
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-06										
A	1	550.2	0.0350	1799.2	4.04	14.6	3.4	27.5	25.6	2.7
B	10	71.84	0.0145	148.8	10.6	35.2	38.8	100.0	38.39	0.48
total gas age			n=2		14.7	29.5			34.9	1.1
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-07										
A	1	2380.1	0.0008	8073.5	1.47	648.5	-0.2	18.6	-7.8	9.6
B	10	152.4	0.0102	432.7	6.44	50.0	16.1	100.0	33.80	0.99
total gas age			n=2		7.91	161.4			26.1	2.6
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-08										
A	1	378.1	0.0167	1220.7	3.01	30.6	4.6	28.3	24.1	2.4
B	10	220.9	0.0734	668.5	7.65	6.9	10.6	100.0	32.2	1.3
total gas age			n=2		10.7	13.6			29.9	1.6
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-09										
A	1	375.4	0.0093	1206.2	7.63	55.1	5.1	26.6	26.3	1.5
B	10	64.61	0.0100	124.1	21.1	51.1	43.2	100.0	38.48	0.27
total gas age			n=2		28.7	52.1			35.24	0.59
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-10										
A	1	400.7	0.1988	1292.5	1.64	2.6	4.7	16.6	25.9	3.4
B	10	77.52	0.0572	162.6	8.25	8.9	38.0	100.0	40.58	0.51
total gas age			n=2		9.89	7.9			38.16	1.00
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-11										
A	1	1062.2	0.0115	3529.8	5.58	44.3	1.8	24.6	26.4	4.0
B	10	88.71	0.0266	216.1	17.1	19.2	28.0	100.0	34.29	0.53
total gas age			n=2		22.6	25.4			32.4	1.4
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-01										
A	1	2617.5	0.0160	8774.7	0.822	31.8	0.9	1.4	34	12
B	10	90.24	0.0641	219.9	58.9	8.0	28.0	100.0	35.11	0.32
total gas age			n=2		59.7	8.3			35.10	0.49
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-02										
A	1	2544.7	-0.0132	8477.1	0.912	-	1.6	3.3	55	13
B	10	102.7	0.0307	264.2	26.4	16.6	24.0	100.0	34.18	0.43
total gas age			n=2		27.3	16.6			34.88	0.84
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-03										
A	1	1410.7	0.0051	4763.5	0.810	99.5	0.2	6.9	4.4	9.2
B	10	40.63	0.0207	49.92	10.9	24.7	63.7	100.0	35.95	0.36
total gas age			n=2		11.7	29.9			33.76	0.97
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-04										
A	1	884.6	0.0424	2926.8	0.679	12.0	2.2	13.7	27.4	8.0
B	10	54.22	0.0391	96.29	4.28	13.0	47.5	100.0	35.79	0.71
total gas age			n=2		4.96	12.9			34.6	1.7
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308-05										
A	1	1657.5	0.0212	5537.0	2.86	24.0	1.3	14.7	29.7	6.6
B	10	69.80	0.0243	150.7	16.7	21.0	36.2	100.0	35.09	0.41
total gas age			n=2		19.5	21.4			34.3	1.3

Table 3. Argon isotopic results for single-crystal step-heating results.

ID	Power (watts)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-16} mol)	K/Ca	$^{40}Ar^*$ (%)	^{39}Ar (%)	Age (Ma)	±1σ (Ma)
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-02										
A	1	133.1	-0.9089	-35.7170	0.030	-	107.9	0.5	189	56
B	10	28.89	0.0250	14.93	6.10	20.4	84.7	100.0	33.60	0.29
total gas age			n=2		6.13	20.4			34.35	0.56
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-03										
A	1	416.2	0.0962	1269.3	0.030	5.3	9.9	0.5	56	50
B	10	31.46	0.0484	24.22	5.43	10.5	77.3	100.0	33.36	0.35
total gas age			n=2		5.46	10.5			33.49	0.62
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-04										
A	2	47.59	0.1204	204.3	0.097	4.2	-26.9	2.4	-18	18
B	10	28.62	0.0083	20.72	3.96	61.2	78.6	100.0	30.90	0.52
total gas age			n=2		4.06	59.8			29.74	0.93
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-05										
A	2	52.14	0.1841	258.0	0.103	2.8	-46.2	1.1	-34	17
B	10	26.90	0.0140	8.747	9.65	36.5	90.4	100.0	33.38	0.22
total gas age			n=2		9.75	36.2			32.67	0.41
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-06										
A	2	142.3	-0.0576	526.5	0.058	-	-9.3	0.7	-18	30
B	10	29.50	0.0139	19.80	8.40	36.8	80.2	100.0	32.47	0.26
total gas age			n=2		8.46	36.8			32.12	0.47
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-07										
A	2	61.95	-1.1492	-270.5623	0.037	-	228.9	0.6	186	55
B	10	60.74	0.0182	120.5	6.27	28.0	41.4	100.0	34.47	0.62
total gas age			n=2		6.30	28.0			35.35	0.93
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-08										
A	2	85.40	0.1762	152.6	0.122	2.9	47.2	1.5	55	14
B	10	45.55	0.0396	70.06	8.21	12.9	54.6	100.0	34.10	0.43
total gas age			n=2		8.33	12.7			34.40	0.64
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-09										
A	2	128.6	-0.1299	312.6	0.103	-	28.1	0.7	49	18
B	10	46.13	0.0143	70.36	13.8	35.8	54.9	100.0	34.77	0.36
total gas age			n=2		13.9	35.8			34.88	0.49
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-10										
A	2	1539.2	0.2554	5352.9	0.228	2.0	-2.8	1.7	-60	22
B	10	40.53	0.0277	58.68	13.2	18.5	57.2	100.0	31.84	0.32
total gas age			n=2		13.5	18.2			30.29	0.69
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305-11										
A	2	130.3	-0.4307	375.1	0.089	-	14.9	0.5	27	19
B	10	30.65	0.0268	21.17	16.3	19.0	79.6	100.0	33.48	0.18
total gas age			n=2		16.3	19.0			33.45	0.28
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-01										
A	1	2813.9	0.0062	9442.1	5.13	82.0	0.8	17.8	32.8	8.0
B	10	132.1	0.0104	366.0	23.7	49.3	18.1	100.0	33.01	0.60
total gas age			n=2		28.9	55.1			33.0	1.9
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-02										
A	1	1830.8	0.0219	6134.9	3.54	23.3	1.0	22.9	24.8	6.3
B	10	114.9	0.0336	304.0	11.9	15.2	21.8	100.0	34.52	0.76
total gas age			n=2		15.4	17.0			32.3	2.0
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306-03										
A	1	752.9	0.0166	2478.6	3.91	30.7	2.7	8.3	28.2	3.8
B	10	64.62	0.0528	126.2	43.0	9.7	42.3	100.0	37.67	0.28
total gas age			n=2		46.9	11.4			36.88	0.58

Table 3. Argon isotopic results for single-crystal step-heating results.

ID	Power (watts)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-16} mol)	K/Ca	$^{40}Ar^*$ (%)	^{39}Ar (%)	Age (Ma)	±1σ (Ma)
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-09										
A	1	966.9	-0.0011	3167.5	0.400	-	3.2	4.9	43	11
B	10	62.94	0.0131	117.9	7.79	39.0	44.6	100.0	39.01	0.64
total gas age			n=2		8.19	39.0			39.2	1.1
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309-10										
A	1	1166.9	0.0379	3898.4	0.850	13.5	1.3	3.1	20.8	8.9
B	10	52.16	0.0174	82.41	26.3	29.3	53.3	100.0	38.61	0.21
total gas age			n=2		27.1	28.8			38.05	0.49
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-01										
A	1	6054.9	-0.0894	20500.4	0.192	-	0.0	0.7	-4	44
B	10	50.00	0.0403	78.31	27.9	12.7	53.7	100.0	37.27	0.22
total gas age			n=2		28.1	12.7			36.99	0.52
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-02										
A	1	4722.0	0.6563	15551.6	0.051	0.78	2.7	0.5	169	88
B	10	77.06	2.514	163.9	9.92	0.20	37.4	100.0	40.06	0.56
total gas age			n=2		9.97	0.21			40.7	1.0
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-03										
A	2	2027.7	0.4355	6858.8	1.44	1.2	0.0	3.5	1.4	9.6
B	10	47.83	0.0624	72.07	39.3	8.2	55.5	100.0	36.82	0.20
total gas age			n=2		40.7	7.9			35.57	0.53
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-04										
A	2	3475.9	0.0537	11818.5	1.38	9.5	-0.5	4.3	-23	15
B	10	34.04	0.0330	22.46	30.5	15.5	80.5	100.0	38.01	0.16
total gas age			n=2		31.9	15.2			35.36	0.80
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-05										
A	2	1508.8	0.1730	5034.5	1.15	2.9	1.4	5.5	29.3	8.0
B	10	49.86	0.0302	78.04	19.9	16.9	53.8	100.0	37.18	0.36
total gas age			n=2		21.0	16.1			36.75	0.77
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-06										
A	2	4158.0	0.0948	13903.8	1.24	5.4	1.2	3.2	68	16
B	10	35.37	0.0317	28.30	37.8	16.1	76.4	100.0	37	0
total gas age			n=2		39.0	15.8			38.44	0.67
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-07										
A	2	353.3	0.2389	1112.0	0.422	2.1	7.0	1.1	34.4	6.4
B	10	28.96	0.0616	5.560	39.6	8.3	94.3	100.0	37.89	0.11
total gas age			n=2		40.0	8.2			37.85	0.17
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-08										
A	2	458.4	0.5554	1612.9	0.151	0.92	-4.0	1.9	-26	12
B	10	34.11	0.0255	23.18	7.91	20.0	79.9	100.0	37.81	0.25
total gas age			n=2		8.07	19.6			36.62	0.47
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310-09										
A	2	2737.1	0.0594	9194.7	1.24	8.6	0.7	8.0	28	11
B	10	30.67	0.0126	13.62	14.3	40.4	86.9	100.0	36.96	0.15
total gas age			n=2		15.5	37.9			36.2	1.0

Notes:
Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interferring reactions.
Individual analyses show analytical error only; plateau and total gas age errors include error in J and irradiation parameters.
n= number of heating steps
K/Ca = molar ratio calculated from reactor produced $^{39}Ar_K$ and $^{37}Ar_{Ca}$.

Table 4. Argon isotopic data for B steps of single-crystal step-heating results.

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)	±1□ (Ma)
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309								
06B	60.89	0.0331	114.4	1.61	15.4	44.5	37.62	0.35
07B	120.0	0.0168	313.4	0.323	30.3	22.8	38.0	1.2
10B	52.16	0.0174	82.41	2.63	29.3	53.3	38.61	0.21
05B	42.02	0.0401	47.56	3.73	12.7	66.6	38.83	0.16
04B	49.11	0.0239	71.44	0.636	21.4	57.0	38.88	0.50
03B	44.63	0.0305	56.19	1.41	16.7	62.8	38.92	0.31
09B	62.94	0.0131	117.9	0.779	39.0	44.6	39.01	0.64
08B	85.44	0.0220	193.8	0.869	23.2	33.0	39.12	0.62
01B	134.4	0.0542	358.8	5.14	9.4	21.1	39.33	0.45
02B	128.4	0.0302	338.6	1.08	16.9	22.1	39.40	0.94
weighted mean	MSWD = 1.7	n=10			21.4 ±9.2		38.73	0.22*
DV00-12, single crystal biotite, J=0.0007716, NM-138, Lab#=52306								
08B	*220.9*	*0.0734*	*668.5*	*0.765*	*6.9*	*10.6*	*32.2*	*1.3*
01B	*132.1*	*0.0104*	*366.0*	*2.37*	*49.3*	*18.1*	*33.01*	*0.60*
07B	*152.4*	*0.0102*	*432.7*	*0.644*	*50.0*	*16.1*	*33.80*	*0.99*
11B	*88.71*	*0.0266*	*216.1*	*1.71*	*19.2*	*28.0*	*34.29*	*0.53*
02B	*114.9*	*0.0336*	*304.0*	*1.19*	*15.2*	*21.8*	*34.52*	*0.76*
05B	96.96	0.0201	237.0	0.852	25.3	27.8	37.08	0.78
03B	64.62	0.0528	126.2	4.30	9.7	42.3	37.67	0.28
06B	71.84	0.0145	148.8	1.06	35.2	38.8	38.39	0.48
09B	64.61	0.0100	124.1	2.11	51.1	43.2	38.48	0.27
04B	85.66	0.0035	193.0	0.753	144.8	33.4	39.42	0.63
10B	77.52	0.0572	162.6	0.825	8.9	38.0	40.58	0.51
weighted mean	MSWD = 6.1**	n=6			45.8 ±51.0		38.42	0.82*

Notes:
Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interferring reactions.
Individual analyses show analytical error only; plateau and total gas age errors include error in J and irradiation parameters.
n= number of heating steps
K/Ca = molar ratio calculated from reactor produced $^{39}Ar_K$ and $^{37}Ar_{Ca}$.

* 2□ error

** MSWD outside 95% confidence interval

Table 4. Argon isotopic data for B steps of single-crystal step-heating results.

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)
SV21701-1, single crystal biotite, J=0.0007779, NM-138, Lab#=52309								
06B	60.89	0.0331	114.4	1.61	15.4	44.5	37.62	0.35
07B	120.0	0.0168	313.4	0.323	30.3	22.8	38.0	1.2
10B	52.16	0.0174	82.41	2.63	29.3	53.3	38.61	0.21
05B	42.02	0.0401	47.56	3.73	12.7	66.6	38.83	0.16
04B	49.11	0.0239	71.44	0.636	21.4	57.0	38.88	0.50
03B	44.63	0.0305	56.19	1.41	16.7	62.8	38.92	0.31
09B	62.94	0.0131	117.9	0.779	39.0	44.6	39.01	0.64
08B	85.44	0.0220	193.8	0.869	23.2	33.0	39.12	0.62
01B	134.4	0.0542	358.8	5.14	9.4	21.1	39.33	0.45
02B	128.4	0.0302	338.6	1.08	16.9	22.1	39.40	0.94
weighted mean	MSWD = 1.7	n=10			21.4 ±9.2		38.73	0.22*
DV00-11, single crystal biotite, J=0.0007678, NM-138, Lab#=52305								
04B	28.62	0.0083	20.72	0.396	61.2	78.6	30.90	0.52
10B	40.53	0.0277	58.68	1.32	18.5	57.2	31.84	0.32
06B	29.50	0.0139	19.80	0.840	36.8	80.2	32.47	0.26
03B	31.46	0.0484	24.22	0.543	10.5	77.3	33.36	0.35
05B	26.90	0.0140	8.747	0.965	36.5	90.4	33.38	0.22
11B	30.65	0.0268	21.17	1.63	19.0	79.6	33.48	0.18
02B	28.89	0.0250	14.93	0.610	20.4	84.7	33.60	0.29
08B	45.55	0.0396	70.06	0.821	12.9	54.6	34.10	0.43
07B	60.74	0.0182	120.5	0.627	28.0	41.4	34.47	0.62
09B	46.13	0.0143	70.36	1.38	35.8	54.9	34.77	0.36
weighted mean	MSWD = 8.7**	n=10			28.0 ±15.2		33.25	0.59*
SV21701-4, single crystal biotite, J=0.0007776, NM-138, Lab#=52308								
08B	73.95	0.0297	172.5	0.452	17.2	31.1	31.95	0.84
09B	41.44	0.0595	58.49	0.790	8.6	58.3	33.59	0.36
02B	102.7	0.0307	264.2	2.64	16.6	24.0	34.18	0.43
10B	52.73	0.0605	94.74	6.30	8.4	46.9	34.37	0.21
05B	69.80	0.0243	150.7	1.67	21.0	36.2	35.09	0.41
01B	90.24	0.0641	219.9	5.89	8.0	28.0	35.11	0.32
04B	54.22	0.0391	96.29	0.428	13.0	47.5	35.79	0.71
03B	40.63	0.0207	49.92	1.09	24.7	63.7	35.95	0.36
06B	61.39	0.0402	119.6	4.27	12.7	42.4	36.19	0.28
07B	63.14	0.0251	124.2	1.56	20.4	41.9	36.74	0.45
weighted mean	MSWD = 9.2**	n=10			15.0 ±5.9		34.99	0.71*
SV21701-2, single crystal biotite, J=0.0007769, NM-138, Lab#=52310								
03B	47.83	0.0624	72.07	3.93	8.2	55.5	36.82	0.20
09B	30.67	0.0126	13.62	1.43	40.4	86.9	36.96	0.15
05B	49.86	0.0302	78.04	1.99	16.9	53.8	37.18	0.36
01B	50.00	0.0403	78.31	2.79	12.7	53.7	37.27	0.22
06B	35.37	0.0317	28.30	3.78	16.1	76.4	37.47	0.17
08B	34.11	0.0255	23.18	0.791	20.0	79.9	37.81	0.25
07B	28.96	0.0616	5.560	3.96	8.3	94.3	37.89	0.11
04B	34.04	0.0330	22.46	3.05	15.5	80.5	38.01	0.16
02B	77.06	2.514	163.9	0.992	0.20	37.4	40.06	0.56
weighted mean	MSWD = 8.9**	n=9			15.4 ±11.1		37.58	0.42*

Table 5. Argon isotopic results for bulk step-heating analyses.

ID	Temp (°C)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-16} mol)	K/Ca	$^{40}Ar^*$ (%)	^{39}Ar (%)	Age (Ma)	±1σ (Ma)
DV00-11, 4.06 mg biotite, J=0.0007678, NM-138, Lab#=52305-25										
A	*2*	*975.9*	*-0.0808*	*3282.0*	*1.21*	*-*	*0.6*	*0.2*	*8.39*	*6.03*
B	*5*	*127.0*	*0.0826*	*352.8*	*12.2*	*6.2*	*17.9*	*2.7*	*31.16*	*0.62*
C	*7*	*41.41*	*0.0394*	*59.23*	*17.8*	*12.9*	*57.7*	*6.2*	*32.83*	*0.27*
D	10	30.06	0.0298	19.42	36.4	17.1	80.9	13.4	33.39	0.14
E	12	28.74	0.0220	14.58	30.2	23.2	85.0	19.4	33.54	0.14
F	15	27.88	0.0246	11.95	44.1	20.8	87.3	28.2	33.43	0.11
G	20	27.07	0.0229	8.998	90.3	22.2	90.2	46.2	33.51	0.08
H	25	27.07	0.0233	8.708	97.1	21.9	90.5	65.5	33.62	0.09
I	30	27.92	0.0571	11.55	80.3	8.9	87.8	81.4	33.64	0.09
J	40	31.45	0.0117	23.29	78.5	43.7	78.1	97.0	33.72	0.13
K	40	48.80	0.0312	82.52	15.0	16.3	50.0	100.0	33.51	0.35
total gas age			n=11		502.9	22.1			33.43	0.30*
plateau		MSWD = 0.87	n=8	steps D-K	471.8	22.8		93.8	33.56	0.10*
SV21701-1, 5.19 mg biotite, J=0.0007779,NM-138, Lab#=52309-25										
A	*2*	*8685.4*	*0.0073*	*29017.5*	*4.64*	*69.7*	*1.3*	*0.7*	*149.04*	*28.68*
B	*5*	*1352.7*	*0.0378*	*4465.7*	*41.3*	*13.5*	*2.4*	*6.7*	*45.86*	*6.56*
C	*7*	*210.4*	*0.0301*	*626.1*	*60.9*	*16.9*	*12.1*	*15.6*	*35.27*	*0.68*
D	10	65.44	0.0211	127.9	114.0	24.2	42.2	32.2	38.38	0.20
E	12	45.77	0.0229	60.23	105.0	22.3	61.1	47.6	38.84	0.16
F	15	38.64	0.0393	36.56	106.0	13.0	72.1	63.0	38.66	0.13
G	20	37.60	0.0705	33.12	116.2	7.2	74.0	80.0	38.62	0.11
H	25	34.78	0.1034	23.44	68.9	4.9	80.1	90.0	38.69	0.13
I	30	33.81	0.1173	20.45	36.8	4.4	82.2	95.4	38.57	0.14
J	40	35.37	0.1938	26.49	27.7	2.6	77.9	99.4	38.28	0.20
K	40	46.97	0.4360	66.98	3.84	1.2	57.9	100.0	37.80	0.86
total gas age			n=11		685.5	14.3			39.5	1.5*
plateau		MSWD = 1.1	n=8	steps D-K	578.5	13.7		84.4	38.61	0.13*
SV21701-2, 5.15 mg biotite, J=0.0007769, NM-138, Lab#=52310-25										
A	*2*	*13886.2*	*0.6969*	*46757.1*	*1.67*	*0.73*	*0.5*	*0.3*	*95.00*	*43.68*
B	*5*	*1664.0*	*0.4936*	*5514.5*	*17.6*	*1.0*	*2.1*	*3.6*	*47.76*	*5.66*
C	*7*	*190.5*	*0.2209*	*557.0*	*20.7*	*2.3*	*13.6*	*7.5*	*35.93*	*0.66*
D	*10*	*62.25*	*0.1687*	*120.9*	*45.2*	*3.0*	*42.6*	*16.0*	*36.83*	*0.25*
E	12	37.77	0.1620	35.85	47.1	3.1	72.0	24.8	37.71	0.18
F	15	31.88	0.1760	17.25	63.5	2.9	84.1	36.7	37.17	0.10
G	20	29.27	0.1775	7.630	126.9	2.9	92.3	60.6	37.49	0.08
H	25	28.83	0.1996	6.080	81.2	2.6	93.8	75.8	37.53	0.09
I	30	28.88	0.2019	6.984	54.0	2.5	92.9	85.9	37.23	0.10
J	40	29.59	0.1385	8.588	68.5	3.7	91.5	98.8	37.54	0.09
K	40	33.45	0.2371	22.29	6.59	2.2	80.4	100.0	37.30	0.36
total gas age			n=11		532.9	2.8			37.86	0.92*
plateau		MSWD = 2.7**	n=7	steps E-K	447.8	2.9		84.0	37.43	0.18*
SV21701-4, 4.20 mg, J=0.0007776, NM-138, Lab#=52308-50										
A	*2*	*27756.0*	*0.5397*	*93878.3*	*0.392*	*0.95*	*0.1*	*0.1*	*21.02*	*112.82*
B	*5*	*6248.8*	*0.1108*	*20970.4*	*4.40*	*4.6*	*0.8*	*0.8*	*71.66*	*18.51*
C	*7*	*3230.1*	*0.0679*	*10868.9*	*5.99*	*7.5*	*0.6*	*1.9*	*25.57*	*12.41*
D	*10*	*1494.0*	*0.0555*	*4952.9*	*12.0*	*9.2*	*2.0*	*4.0*	*42.15*	*4.66*
E	*12*	*706.1*	*0.0316*	*2319.0*	*13.7*	*16.1*	*3.0*	*6.4*	*29.02*	*2.24*

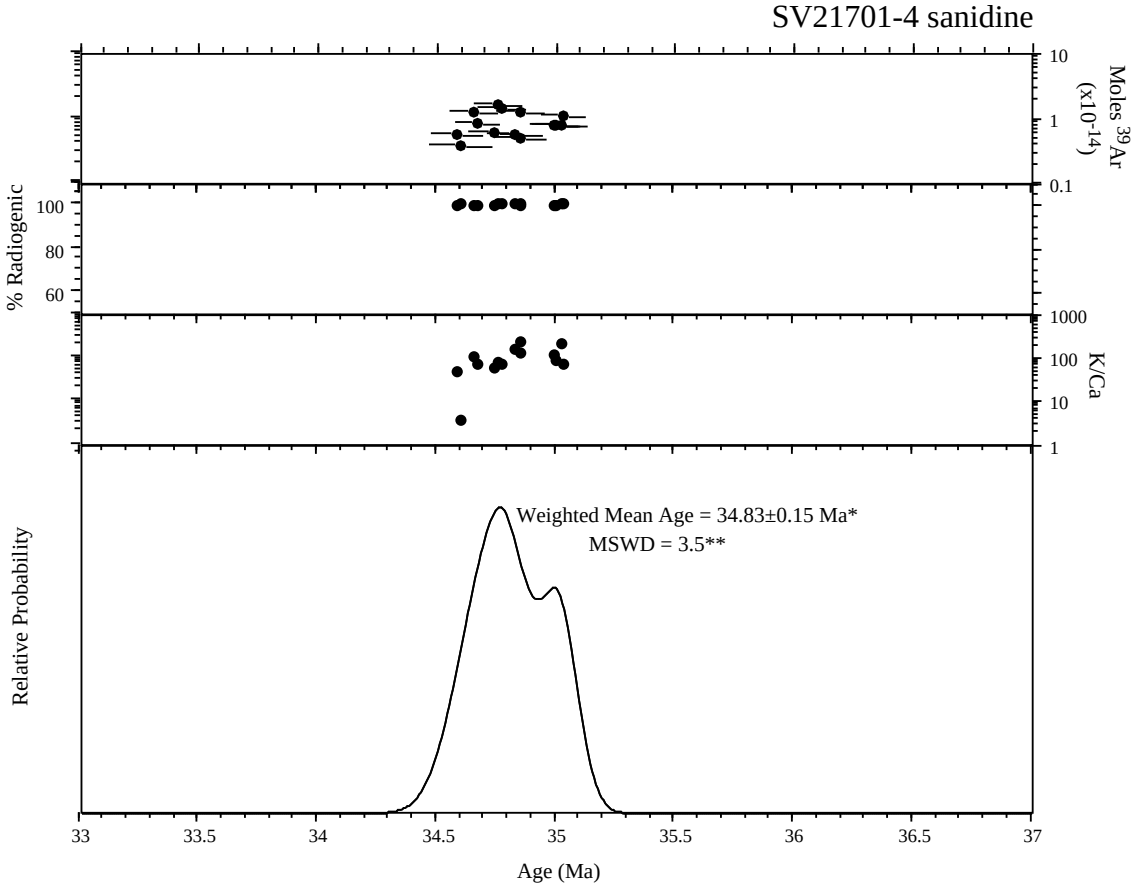


Figure 1. Age probability distribution diagram of SV21701-4 sanidine.
* 2σ error **MSWD outside 95% confidence interval

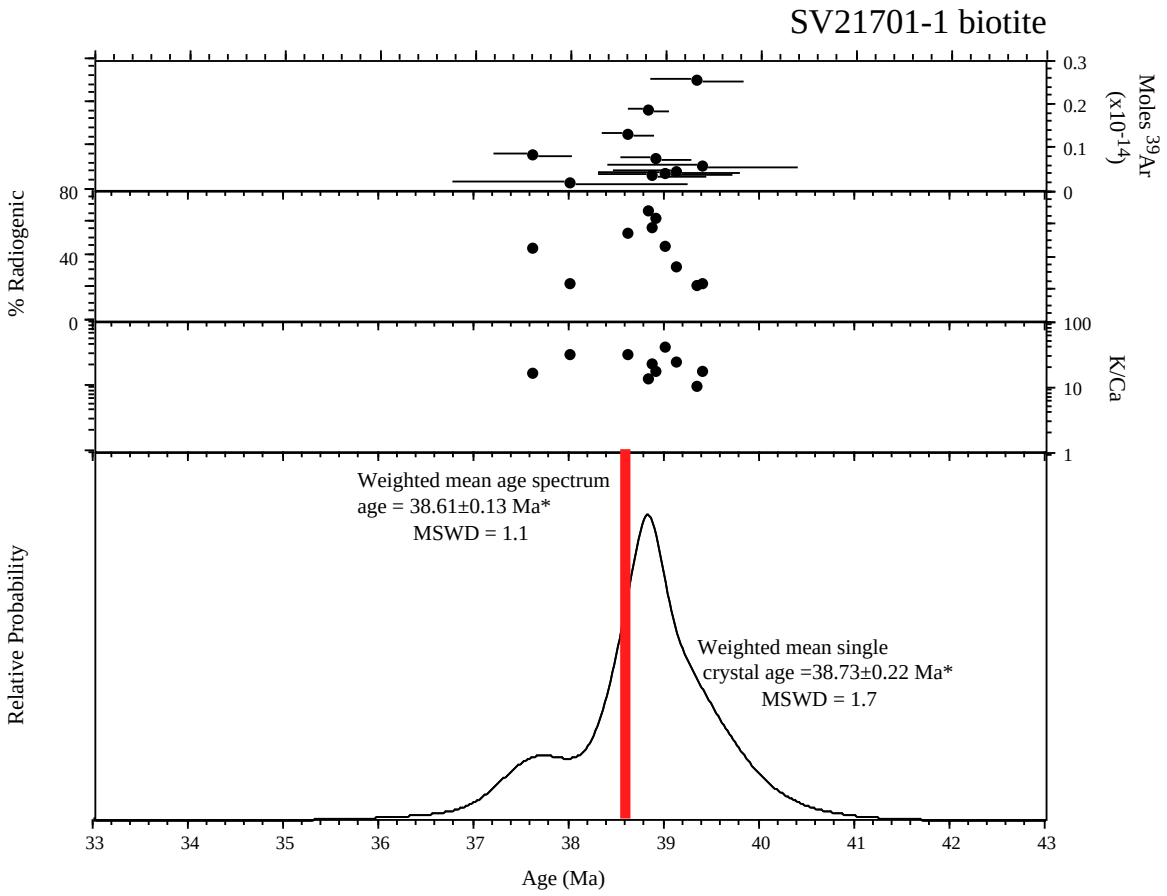


Figure 2. Age probability distribution diagram of b steps for sample SV21701-1 single crystal biotite. Red bar indicates weighted mean age calculated from bulk step-heating analysis. *2σ error

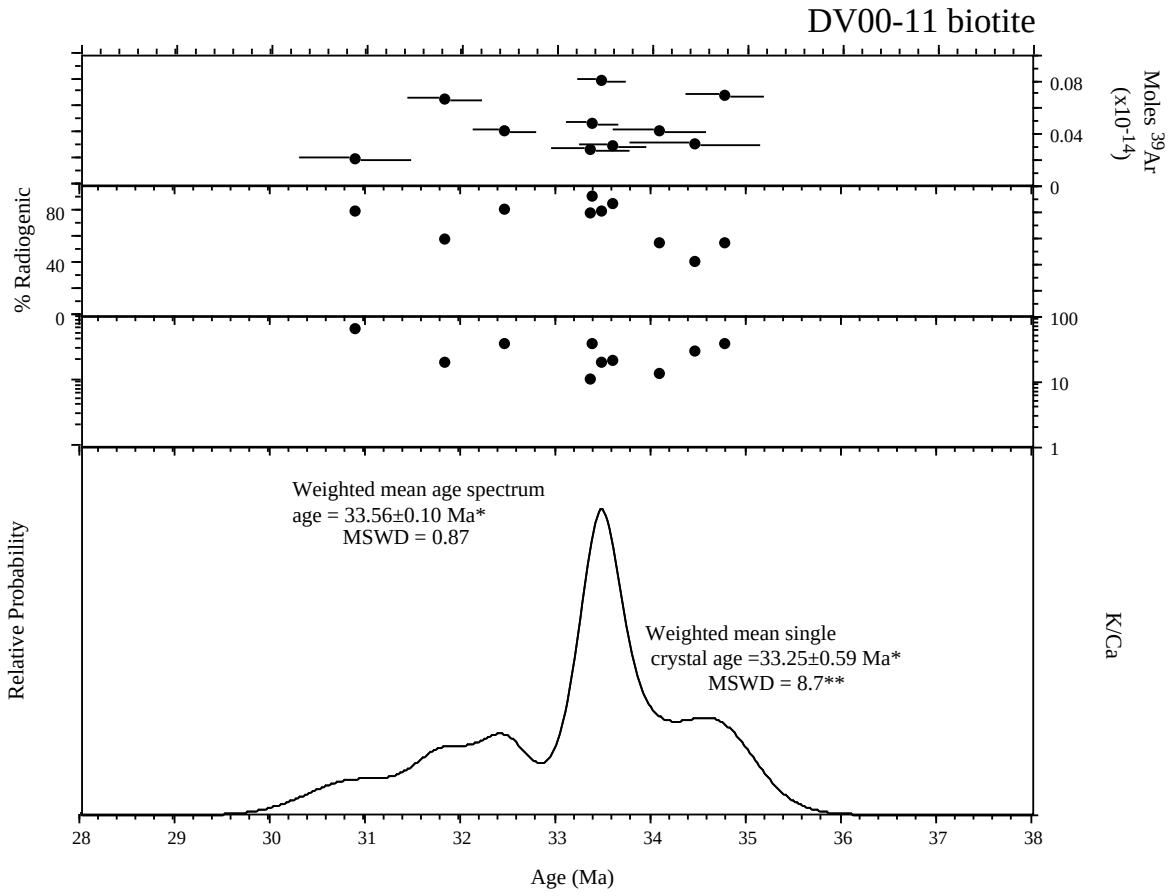


Figure 3. Age probability distribution diagram of b steps for sample DV00-11 single crystal biotite. Red bar indicates weighted mean age calculated from bulk step-heating analysis. *2σ error **outside 95% confidence interval

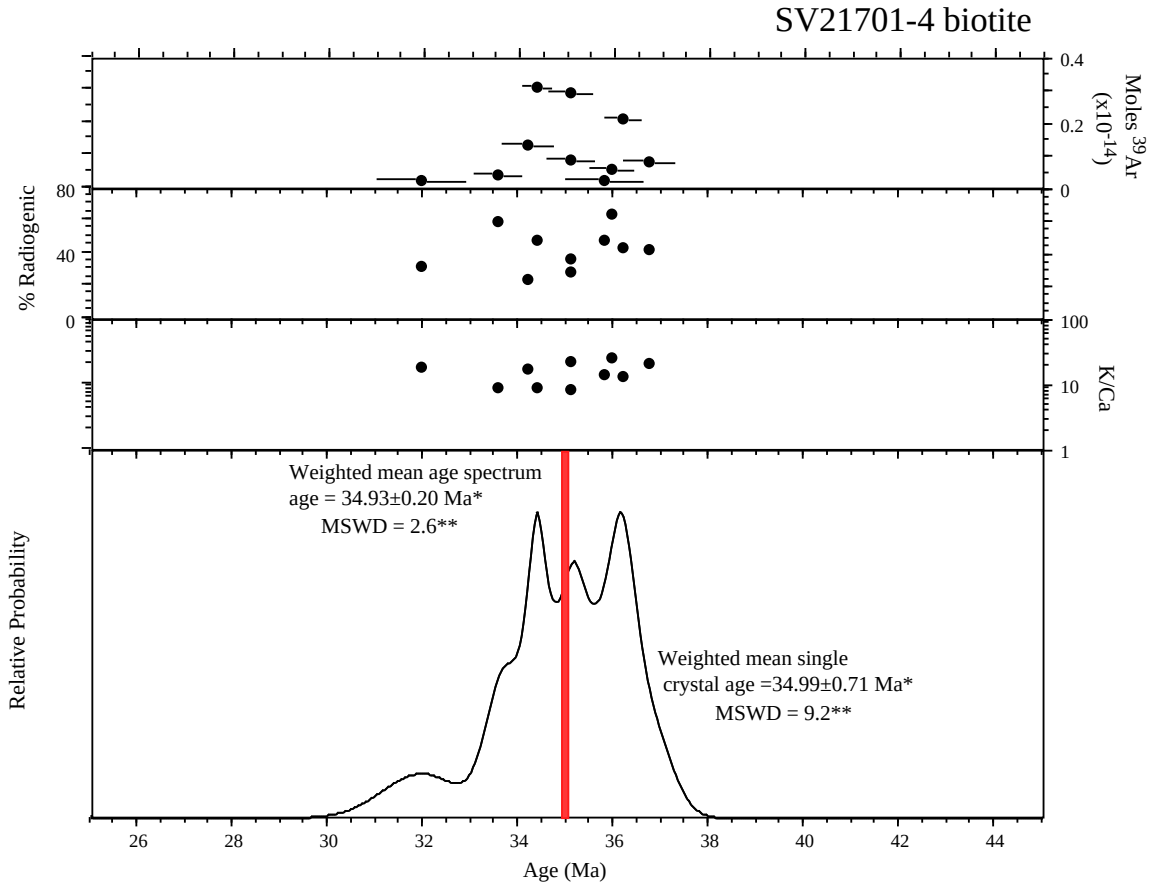


Figure 4. Age probability distribution diagram of b steps for sample SV21701-4 single crystal biotite. Red bar indicates weighted mean age calculated from bulk step-heating analysis. *2σ error **outside 95%confidence interval

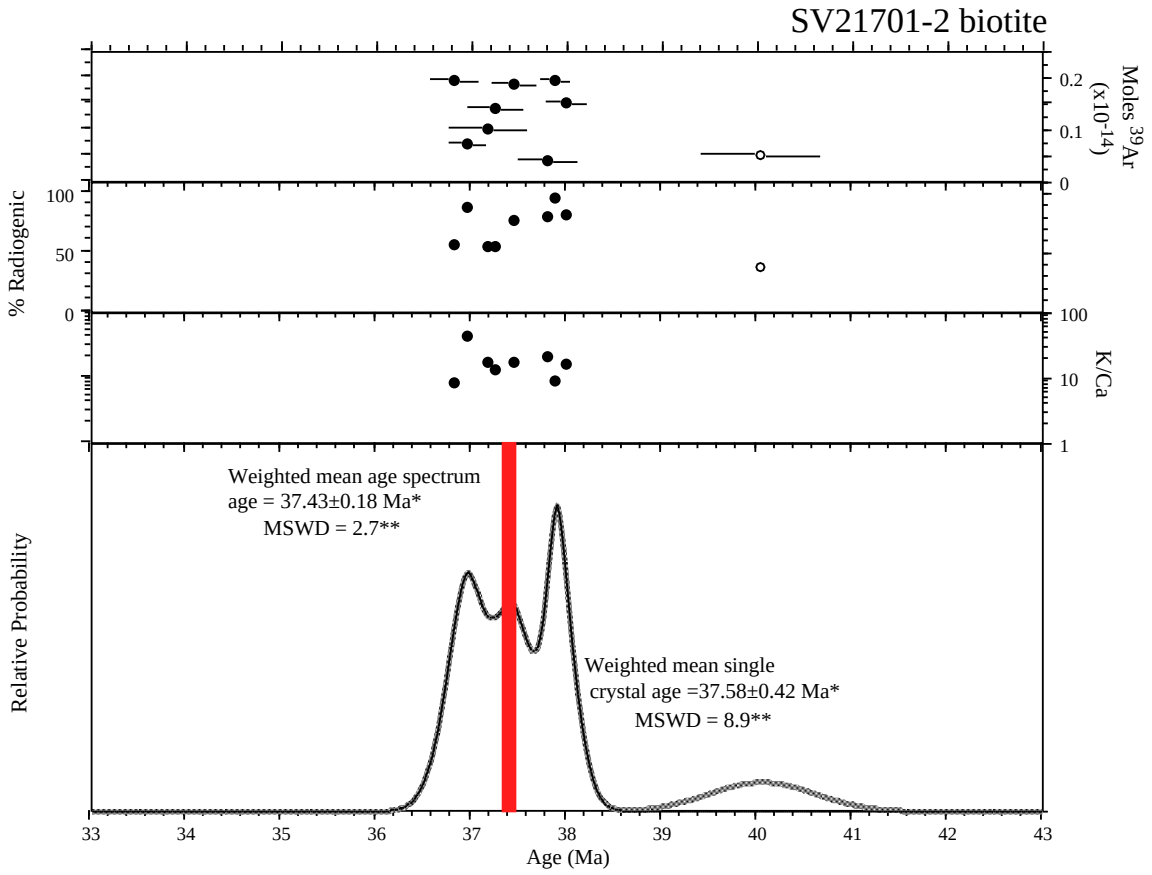


Figure 5. Age probability distribution diagram of b steps for sample SV21701-2 single crystal biotite. Red bar indicates weighted mean age calculated from bulk step-heating analysis. *2σ error **outside 95% confidence interval

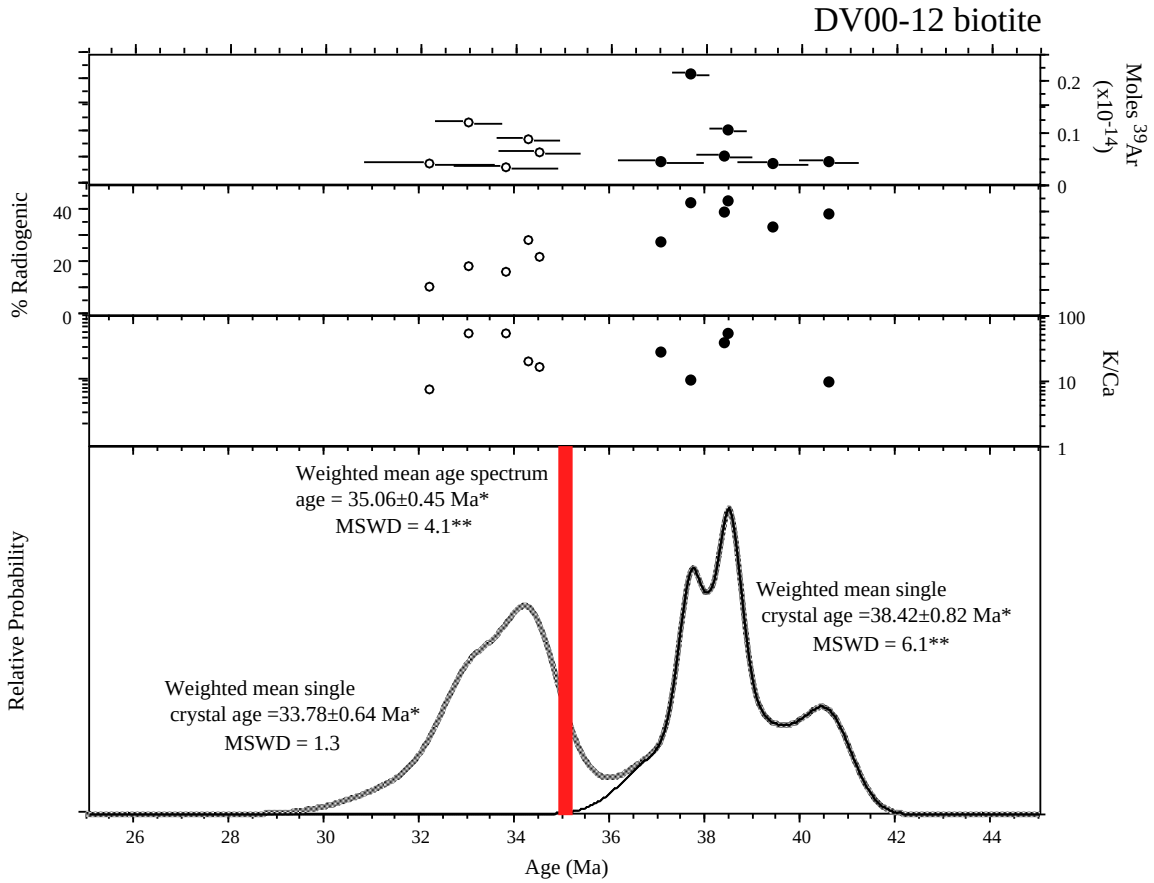


Figure 6. Age probability distribution diagram of b steps for sample DV00-12 single crystal biotite. Red bar indicates weighted mean age calculated from bulk step-heating analysis. *2σ error **outside 95% confidence interval

DV00-11 Biotite

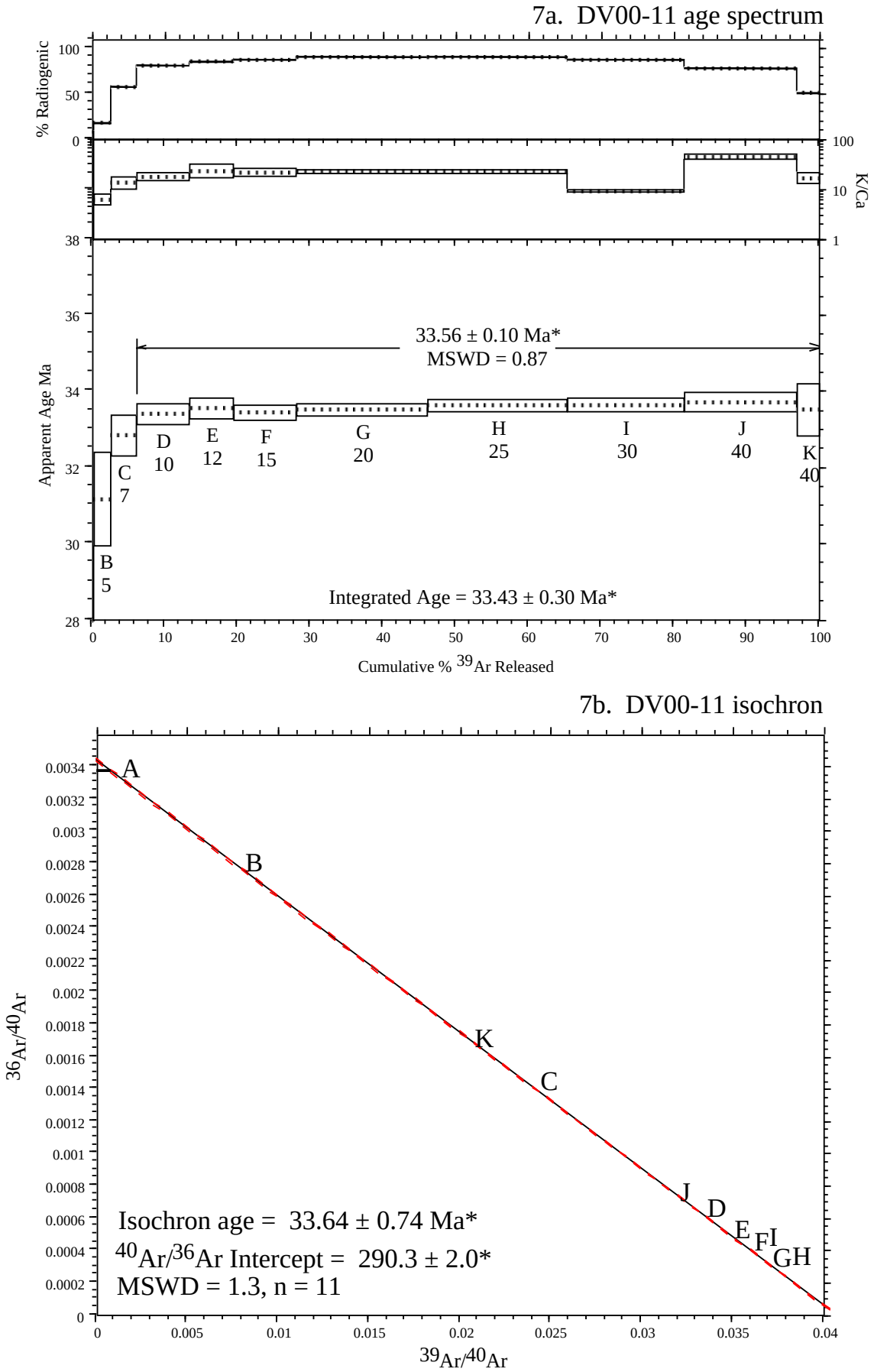
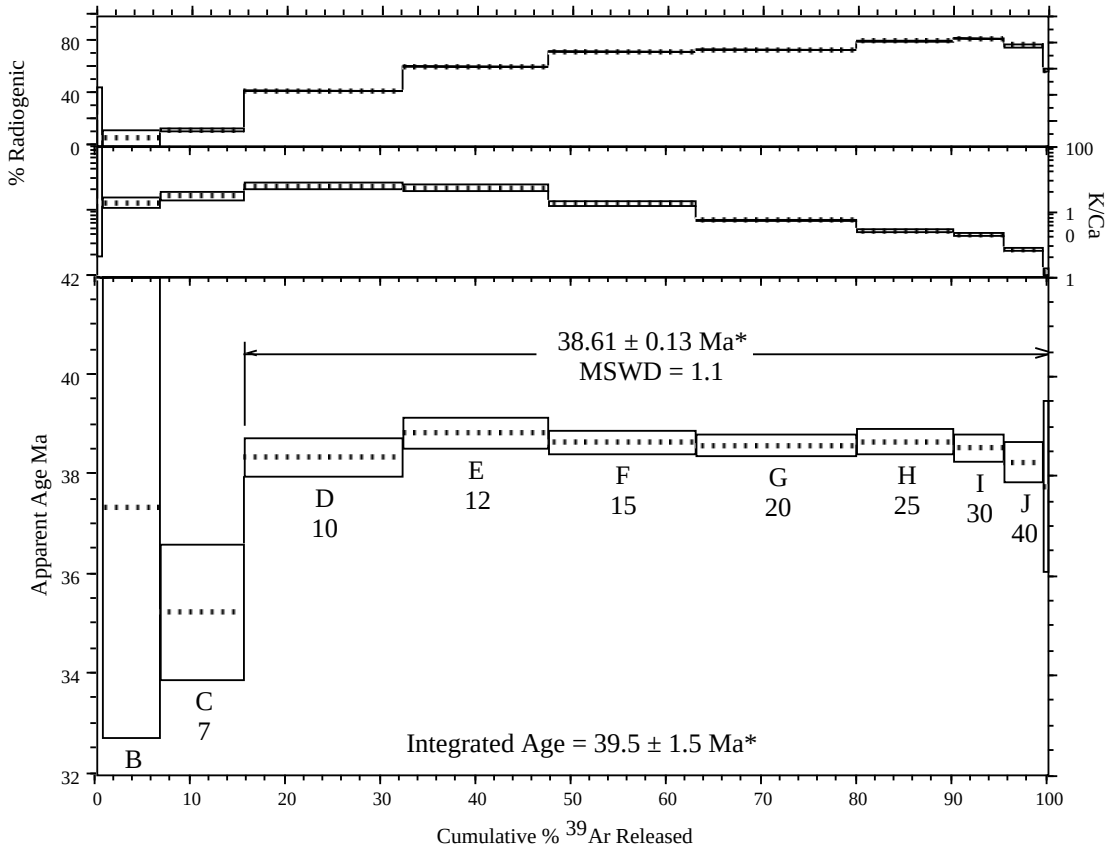


Figure 7. Age spectrum (7a) and isochron (7b) for sample DV00-11 biotite.
* 2 σ error

8a. SV21701-1 age spectrum



8b. SV21701-1 isochon

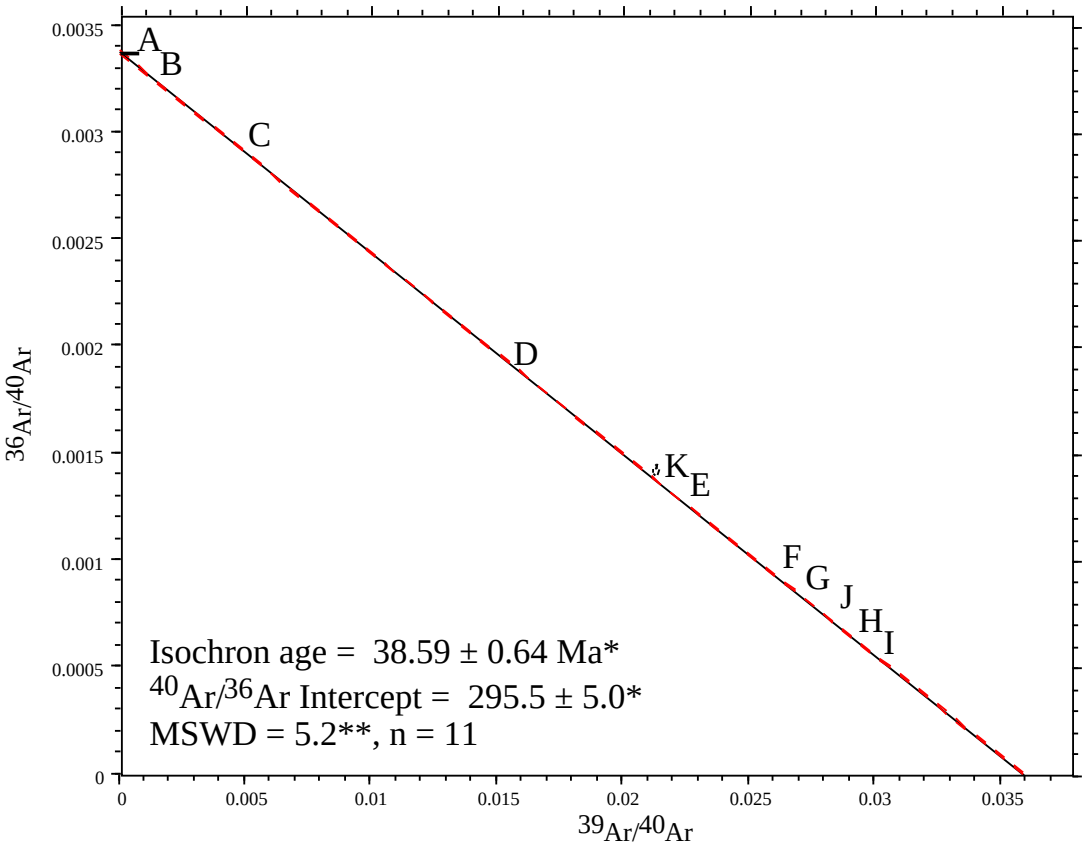
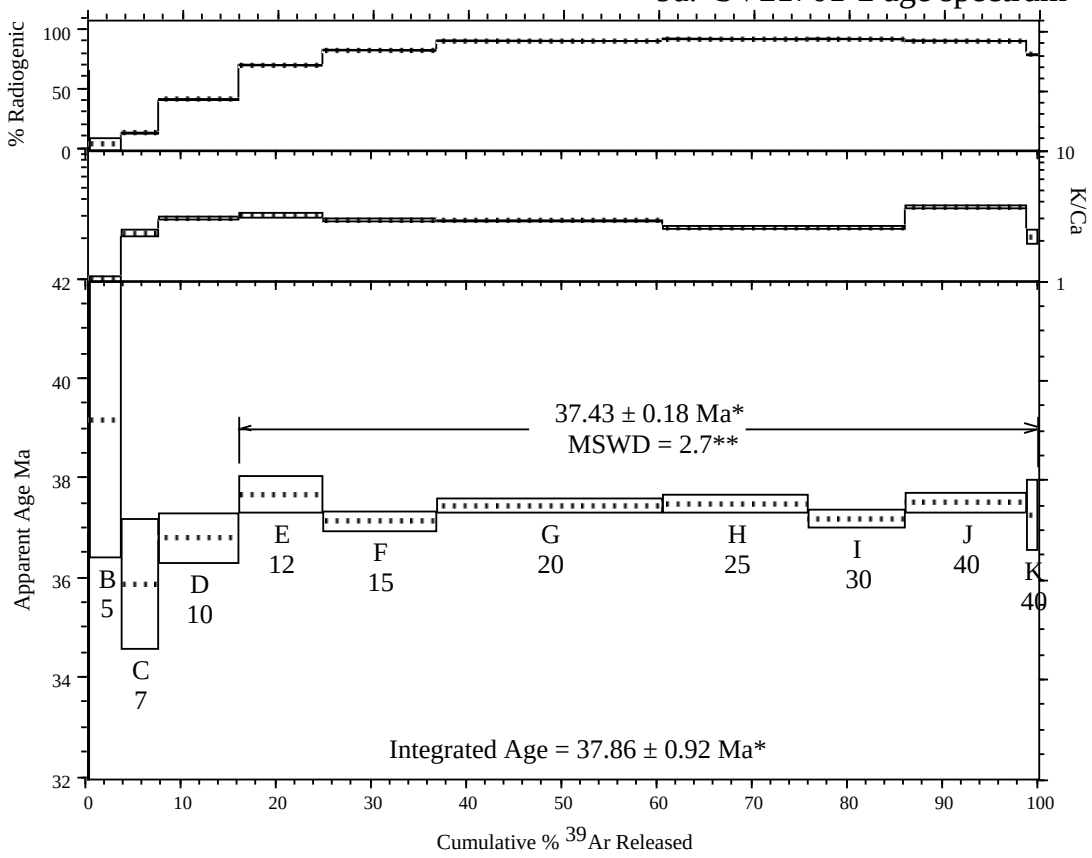


Figure 8. Age spectrum (8a) and isochron (8b) for sample SV21701-1 biotite.
* 2 σ error ** MSWD outside 95% confidence interval

SV21701-2 biotite

9a. SV21701-2 age spectrum



9b. SV21701-2 isochron

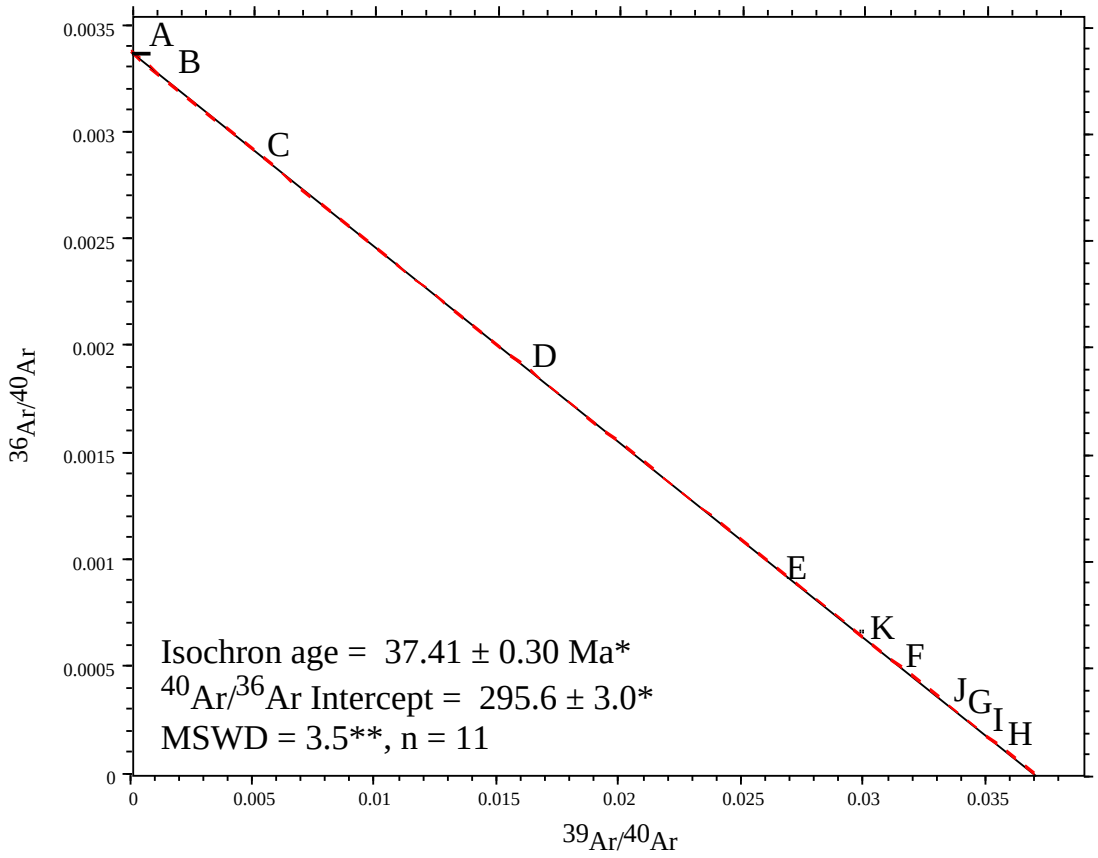
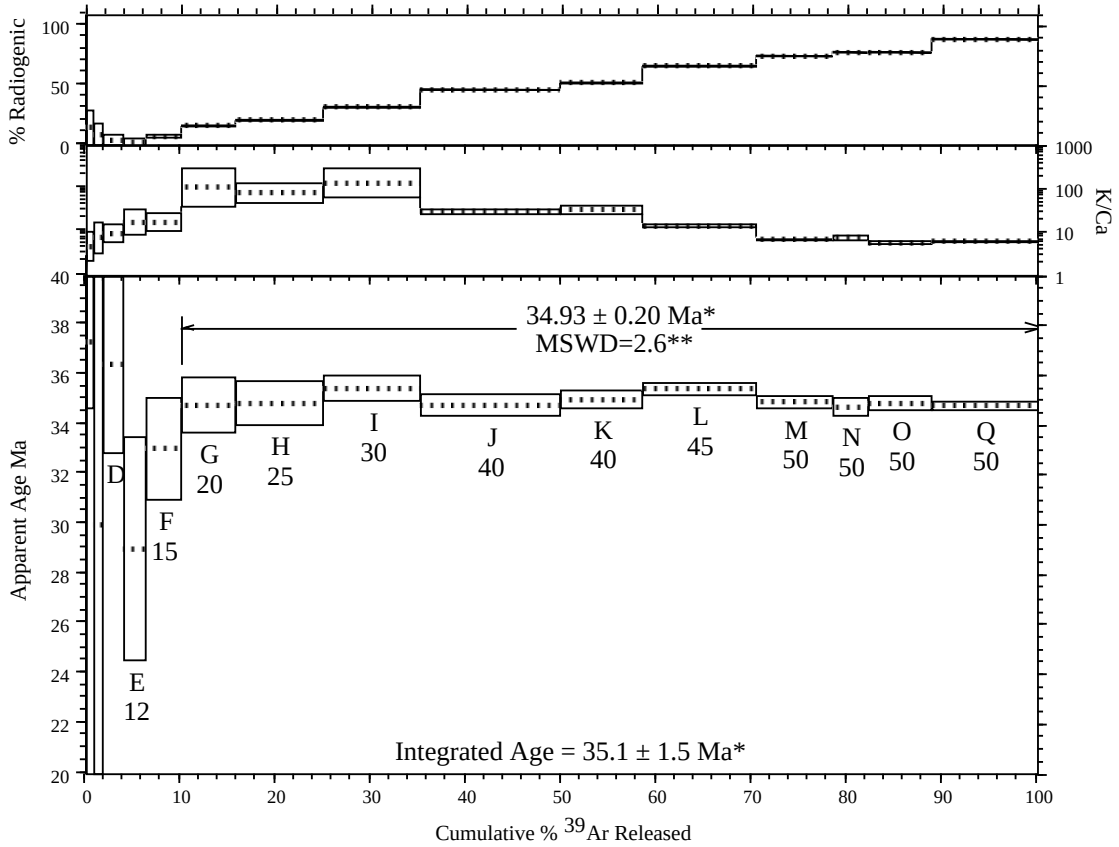


Figure 9. Age spectrum (9a) and isochron (9b) for sample SV21701-2 biotite.
* 2 σ error ** MSWD outside 95% confidence interval

10a. SV21701-4 age spectrum



10b. SV21701-4 isochron

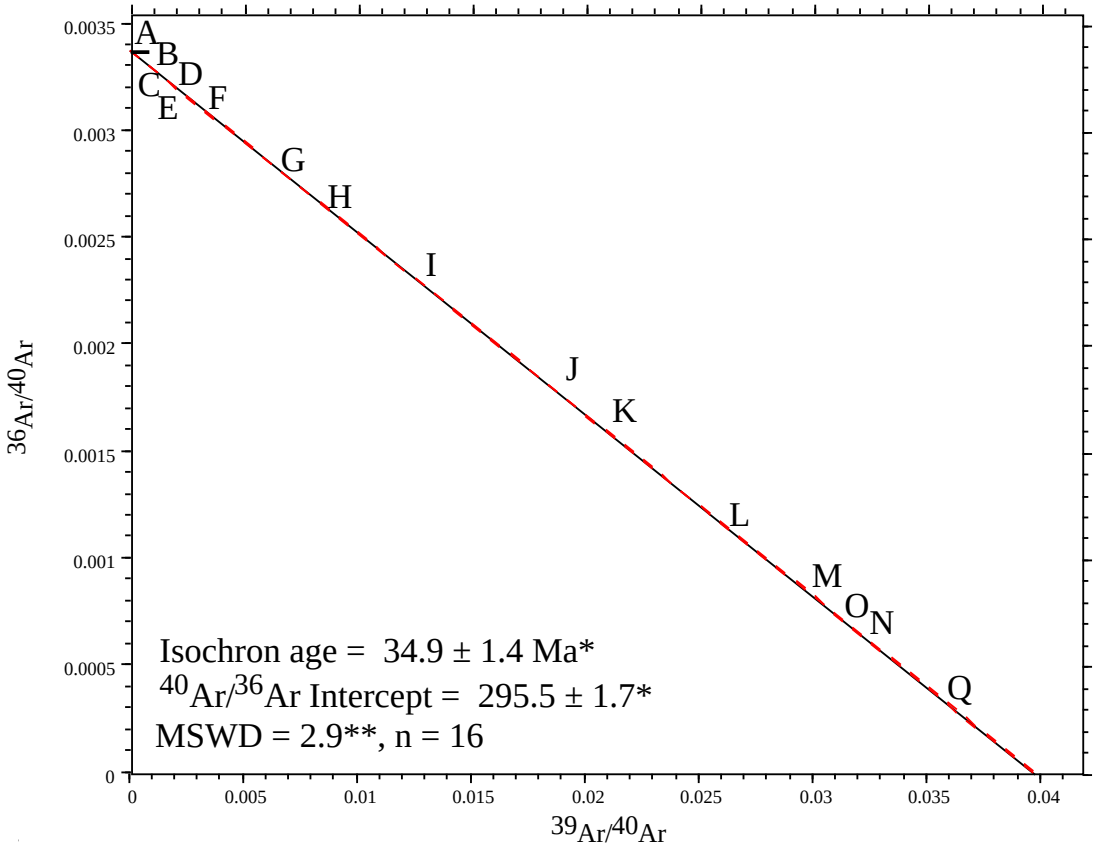
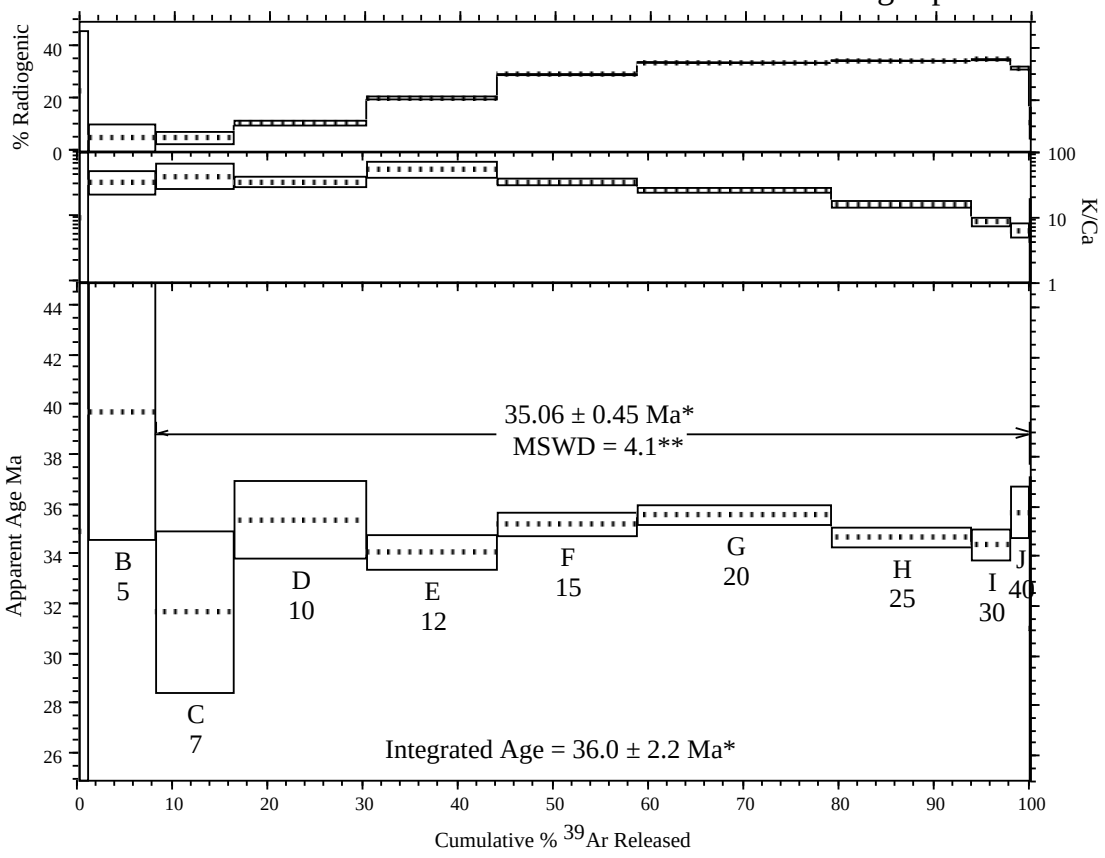


Figure 10. Age spectrum (10a) and isochron (10b) for sample SV21701-4 biotite.
* 2 σ error ** MSWD outside 95% confidence interval

11a. DV00-12 age spectrum



11b. DV00-12 isochron

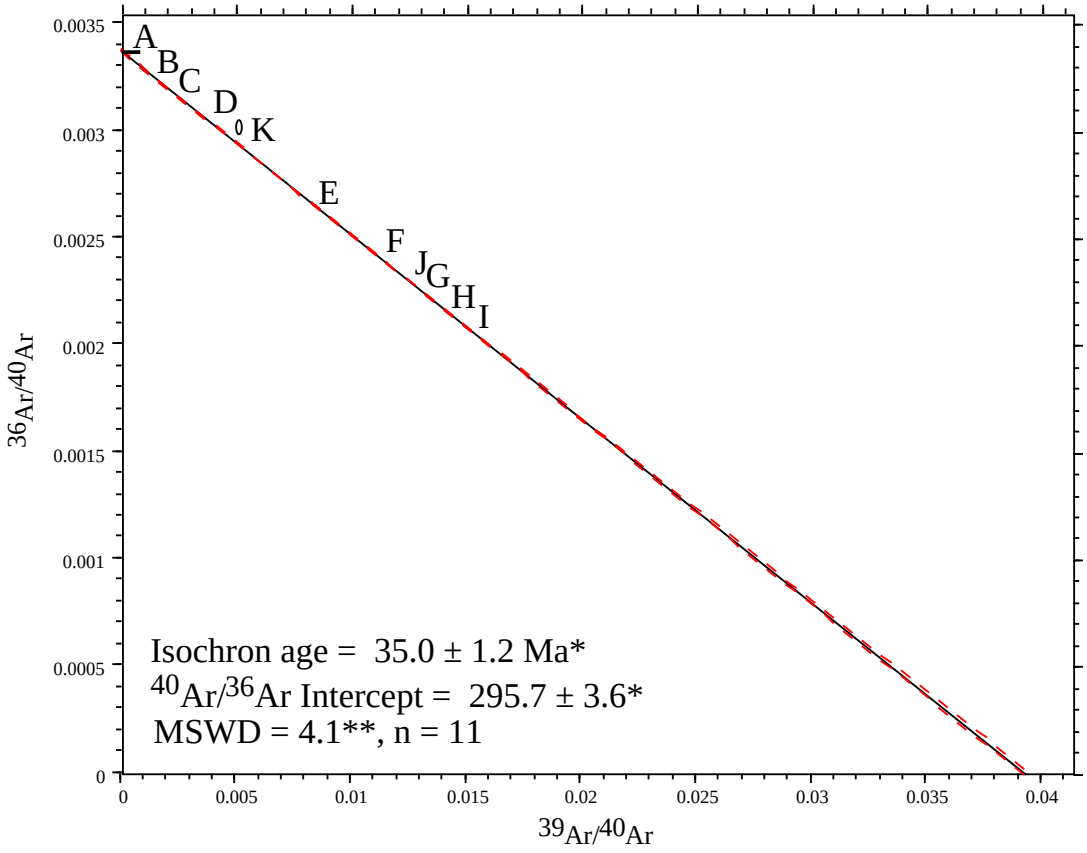


Figure 11. Age spectrum (11a) and isochron (11b) for sample DV00-12 biotite.
* 2 σ error ** MSWD outside 95% confidence interval

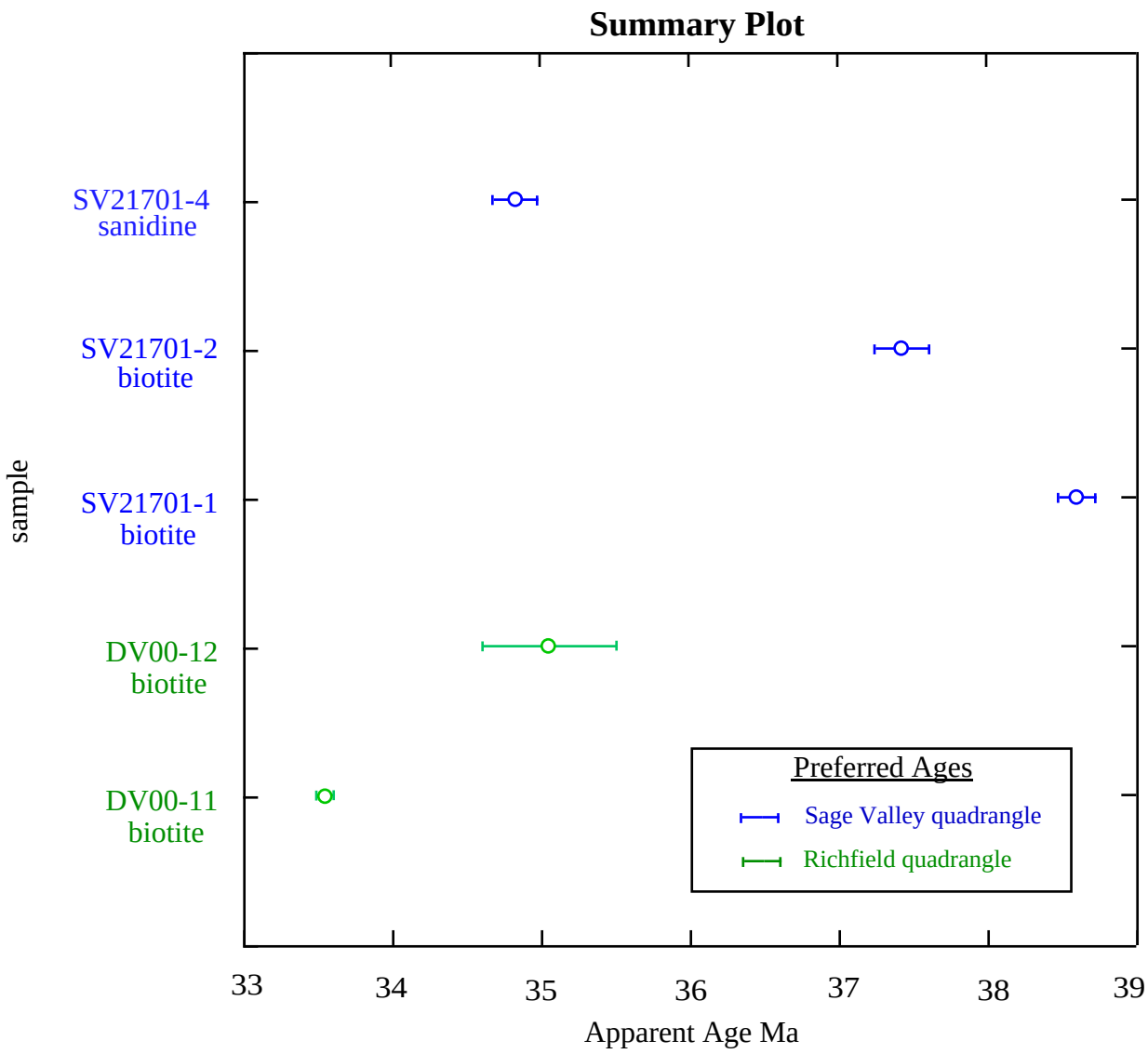


Figure 12. Summary of apparent ages from the Sage Valley and Richfield quadrangles.