^{40}Ar/^{39}Ar Geochronology Results for the Furner Ridge, Jericho, and Tintic Mountain Quadrangles, Utah

by

Utah Geological Survey and
Pacific Centre for Isotope and Geochemical Research

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UTAH DNR GEOLOGICAL SURVEY

OPEN-FILE REPORT 582
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
2011

Introduction

This Open-File Report makes available raw analytical data from laboratory procedures completed to determine the age of rock samples collected during geologic investigations funded or partially supported by the Utah Geological Survey (UGS). Table 1 provides the sample numbers and locations. Table 2 provides the rock names and map units from which the samples were collected; see the map references for additional information such as geologic setting, and significance or interpretation of the samples in the context of the area where they were collected. This report was prepared by the Pacific Centre for Isotope and Geochemical Research (PCIGR) 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	Latitude (N)	Longitude (W)
TM111907-6	Tintic Mountain	39° 46' 20.2"	112° 07' 01.9"
J112007-1	Jericho	39° 37' 31.4"	112° 07' 42.4"
FR112007-2	Furner Ridge	39° 39' 31.0"	112° 04' 13.8"

Location data based on NAD27.

Table 2. Rock names and map units.

Sample #	Rock Name	Map Unit	Map Unit Reference
TM111907-6	andesite	Flows of Rattlesnake Peak	Keith and others, 2009
J112007-1	dacite	Not named	Hayden and others, 2008; Kwon and Mitra, 2005
FR112007-2	rhyolite	Fernow Quartz Latite	Morris, 1977

Rock names based on total alkali-silica classification diagram of Le Bas and others (1986). Clark (2009) presents geochemical data for these samples.

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 the PCIGR 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.

References

Clark, D.L., 2009, Whole-rock geochemical data for Furner Ridge, Jericho, and Tintic Mountain quadrangles, Utah: Utah Geological Survey Open-File Report 559, 6 pages, also available online, <http://geology.utah.gov/online/ofr/ofr-559.pdf>.

Hayden, J.M., Lawton, T.F., and Clark, D.L., 2008, Provisional geologic map of the Champlin Peak quadrangle, Juab and Millard Counties, Utah: Utah Geological Survey Miscellaneous Publication 08-1, 3 plates, scale 1:24,000, CD.

Keith, J.D., Tingey, D.G., Hannah, J.L., Nelson, S.T., Moore, D.K., Cannan, T.M., MacBeth, A.P., and Pulsifer, T., 2009, Provisional geologic map of the Tintic Mountain quadrangle, Juab and Utah Counties, Utah: Utah Geological Survey Open-File Report 545, 15 p., 1 plate, scale 1:24,000.

Kwon, S., and Mitra, G., 2005, Provisional structural geologic map of the Jericho quadrangle, Juab County, Utah: Utah Geological Survey Open-File Report 444, 2 plates, scale 1:24,000.

Le Bas, M.J., Le Maitre, R.W., Streckeisen, A.L., and Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali-silica diagram: Journal of Petrology, v. 27, part 3, p. 745-750.

Morris, H.T., 1977, Geologic map and sections of the Furner Ridge quadrangle, Juab County, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1045, 1 plate, scale 1:24,000.

Pacific Centre for Isotope and Geochemical Research (PCIGR)
The University of British Columbia
Department of Earth and Ocean Sciences
6339 Stores Road
Vancouver, B.C. V6T 1Z4

Report prepared by Janet Gabites, PCIGR
for the Utah Geological Survey
December 17, 2010

METHODOLOGY

The samples were crushed in a ring mill, washed in distilled water and ethanol, and sieved when dry to -40+60mesh. Appropriate mineral grains were picked out of the bulk fraction. Mineral separates were wrapped in aluminum foil and stacked in an irradiation capsule with similar-aged samples and neutron flux monitors (Fish Canyon Tuff sanidine (FCs), 28.03 Ma (Renne et al., 1998).

The samples were irradiated on September 1, 2010 at the McMaster Nuclear Reactor in Hamilton, Ontario, for 85 MWH, with a neutron flux of approximately $6x10^{13}$ neutrons/cm^2/s. Analyses (n=27) of 9 neutron flux monitor positions produced errors of <0.5% in the J value.

The samples were analyzed during November and December 2010 at the Noble Gas Laboratory, Pacific Centre for Isotopic and Geochemical Research, University of British Columbia, Vancouver, BC, Canada. The mineral separates were step-heated at incrementally higher powers in the defocused beam of a 10W CO_2 laser (New Wave Research MIR10) until fused. The gas evolved from each step was analyzed by a VG5400 mass spectrometer equipped with an ion-counting electron multiplier. All measurements were corrected for total system blank, mass spectrometer sensitivity, mass discrimination, radioactive decay during and subsequent to irradiation, as well as interfering Ar from atmospheric contamination and the irradiation of Ca, Cl and K (Isotope production ratios: $(^{40}Ar/^{39}Ar)_K$=0.0302±0.00006, $(^{37}Ar/^{39}Ar)_{Ca}$=1416.4±0.5, $(^{36}Ar/^{39}Ar)_{Ca}$=0.3952±0.0004, Ca/K=1.83±0.01($^{37}Ar_{Ca}/^{39}Ar_K$).).

RESULTS

Details of the analyses, including plateau (spectrum) and inverse correlation plots, are presented in Excel spreadsheets. Initial data entry and calculations were carried out using the software ArArCalc (Koppers, 2002). The plateau and correlation ages were calculated using Isoplot ver.3.09 (Ludwig, 2003). Errors are quoted at the 2-sigma (95% confidence) level and are propagated from all sources except mass spectrometer sensitivity and age of the flux monitor. The best statistically-justified plateau and plateau age were picked based on the following criteria:

1. Three or more contiguous steps comprising more than 50% of the ^{39}Ar;
2. Probability of fit of the weighted mean age greater than 5%;
3. Slope of the error-weighted line through the plateau ages equals zero at 5% confidence;
4. Ages of the two outermost steps on a plateau are not significantly different from the weighted-mean plateau age (at 1.8σ, six or more steps only);
5. Outermost two steps on either side of a plateau must not have nonzero slopes with the same sign (at 1.8σ, nine or more steps only)

The "picks" for the correlation and plateau ages are arbitrary and should be considered illustrative only since they are made outside of a geological framework and may not correspond to the researcher's criteria for plateau and correlation ages.

The Excel spreadsheet contains the data needed for recalculation using spreadsheet add-ins such as Isoplot.

Gabites reported to UGS that sample TM111907-6 was rerun (1) as a self check, and (2) because the sample holder was loaded assuming an old sample, so it was too small for a good analysis on a young rock (hence only four steps). Despite that, the two results were within error. Gabites also reported that the reverse isochron is generally considered the most robust date for the sample. The plateau plot shows up any disturbance in the thermal history.

REFERENCES

Koppers, Anthony A.P. 2002, ArArCALC – software for $^{40}Ar/^{39}Ar$ age calculations. Computers and Geosciences 28 (2002) 605-619.

Ludwig, K.R 2003. Isoplot 3.09 A Geochronological Toolkit for Microsoft Excel. Berkeley Geochronology Center, Special Publication No. 4

Renne, P.R., C.Swisher, C.C., III, Deino, A.L., Karner, D.B., Owens, T. and DePaolo, D.J., 1998. Intercalibration of standards, absolute ages and uncertainties in 40Ar/39Ar dating. Chemical Geology, 145(1-2): 117-152.

APPENDIX

Analytical data for samples TM111907-6 biotite, J112007-1 biotite, and FR112007-2 biotite.

Information on Analysis

TM111907-6 biotite

Total fusion age 34.06 ± 0.63 Ma

Volumes are 1E-13 cm3 NPT
Neutron flux monitors: 28.030 ± 0.084 Ma FCs (Renne et al., 1998)
Isotope production ratios: (40Ar/39Ar)K=0.0302±0.00006, (37Ar/39Ar)Ca=1416.4±0.5, (36Ar/39Ar)Ca=0.3952±0.0004,
Ca/K=1.83±0.01(37ArCa/39ArK).
J = 0.0110032 ± 0.0000550
10-Nov-10

Incremental Heating	40Ar(r)	39Ar(k) (cum %)	Age ± 2σ (Ma)	40Ar(r) (%)	39Ar(k) (%)	K/Ca ± 2σ
2.00 W	0.000	73.351	3.36 ± 676.88	1.44	0.01	1.293 ± 2.019
4.00 W	0.015	74.254	32.89 ± 5.86	87.58	0.90	8.632 ± 1.147
6.00 W	1.241	73.336	33.96 ± 0.70	71.35	73.34	6.352 ± 0.238
7.00 W	0.442	100.000	34.47 ± 0.40	95.93	25.75	24.919 ± 1.382

Normal Isochron	39(k)/36(a) ± 2σ	)(a+r)/36(a) ± 2σ	r.i.
2.00 W	25.6 ± 75.5	299.8 ± 884.6	0.9984
4.00 W	1432.4 ± 2072.8	2685.2 ± 3885.8	0.9999
6.00 W	446.6 ± 21.3	1065.0 ± 49.8	0.9762
7.00 W	6722.7 ± 1551.6	12054.7 ± 2779.8	0.9990

Inverse Isochron	)(k)/40(a+r) ± 2σ	;(a)/40(a+r) ± 2σ	r.i.
2.00 W	0.085317 ± 0.014105	0.003335 ± 0.009840	0.0274
4.00 W	0.533427 ± 0.008512	0.000372 ± 0.000539	0.0039
6.00 W	0.419324 ± 0.004348	0.000939 ± 0.000044	0.0050
7.00 W	0.557685 ± 0.005724	0.000083 ± 0.000019	0.0017

Isotope Ratios	40(r)/39(k)	1σ	40(r+a)	1σ	40Ar/39Ar	1σ	37Ar/39Ar	1σ	36Ar/39Ar	1σ
2.00 W	0.169	17.041	0.001	0.0001	11.748	0.970	0.422	0.329	0.0392	0.0577
4.00 W	1.668	0.150	0.017	0.0001	1.905	0.015	0.063	0.004	0.0007	0.0005
6.00 W	1.723	0.018	1.717	0.0013	2.415	0.013	0.086	0.002	0.0023	0.0001
7.00 W	1.749	0.010	0.453	0.0005	1.823	0.009	0.022	0.001	0.0002	0.0000

Plateau Age

Plateau age = 34.34 ± 0.40 Ma
(2σ, including J-error of .6%)
MSWD = 0.62, probability=0.60
Includes 100% of the ^{39}Ar

Normal Isochron

Age = 34.40 ± 0.45 Ma
Initial $^{40}Ar/^{36}Ar$ =283 ± 19
MSWD = 0.33

Inverse Isochron

Age = 34.42 ± 0.45 Ma
Initial $^{40}Ar/^{36}Ar$ =283 ± 19
MSWD = 0.13

Laser	*Isotope Ratios*												
	TM111907-6 biotite			*(sample/mineral)*									
Power(%)	*40Ar/39Ar*	*1σ*	*37Ar/39Ar*	*1σ*	*36Ar/39Ar*	*1σ*	*Ca/K*	*Cl/K*	*%40Ar atm*	*f 39Ar*	*40Ar*/39ArK*	*Age*	*2σ*
2.00 W	11.75	0.97	0.42	0.33	0.039	0.058	0.77		98.56	0.01	0.169	3.36	± 676.88
4.00 W	1.90	0.02	0.06	0.00	0.001	0.001	0.12		12.42	0.90	1.668	32.89	± 5.86
6.00 W	2.41	0.01	0.09	0.00	0.002	0.000	0.16		28.65	73.34	1.723	33.96	± 0.70
7.00 W	1.82	0.01	0.02	0.00	0.000	0.000	0.04		4.07	25.75	1.749	34.47	± 0.40

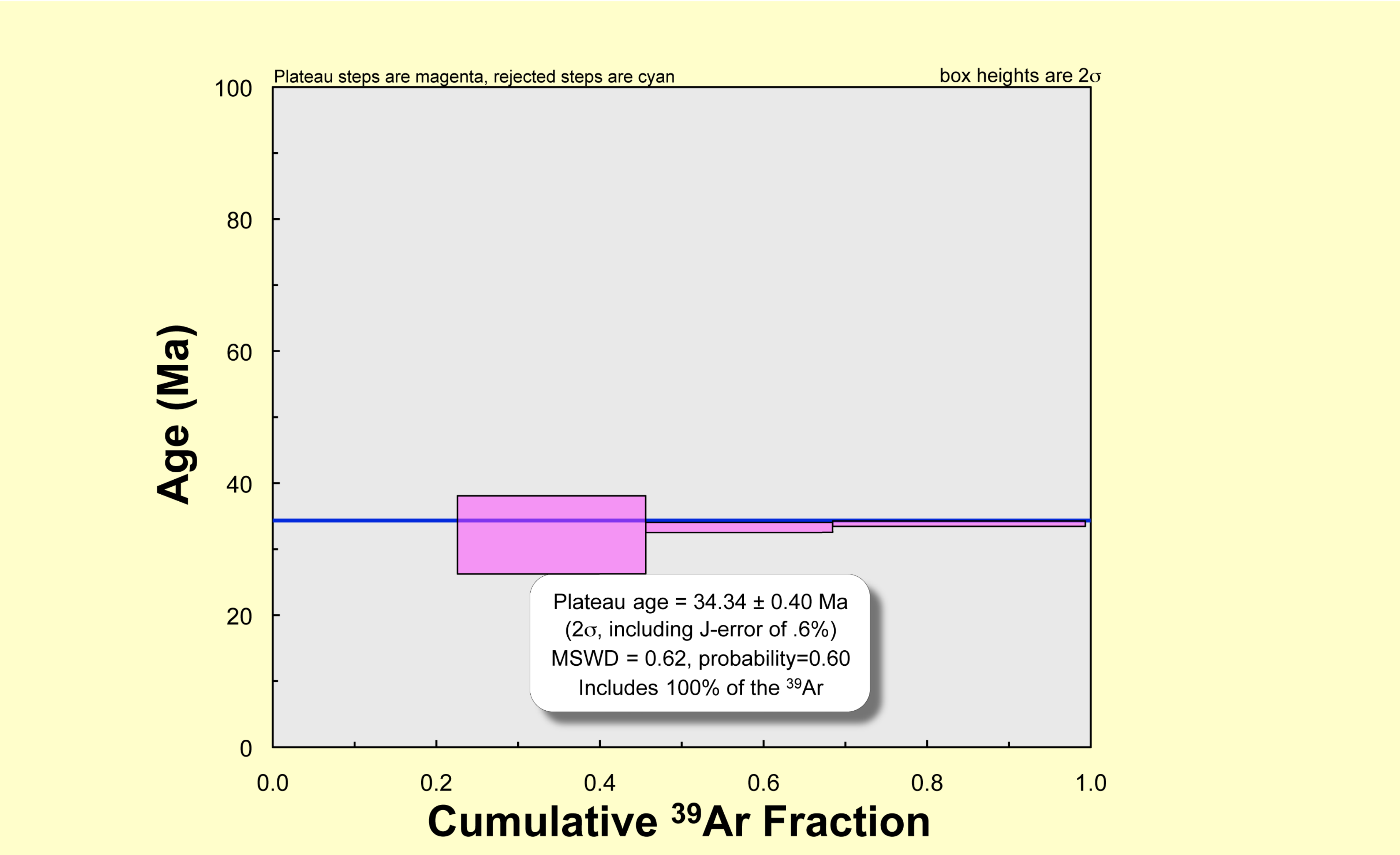
Power(%)	*40Ar/39Ar*	*1σ*	*37Ar/39Ar*	*1σ*	*36Ar/39Ar*	*1σ*	*Ca/K*	*Cl/K*	*%40Ar atm*	*f 39Ar*	*40Ar*/39ArK*	*1σ*
Total/Average	2.010	0.007	0.031	0.001	0.0004	0.0000				100.00	1.742	0.009

J = 0.0110032 ± 0.0000550 Volume 39ArK = 0.982 Integrated Date = 34.06 ± 0.63 Ma

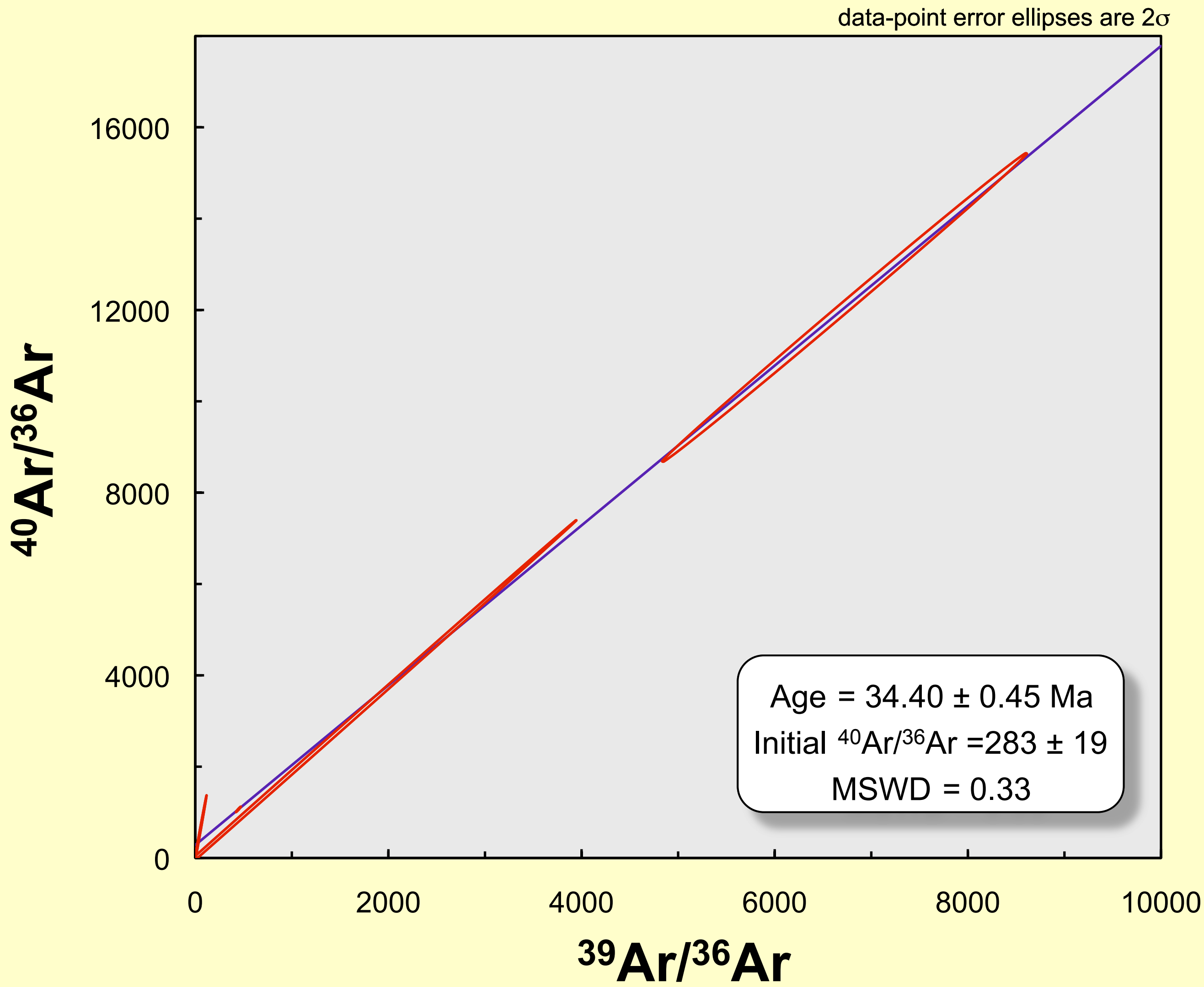
Plateau Age = 34.34 ± 0.40 Ma (2s, including J-error of .3%) MSWD = 0.62, probability = 0.6 100% of the 39Ar, steps 1 through 4

Inverse isochron (correlation age) results, plateau steps: Model 1 Solution (±95%-conf.) on 4 points Age = 34.42 ± 0.45 Ma

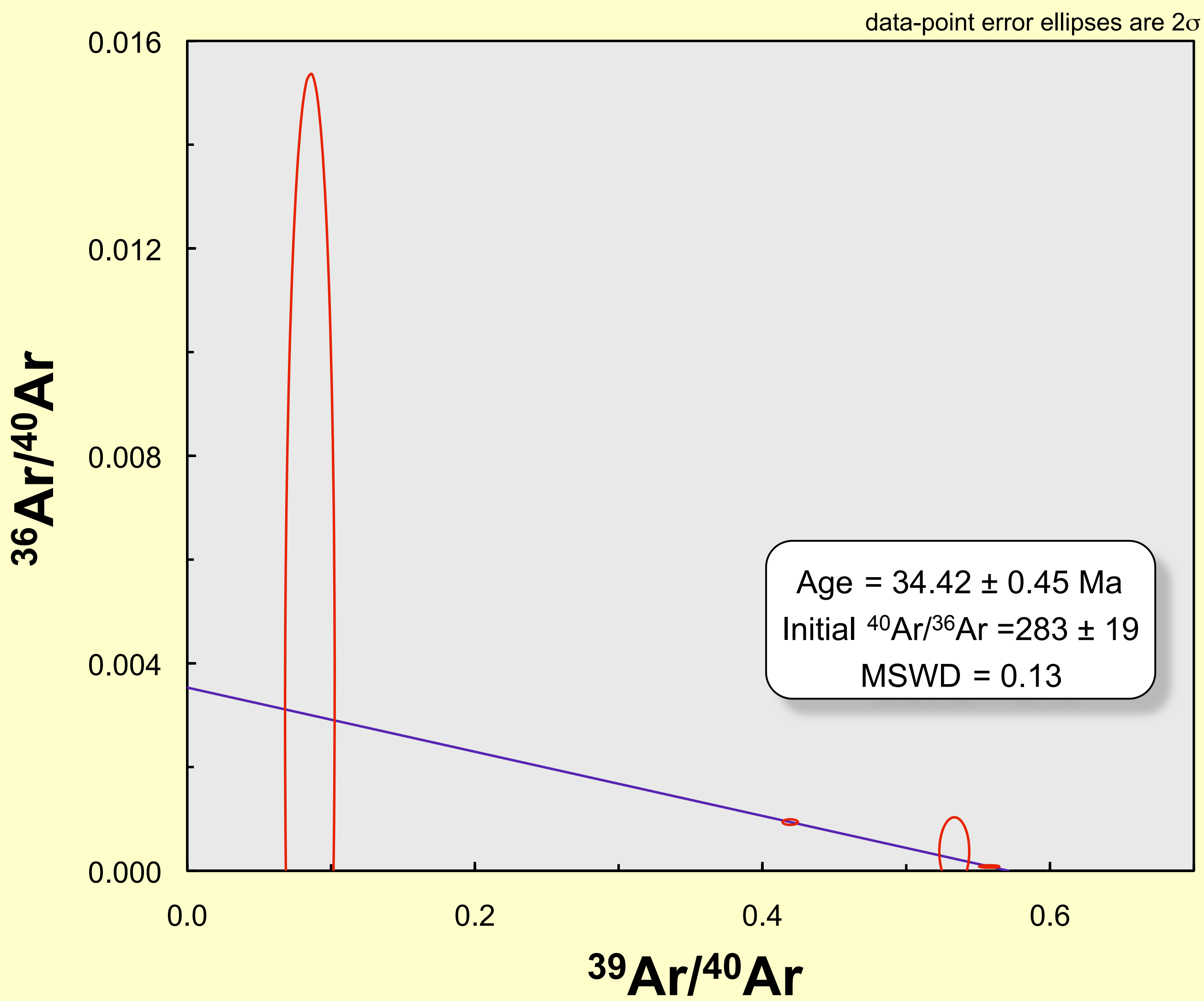
40/36 intercept: 283 ± 19 MSWD = 0.13, Probability = 0.87 (at J=.0110032±.3% 2s)



Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
Age (Ma)
100
80
60
40
20
0
0.0
0.2
0.4
0.6
0.8
1.0
Cumulative ³⁹Ar Fraction
Plateau age = 34.34 ± 0.40 Ma
(2σ, including J-error of .6%)
MSWD = 0.62, probability=0.60
Includes 100% of the ³⁹Ar



data-point error ellipses are 2σ
16000
12000
8000
4000
0
0
2000
4000
6000
8000
10000
40Ar/36Ar
39Ar/36Ar
Age = 34.40 ± 0.45 Ma
Initial 40Ar/36Ar =283 ± 19
MSWD = 0.33


data-point error ellipses are 2σ
0.016
0.012
0.008
0.004
0.000
0.0
0.2
0.4
0.6
36Ar/40Ar
39Ar/40Ar
Age = 34.42 ± 0.45 Ma
Initial 40Ar/36Ar =283 ± 19
MSWD = 0.13

Information on Analysis

TM111907-6 biotite

Total fusion age 34.06 ± 0.46 Ma

Volumes are 1E-13 cm3 NPT
Neutron flux monitors: 28.030 ± 0.084 Ma FCs (Renne et al., 1998)
Isotope production ratios: (40Ar/39Ar)K=0.0302±0.00006, (37Ar/39Ar)Ca=1416.4±0.5, (36Ar/39Ar)Ca=0.3952±0.0004, Ca/K=1.83±0.01(37ArCa/39ArK).
J = 0.0110322 ± 0.0000552
15-Dec-10

Plateau Age

Plateau age = 34.55 ± 0.31 Ma
(2σ, including J-error of .6%)
MSWD = 0.75, probability=0.61
Includes 97.4% of the ^{39}Ar

Normal Isochron

Age = 34.80 ± 0.29 Ma
Initial ^{40}Ar/^{36}Ar =280.3 ± 6.6
MSWD = 1.3

Inverse Isochron

Age = 34.80 ± 0.29 Ma
Initial ^{40}Ar/^{36}Ar =281.0 ± 6.7
MSWD = 1.2

Incremental Heating	40Ar(r)	39Ar(k) (cum %)	Age ± 2σ (Ma)	40Ar(r) (%)	39Ar(k) (%)	K/Ca ± 2σ
2.00 W	0.000	0.216	0.44 ± 41.81	0.05	0.22	3.209 ± 1.072
2.30 W	0.007	0.887	9.05 ± 23.24	1.95	0.67	3.063 ± 0.322
2.60 W	0.053	2.633	25.55 ± 4.74	20.87	1.75	3.090 ± 0.207
3.00 W	0.224	7.999	34.73 ± 1.17	64.15	5.37	2.527 ± 0.097
3.50 W	0.642	23.361	34.81 ± 0.54	79.17	15.36	6.268 ± 0.315
4.00 W	0.921	45.523	34.59 ± 0.44	86.95	22.16	10.003 ± 0.475
4.40 W	0.473	56.873	34.71 ± 0.56	88.81	11.35	14.375 ± 0.922
5.00 W	0.489	68.739	34.34 ± 0.63	84.38	11.87	22.096 ± 2.955
6.00 W	1.019	93.458	34.32 ± 0.50	80.56	24.72	34.818 ± 1.454
7.00 W	0.261	100.000	33.20 ± 1.98	42.74	6.54	13.575 ± 1.219

Normal Isochron	39(k)/36(a) ± 2σ	)(a+r)/36(a) ± 2σ	r.i.
2.00 W	6.3 ± 0.3	295.6 ± 13.1	0.9187
2.30 W	13.0 ± 0.7	301.4 ± 15.5	0.9742
2.60 W	60.8 ± 3.1	373.9 ± 18.5	0.9725
3.00 W	310.3 ± 18.8	841.0 ± 50.3	0.9845
3.50 W	682.0 ± 33.7	1497.0 ± 72.3	0.9778
4.00 W	1271.1 ± 75.5	2520.6 ± 147.6	0.9852
4.40 W	1546.0 ± 176.6	3011.1 ± 342.6	0.9958
5.00 W	1013.7 ± 93.7	2057.2 ± 189.1	0.9936
6.00 W	760.2 ± 37.5	1615.6 ± 78.0	0.9788
7.00 W	133.1 ± 6.1	519.1 ± 23.2	0.9712
0.00 W	0.0 ± 0.0	0.0 ± 0.0	0.0000

Inverse Isochron	)(k)/40(a+r) ± 2σ	;(a)/40(a+r) ± 2σ	r.i.
2.00 W	0.021202 ± 0.000405	0.003383 ± 0.000150	0.0009
2.30 W	0.043028 ± 0.000512	0.003318 ± 0.000170	0.0029
2.60 W	0.162628 ± 0.001917	0.002674 ± 0.000132	0.0152
3.00 W	0.368985 ± 0.003929	0.001189 ± 0.000071	0.0028
3.50 W	0.455593 ± 0.004719	0.000668 ± 0.000032	0.0005
4.00 W	0.504308 ± 0.005135	0.000397 ± 0.000023	0.0007
4.40 W	0.513424 ± 0.005391	0.000332 ± 0.000038	0.0021
5.00 W	0.492757 ± 0.005162	0.000486 ± 0.000045	0.0028
6.00 W	0.470534 ± 0.004756	0.000619 ± 0.000030	0.0010
7.00 W	0.256399 ± 0.002803	0.001927 ± 0.000086	0.0136

Isotope Ratios	40(r)/39(k)	1σ	40(r+a)	1σ	40Ar/39Ar	1σ	37Ar/39Ar	1σ	36Ar/39Ar	1σ
2.00 W	0.022	1.048	0.241	0.0001	47.189	0.451	0.170	0.028	0.1596	0.0039
2.30 W	0.455	0.585	0.370	0.0002	23.268	0.138	0.178	0.009	0.0772	0.0020
2.60 W	1.290	0.120	0.255	0.0004	6.178	0.036	0.177	0.006	0.0165	0.0004
3.00 W	1.758	0.030	0.345	0.0002	2.740	0.015	0.216	0.004	0.0033	0.0001
3.50 W	1.762	0.014	0.800	0.0002	2.225	0.012	0.087	0.002	0.0015	0.0000
4.00 W	1.750	0.011	1.043	0.0003	2.013	0.010	0.055	0.001	0.0008	0.0000
4.40 W	1.757	0.014	0.525	0.0004	1.978	0.010	0.038	0.001	0.0007	0.0000
5.00 W	1.738	0.016	0.571	0.0005	2.060	0.011	0.025	0.002	0.0010	0.0000
6.00 W	1.737	0.013	1.247	0.0004	2.155	0.011	0.016	0.000	0.0013	0.0000
7.00 W	1.680	0.051	0.605	0.0008	3.930	0.021	0.040	0.002	0.0075	0.0002

Laser	Isotope Ratios												
	TM111907-6 biotite			(sample/mineral)									
Power(%)	40Ar/39Ar	1σ	37Ar/39Ar	1σ	36Ar/39Ar	1σ	Ca/K	Cl/K	%40Ar atm	f 39Ar	40Ar*/39ArK	Age	2σ
2.00 W	47.19	0.45	0.17	0.03	0.160	0.004	0.31		99.95	0.22	0.022	0.44	± 41.81
2.30 W	23.27	0.14	0.18	0.01	0.077	0.002	0.33		98.05	0.67	0.455	9.05	± 23.24
2.60 W	6.18	0.04	0.18	0.01	0.017	0.000	0.32		79.13	1.75	1.290	25.55	± 4.74
3.00 W	2.74	0.01	0.22	0.00	0.003	0.000	0.40		35.85	5.37	1.758	34.73	± 1.17
3.50 W	2.23	0.01	0.09	0.00	0.001	0.000	0.16		20.83	15.36	1.762	34.81	± 0.54
4.00 W	2.01	0.01	0.05	0.00	0.001	0.000	0.10		13.05	22.16	1.750	34.59	± 0.44
4.40 W	1.98	0.01	0.04	0.00	0.001	0.000	0.07		11.19	11.35	1.757	34.71	± 0.56
5.00 W	2.06	0.01	0.02	0.00	0.001	0.000	0.05		15.62	11.87	1.738	34.34	± 0.63
6.00 W	2.16	0.01	0.02	0.00	0.001	0.000	0.03		19.44	24.72	1.737	34.32	± 0.50
7.00 W	3.93	0.02	0.04	0.00	0.008	0.000	0.07		57.26	6.54	1.680	33.20	± 1.98

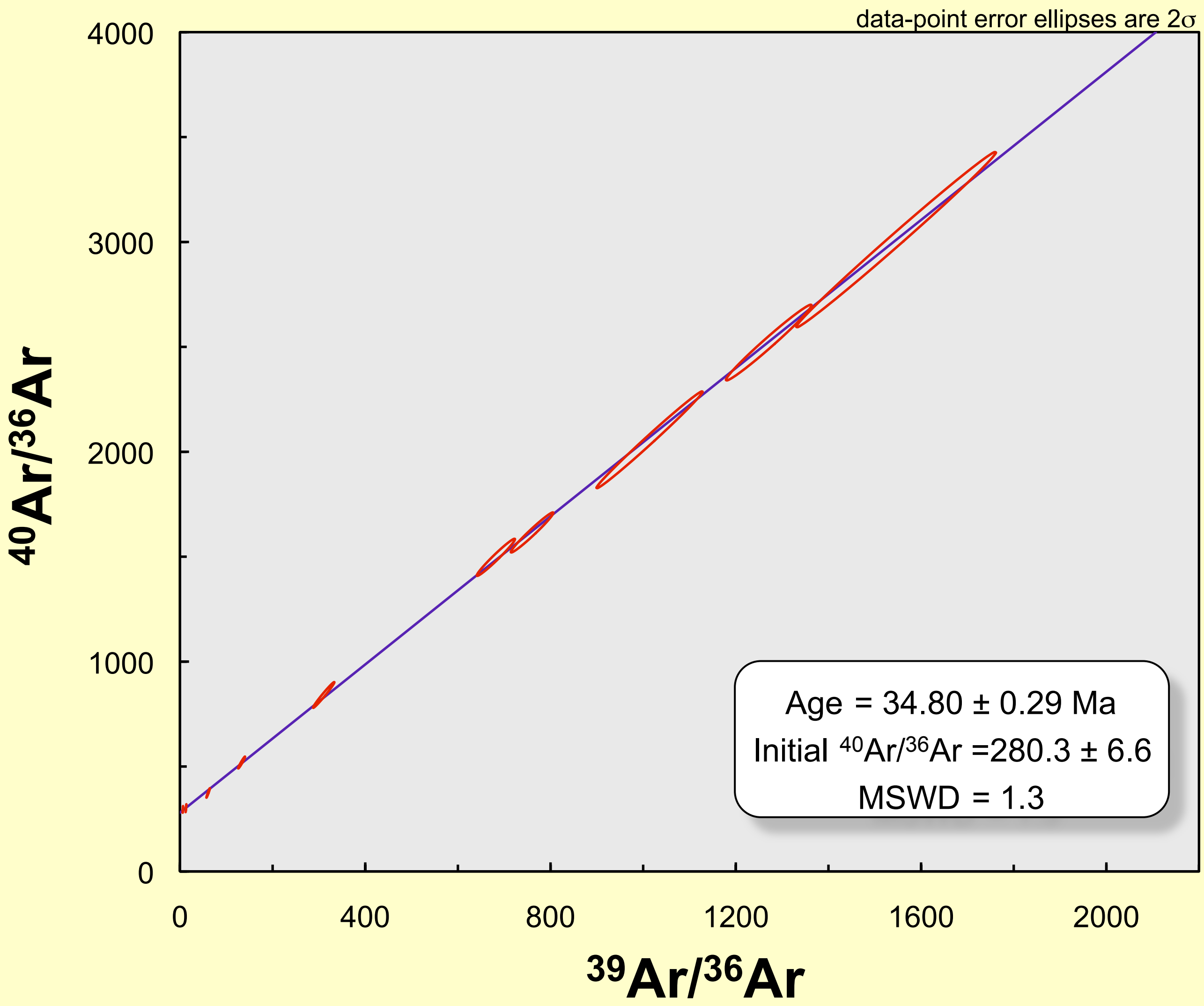
Power(%)	40Ar/39Ar	1σ	37Ar/39Ar	1σ	36Ar/39Ar	1σ	Ca/K	Cl/K	%40Ar atm	f 39Ar	40Ar*/39ArK	1σ
Total/Average	2.305	0.004	0.023	0.000	0.0011	0.0000				100.00	1.747	0.006

J = 0.0110322 ± 0.0000552 Volume 39ArK = 2.373 Integrated Date = 34.06 ± 0.46 Ma

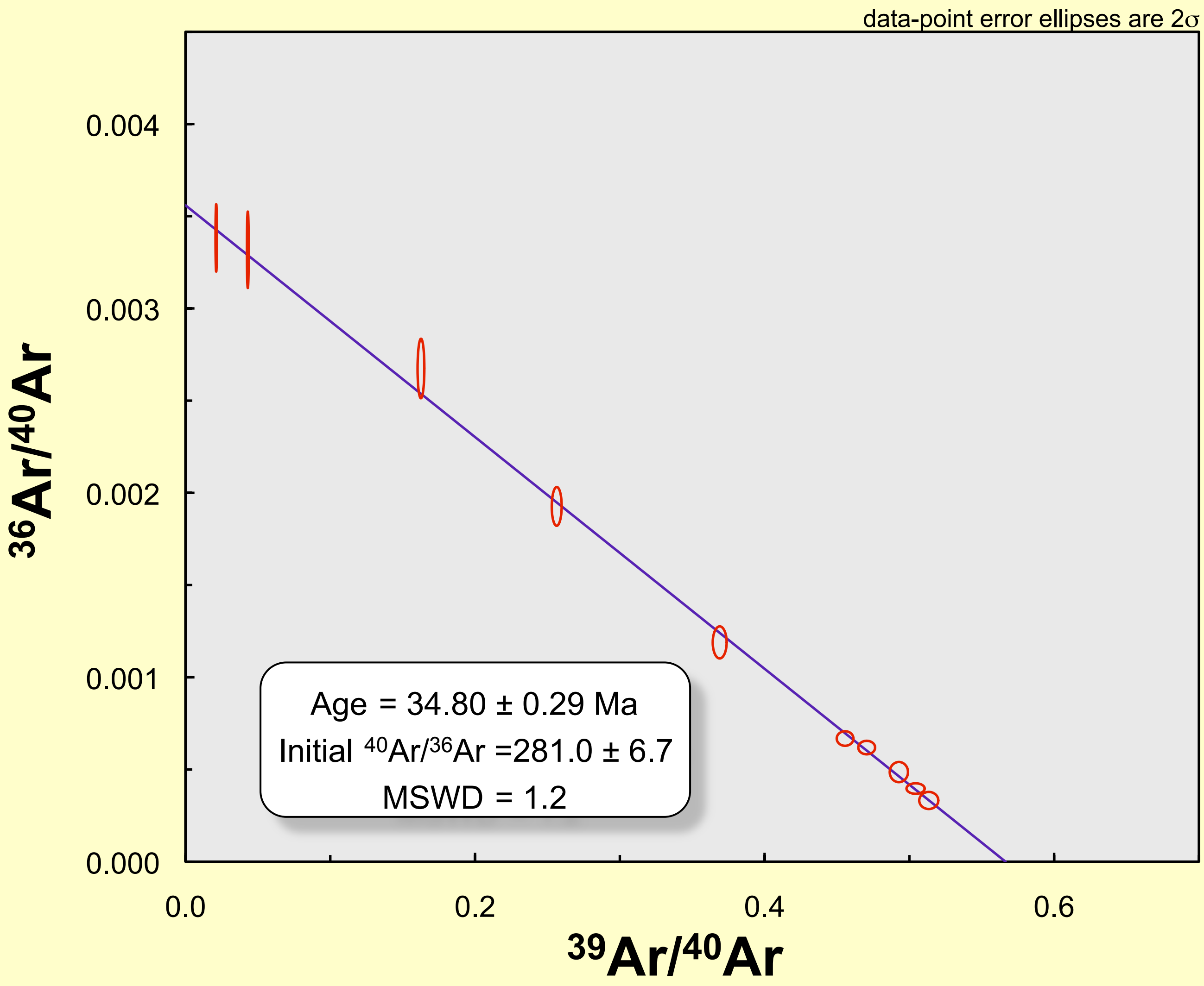
Plateau Age = 34.55 ± 0.31 Ma (2s, including J-error of .3%) MSWD = 0.75, probability=0.61 97.4% of the 39Ar, steps 3 through 10

Inverse isochron (correlation age) results, plateau steps: Model 1 Solution (±95%-conf.) on 6 points Age = 35.0±1.4 Ma

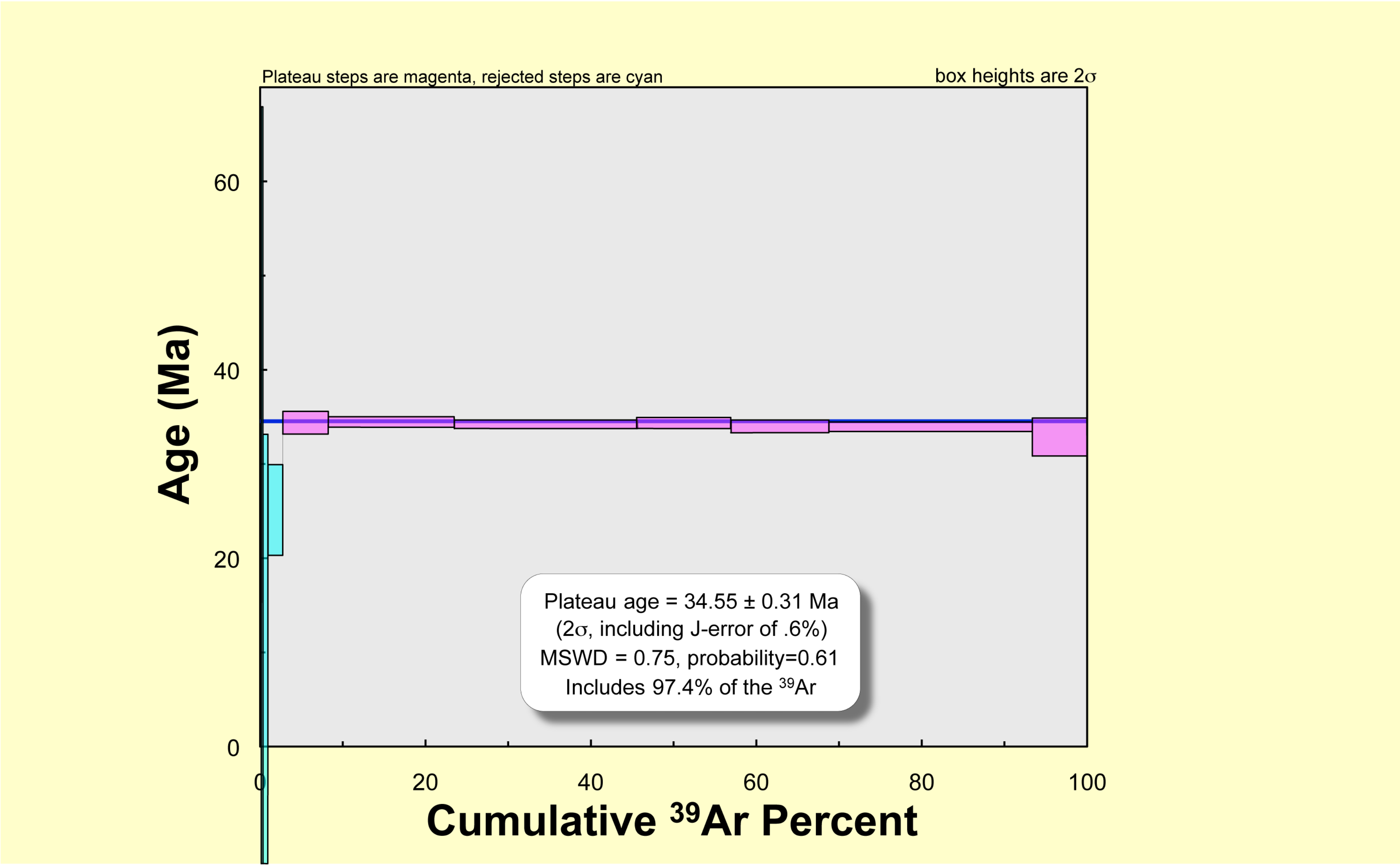
40/36 intercept: 34.80 ± 0.29 MSWD = 1.2, Probability = 0.27 (at J=.010322±.3% 2s)



data-point error ellipses are 2σ
4000
3000
2000
1000
0
0
400
800
1200
1600
2000
^{40}Ar/^{36}Ar
^{39}Ar/^{36}Ar
Age = 34.80 ± 0.29 Ma
Initial ^{40}Ar/^{36}Ar =280.3 ± 6.6
MSWD = 1.3



data-point error ellipses are 2σ
0.004
0.003
0.002
0.001
0.000
0.0
0.2
0.4
0.6
36Ar/40Ar
39Ar/40Ar
Age = 34.80 ± 0.29 Ma
Initial 40Ar/36Ar =281.0 ± 6.7
MSWD = 1.2



Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
Age (Ma)
0
20
40
60
0
20
40
60
80
100
Cumulative ^{39}Ar Percent
Plateau age = 34.55 ± 0.31 Ma
(2σ, including J-error of .6%)
MSWD = 0.75, probability=0.61
Includes 97.4% of the ^{39}Ar

Information on Analysis

J112007-1 biotite

Total fusion age 37.94 ± 0.46 Ma

Volumes are 1E-13 cm3 NPT
Neutron flux monitors: 28.030 ± 0.084 Ma FCs (Renne et al., 1998)
Isotope production ratios: (40Ar/39Ar)K=0.0302±0.00006, (37Ar/39Ar)Ca=1416.4±0.5, (36Ar/39Ar)Ca=0.3952±0.0004,
Ca/K=1.83±0.01(37ArCa/39ArK).
J = 0.0110451 ± 0.0000552
14-Dec-10

Plateau Age

Plateau age = 38.57 ± 0.32 Ma
(2σ, including J-error of .6%)
MSWD = 0.99, probability=0.43
Includes 76% of the ^{39}Ar

Normal Isochron

Age = 39.12 ± 0.36 Ma
Initial $^{40}Ar/^{36}Ar$ =269.8 ± 8.0
MSWD = 1.4

Inverse Isochron

Age = 39.12 ± 0.37 Ma
Initial $^{40}Ar/^{36}Ar$ =270.3 ± 8.2
MSWD = 1.4

Incremental Heating	40Ar(r)	39Ar(k) (cum %)	Age ± 2σ (Ma)	40Ar(r) (%)	39Ar(k) (%)	K/Ca ± 2σ
2.00 W	0.003	0.021	24.93 ± 80.17	3.77	0.02	4.873 ± 4.516
2.40 W	0.017	0.921	4.07 ± 18.29	0.94	0.90	8.218 ± 0.647
2.60 W	0.138	1.982	27.69 ± 4.60	22.26	1.06	8.944 ± 0.457
3.00 W	0.500	4.912	36.25 ± 1.54	51.99	2.93	16.434 ± 1.228
3.30 W	1.033	10.661	38.15 ± 0.85	70.94	5.75	29.346 ± 2.173
3.60 W	1.398	18.288	38.91 ± 0.63	77.65	7.63	29.665 ± 1.681
3.90 W	2.518	32.007	38.96 ± 0.57	84.15	13.72	12.438 ± 0.480
4.10 W	1.478	40.109	38.73 ± 0.52	84.99	8.10	2.518 ± 0.088
4.30 W	1.343	47.503	38.57 ± 0.55	82.56	7.39	7.660 ± 0.302
4.60 W	1.889	57.966	38.33 ± 0.83	69.34	10.46	10.019 ± 0.364
4.90 W	2.219	70.258	38.32 ± 0.66	75.90	12.29	8.487 ± 0.348
5.20 W	1.922	80.940	38.20 ± 0.58	83.80	10.68	8.551 ± 0.310
5.50 W	1.398	88.706	38.22 ± 0.56	85.38	7.77	7.084 ± 0.285
5.90 W	1.340	96.121	38.35 ± 0.54	84.83	7.42	5.903 ± 0.230
6.50 W	0.453	98.628	38.40 ± 0.98	70.04	2.51	1.939 ± 0.069
7.00 W	0.180	99.703	35.56 ± 1.96	50.73	1.08	0.918 ± 0.035
7.50 W	0.040	100.000	28.47 ± 6.12	23.28	0.30	0.378 ± 0.015

Normal Isochron	39(k)/36(a) ± 2σ	(a+r)/36(a) ± 2σ	r.i.
2.00 W	9.2 ± 1.2	307.1 ± 39.0	0.9891
2.40 W	13.8 ± 0.6	298.3 ± 12.8	0.9732
2.60 W	61.0 ± 3.0	380.7 ± 18.3	0.9710
3.00 W	177.7 ± 8.3	621.3 ± 28.4	0.9749
3.30 W	388.6 ± 19.4	1045.6 ± 51.2	0.9745
3.60 W	550.6 ± 25.2	1379.7 ± 61.5	0.9718
3.90 W	866.3 ± 41.5	2003.7 ± 93.7	0.9670
4.10 W	935.0 ± 50.3	2128.2 ± 112.6	0.9813
4.30 W	773.6 ± 40.2	1805.3 ± 92.0	0.9798
4.60 W	357.2 ± 16.0	988.3 ± 43.3	0.9694
4.90 W	504.7 ± 22.2	1274.1 ± 54.4	0.9656
5.20 W	860.4 ± 39.9	1958.7 ± 88.4	0.9623
5.50 W	981.9 ± 55.8	2194.5 ± 122.9	0.9790
5.90 W	932.6 ± 48.7	2105.3 ± 107.9	0.9758
6.50 W	368.8 ± 21.2	1012.3 ± 57.1	0.9820
7.00 W	172.2 ± 8.8	605.1 ± 31.1	0.9324
7.50 W	62.8 ± 4.1	385.7 ± 25.1	0.9586

Inverse Isochron	(k)/40(a+r) ± 2σ	(a)/40(a+r) ± 2σ	r.i.
2.00 W	0.030035 ± 0.000568	0.003256 ± 0.000414	0.0050
2.40 W	0.046228 ± 0.000468	0.003352 ± 0.000144	0.0016
2.60 W	0.160156 ± 0.001879	0.002627 ± 0.000126	0.0298
3.00 W	0.286021 ± 0.002977	0.001609 ± 0.000074	0.0110
3.30 W	0.371634 ± 0.004167	0.000956 ± 0.000047	0.0206
3.60 W	0.399050 ± 0.004304	0.000725 ± 0.000032	0.0111
3.90 W	0.432342 ± 0.005277	0.000499 ± 0.000023	0.0398
4.10 W	0.439341 ± 0.004552	0.000470 ± 0.000025	0.0090
4.30 W	0.428511 ± 0.004451	0.000554 ± 0.000028	0.0085
4.60 W	0.361415 ± 0.003990	0.001012 ± 0.000044	0.0232
4.90 W	0.396145 ± 0.004536	0.000785 ± 0.000034	0.0175
5.20 W	0.439282 ± 0.005544	0.000511 ± 0.000023	0.0455
5.50 W	0.447463 ± 0.005184	0.000456 ± 0.000026	0.0274
5.90 W	0.442964 ± 0.005057	0.000475 ± 0.000024	0.0272
6.50 W	0.364370 ± 0.003953	0.000988 ± 0.000056	0.0072
7.00 W	0.284557 ± 0.005367	0.001653 ± 0.000085	0.1880
7.50 W	0.162783 ± 0.003053	0.002593 ± 0.000169	0.1377

Isotope Ratios	40(r)/39(k)	1σ	40(r+a)	1σ	40Ar/39Ar	1σ	37Ar/39Ar	1σ	36Ar/39Ar	1σ
2.00 W	1.257	2.035	0.066	0.0001	33.322	0.315	0.112	0.052	0.1085	0.0070
2.40 W	0.204	0.459	1.811	0.0008	21.661	0.110	0.066	0.003	0.0725	0.0016
2.60 W	1.397	0.117	0.617	0.0013	6.274	0.037	0.061	0.002	0.0164	0.0004
3.00 W	1.833	0.039	0.953	0.0011	3.526	0.018	0.033	0.001	0.0056	0.0001
3.30 W	1.930	0.022	1.440	0.0024	2.721	0.015	0.019	0.001	0.0026	0.0001
3.60 W	1.969	0.016	1.779	0.0021	2.536	0.014	0.018	0.001	0.0018	0.0000
3.90 W	1.972	0.015	2.954	0.0070	2.343	0.014	0.044	0.001	0.0012	0.0000
4.10 W	1.960	0.013	1.717	0.0019	2.306	0.012	0.217	0.004	0.0011	0.0000
4.30 W	1.952	0.014	1.606	0.0017	2.364	0.012	0.071	0.001	0.0013	0.0000
4.60 W	1.940	0.021	2.695	0.0045	2.797	0.015	0.054	0.001	0.0028	0.0001
4.90 W	1.939	0.017	2.888	0.0042	2.554	0.015	0.064	0.001	0.0020	0.0000
5.20 W	1.933	0.015	2.264	0.0058	2.307	0.015	0.064	0.001	0.0012	0.0000
5.50 W	1.934	0.014	1.616	0.0034	2.265	0.013	0.077	0.002	0.0011	0.0000
5.90 W	1.941	0.014	1.558	0.0031	2.288	0.013	0.092	0.002	0.0011	0.0000
6.50 W	1.943	0.025	0.640	0.0007	2.774	0.015	0.282	0.005	0.0028	0.0001
7.00 W	1.798	0.050	0.352	0.0024	3.543	0.033	0.594	0.011	0.0060	0.0001
7.50 W	1.437	0.156	0.170	0.0011	6.167	0.058	1.442	0.029	0.0163	0.0005

Laser	Isotope Ratios												
	J112007-1 biotite			(sample/mineral)									
Power(%)	40Ar/39Ar	1σ	37Ar/39Ar	1σ	36Ar/39Ar	1σ	Ca/K	Cl/K	%40Ar atm	f 39Ar	40Ar*/39ArK	Age	2σ
2.00 W	33.32	0.31	0.11	0.05	0.108	0.007	0.21		96.23	0.02	1.257	24.93	± 80.17
2.40 W	21.66	0.11	0.07	0.00	0.073	0.002	0.12		99.06	0.90	0.204	4.07	± 18.29
2.60 W	6.27	0.04	0.06	0.00	0.016	0.000	0.11		77.74	1.06	1.397	27.69	± 4.60
3.00 W	3.53	0.02	0.03	0.00	0.006	0.000	0.06		48.01	2.93	1.833	36.25	± 1.54
3.30 W	2.72	0.02	0.02	0.00	0.003	0.000	0.03		29.06	5.75	1.930	38.15	± 0.85
3.60 W	2.54	0.01	0.02	0.00	0.002	0.000	0.03		22.35	7.63	1.969	38.91	± 0.63
3.90 W	2.34	0.01	0.04	0.00	0.001	0.000	0.08		15.85	13.72	1.972	38.96	± 0.57
4.10 W	2.31	0.01	0.22	0.00	0.001	0.000	0.40		15.01	8.10	1.960	38.73	± 0.52
4.30 W	2.36	0.01	0.07	0.00	0.001	0.000	0.13		17.44	7.39	1.952	38.57	± 0.55
4.60 W	2.80	0.02	0.05	0.00	0.003	0.000	0.10		30.66	10.46	1.940	38.33	± 0.83
4.90 W	2.55	0.01	0.06	0.00	0.002	0.000	0.12		24.10	12.29	1.939	38.32	± 0.66
5.20 W	2.31	0.01	0.06	0.00	0.001	0.000	0.12		16.20	10.68	1.933	38.20	± 0.58
5.50 W	2.26	0.01	0.08	0.00	0.001	0.000	0.14		14.62	7.77	1.934	38.22	± 0.56
5.90 W	2.29	0.01	0.09	0.00	0.001	0.000	0.17		15.17	7.42	1.941	38.35	± 0.54
6.50 W	2.77	0.02	0.28	0.00	0.003	0.000	0.52		29.96	2.51	1.943	38.40	± 0.98
7.00 W	3.54	0.03	0.59	0.01	0.006	0.000	1.09		49.27	1.08	1.798	35.56	± 1.96
7.50 W	6.17	0.06	1.44	0.03	0.016	0.001	2.64		76.72	0.30	1.437	28.47	± 6.12

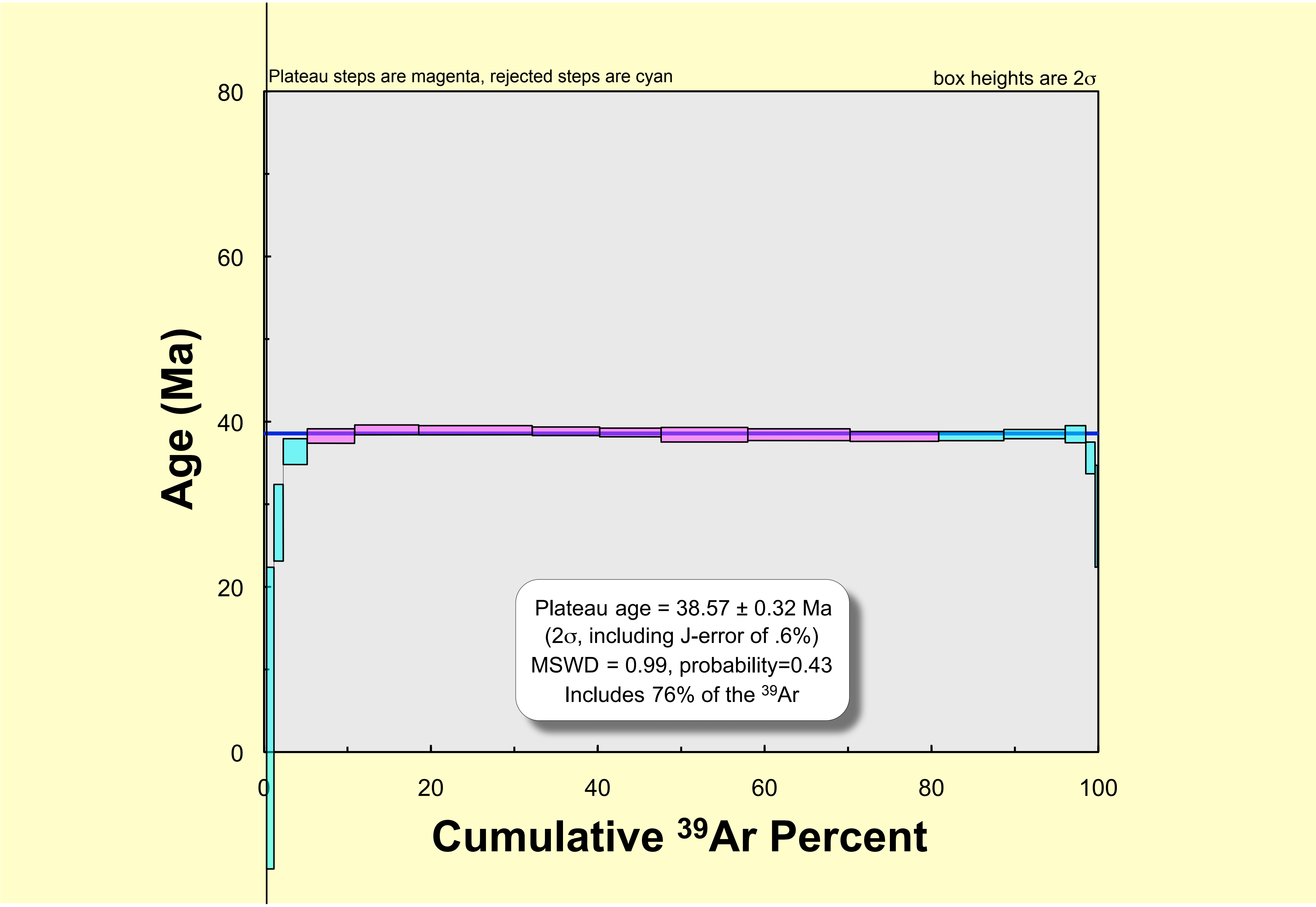
Power(%)	40Ar/39Ar	1σ	37Ar/39Ar	1σ	36Ar/39Ar	1σ	Ca/K	Cl/K	%40Ar atm	f 39Ar	40Ar*/39ArK	1σ
Total/Average	2.612	0.004	0.041	0.000	0.0014	0.0000				100.00	1.944	0.005

J = 0.0110451 ± 0.0000552 Volume 39ArK = 9.309 Integrated Date = 37.94 ± 0.46 Ma

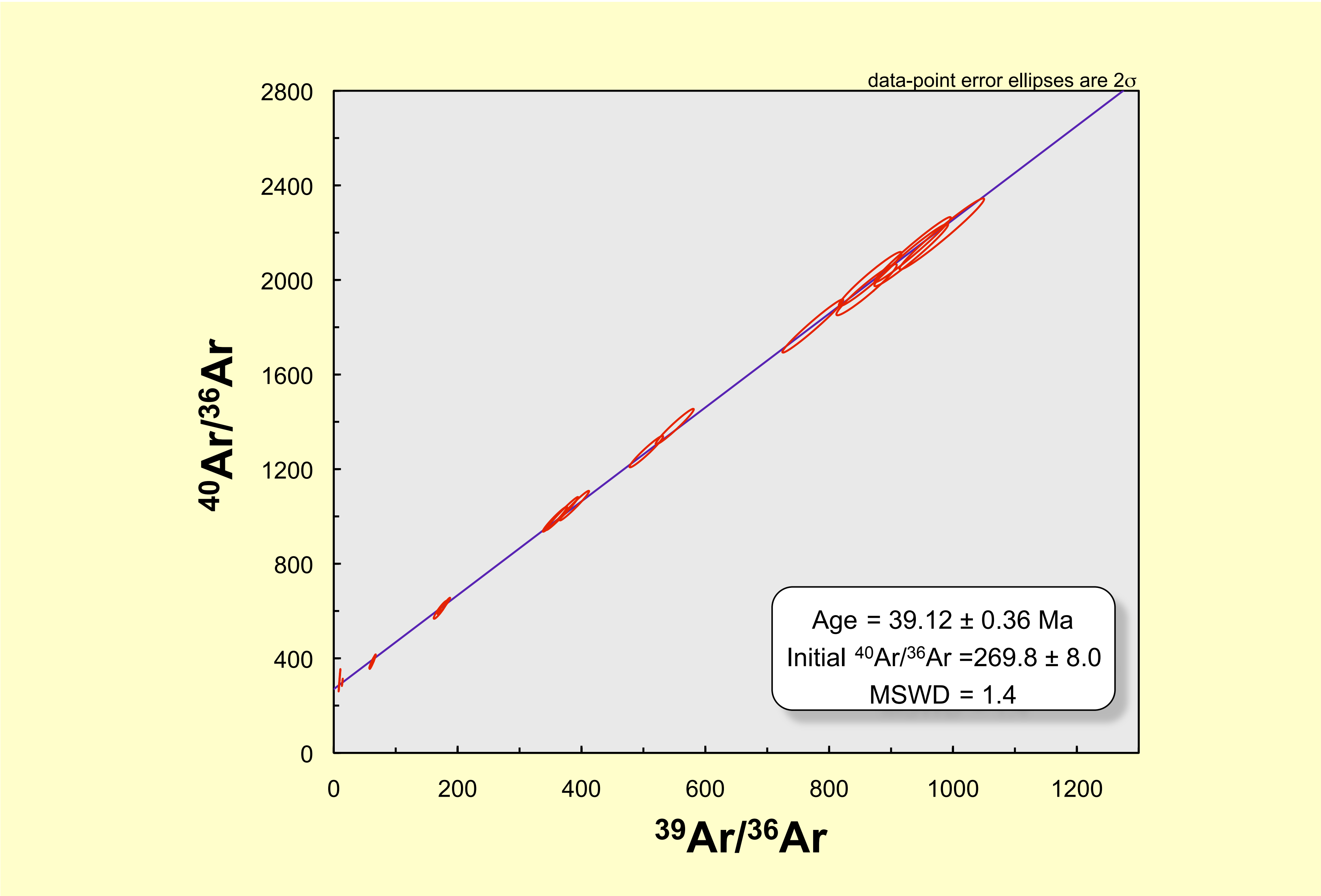
Plateau Age = 38.57 ± 0.32 Ma (2s, including J-error of .3%) MSWD = 0.99, probability = 0.43 76% of the 39Ar, steps 5 through 12

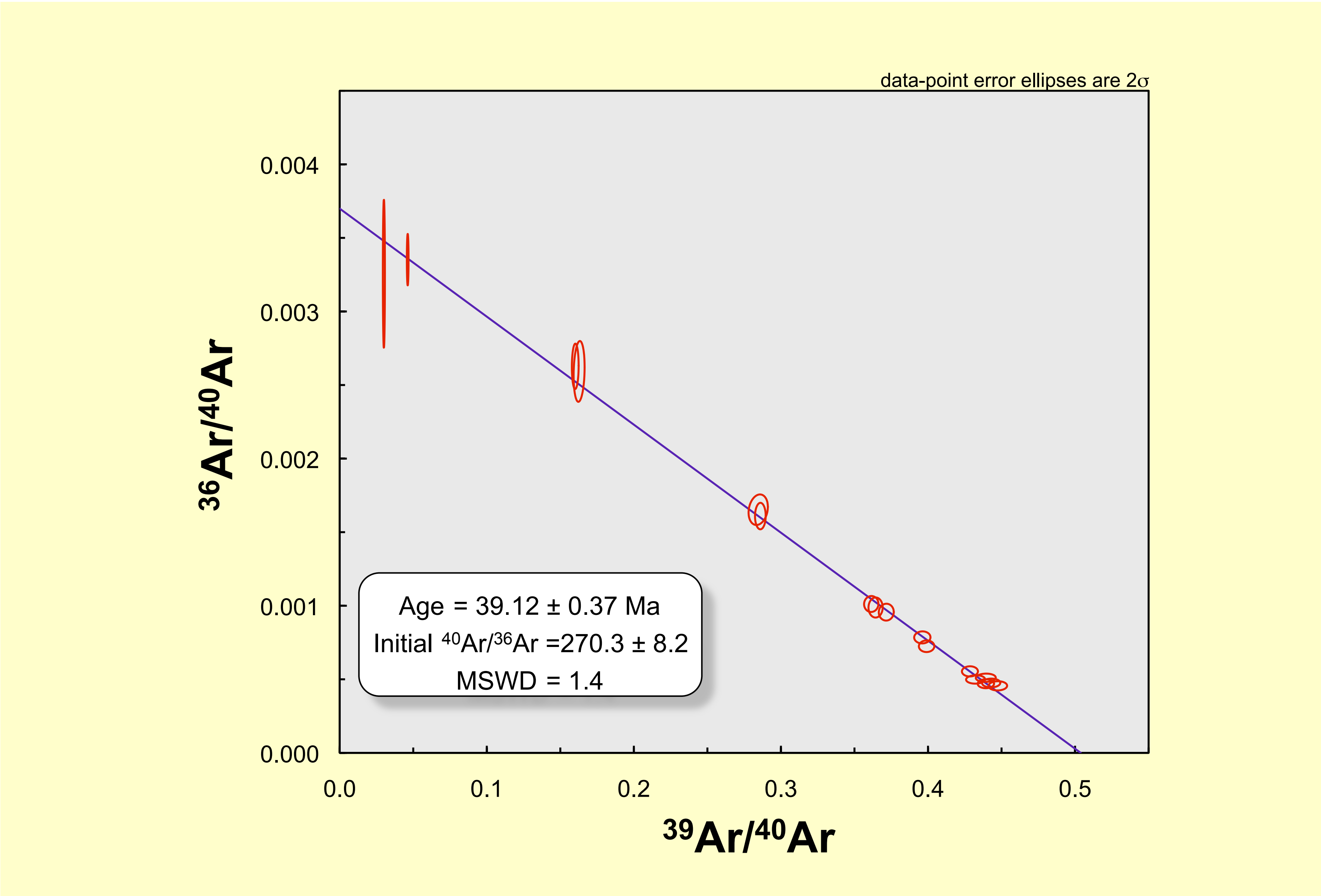
Inverse isochron (correlation age) results, plateau steps: Model 1 Solution (±95%-conf.) on 17 points Age = 39.12 ± 0.37 Ma

40/36 intercept: 270.3 ± 8.2 MSWD = 1.4, Probability = 0.13 (at J=.0110451±.3% 2s)



Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
80
60
40
20
0
Age (Ma)
0
20
40
60
80
100
Cumulative 39Ar Percent
Plateau age = 38.57 ± 0.32 Ma
(2σ, including J-error of .6%)
MSWD = 0.99, probability=0.43
Includes 76% of the 39Ar


data-point error ellipses are 2σ
2800
2400
2000
1600
1200
800
400
0
0
200
400
600
800
1000
1200
40Ar/36Ar
39Ar/36Ar
Age = 39.12 ± 0.36 Ma
Initial 40Ar/36Ar =269.8 ± 8.0
MSWD = 1.4



data-point error ellipses are 2σ
0.004
0.003
0.002
0.001
0.000
0.0
0.1
0.2
0.3
0.4
0.5
36Ar/40Ar
39Ar/40Ar
Age = 39.12 ± 0.37 Ma
Initial 40Ar/36Ar =270.3 ± 8.2
MSWD = 1.4

Information on Analysis

FR112007-2 biotite

Total fusion age 29.88 ± 0.73 Ma

Volumes are 1E-13 cm3 NPT
Neutron flux monitors: 28.030 ± 0.084 Ma FCs (Renne et al., 1998)
Isotope production ratios: (40Ar/39Ar)K=0.0302±0.00006, (37Ar/39Ar)Ca=1416.4±0.5, (36Ar/39Ar)Ca=0.3952±0.0004, Ca/K=1.83±0.01(37ArCa/39ArK).
J = 0.0110158 ± 0.0000551
9-Nov-10

Plateau Age

Plateau age = 35.77 ± 0.88 Ma (2σ)
MSWD = 0.5
Includes 52% of the ^{39}Ar

Normal Isochron

Age = 39.8 ± 5.1 Ma
Initial ^{40}Ar/^{36}Ar =225 ± 59
MSWD = 24

Inverse Isochron

Age = 36.1 ± 9.3 Ma
Initial ^{40}Ar/^{36}Ar =230 ± 63
MSWD = 61

Incremental Heating	40Ar(r)	39Ar(k) (cum %)	Age ± 2σ (Ma)	40Ar(r) (%)	39Ar(k) (%)	K/Ca ± 2σ
2.00 W	0.003	1.166	-6.10 ± 18.68	1.60	1.17	19.779 ± 7.349
2.30 W	0.007	8.229	2.33 ± 4.97	1.99	7.06	23.243 ± 2.922
2.60 W	0.042	14.966	15.65 ± 1.89	30.76	6.74	24.987 ± 2.420
2.90 W	0.073	21.963	25.67 ± 2.25	50.08	7.00	27.919 ± 4.630
3.40 W	0.173	36.061	30.37 ± 1.25	55.48	14.10	26.808 ± 2.500
3.80 W	0.172	48.628	33.73 ± 1.22	59.10	12.57	23.590 ± 1.443
4.50 W	0.415	77.089	36.03 ± 1.19	60.12	28.46	10.062 ± 0.741
5.20 W	0.261	95.158	35.70 ± 1.36	61.15	18.07	6.660 ± 0.290
6.00 W	0.034	97.565	34.71 ± 2.37	59.03	2.41	1.557 ± 0.082
7.00 W	0.024	99.220	36.52 ± 2.95	64.78	1.65	1.730 ± 0.128
8.00 W	0.010	100.000	30.56 ± 12.20	55.98	0.78	3.793 ± 0.563

Normal Isochron	39(k)/36(a) ± 2σ	)(a+r)/36(a) ± 2σ	r.i.	
2.00 W	15.2 ± 0.8	290.8 ± 14.0	0.9643	
2.30 W	51.4 ± 2.3	301.5 ± 13.1	0.9630	
2.60 W	169.3 ± 9.4	429.1 ± 23.4	0.9805	x
2.90 W	233.9 ± 21.1	599.0 ± 53.7	0.9926	x
3.40 W	245.5 ± 12.6	673.0 ± 33.9	0.9740	
3.80 W	256.4 ± 13.4	733.7 ± 37.6	0.9771	
4.50 W	250.1 ± 12.0	752.3 ± 35.4	0.9691	
5.20 W	263.9 ± 16.0	773.2 ± 46.1	0.9843	
6.00 W	248.2 ± 24.7	732.1 ± 72.3	0.9886	
7.00 W	302.5 ± 46.2	855.7 ± 130.5	0.9966	
8.00 W	249.1 ± 130.6	680.9 ± 356.9	0.9994	x

Inverse Isochron	)(k)/40(a+r) ± 2σ	(a)/40(a+r) ± 2σ	r.i.
2.00 W	0.052362 ± 0.000685	0.003438 ± 0.000166	0.0416
2.30 W	0.170574 ± 0.002062	0.003316 ± 0.000144	0.0269
2.60 W	0.394466 ± 0.004300	0.002331 ± 0.000127	0.0092
2.90 W	0.390430 ± 0.004264	0.001669 ± 0.000150	0.0115
3.40 W	0.364839 ± 0.004252	0.001486 ± 0.000075	0.0268
3.80 W	0.349419 ± 0.003880	0.001363 ± 0.000070	0.0198
4.50 W	0.332432 ± 0.003934	0.001329 ± 0.000063	0.0536
5.20 W	0.341317 ± 0.003648	0.001293 ± 0.000077	0.0114
6.00 W	0.339004 ± 0.005067	0.001366 ± 0.000135	0.0304
7.00 W	0.353520 ± 0.004429	0.001169 ± 0.000178	0.0159
8.00 W	0.365802 ± 0.006546	0.001469 ± 0.000770	0.0064

Isotope Ratios	40(r)/39(k)	1σ	40(r+a)	1σ	40Ar/39Ar	1σ	37Ar/39Ar	1σ	36Ar/39Ar	1σ
2.00 W	0.305	0.467	0.178	0.0005	19.128	0.125	0.028	0.005	0.0657	0.0016
2.30 W	0.117	0.125	0.331	0.0006	5.893	0.036	0.023	0.001	0.0195	0.0004
2.60 W	0.789	0.048	0.136	0.0002	2.565	0.014	0.022	0.001	0.0059	0.0002
2.90 W	1.298	0.057	0.143	0.0002	2.591	0.014	0.020	0.002	0.0043	0.0002
3.40 W	1.537	0.032	0.309	0.0006	2.771	0.016	0.020	0.001	0.0041	0.0001
3.80 W	1.709	0.031	0.287	0.0005	2.892	0.016	0.023	0.001	0.0039	0.0001
4.50 W	1.827	0.030	0.684	0.0019	3.038	0.018	0.054	0.002	0.0040	0.0001
5.20 W	1.810	0.035	0.423	0.0006	2.960	0.016	0.082	0.002	0.0038	0.0001
6.00 W	1.759	0.061	0.057	0.0002	2.979	0.022	0.351	0.009	0.0041	0.0002
7.00 W	1.852	0.076	0.037	0.0001	2.858	0.018	0.315	0.012	0.0034	0.0003
8.00 W	1.547	0.311	0.017	0.0001	2.764	0.025	0.144	0.011	0.0041	0.0011

Laser	Isotope Ratios												
	FR112007-2 biotite			(sample/mineral)									
Power(%)	*40Ar/39Ar*	*1σ*	*37Ar/39Ar*	*1σ*	*36Ar/39Ar*	*1σ*	*Ca/K*	*Cl/K*	*%40Ar atm*	*f 39Ar*	*40Ar*/39ArK*	*Age*	*2σ*
2.00 W	19.13	0.13	0.03	0.01	0.066	0.002	0.05		101.60	1.17	0.305	-6.10	± 18.68
2.30 W	5.89	0.04	0.02	0.00	0.019	0.000	0.04		98.01	7.06	0.117	2.33	± 4.97
2.60 W	2.57	0.01	0.02	0.00	0.006	0.000	0.04		69.24	6.74	0.789	15.65	± 1.89
2.90 W	2.59	0.01	0.02	0.00	0.004	0.000	0.04		49.92	7.00	1.298	25.67	± 2.25
3.40 W	2.77	0.02	0.02	0.00	0.004	0.000	0.04		44.52	14.10	1.537	30.37	± 1.25
3.80 W	2.89	0.02	0.02	0.00	0.004	0.000	0.04		40.90	12.57	1.709	33.73	± 1.22
4.50 W	3.04	0.02	0.05	0.00	0.004	0.000	0.10		39.88	28.46	1.827	36.03	± 1.19
5.20 W	2.96	0.02	0.08	0.00	0.004	0.000	0.15		38.85	18.07	1.810	35.70	± 1.36
6.00 W	2.98	0.02	0.35	0.01	0.004	0.000	0.64		40.97	2.41	1.759	34.71	± 2.37
7.00 W	2.86	0.02	0.32	0.01	0.003	0.000	0.58		35.22	1.65	1.852	36.52	± 2.95
8.00 W	2.76	0.02	0.14	0.01	0.004	0.001	0.26		44.02	0.78	1.547	30.56	± 12.20

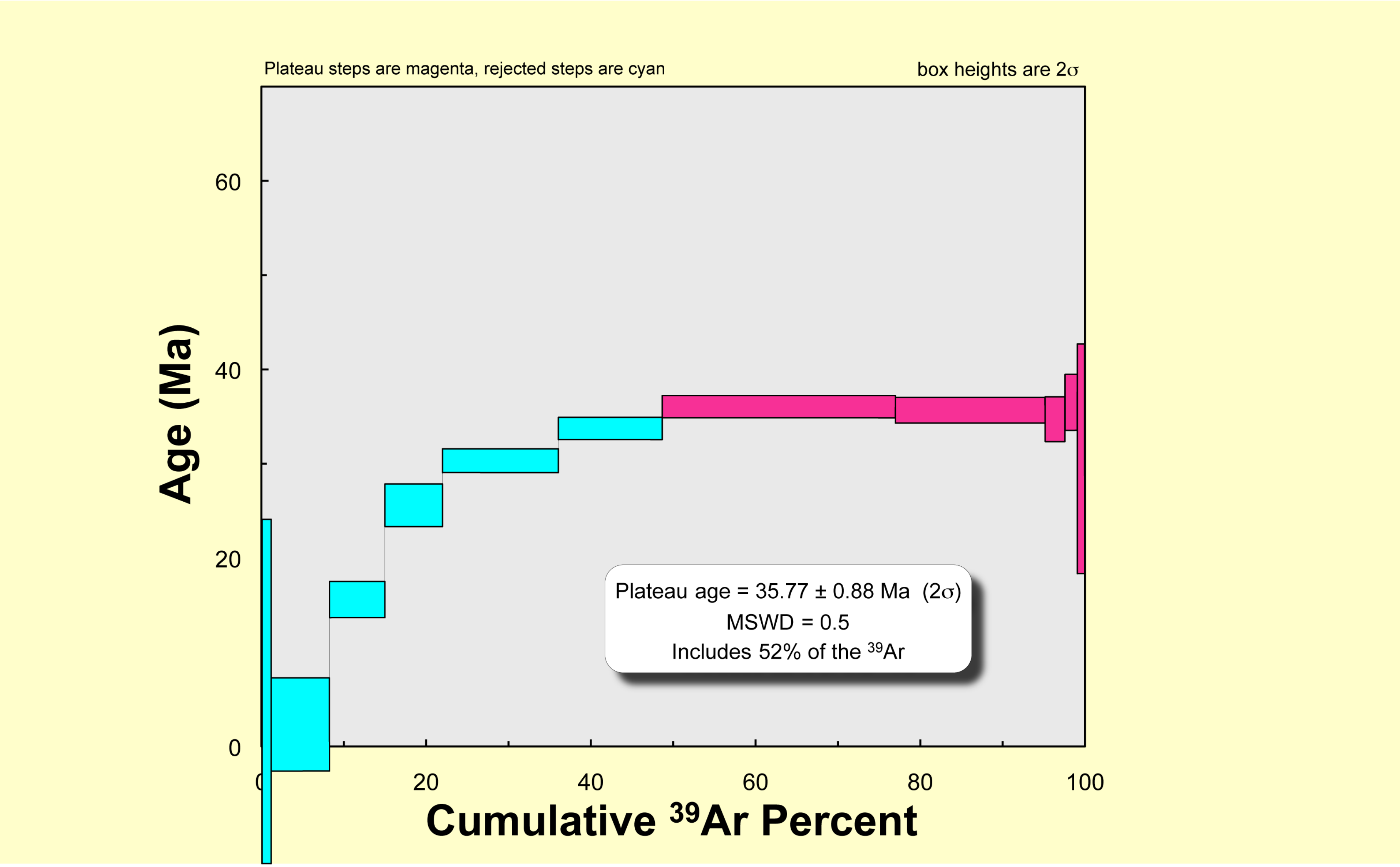
Power(%)	*40Ar/39Ar*	*1σ*	*37Ar/39Ar*	*1σ*	*36Ar/39Ar*	*1σ*	*Ca/K*	*Cl/K*	*%40Ar atm*	*f 39Ar*	*40Ar*/39ArK*	*1σ*
Total/Average	2.903	0.006	0.028	0.000	0.0043	0.0000				100.00	1.601	0.014

J = 0.0110158 ± 0.0000551 Volume 39ArK = 0.799 Integrated Date = 29.88 ± 0.73 Ma

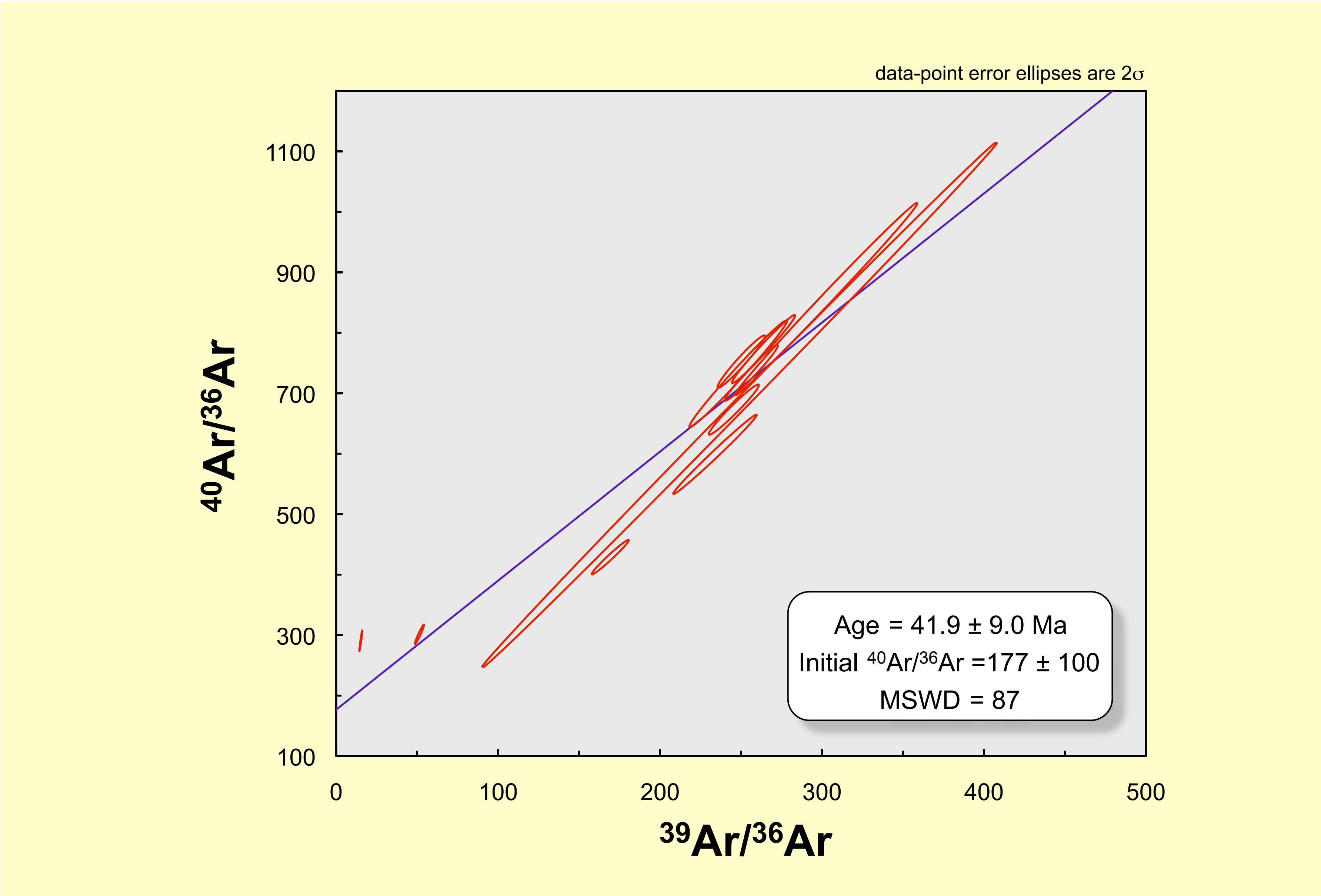
Plateau Age = 35.77 ± 0.88 Ma (2s, including J-error of .3%) MSWD = 0.5 52% of the 39Ar, steps 7 through 11

Inverse isochron (correlation age) results, plateau steps: Model 1 Solution (±95%-conf.) on 11 points Age = 36.1 ± 9.3 Ma

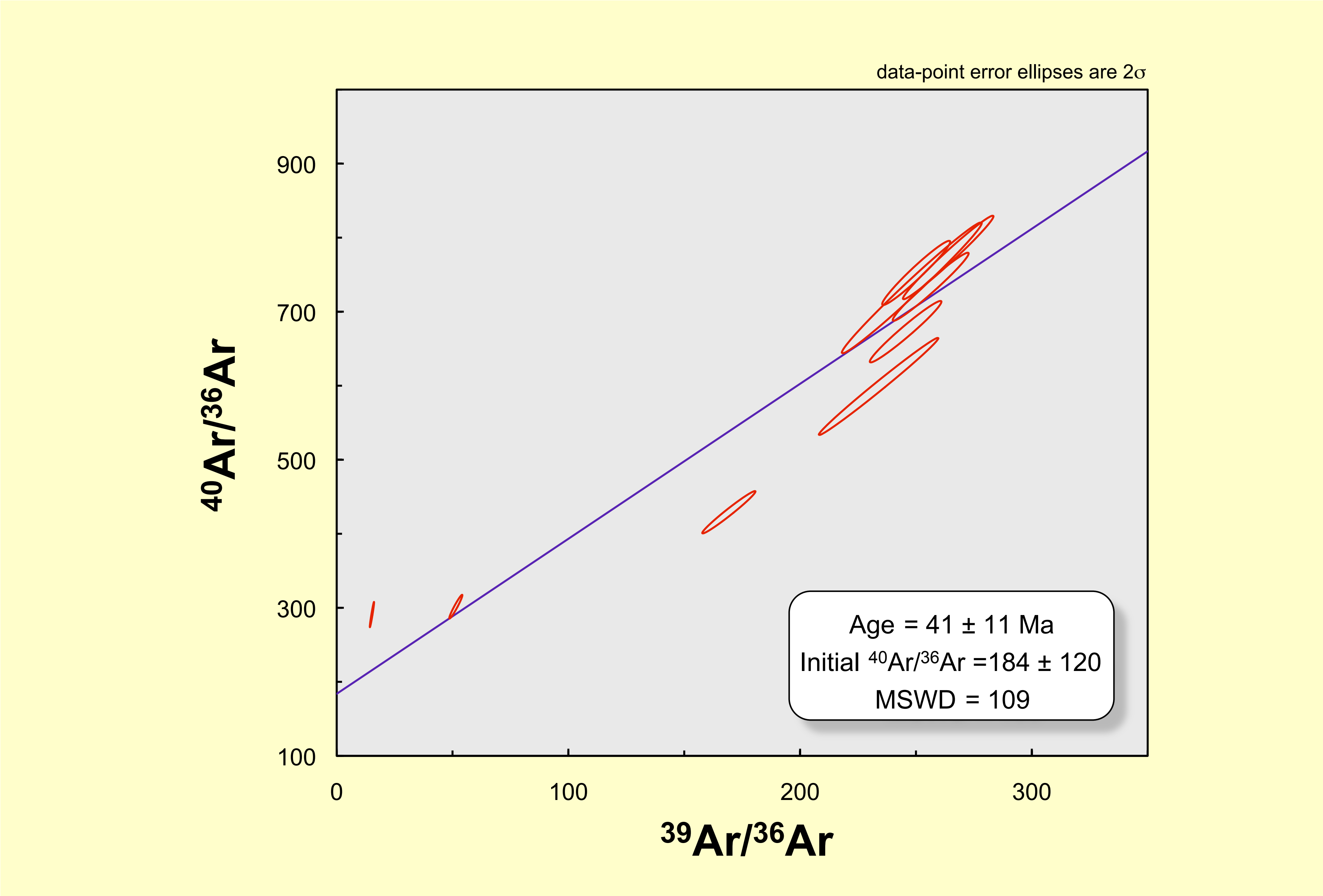
40/36 intercept: 230 ± 63 MSWD = 61, Probability = 0 (at J=.0110158±.3% 2s)



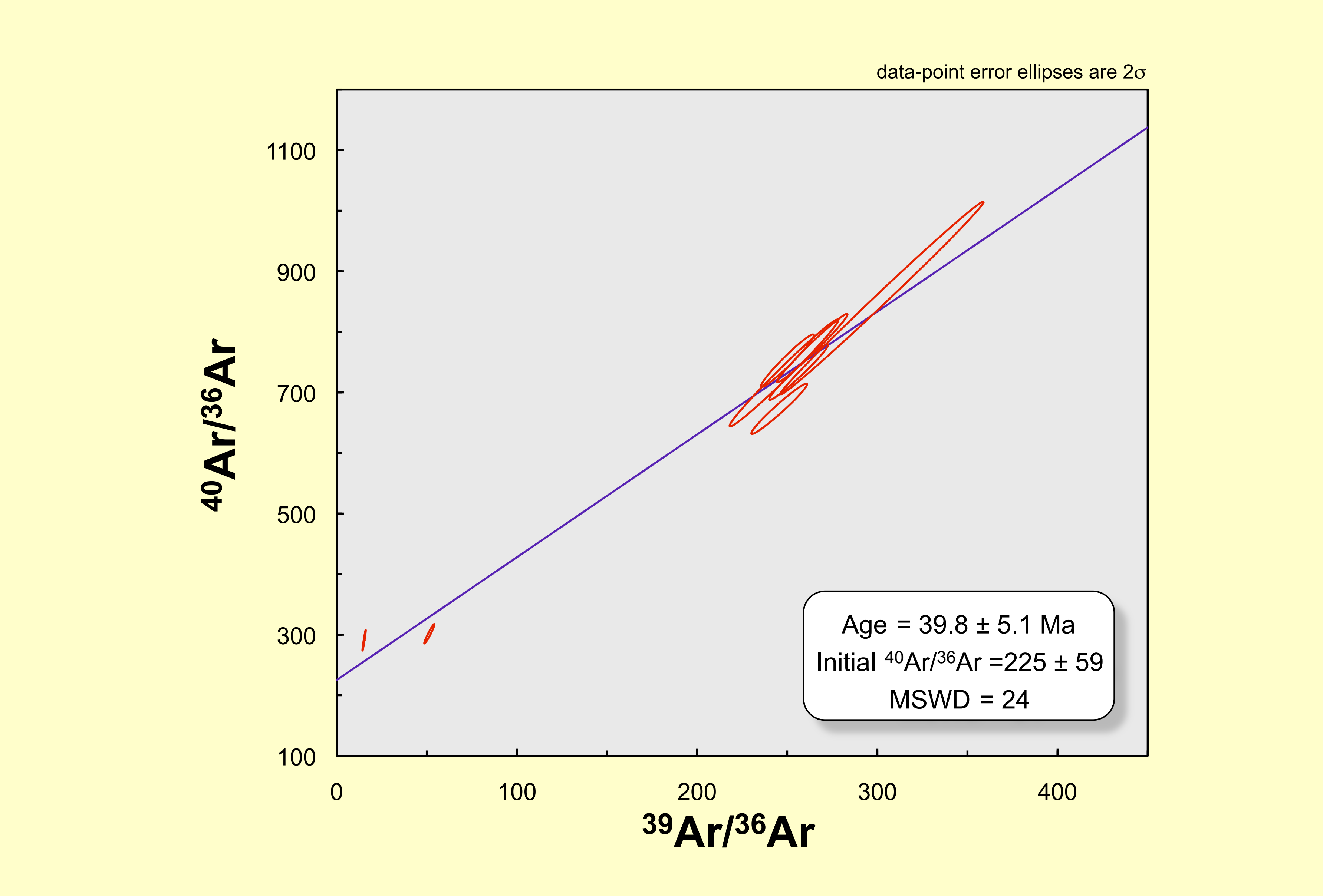
Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
Age (Ma)
60
40
20
0
0
20
40
60
80
100
Cumulative ^{39}Ar Percent
Plateau age = 35.77 ± 0.88 Ma (2σ)
MSWD = 0.5
Includes 52% of the ^{39}Ar



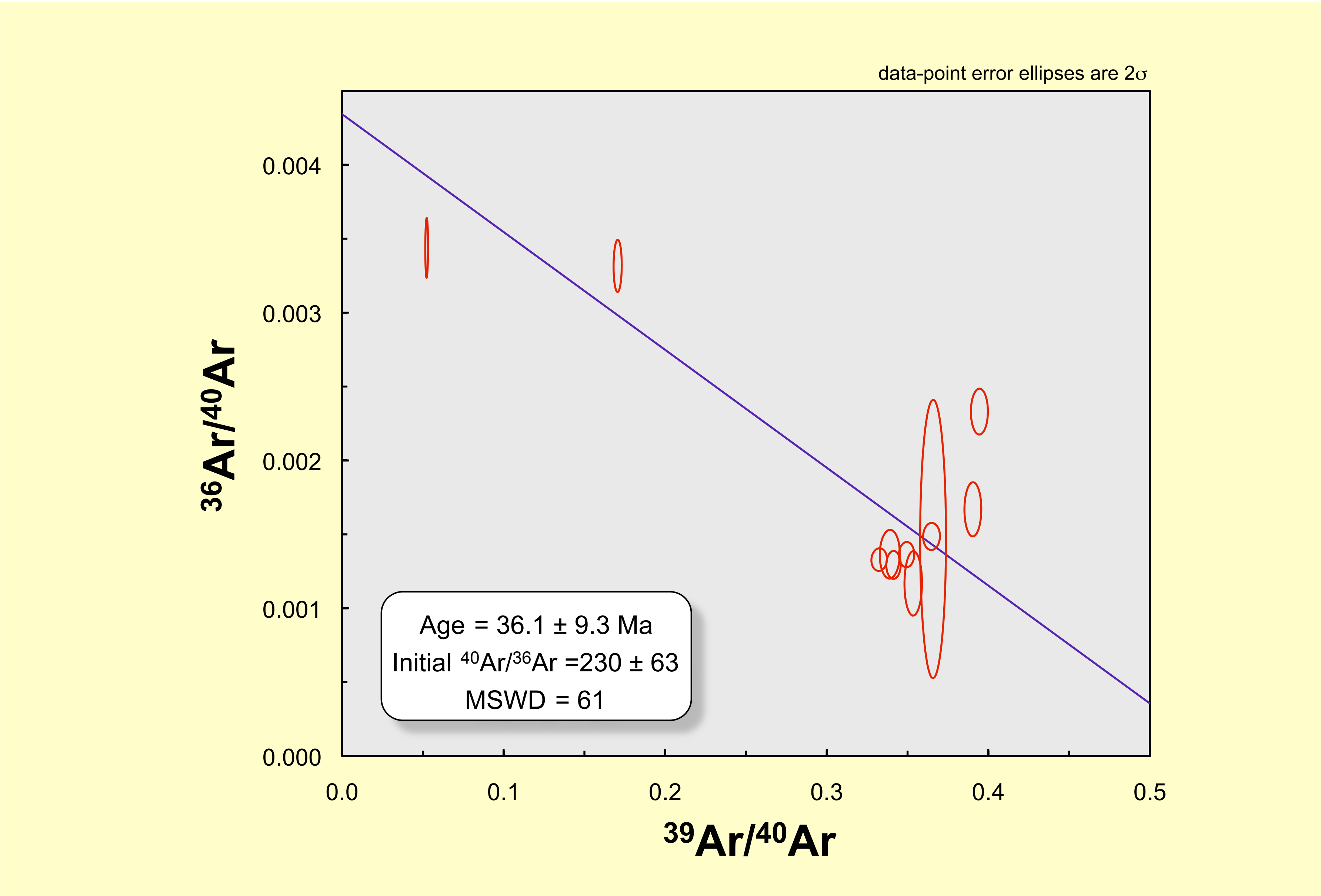
data-point error ellipses are 2σ
1100
900
700
500
300
100
0
100
200
300
400
500
$^{40}Ar/^{36}Ar$
$^{39}Ar/^{36}Ar$
Age = 41.9 ± 9.0 Ma
Initial $^{40}Ar/^{36}Ar$ =177 ± 100
MSWD = 87



data-point error ellipses are 2σ
900
700
500
300
100
0
100
200
300
$^{40}Ar/^{36}Ar$
$^{39}Ar/^{36}Ar$
Age = 41 ± 11 Ma
Initial $^{40}Ar/^{36}Ar$ =184 ± 120
MSWD = 109



data-point error ellipses are 2σ
1100
900
700
500
300
100
0
100
200
300
400
40Ar/36Ar
39Ar/36Ar
Age = 39.8 ± 5.1 Ma
Initial 40Ar/36Ar =225 ± 59
MSWD = 24


data-point error ellipses are 2σ
0.004
0.003
0.002
0.001
0.000
36Ar/40Ar
0.0
0.1
0.2
0.3
0.4
0.5
39Ar/40Ar
Age = 36.1 ± 9.3 Ma
Initial 40Ar/36Ar =230 ± 63
MSWD = 61