

Division of Geological & Geophysical Surveys

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**$^{40}\text{AR}/^{39}\text{AR}$ AGES OF ROCKS COLLECTED IN THE
LIVENGOOD C-3, C-4, AND B-4 QUADRANGLES, ALASKA**

by

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Note: This report (including all analytical data, tables, and figures) is available in digital PDF format from the DGGs web site (<http://www.dggs.dnr.state.ak.us>) at no charge.

$^{40}\text{Ar}/^{39}\text{Ar}$ AGES OF ROCKS COLLECTED IN THE LIVENGOOD C-3, C-4, AND B-4 QUADRANGLES, ALASKA

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INTRODUCTION

Mineral resource personnel from the Alaska Division of Geological & Geophysical Surveys (DGGs) carried out a geological field survey, including mapping and sampling in the Livengood quadrangle, Alaska from May 28-June 16, 2003. The fieldwork provides basic information critical to building an understanding of Alaska's geology and is funded by the Alaska Airborne Geophysical/Geological Mineral Inventory Program, an integrated program of airborne geophysical surveys followed by geological mapping programs, and the U.S. Geological Survey STATEMAP program (project number 03HQPA0003). The age data in this report will be interpreted in the Livengood bedrock geologic map planned for publication in 2004 (Athey and others, in prep.).

During the DGGs Livengood 2003 project, four rock samples were collected for age dating by the $^{40}\text{Ar}/^{39}\text{Ar}$ method; this report includes age data for three of those samples. This report also contains data for two samples collected during the U.S. Geological Survey Trans-Alaska Crustal Transect (TACT) project in 1987 (Nokleberg, written commun., 1988; Weber and others, 1992), one sample collected during the DGGs Rampart-Manley project 1996-1998 (Reifenstuhl and others, 1998), and one sample collected during the Placer Dome U.S. 1997 Tolovana project (McCoy, written commun., 2003). The two TACT samples were originally analyzed by the K-Ar method in 1988 and then reanalyzed by the $^{40}\text{Ar}/^{39}\text{Ar}$ method in 1998. The locations of these samples are shown in Figure 1. Location data (in Universal Transverse Mercator [UTM] coordinates based on the Clarke 1866 spheroid, NAD27 datum, UTM zone 6 projection), descriptions, and analytical results for each sample are tabulated in Tables 1 and 2.

ANALYTICAL METHODS

All $^{40}\text{Ar}/^{39}\text{Ar}$ analyses were performed by P.W. Layer and J. Drake of the Geochronology Laboratory at the University of Alaska Fairbanks (UAF). $^{40}\text{Ar}/^{39}\text{Ar}$ analyses were performed on single grains or rock chips as noted in Table 1. Mineral separates for $^{40}\text{Ar}/^{39}\text{Ar}$ analyses were prepared at the UAF Geochronology Laboratory. Douglas (1997) recorded analytical techniques specific to the UAF Geochronology Laboratory.

$^{40}\text{Ar}/^{39}\text{Ar}$ incremental thermal-release spectra were produced by incrementally heating a sample and measuring the apparent age, as reflected by $^{40}\text{Ar}/^{39}\text{Ar}$ ratios, for each thermal step (Table 2). Each fraction of argon that was released is displayed on the x-axis of the age spectra. The "integrated" age is the age given by the total gas measured and is equivalent to a potassium-argon (K-Ar) age. The spectrum provides a "plateau" age if three or more consecutive gas fractions represent at least 60% of the total gas release and are within two standard deviations of each other. The plateau age represents an approximation to the true original cooling age. Plateau ages were calculated as described in McDougall and Harrison (1988). If a plateau is not present then the argon spectrum is very irregular and the integrated age has little geologic significance.

If the integrated age is > 5 Ma younger than the plateau age, the analyzed mineral has been significantly reheated, and the plateau age is only a minimum age. If a sample has experienced a partial thermal reset and (or) has cooled very slowly, argon is lost from the margins of the sample mineral. This argon loss is reflected in lower apparent-ages for the lower-temperature fraction. In this case, the lowest temperature fraction, sometimes expressed as a plateau as defined above, shows the approximate age of reheating (reset age).

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Figure 1. Location map of Livengood $^{40}\text{Ar}/^{39}\text{Ar}$ samples. Map is projected in UTM coordinates based on the Clarke 1866 spheroid, NAD27 datum, UTM zone 6. Base map from 1:250,000 Livengood Quadrangle, U.S. Geological Survey digital raster graphic image, 1997.

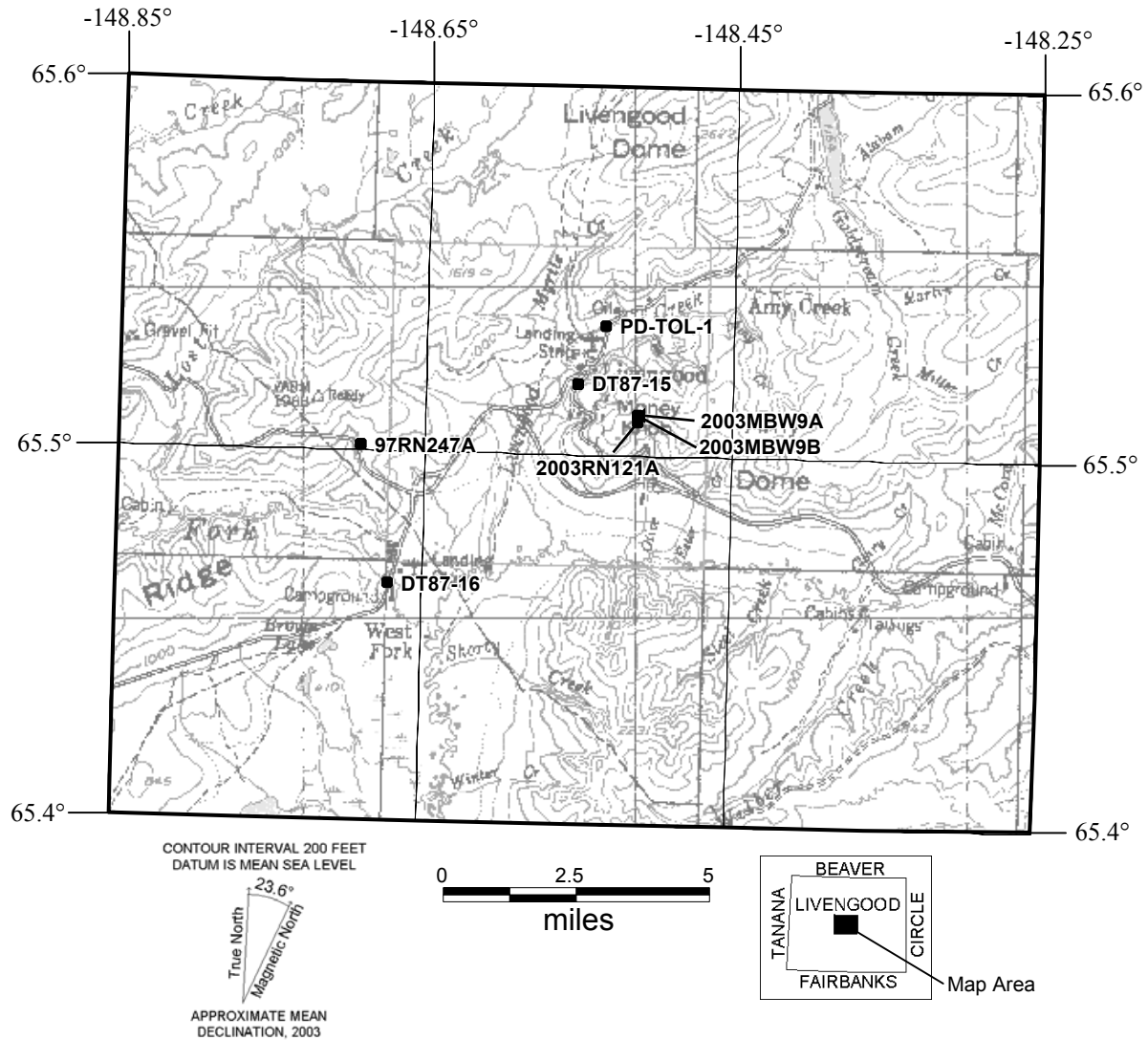
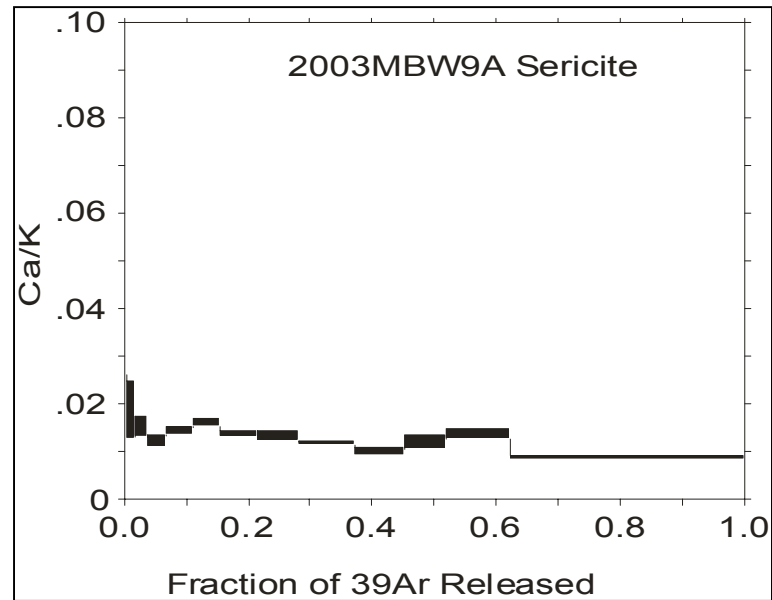
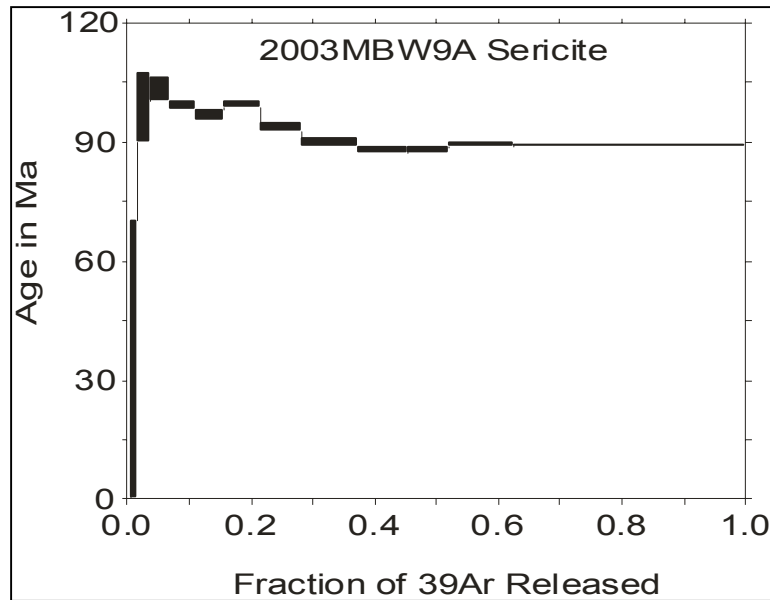


Table 1. Description, location, and summary data table of Livengood $^{40}\text{Ar}/^{39}\text{Ar}$ samples. Location data are projected in UTM coordinates based on Clarke 1866 spheroid, NAD27 datum, UTM zone 6. The MSWD or Mean Square Weighted Deviates is a statistical "goodness-of-fit" indicator where the higher the MSWD value, the poorer the line fits the data. Commonly accepted MSWD values are less than 2.5. All samples were run with standard MMhb-1 with an age of 513.9 Ma (Lanphere and Dalrymple, 2000). Sample reference: (1) Athey and others, in prep.; (2) Reifenhuhl and others, 1998; (3) McCoy, written commun., 2003; (4) Nokleberg, written commun., 1988; Weber and others, 1992. Note: '---' = not applicable.

<u>Sample</u>	<u>Analysis</u>	<u>Easting (m)</u>	<u>Northing (m)</u>	<u>Rock description</u>	<u>Material</u>	<u>Integrated Age (Ma)</u>	<u>Plateau Age (Ma)</u>	<u>Plateau information</u>	<u>Reset Age 1 (Ma)</u>	<u>Reset Age 2 (Ma)</u>	<u>Sample Reference</u>	<u>Comments</u>
2003MBW9A	1	430052	7266066	Strongly sericite-altered intrusive rock with arsenopyrite disseminated and in veins.	Sericite	90.2 ± 0.8	88.9 ± 0.3	5 fractions 72% of ^{39}Ar released MSWD = 1.0	---	---	1	Analyzed very fine grained sericite-rich rock chip.
2003MBW9B	1	430052	7266066	Light to medium gray quartz monzonite* dike; porphyritic feldspar (up to 1.5 cm) and biotite; texture and biotite preservation varies.	Biotite	91.9 ± 0.4	91.7 ± 0.4	10 fractions 93% of ^{39}Ar released MSWD = 1.1	---	---	1	---
2003RN121A	1	430070	7265879	Equigranular quartz syenite* dike (3 m wide) with ~25% biotite, ~75% feldspar, and no visible quartz; one piece with K-feldspar up to 1 cm.	Biotite	93.1 ± 0.5	93.2 ± 0.4	12 fractions 98% of ^{39}Ar released MSWD = 0.3	---	---	1	---
97RN247A	1	421700	7265200	Amy Creek basalt from Elliott Hwy.	Whole rock	199.1 ± 0.9	---	---	~200	~100	2	---
97RN247A	2	421700	7265200	Amy Creek basalt from Elliott Hwy.	Whole rock	192.2 ± 1.0	---	---	---	---	2	---
PD-TOL-1	1	429024	7268666	Amy Creek basalt from bedrock outcrop in placer pit.	Whole rock	235.5 ± 1.0	---	---	~250	---	3	---
DT87-15	1	428281	7267040	Hornblende gabbro.	Hornblende	537.3 ± 2.9	535.3 ± 2.7	9 fractions 92% of ^{39}Ar released MSWD = 1.09	---	---	4	---
DT87-16	1	422519	7261024	Hornblende gabbro.	Hornblende	390.0 ± 1.8	---	---	~250	---	4	Spectrum shows younger age due to alteration, see Ca/K ratios.

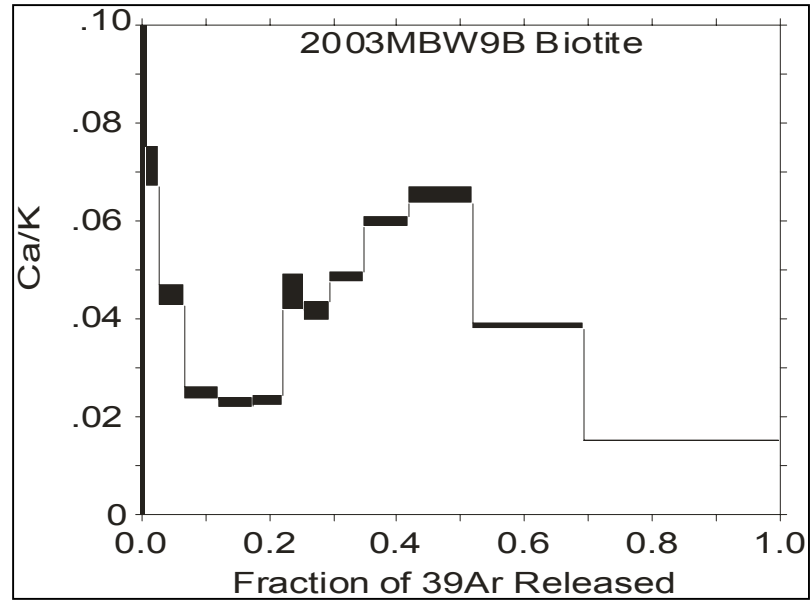
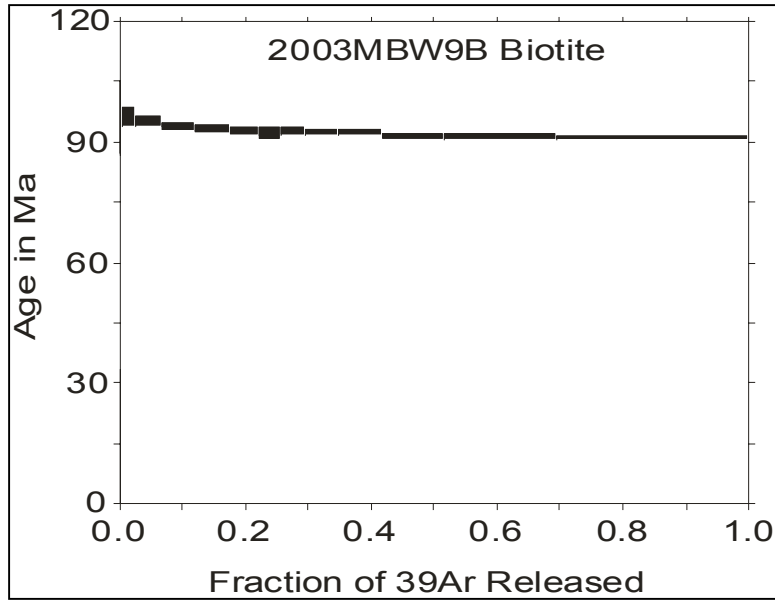
* Rock name based on CIPW normative compositions calculated from X-ray fluorescence spectrometry major-oxide data (Athey and others, 2004).

Table 2. $^{40}\text{Ar}/^{39}\text{Ar}$ sample spectra and step-heating data.
 (A) Sample 2003MBW9A. Plateau age of 88.9 ± 0.3 Ma.



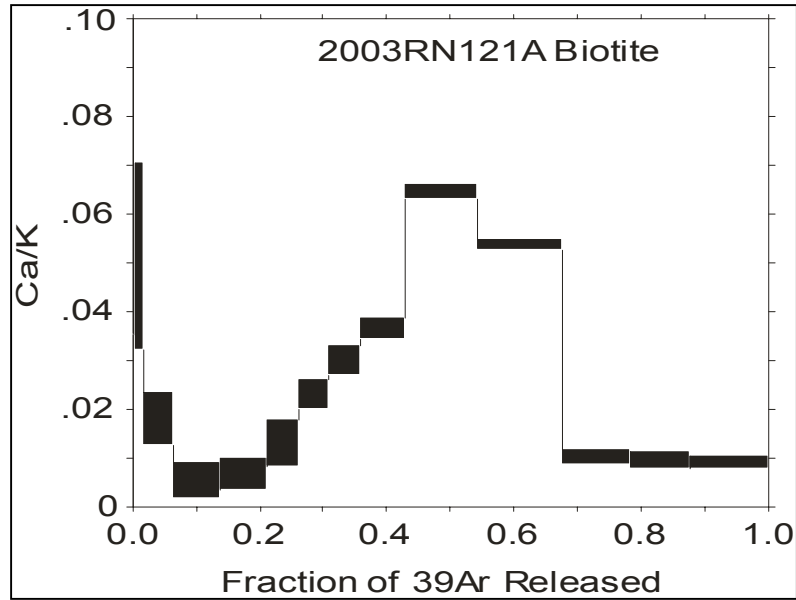
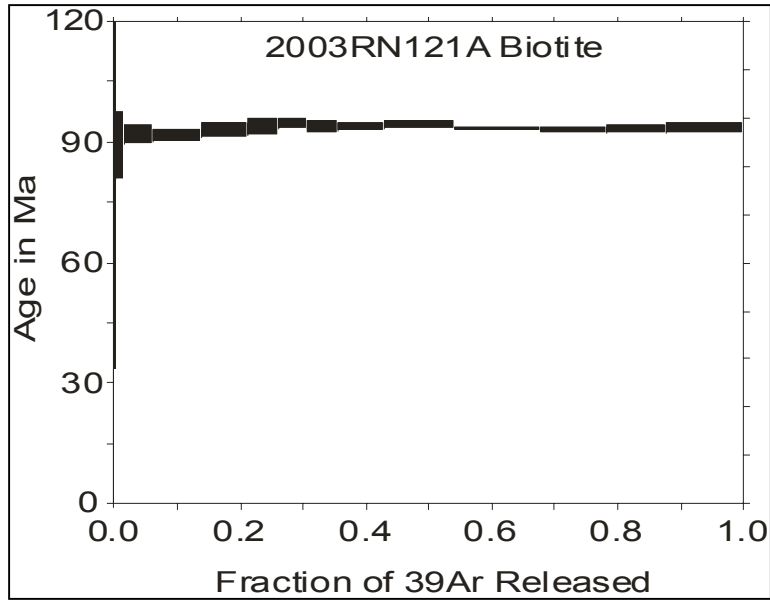
2003MBW9A Sericite														Weighted average of J from standards = 0.002512 +/- 0.000006			
Laser Power (mW)	Cumulative ^{39}Ar	$^{40}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$ measured	+/-	% Atm. ^{40}Ar	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_k$	+/-	Age (Ma)	+/- (Ma)	
250	0.0003	1612.681	92.941	-0.0766	0.0796	5.2737	0.3090	96.6	-0.1405	0.1461	-0.00115	0.01402	54.28	22.34	230.6	89.1	
500	0.0059	499.678	27.666	0.0185	0.0041	1.7029	0.0121	100.7	0.0339	0.0076	0.00274	0.00094	-3.55	27.54	-16.2	125.9	
750	0.0168	265.621	8.196	0.0103	0.0034	0.8731	0.0055	97.1	0.0188	0.0063	0.00113	0.00047	7.60	8.13	34.1	36.2	
1000	0.0366	112.882	2.066	0.0083	0.0013	0.3063	0.0017	80.2	0.0153	0.0023	0.00091	0.00021	22.35	2.05	98.6	8.8	
1250	0.0694	53.415	0.688	0.0068	0.0007	0.1011	0.0006	56.0	0.0125	0.0013	0.00059	0.00013	23.50	0.70	103.5	3.0	
1500	0.1105	35.801	0.311	0.0079	0.0005	0.0450	0.0003	37.1	0.0145	0.0009	0.00050	0.00009	22.49	0.31	99.1	1.4	
1750	0.1550	30.741	0.339	0.0089	0.0005	0.0298	0.0003	28.7	0.0163	0.0009	0.00043	0.00008	21.91	0.35	96.7	1.5	
2000	0.2163	25.925	0.172	0.0076	0.0004	0.0113	0.0003	12.9	0.0140	0.0007	0.00042	0.00010	22.56	0.19	99.4	0.8	
2500	0.2811	22.253	0.228	0.0072	0.0006	0.0034	0.0003	4.5	0.0133	0.0010	0.00038	0.00007	21.22	0.25	93.7	1.1	
3000	0.3733	20.806	0.274	0.0064	0.0002	0.0015	0.0001	2.1	0.0117	0.0004	0.00038	0.00005	20.35	0.28	89.9	1.2	
3500	0.4518	20.156	0.182	0.0055	0.0005	0.0007	0.0002	1.1	0.0102	0.0010	0.00037	0.00007	19.91	0.19	88.1	0.8	
4000	0.5198	20.350	0.130	0.0066	0.0008	0.0016	0.0005	2.4	0.0122	0.0014	0.00059	0.00011	19.84	0.20	87.8	0.9	
5000	0.6238	20.803	0.092	0.0075	0.0005	0.0021	0.0004	2.9	0.0137	0.0010	0.00050	0.00007	20.17	0.14	89.2	0.6	
9000	1.0000	20.759	0.056	0.0049	0.0002	0.0020	0.0001	2.8	0.0090	0.0004	0.00052	0.00004	20.14	0.06	89.0	0.3	
Integrated		30.841	0.190	0.0063	0.0001	0.0352	0.0001	33.8	0.0116	0.0003	0.00051	0.00002	20.41	0.19	90.2	0.9	

Table 2 continued. $^{40}\text{Ar}/^{39}\text{Ar}$ sample spectra and step-heating data.
 (B) Sample 2003MBW9B. Plateau age of 91.7 ± 0.4 Ma.



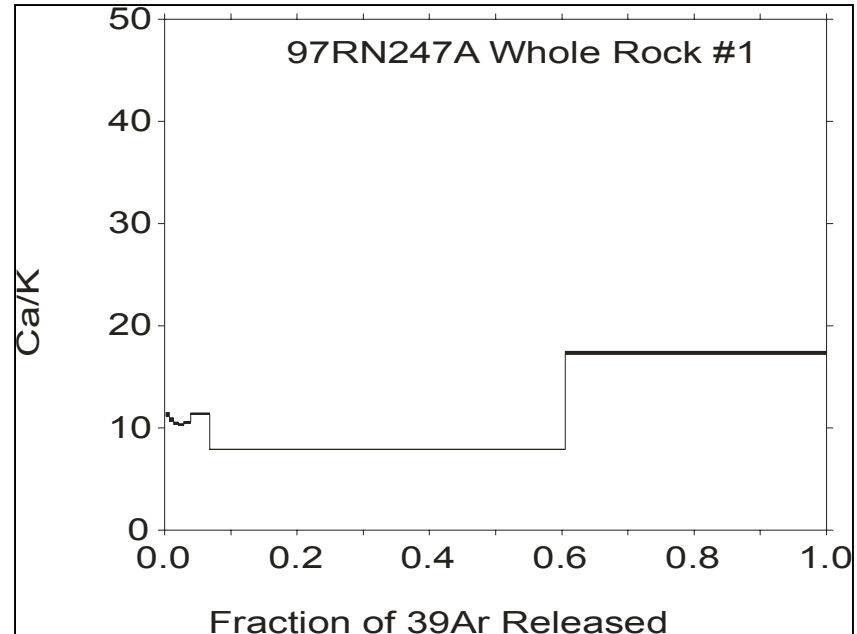
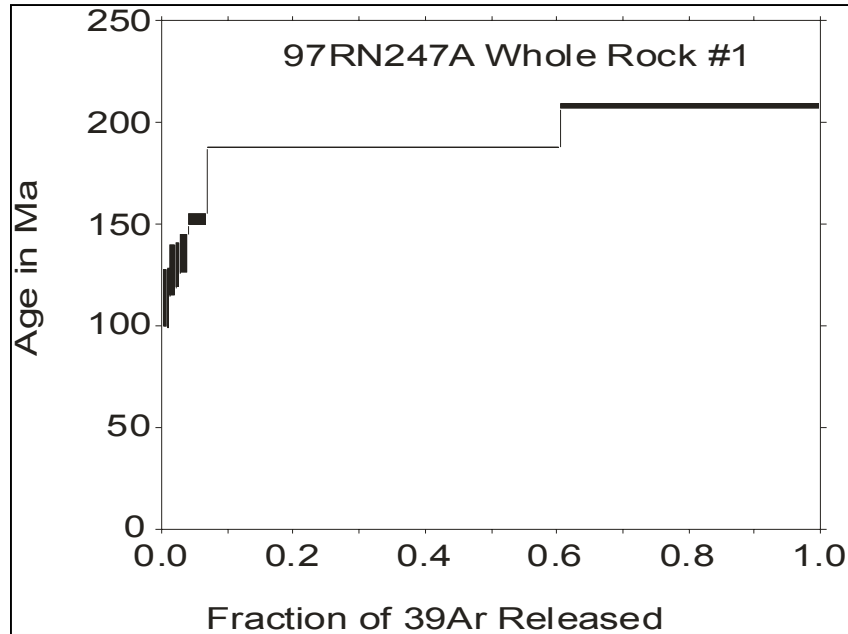
2003MBW9B Biotite													Weighted average of J from standards = 0.002512 ± 0.000006			
Laser Power (mW)	Cumulative ^{39}Ar	$^{40}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$ measured	+/-	% Atm. ^{40}Ar	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_k$	+/-	Age (Ma)	+/- (Ma)
250	0.0011	153.764	5.165	0.7959	0.0463	0.4595	0.0390	88.3	1.4612	0.0851	0.00619	0.00600	18.02	10.72	79.9	46.5
500	0.0055	40.167	0.641	0.0776	0.0093	0.0622	0.0072	45.7	0.1424	0.0171	0.00594	0.00153	21.78	2.16	96.1	9.3
750	0.0259	23.592	0.234	0.0388	0.0022	0.0060	0.0017	7.5	0.0712	0.0041	0.00691	0.00039	21.79	0.56	96.1	2.4
1000	0.0676	22.055	0.195	0.0244	0.0011	0.0017	0.0009	2.3	0.0448	0.0020	0.00702	0.00024	21.52	0.33	95.0	1.4
1250	0.1198	21.637	0.201	0.0136	0.0007	0.0014	0.0007	2.0	0.0250	0.0013	0.00677	0.00018	21.18	0.28	93.5	1.2
1500	0.1758	21.290	0.170	0.0124	0.0007	0.0007	0.0006	1.0	0.0228	0.0012	0.00659	0.00018	21.06	0.24	93.0	1.0
1750	0.2212	21.155	0.189	0.0127	0.0006	0.0005	0.0004	0.7	0.0233	0.0012	0.00657	0.00017	20.97	0.22	92.6	0.9
2000	0.2553	21.272	0.223	0.0247	0.0020	0.0015	0.0010	2.1	0.0453	0.0037	0.00681	0.00023	20.81	0.36	91.9	1.6
2500	0.2957	21.441	0.226	0.0226	0.0011	0.0014	0.0003	2.0	0.0415	0.0020	0.00693	0.00018	20.99	0.24	92.7	1.1
3000	0.3477	21.287	0.180	0.0264	0.0006	0.0012	0.0003	1.7	0.0485	0.0012	0.00716	0.00015	20.90	0.20	92.3	0.9
3500	0.4195	21.166	0.145	0.0326	0.0006	0.0007	0.0003	1.0	0.0599	0.0010	0.00720	0.00012	20.93	0.16	92.4	0.7
4000	0.5176	21.140	0.144	0.0355	0.0011	0.0015	0.0005	2.1	0.0652	0.0019	0.00735	0.00017	20.67	0.20	91.3	0.9
5000	0.6940	20.900	0.210	0.0210	0.0003	0.0009	0.0001	1.2	0.0385	0.0006	0.00687	0.00008	20.61	0.21	91.1	0.9
9000	1.0000	20.905	0.136	0.0083	0.0002	0.0010	0.0001	1.3	0.0151	0.0003	0.00602	0.00005	20.60	0.14	91.0	0.6
Integrated		21.405	0.064	0.0202	0.0002	0.0019	0.0001	2.7	0.0371	0.0004	0.00666	0.00004	20.81	0.07	91.9	0.4

Table 2 continued. $^{40}\text{Ar}/^{39}\text{Ar}$ sample spectra and step-heating data.
 (C) Sample 2003RN121A. Plateau age of 93.2 ± 0.4 Ma.



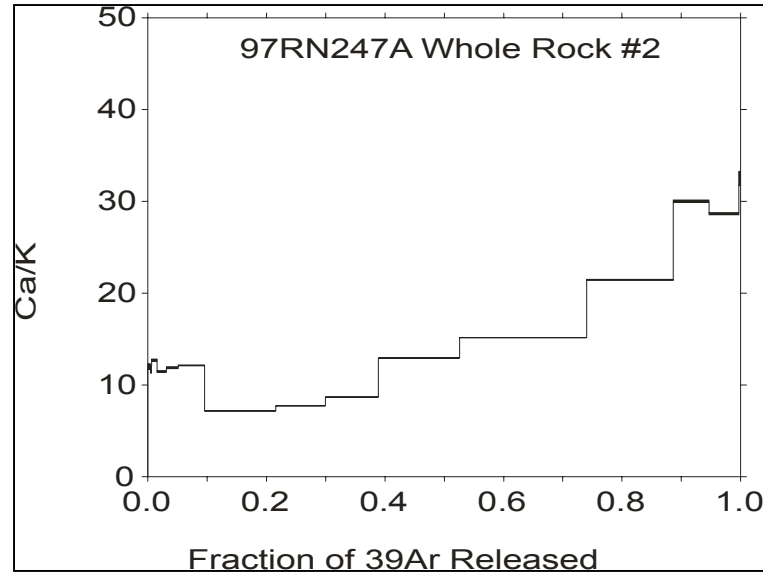
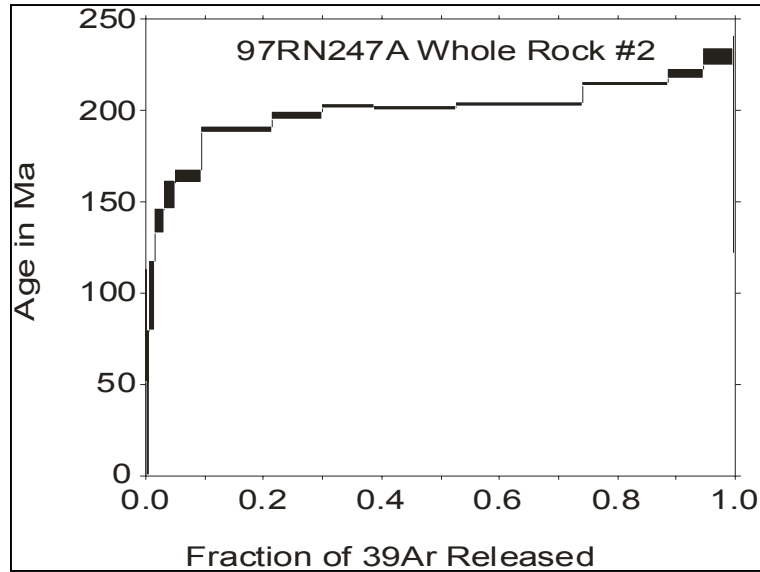
2003RN121A Biotite												Weighted average of J from standards = 0.002512 ± 0.000006				
Laser Power (mW)	Cumulative ^{39}Ar	$^{40}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$ measured	+/-	% Atm. ^{40}Ar	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_k$	+/-	Age (Ma)	+/- (Ma)
250	0.0033	28.999	0.930	0.0634	0.0441	0.0396	0.0252	40.3	0.1163	0.0810	0.00446	0.00462	17.28	7.45	76.7	32.4
500	0.0169	24.387	0.217	0.0281	0.0104	0.0143	0.0068	17.3	0.0515	0.0191	0.00491	0.00092	20.14	2.02	89.0	8.7
750	0.0633	22.200	0.140	0.0099	0.0029	0.0046	0.0019	6.1	0.0181	0.0054	0.00625	0.00031	20.83	0.57	92.0	2.5
1000	0.1385	21.180	0.112	0.0031	0.0020	0.0015	0.0013	2.1	0.0056	0.0037	0.00577	0.00021	20.72	0.39	91.5	1.7
1250	0.2110	21.430	0.125	0.0037	0.0018	0.0012	0.0014	1.6	0.0068	0.0034	0.00535	0.00022	21.05	0.42	93.0	1.8
1500	0.2621	22.037	0.156	0.0071	0.0026	0.0027	0.0017	3.6	0.0130	0.0048	0.00501	0.00027	21.22	0.52	93.7	2.2
1750	0.3075	22.396	0.142	0.0126	0.0016	0.0033	0.0010	4.4	0.0231	0.0030	0.00510	0.00026	21.39	0.34	94.4	1.5
2000	0.3572	22.157	0.054	0.0164	0.0016	0.0030	0.0012	4.0	0.0301	0.0030	0.00515	0.00027	21.24	0.35	93.8	1.5
2500	0.4297	21.858	0.093	0.0199	0.0011	0.0020	0.0007	2.8	0.0365	0.0021	0.00479	0.00016	21.23	0.23	93.7	1.0
3000	0.5426	21.764	0.235	0.0352	0.0008	0.0014	0.0005	1.9	0.0646	0.0015	0.00499	0.00013	21.32	0.27	94.1	1.2
3500	0.6769	21.443	0.153	0.0293	0.0006	0.0011	0.0004	1.5	0.0538	0.0010	0.00500	0.00009	21.09	0.19	93.1	0.8
4000	0.7826	21.294	0.124	0.0056	0.0009	0.0006	0.0005	0.9	0.0103	0.0016	0.00398	0.00011	21.08	0.19	93.1	0.8
5000	0.8789	21.321	0.134	0.0052	0.0009	0.0008	0.0007	1.1	0.0096	0.0016	-0.00656	0.01360	21.05	0.24	93.0	1.0
9000	1.0000	20.964	0.128	0.0051	0.0007	-0.0008	0.0009	-1.1	0.0094	0.0013	0.00087	0.00107	21.16	0.30	93.4	1.3
Integrated		21.612	0.046	0.0144	0.0004	0.0017	0.0003	2.3	0.0264	0.0008	0.00341	0.00132	21.09	0.10	93.1	0.5

Table 2 continued. $^{40}\text{Ar}/^{39}\text{Ar}$ sample spectra and step-heating data.
 (D) Sample 97RN247A(1). Possible reset ages of ~200 Ma and ~100 Ma.



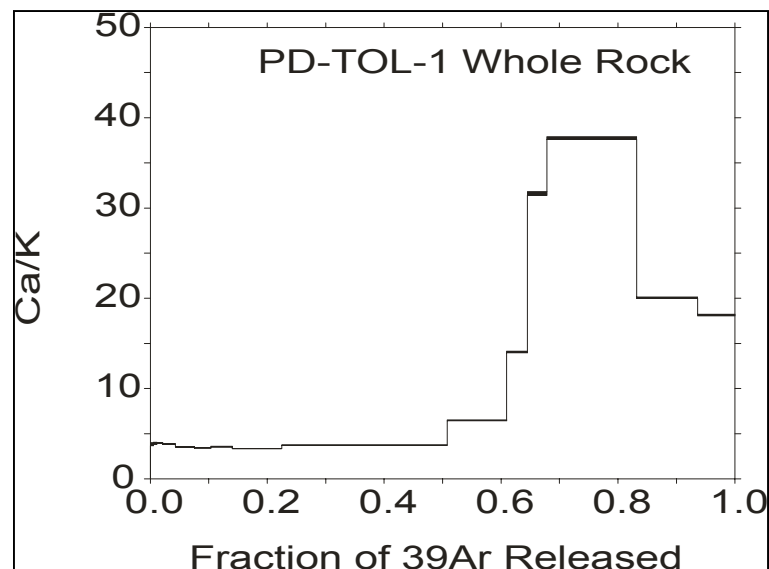
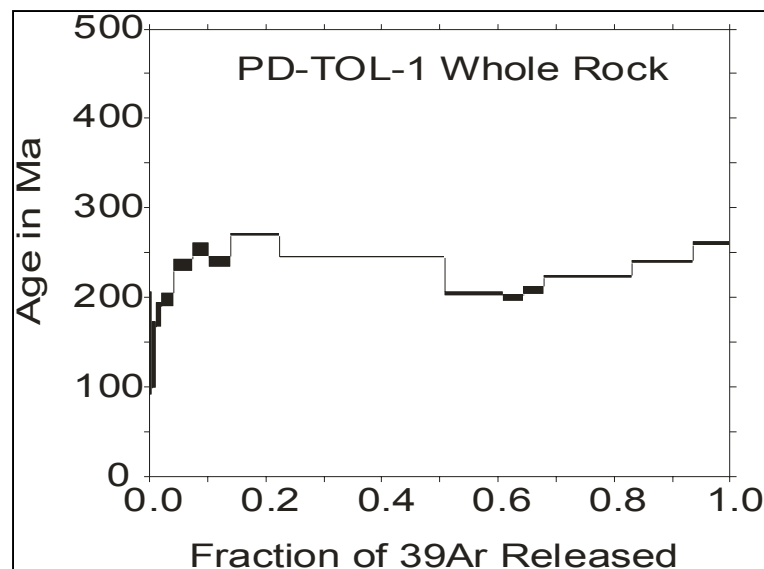
97RN247A Whole Rock #1														Weighted average of J from standards = 0.009104 +/- 0.000030		
Laser Power (mW)	Cumulative ^{39}Ar	$^{40}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$ measured	+/-	% Atm. ^{40}Ar	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age (Ma)	+/- (Ma)
100	0.0010	47.731	1.077	6.7439	0.1778	0.1536	0.0125	94.1	12.4287	0.3292	0.02764	0.00472	2.84	3.58	46.1	57.3
200	0.0028	33.540	0.663	6.1820	0.1223	0.0815	0.0106	70.5	11.3890	0.2263	0.02312	0.00248	9.93	3.12	156.2	47.0
400	0.0077	17.262	0.323	6.1386	0.1136	0.0359	0.0031	59.0	11.3087	0.2101	0.01753	0.00076	7.10	0.91	113.0	14.1
500	0.0135	13.817	0.287	5.8621	0.1110	0.0242	0.0032	48.6	10.7973	0.2052	0.01400	0.00063	7.12	0.99	113.3	15.2
600	0.0205	14.551	0.157	5.6727	0.0723	0.0236	0.0028	45.0	10.4473	0.1336	0.01238	0.00068	8.01	0.83	127.0	12.7
700	0.0290	15.087	0.168	5.5998	0.0642	0.0248	0.0024	45.9	10.3124	0.1187	0.01204	0.00074	8.18	0.72	129.6	11.0
900	0.0395	14.532	0.161	5.7071	0.0627	0.0217	0.0021	41.2	10.5108	0.1159	0.01135	0.00063	8.56	0.63	135.4	9.7
1500	0.0686	15.909	0.108	6.1800	0.0423	0.0227	0.0006	39.3	11.3853	0.0783	0.01157	0.00030	9.68	0.21	152.4	3.1
2500	0.6053	13.167	0.060	4.2821	0.0128	0.0050	0.0001	8.7	7.8790	0.0237	0.00912	0.00005	12.02	0.06	187.4	0.9
8500	1.0000	14.199	0.112	9.3893	0.0763	0.0052	0.0001	5.8	17.3341	0.1417	0.01738	0.00019	13.43	0.11	208.1	1.7
Integrated		13.790	0.055	6.4173	0.0274	0.0066	0.0001	10.6	11.8242	0.0507	0.01264	0.00008	12.35	0.06	192.2	1.0

Table 2 continued. $^{40}\text{Ar}/^{39}\text{Ar}$ sample spectra and step-heating data.
 (E) Sample 97RN247A(2).



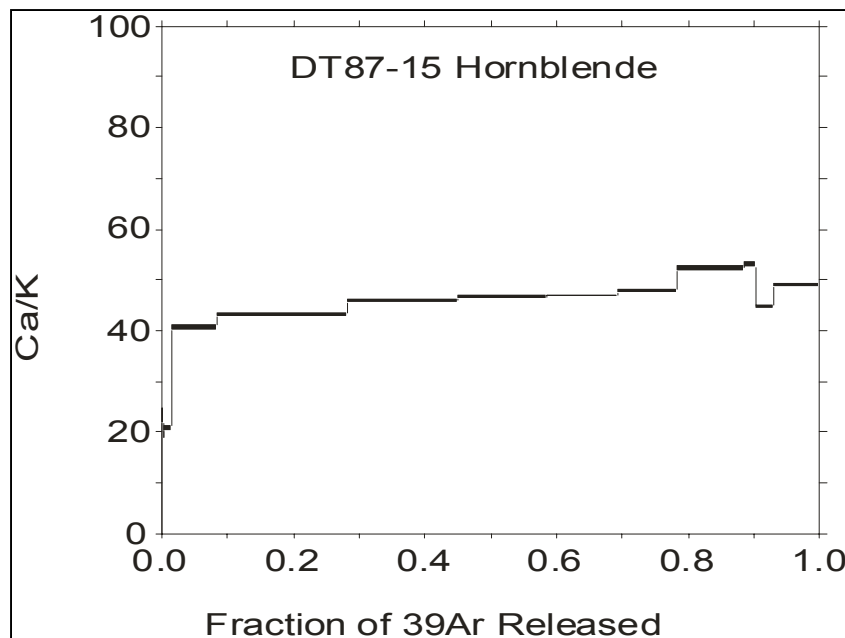
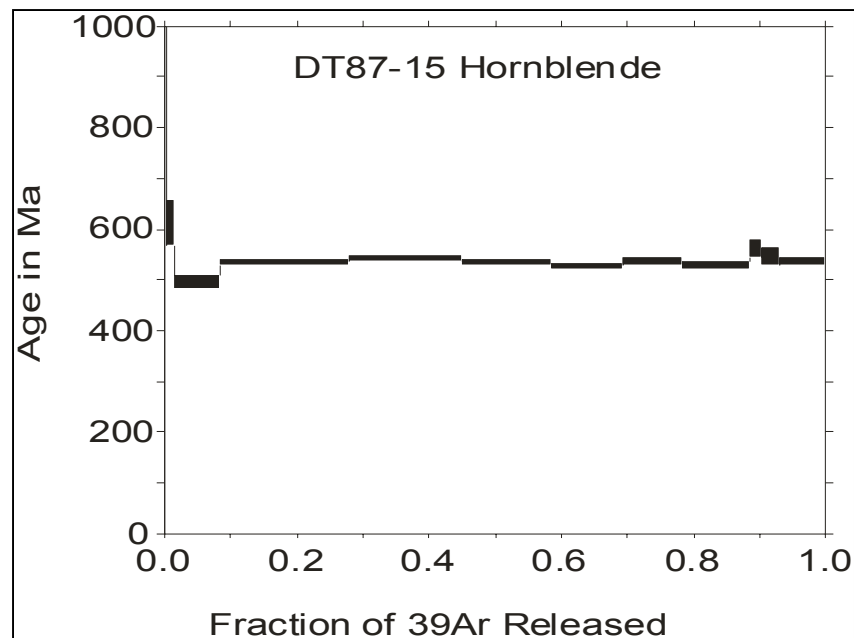
97RN247A Whole Rock #2		Weighted average of J from standards = 0.009104 +/- 0.000030														
Laser Power (mW)	Cumulative ^{39}Ar	$^{40}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$ measured	+/-	% Atm. ^{40}Ar	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_k$	+/-	Age (Ma)	+/- (Ma)
100	0.0037	35.032	0.849	6.5189	0.1770	0.1030	0.0072	85.5	12.0123	0.3275	0.02465	0.00200	5.09	2.01	81.8	31.6
150	0.0059	21.878	0.645	6.3563	0.2098	0.0712	0.0122	94.1	11.7115	0.3881	0.01698	0.00402	1.29	3.58	21.0	58.0
300	0.0157	13.437	0.090	6.8838	0.0799	0.0264	0.0041	54.4	12.6877	0.1479	0.01417	0.00103	6.14	1.22	98.2	19.0
450	0.0311	17.101	0.154	6.2278	0.0646	0.0296	0.0015	48.6	11.4737	0.1195	0.01280	0.00045	8.82	0.46	139.3	7.0
600	0.0510	23.582	0.220	6.4527	0.0610	0.0484	0.0017	58.6	11.8897	0.1128	0.01533	0.00035	9.79	0.51	154.0	7.7
750	0.0954	13.711	0.063	6.5853	0.0324	0.0129	0.0008	24.2	12.1352	0.0599	0.01048	0.00027	10.42	0.24	163.5	3.6
950	0.2158	13.054	0.055	3.9033	0.0132	0.0040	0.0003	6.8	7.1802	0.0243	0.00315	0.00012	12.17	0.09	189.6	1.4
1200	0.2991	13.176	0.046	4.1973	0.0160	0.0028	0.0005	3.9	7.7226	0.0295	0.00538	0.00017	12.67	0.15	197.0	2.2
1500	0.3890	13.411	0.043	4.7343	0.0169	0.0026	0.0002	3.1	8.7136	0.0313	0.01172	0.00017	13.00	0.08	201.8	1.1
2000	0.5258	13.467	0.035	7.0249	0.0198	0.0035	0.0003	3.8	12.9488	0.0367	0.01538	0.00013	12.98	0.08	201.6	1.2
2500	0.7405	13.545	0.050	8.2143	0.0227	0.0038	0.0002	3.8	15.1532	0.0421	0.01524	0.00007	13.08	0.08	203.0	1.2
3000	0.8864	14.305	0.045	11.6081	0.0357	0.0047	0.0003	3.6	21.4614	0.0665	0.01384	0.00008	13.87	0.10	214.5	1.5
3500	0.9471	14.978	0.047	16.1758	0.0703	0.0069	0.0006	5.6	29.9962	0.1317	0.01207	0.00013	14.26	0.19	220.2	2.7
5000	0.9972	15.514	0.058	15.4596	0.0636	0.0064	0.0011	4.7	28.6547	0.1191	0.01246	0.00019	14.91	0.32	229.7	4.7
8500	1.0000	14.854	0.377	17.4966	0.4167	0.0158	0.0135	22.7	32.4738	0.7822	0.01946	0.00200	11.60	4.04	181.1	60.0
Integrated		14.092	0.017	8.1000	0.0098	0.0065	0.0001	9.3	14.9412	0.0182	0.01192	0.00004	12.82	0.04	199.1	0.9

Table 2 continued. $^{40}\text{Ar}/^{39}\text{Ar}$ sample spectra and step-heating data.
 (F) Sample PD-TOL-1. Possible reset age of ~250 Ma.



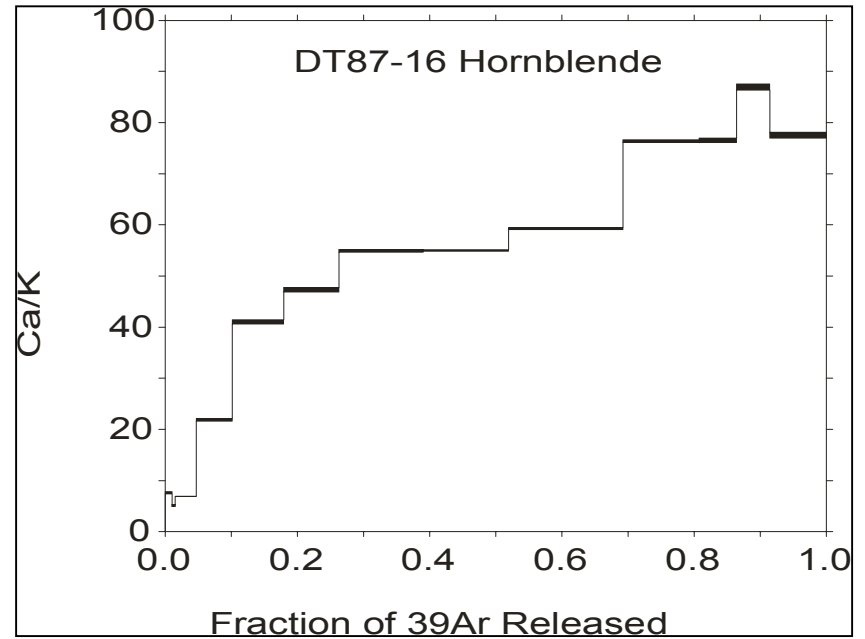
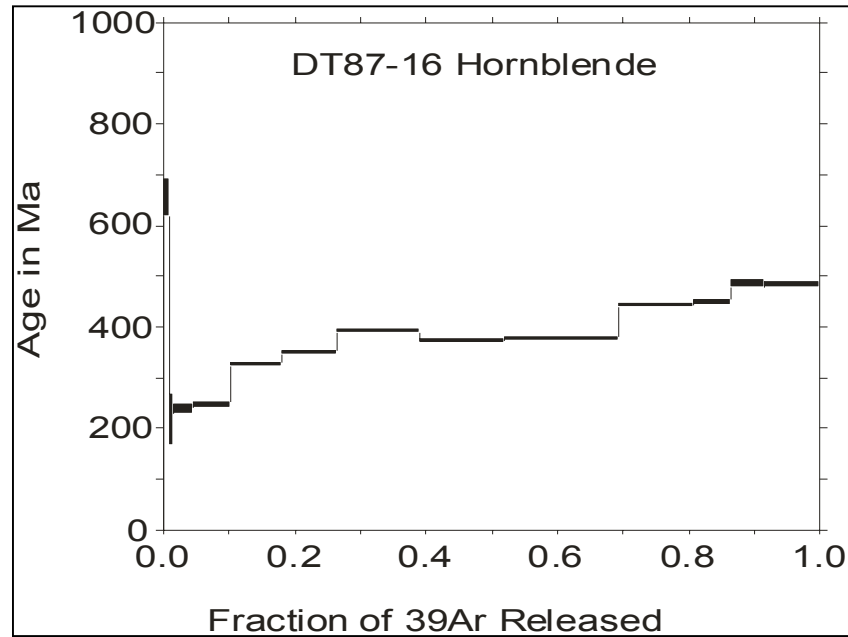
PD-TOL-1 Whole Rock													Weighted average of J from standards = 0.007800 +/- 0.000020			
Laser Power (mW)	Cumulative ^{39}Ar	$^{40}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$ measured	+/-	% Atm. ^{40}Ar	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age (Ma)	+/- (Ma)
150	0.0053	113.436	1.524	2.0791	0.0869	0.3471	0.0156	90.3	3.8201	0.1598	0.05044	0.00196	11.02	4.43	148.8	57.3
200	0.0109	46.659	0.741	2.1404	0.0639	0.1243	0.0097	78.4	3.9328	0.1175	0.02351	0.00192	10.07	2.83	136.4	36.9
300	0.0214	30.038	0.303	2.1592	0.0352	0.0565	0.0036	55.0	3.9674	0.0648	0.01381	0.00129	13.51	1.05	180.7	13.4
450	0.0427	28.487	0.194	2.1004	0.0297	0.0467	0.0020	47.9	3.8593	0.0546	0.01031	0.00046	14.84	0.58	197.7	7.3
600	0.0756	33.474	0.297	1.9165	0.0269	0.0530	0.0019	46.4	3.5210	0.0496	0.00754	0.00053	17.94	0.58	236.2	7.1
750	0.1035	36.400	0.234	1.8681	0.0204	0.0581	0.0021	46.8	3.4318	0.0376	0.00977	0.00049	19.36	0.64	253.7	7.9
900	0.1401	38.083	0.243	1.9365	0.0277	0.0676	0.0017	52.1	3.5576	0.0510	0.01190	0.00040	18.26	0.49	240.2	6.0
1050	0.2250	30.021	0.131	1.8171	0.0086	0.0319	0.0005	31.0	3.3380	0.0159	0.00602	0.00024	20.73	0.17	270.4	2.0
1200	0.5082	21.252	0.039	2.0356	0.0066	0.0093	0.0002	12.2	3.7400	0.0121	0.00224	0.00006	18.65	0.07	245.0	0.8
1350	0.6094	16.492	0.080	3.5160	0.0283	0.0047	0.0005	6.9	6.4662	0.0522	0.00596	0.00015	15.37	0.15	204.3	1.9
1500	0.6452	15.791	0.085	7.6209	0.0531	0.0047	0.0011	5.1	14.0530	0.0983	0.02092	0.00054	15.04	0.33	200.1	4.2
1800	0.6781	17.251	0.086	17.0349	0.1038	0.0100	0.0012	9.7	31.6072	0.1947	0.04679	0.00057	15.72	0.36	208.7	4.6
2500	0.8316	18.799	0.061	20.2976	0.0696	0.0123	0.0003	11.2	37.7419	0.1311	0.03924	0.00015	16.88	0.09	223.2	1.2
3500	0.9360	20.480	0.077	10.8512	0.0335	0.0107	0.0004	11.4	20.0521	0.0624	0.02737	0.00029	18.24	0.13	240.0	1.6
8500	1.0000	22.725	0.057	9.8260	0.0523	0.0124	0.0006	12.9	18.1454	0.0971	0.02843	0.00034	19.90	0.19	260.3	2.4
Integrated		23.130	0.027	7.1051	0.0103	0.0201	0.0002	23.3	13.0974	0.0191	0.01646	0.00007	17.79	0.06	234.5	1.0

Table 2 continued. $^{40}\text{Ar}/^{39}\text{Ar}$ sample spectra and step-heating data.
 (G) Sample DT87-15. Plateau age of 535.3 ± 2.7 Ma.



DT87-15 Hornblende														Weighted average of J from standards = 0.009104 +/- 0.000030		
Laser Power (mW)	Cumulative ^{39}Ar	$^{40}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$ measured	+/-	% Atm. ^{40}Ar	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age (Ma)	+/- (Ma)
100	0.0028	524.907	33.833	12.5682	0.8926	1.2211	0.0983	68.6	23.2512	1.6649	0.63601	0.04273	166.36	20.66	1663.5	134.9
150	0.0041	213.854	21.969	9.1595	1.1300	0.7055	0.1334	97.2	16.9073	2.0984	0.17066	0.02928	6.06	33.34	96.9	518.9
300	0.0151	116.833	2.995	11.3256	0.3018	0.2492	0.0139	62.3	20.9352	0.5619	0.26356	0.00754	44.34	3.96	611.7	46.4
450	0.0852	46.586	0.518	21.8482	0.2940	0.0472	0.0031	26.4	40.6668	0.5551	0.93099	0.00987	34.74	1.02	495.7	12.8
600	0.2807	42.664	0.299	23.1366	0.1770	0.0238	0.0009	12.4	43.1016	0.3347	1.27412	0.00986	37.91	0.38	534.9	4.7
750	0.4490	40.859	0.222	24.5981	0.1260	0.0162	0.0010	7.2	45.8686	0.2387	1.35276	0.00671	38.51	0.37	542.2	4.5
950	0.5848	40.593	0.329	24.9078	0.2123	0.0179	0.0013	8.4	46.4557	0.4026	1.23497	0.00999	37.77	0.49	533.1	6.0
1200	0.6941	40.028	0.216	25.0424	0.1435	0.0180	0.0014	8.6	46.7108	0.2721	1.26309	0.00718	37.17	0.47	525.8	5.7
1500	0.7840	41.316	0.209	25.5997	0.1368	0.0193	0.0020	9.1	47.7679	0.2596	1.23578	0.00598	38.15	0.62	537.7	7.6
2000	0.8860	39.959	0.313	27.9772	0.2247	0.0183	0.0018	8.3	52.2866	0.4278	1.07940	0.00854	37.29	0.62	527.3	7.6
2500	0.9044	44.034	0.479	28.4611	0.3072	0.0229	0.0051	10.5	53.2080	0.5852	1.10795	0.01294	40.12	1.60	561.6	19.2
3500	0.9309	43.185	0.287	23.9951	0.2337	0.0227	0.0048	11.4	44.7263	0.4425	1.25278	0.00948	38.85	1.48	546.3	17.9
8500	1.0000	41.164	0.262	26.2323	0.1654	0.0195	0.0019	9.2	48.9688	0.3142	1.25664	0.00878	37.99	0.62	535.8	7.6
Integrated		43.982	0.109	24.6165	0.0642	0.0281	0.0006	14.7	45.9034	0.1217	1.21430	0.00309	38.11	0.20	537.3	2.9

Table 2 continued. $^{40}\text{Ar}/^{39}\text{Ar}$ sample spectra and step-heating data.
 (H) Sample DT87-16. Possible reset age of ~250 Ma.



DT87-16 Hornblende													Weighted average of J from standards = 0.009104 +/- 0.000030			
Laser Power (mW)	Cumulative ^{39}Ar	$^{40}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$ measured	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$ measured	+/-	% Atm. ^{40}Ar	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age (Ma)	+/- (Ma)
100	0.0099	94.787	2.184	4.1144	0.1162	0.1594	0.0109	49.4	7.5696	0.2143	0.08474	0.00220	48.10	3.33	655.2	38.0
150	0.0149	22.805	0.541	2.7596	0.1062	0.0303	0.0116	38.3	5.0725	0.1956	0.02381	0.00255	14.07	3.44	217.4	50.1
300	0.0469	28.738	0.214	3.7447	0.0368	0.0458	0.0025	46.1	6.8878	0.0678	0.03207	0.00056	15.50	0.76	238.2	11.0
450	0.1013	21.088	0.221	11.8278	0.1393	0.0203	0.0012	24.3	21.8707	0.2596	0.21848	0.00252	16.07	0.40	246.3	5.8
600	0.1792	25.685	0.240	22.0228	0.2165	0.0200	0.0010	16.5	40.9966	0.4088	0.58428	0.00549	21.72	0.37	325.6	5.1
750	0.2629	26.683	0.215	25.3449	0.2212	0.0187	0.0010	13.6	47.2847	0.4197	0.64419	0.00565	23.42	0.35	348.7	4.7
950	0.3901	29.832	0.183	29.3752	0.1419	0.0196	0.0005	12.1	54.9503	0.2705	0.88355	0.00470	26.72	0.24	392.8	3.2
1200	0.5193	28.216	0.108	29.3970	0.0791	0.0194	0.0008	12.5	54.9919	0.1509	0.85472	0.00229	25.14	0.26	371.8	3.4
1500	0.6929	28.088	0.111	31.6448	0.1126	0.0185	0.0005	11.0	59.2853	0.2153	0.87642	0.00361	25.51	0.18	376.7	2.4
2000	0.8076	32.847	0.106	40.5019	0.1351	0.0205	0.0008	9.2	76.3280	0.2615	0.92015	0.00356	30.60	0.27	443.3	3.5
2500	0.8642	32.998	0.151	40.5881	0.2205	0.0197	0.0011	8.4	76.4949	0.4268	0.98025	0.00485	31.01	0.36	448.5	4.6
3500	0.9151	35.665	0.251	45.9663	0.3147	0.0209	0.0020	7.6	86.9435	0.6136	1.04478	0.00750	33.94	0.66	485.8	8.3
8500	1.0000	36.297	0.250	41.1082	0.2928	0.0216	0.0011	9.1	77.5019	0.5673	1.38121	0.00962	33.87	0.42	484.9	5.2
Integrated		30.209	0.055	30.5204	0.0528	0.0220	0.0003	13.9	57.1359	0.1008	0.81972	0.00148	26.51	0.10	390.0	1.8