

Alaska Division of Geological & Geophysical Surveys

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**$^{40}\text{Ar}/^{39}\text{Ar}$ AGES FROM THE SELAWIK A-2, A-3 AND A-4 AND
CANDLE B-5 QUADRANGLES, ALASKA**

by

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

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PAUL W. LAYER¹ AND DIANA N. SOLIE²

INTRODUCTION

In 1991, the Alaska Division of Geological & Geophysical Surveys (DGGs) conducted helicopter-supported field work in west-central Alaska as part a statewide project to review selected areas of federal land that were eligible at the time for selection by Alaska to become state land. DGGs's role in the project was to evaluate mineral resource potential in the eligible units of land by acquiring data to outline permissive mineral terranes and to define mineral deposit types that could occur in each land selection unit (DGGs Staff, 1992). The data in this report resulted from investigations in the Selawik Hills and Granite Mountain areas as part of the land selection project. Geochemical and major oxide data (Solie and others, 1993a) and electron microprobe data (Solie and others, 1993b) were previously published. A brief discussion of our $^{40}\text{Ar}/^{39}\text{Ar}$ results from the Selawik Hills was presented at a Geological Society of America meeting (Solie and Layer, 1993). The purpose of this DGGs Raw Data File (RDF) is to present all our $^{40}\text{Ar}/^{39}\text{Ar}$ results from the Selawik Hills and Granite Mountain and make them available for use.

FIELD AND ANALYTICAL METHODS

All field locations were visually determined by the geologists in the field and recorded on 1:63,360-scale topographic maps. Table 1 presents coordinates digitized from the field maps; sample locations are shown on figures 1 and 2. Latitude and longitude coordinates are based on the NAD 27 Alaska datum and the UTM coordinates are based on the NAD 27 datum, UTM zone 4 projection.

DGGs submitted eight rock samples to the UAF Geochronology Laboratory for $^{40}\text{Ar}/^{39}\text{Ar}$ dating; three were collected from Granite Mountain in the Candle B-5 Quadrangle and five were collected from the Selawik Hills in the Selawik Quadrangle. Major oxide and selected trace element analyses for some of the samples are included in Solie and others (1993a). Separates for $^{40}\text{Ar}/^{39}\text{Ar}$ dating were prepared to >99.5 percent purity (visual inspection) using standard heavy liquid and magnetic separation techniques followed by hand-picking under a binocular microscope. Thin section examination of the samples prior to crushing indicated that the chosen minerals were free from alteration and sufficiently coarse-grained for mechanical separation. For all minerals, grains in the size range of 250–500 microns were used. For each sample, ~50–80 mg of biotite or 250–350 mg of hornblende or 'whole rock' (phenocryst-free groundmass) was packaged in an aluminum foil tube and irradiated in position 5C at the McMaster University nuclear reactor, in Hamilton, Ontario, Canada. Approximately 20 samples were irradiated at a time. Six packages containing ~20 mg of the standard mineral MMhb-1 (Samson and Alexander, 1987) with an age of 513.9 Ma (Lanphere and others, 1990) were also irradiated with the samples to determine the irradiation parameter (J) and the flux gradient in the reactor. Samples and standards were analyzed 45 to 90 days after irradiation.

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The irradiated samples were step-heated on-line in a Modifications Ltd. low-blank furnace. Temperature control was better than 5 degrees and a maximum temperature in excess of 1600°C was achievable to ensure complete sample fusion. The extracted argon was purified in a two-stage process using a liquid nitrogen cold finger and two SAES Zr-Al getters. Prior to measurement of the Ar, the gas was collected on an activated charcoal finger. The purified Ar gas was measured using a Nuclide 6-60-SGA 15 cm mass spectrometer. The sensitivity of the spectrometer is 6.5×10^{-15} mol/mV and system noise is generally around 0.02 mV. System blanks are generally better than 1×10^{-14} mol for ^{40}Ar . Argon isotopic measurements for both samples and standards were corrected for the system blanks, for decay of ^{37}Ar and ^{39}Ar , and for reactor-induced isotopic interferences. Ages were calculated using the equations and corrections from McDougall and Harrison (1999) and the constants from Steiger and Jäger (1977). Age, Ca/K and Cl/K spectra plots are shown in figure 3, and analytical age data are shown in Tables 2 and 3. All errors on analyses are reported at the 1-sigma level.

For each mass spectrometer analysis, five Ar isotope abundances are measured. ^{36}Ar is used to determine the amount of atmospheric or initial Ar in the sample, ^{37}Ar provides an estimation of the Ca content in the mineral, ^{38}Ar provides an estimation of the Cl content, ^{39}Ar reflects the K content and ^{40}Ar is a mixture of initial and radiogenic Ar. The age of the sample is proportional to the ratio of the amount of radiogenic ^{40}Ar to the amount of ^{39}Ar produced by neutron bombardment from ^{40}K .

All samples were dated by the $^{40}\text{Ar}/^{39}\text{Ar}$ step-heating method. In this method, a sample is heated to progressively higher temperatures in a double-vacuum resistance-heated furnace, and the argon isotopes are measured and age determined for each step (fraction). The integrated age is the age given by the total gas measured in all fractions and is equivalent to a potassium-argon (K-Ar) age. The fractions are commonly plotted on an age spectrum plot for analysis. A spectrum provides a plateau age if three or more consecutive gas fractions represent at least 50% of the total gas release and are within two standard deviations of each other (Mean Square Weighted Deviation less than ~2.5). If the fractions do not meet the criteria for a plateau due to intrafraction scatter in ages, then a weighted mean age of 'plateau-like' fractions, with each fraction weighted by the volume of ^{39}Ar released, is calculated.

BRIEF SAMPLE DESCRIPTIONS

Granite Mountain samples:

91SL113: Biotite hornblende quartz monzonite

91GL227: Hornblende granite/quartz monzonite

91DNS63A: Amphibole nepheline-bearing syenite. Light gray, medium- to coarse-grained, slight feldspar alignment, mafic enclaves up to about 8 cm diameter.

Selawik Hills samples:

91DNS45: Amphibole alkali feldspar syenite. Coarse-grained, thin alkali feldspar up to 3 cm long, small alkali feldspars and rims of large alkali feldspars are pink, cores are dark gray. No visible quartz or feldspathoids. Nonfoliated.

91DNS61E: Hunt Creek Complex, north of fault. Amphibole garnet nepheline syenite with purple fluorite. Medium-gray, fine-grained, nonfoliated.

91DNS76: Pyroxene amphibole syenite, very strongly foliated; no visible quartz or feldspathoids.

91DNS89: Fine-grained, quartz-rich biotite granite/quartz monzonite. Variable mafic percentage (<5% to ~15%) creates local banded effect. Biotite slightly chloritic.

91RN229B: Metamorphic rock. Coarse-grained biotite (phlogopite?), amphibole, pyroxene skarn(?) with ~15% carbonate.

DISCUSSION

The $^{40}\text{Ar}/^{39}\text{Ar}$ data show that plutonic rock types in the Selawik Hills plutonic complex were emplaced in the order syenite/monzonite (nonfoliated, 106.6 ± 0.8 Ma; foliated, 101.7 ± 0.7 Ma; both on hornblende), followed by nepheline syenite (103.7 ± 0.8 Ma on hornblende) and then quartz monzonite (100.4 ± 3.7 Ma on biotite). There is no evidence of disturbance of the Ar isotopic system in the dated plutonic minerals, and the ages compare fairly well with previously published K/Ar data (Miller, 1971). A cooling history of about ten m.y. for the Selawik Hills rocks is suggested, based on comparison of $^{40}\text{Ar}/^{39}\text{Ar}$ ages with apatite fission-track data (Murphy and others, 1992). The $^{40}\text{Ar}/^{39}\text{Ar}$ results from the Selawik Hills are further discussed in Solie and Layer (1993).

$^{40}\text{Ar}/^{39}\text{Ar}$ data from Granite Mountain hornblende samples yielded ages slightly older, but overlapping, those from Selawik Hills samples. In this suite, the silica-undersaturated phase (nepheline syenite) appears to be younger (105.7 ± 0.8 Ma on hornblende) than the silica-saturated phase(s) (granite/quartz monzonite) (106.8 ± 0.8 Ma and 107.1 ± 0.8 Ma, both on hornblende).

ACKNOWLEDGMENTS

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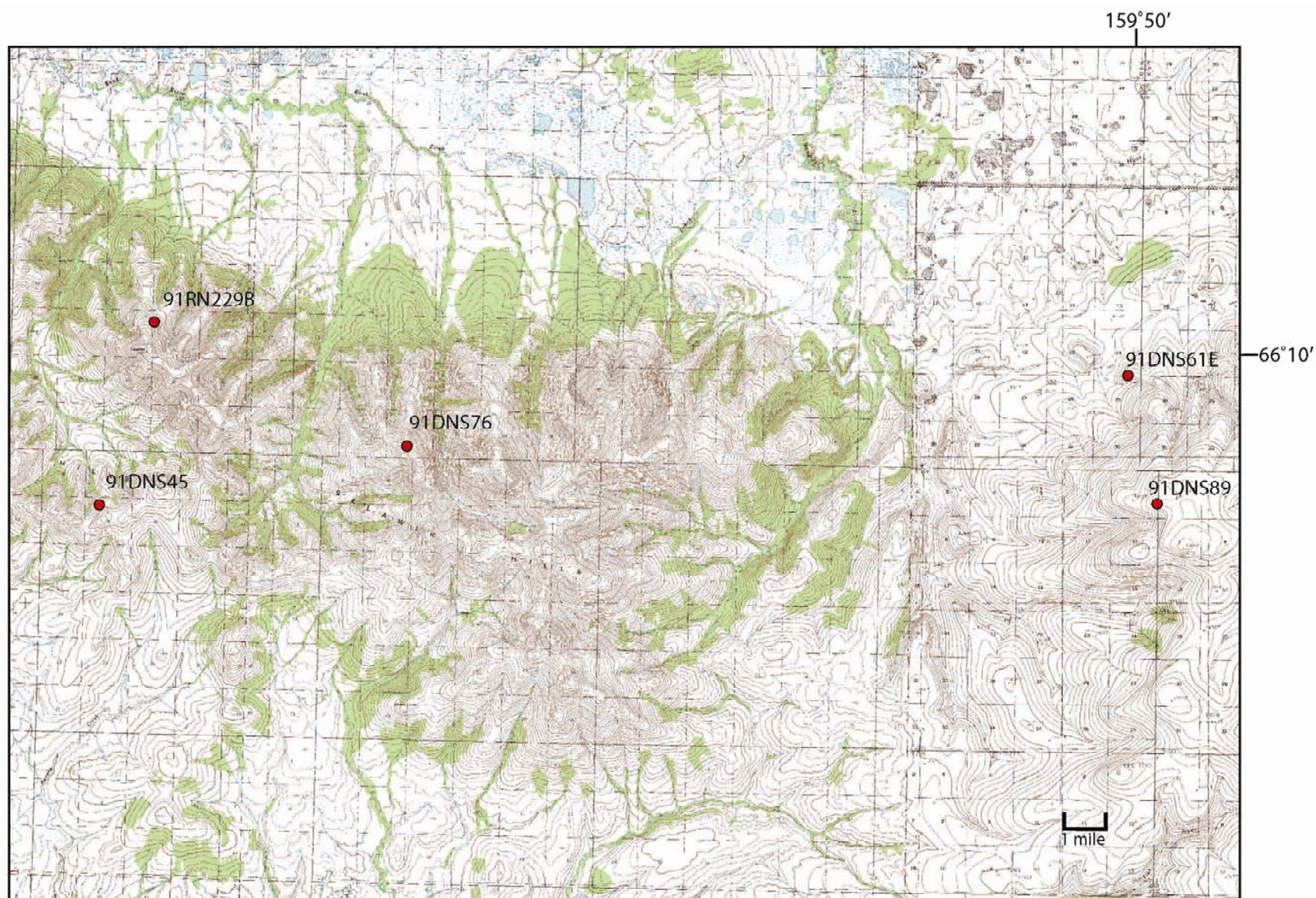


Figure 2. Sample locations in the Selawik Hills area, Selawik A-2, A-3 and A-4 quadrangles.

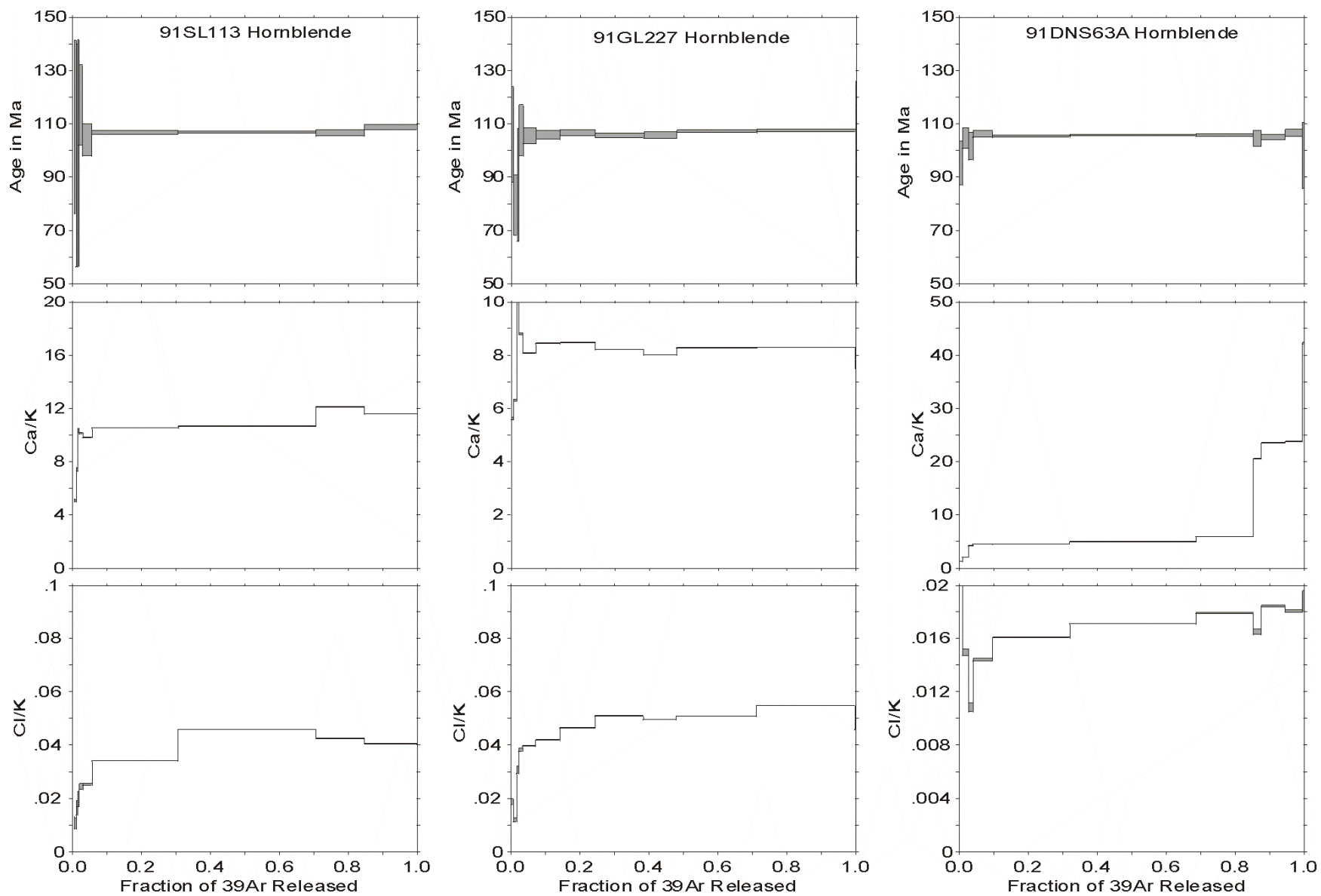


Figure 3. Age, Ca/K and Cl/K spectra plots for Selawik Hills and Granite Mountain samples.

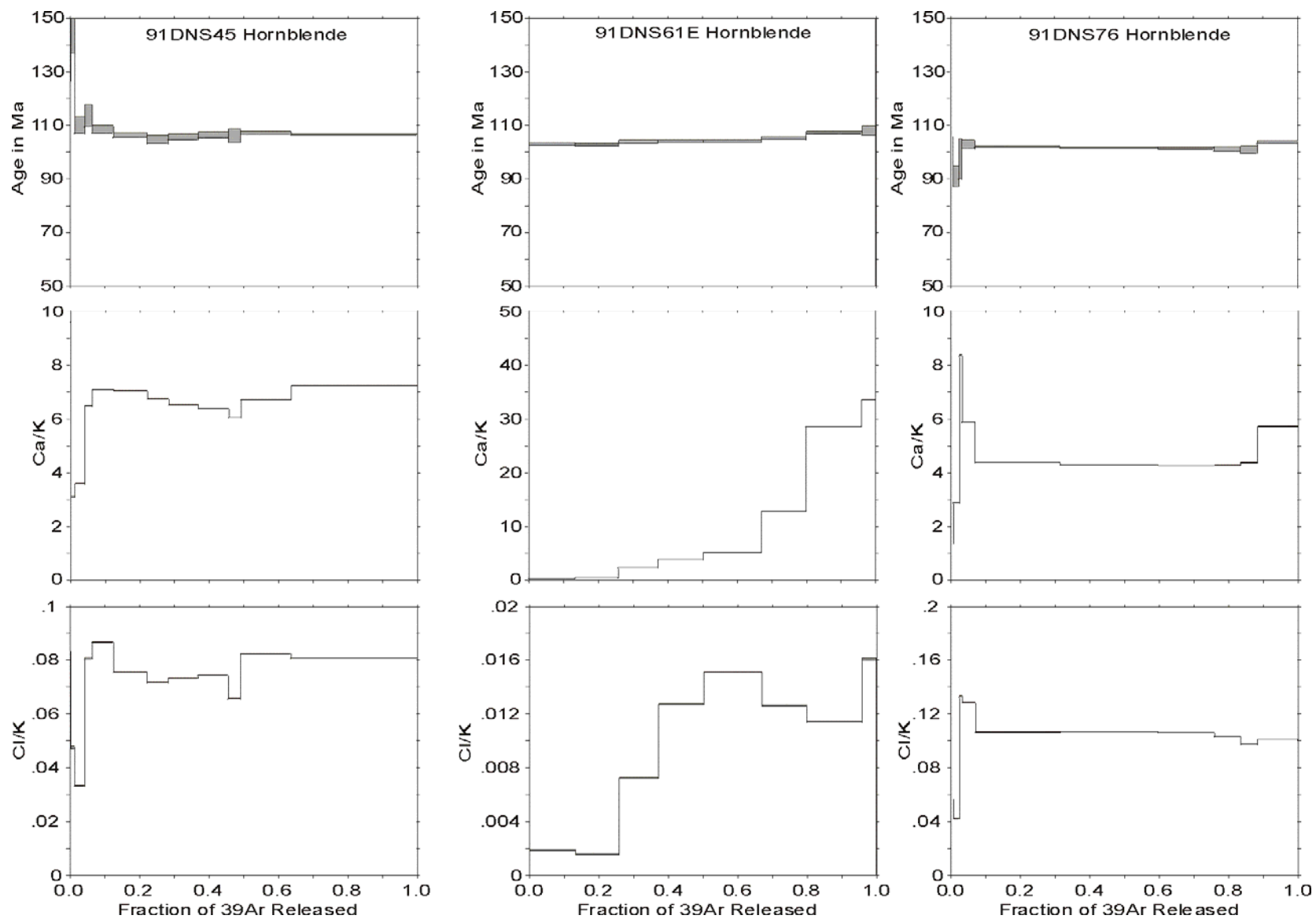


Figure 3 (continued). Age, Ca/K and Cl/K spectra plots for Selawik Hills and Granite Mountain samples.

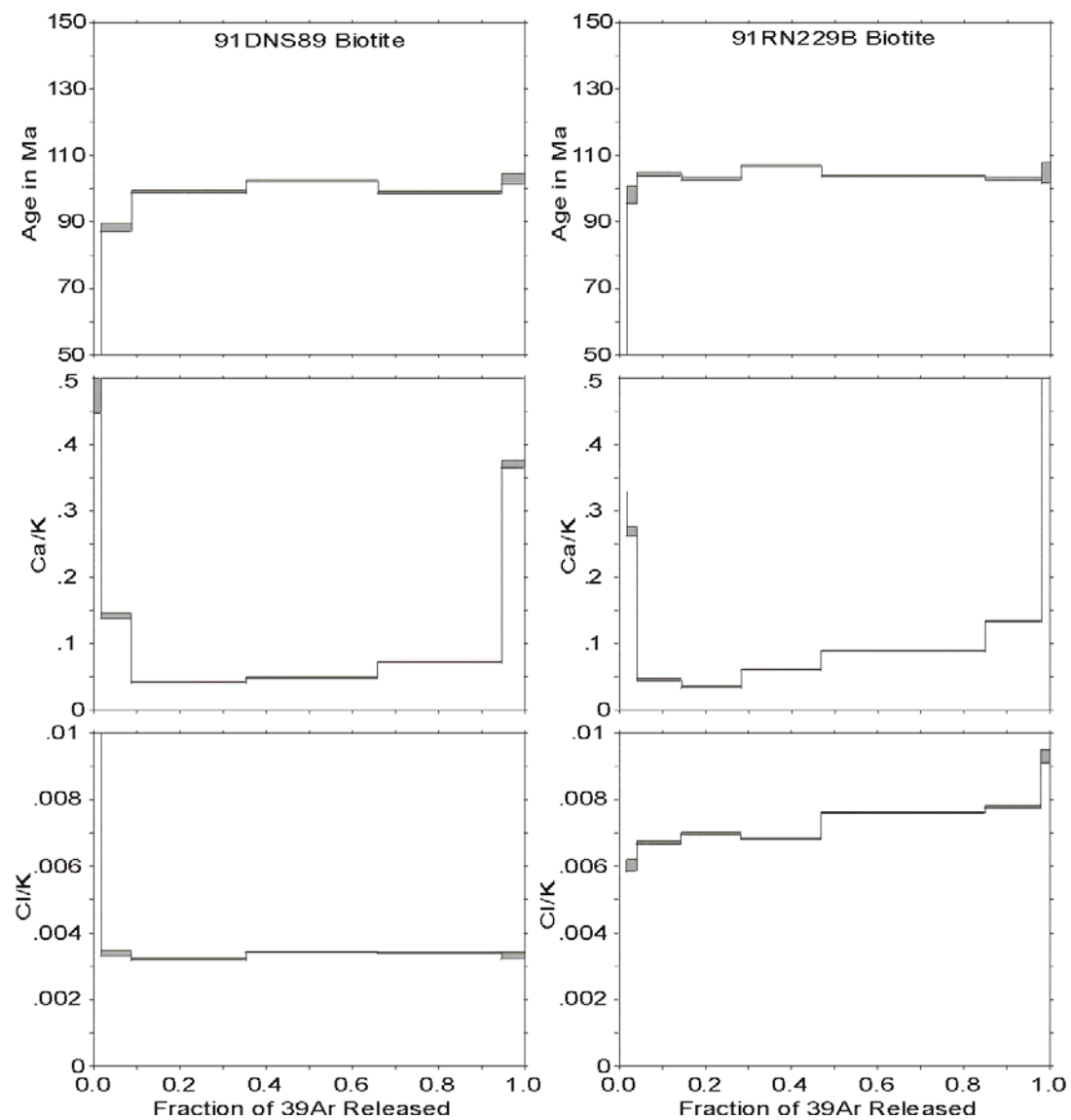


Figure 3 (continued). Age, Ca/K and Cl/K spectra plots for Selawik Hills and Granite Mountain samples.

Table 1. Coordinates for $^{40}\text{Ar}/^{39}\text{Ar}$ samples

SampleNo	Easting	Northing	Latitude	Longitude
91SL113	401129	7256655	65.41920	161.13032
91GL227	400458	7260109	65.44996	161.14730
91DNS63A	394311	7255163	65.40369	161.27593
91DNS45	427131	7333367	66.11402	160.61280
91DNS61E	462233	7337755	66.15953	159.83734
91DNS76	437636	7335341	66.13397	161.38135
91DNS89	463220	7333414	66.12071	159.81421
91RN229B	429023	7339612	66.17045	161.57441

Easting and Northing are Zone 4 UTM coordinates in meters.

Latitude and Longitude are in decimal degrees. Based on NAD27 Alaska datum.

Table 2: Selawik Hills and Granite Mountain $^{40}\text{Ar}/^{39}\text{Ar}$ summary

Sample name	Rock type	Min.	Mass	#	Integrated age (Ma)	K ₂ O [†]	CaO [†]	Plateau age (Ma)	Plateau information	Isochron Age (Ma)
91SL113	Quartz Monzonite	hbd	0.2886	11	107.0 ± 0.9	0.72	9.30	107.1 ± 0.8	97% ^{39}Ar release, N=5, MSWD = 0.8	106.9 ± 0.9 $^{40}\text{Ar}/^{36}\text{Ar}_i = 305 \pm 24$
91GL227	Quartz Monzonite	hbd	0.3189	12	106.3 ± 0.8	0.93	9.13	106.8 ± 0.8	98% ^{39}Ar release, N=8, MSWD = 1.1	107.1 ± 0.8 $^{40}\text{Ar}/^{36}\text{Ar}_i = 294 \pm 9$
91DNS63A	Nepheline Syenite	hbd	0.3547	11	105.6 ± 0.8	1.39	12.79	105.7 ± 0.8	97% ^{39}Ar release, N=8, MSWD = 0.4	105.8 ± 0.8 $^{40}\text{Ar}/^{36}\text{Ar}_i = 278 \pm 12$
91DNS45	Syenite	hbd	0.3291	12	107.4 ± 0.8	1.14	9.16	106.6 ± 0.8	94% ^{39}Ar release, N=8, MSWD = 0.8	106.3 ± 0.8 $^{40}\text{Ar}/^{36}\text{Ar}_i = 308 \pm 4$
91DNS61E	Nepheline Syenite	hbd	0.3588	10	104.6 ± 0.8	1.38	15.37	103.7 ± 0.8	67% ^{39}Ar release, N=5, MSWD = 1.4	104.3 ± 0.8 $^{40}\text{Ar}/^{36}\text{Ar}_i = 292 \pm 2$
91DNS76	Syenite (Gneissic)	hbd	0.3164	11	101.9 ± 0.7	1.68	9.10	101.7 ± 0.7	85% ^{39}Ar release, N=6, MSWD = 0.5	101.6 ± 0.8 $^{40}\text{Ar}/^{36}\text{Ar}_i = 306 \pm 17$
91DNS89	Quartz Monzonite	bio	0.0605	9	98.8 ± 0.7	6.17	0.64	100.4 ± 3.7*	91% ^{39}Ar release, N=4, MSWD = 27.7	-
91RN229B	Metamorphic	bio	0.0772	9	102.7 ± 0.7	7.15	0.81	104.3 ± 2.6*	96% ^{39}Ar release, N=6, MSWD = 13.9	-

Samples run against standard MMhb-1 with an age of 513.9 Ma and processed using the constants of Steiger and Jäger (1977).

Min.: Mineral phase dated: hbd = hornblende, bio = biotite

Mass: mass of sample that was dated

#: Number of fractions in the step heat

† K₂O and CaO contents in weight % as estimated from ^{39}Ar and ^{37}Ar release respectively

* The biotite samples do not meet criteria for plateaus due to high scatter on 'plateau-like' fractions. Age reported is weighted mean age of indicated fractions and error is weighted by the square root of the MSWD (Mean Square Weighted Deviates). These samples also have lower than expected K₂O values for 'biotite' which also may indicate alteration (and 'suspect' plateau ages).

Table 3. $^{40}\text{Ar}/^{39}\text{Ar}$ Analytical data

91SL113 Hornblende																
Weighted average of J from standards = 7.575e-03 5.426e-05																
Temp.	Cum.	$^{40}\text{Ar}/^{39}\text{Ar}$	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$	+/-	% Atm.	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age	+/-
(Deg C)	39Ar	measured		measured		measured		^{40}Ar							(Ma)	(Ma)
500	0.0009	148.3281	8.8293	6.00043	0.41966	0.48412	0.05630	96.2	11.0532	0.7761	0.06550	0.01254	5.7157	14.3549	76.5	188.0
750	0.0059	22.2777	0.2329	2.91508	0.04903	0.05682	0.00847	74.5	5.3589	0.0903	0.01570	0.00208	5.6878	2.5013	76.1	32.8
850	0.0109	8.5446	0.0912	2.76911	0.04868	0.00178	0.00855	3.7	5.0901	0.0897	0.01074	0.00208	8.2138	2.5324	108.9	32.6
900	0.0147	6.7756	0.0925	4.04435	0.07356	-0.00106	0.01089	-9.1	7.4404	0.1357	0.01652	0.00278	7.3824	3.2277	98.2	41.8
950	0.0185	6.6897	0.0931	5.61869	0.09198	-0.00118	0.01109	-11.6	10.3474	0.1700	0.01984	0.00287	7.4593	3.2922	99.2	42.6
1000	0.0293	8.5250	0.0426	5.51237	0.03249	0.00029	0.00394	-3.9	10.1509	0.0600	0.02453	0.00113	8.8564	1.1691	117.1	15.0
1050	0.0562	8.2369	0.0179	5.34423	0.01331	0.00269	0.00158	4.8	9.8402	0.0246	0.02531	0.00039	7.8421	0.4674	104.1	6.0
1100	0.3063	8.2638	0.0076	5.72565	0.00475	0.00218	0.00017	2.6	10.5451	0.0088	0.03412	0.00005	8.0506	0.0507	106.8	0.7
1150	0.7062	8.3979	0.0076	5.79590	0.00471	0.00261	0.00011	4.0	10.6750	0.0087	0.04578	0.00005	8.0639	0.0323	107.0	0.4
1200	0.8465	8.4652	0.0084	6.58224	0.00599	0.00313	0.00030	5.1	12.1295	0.0111	0.04255	0.00008	8.0403	0.0898	106.7	1.2
1600	1.0000	8.9321	0.0087	6.28963	0.00563	0.00407	0.00027	8.2	11.5881	0.0104	0.04053	0.00008	8.2078	0.0820	108.8	1.1
Integrated		8.6328	0.0042	5.91269	0.00271	0.00344	0.00014	6.6	10.8909	0.0050	0.04031	0.00004	8.0638	0.0418	107.0	0.9
91GL227 Hornblende																
Weighted average of J from standards = 7.575e-03 5.426e-05																
Temp.	Cum.	$^{40}\text{Ar}/^{39}\text{Ar}$	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$	+/-	% Atm.	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age	+/-
(Deg C)	39Ar	measured		measured		measured		^{40}Ar							(Ma)	(Ma)
700	0.0063	58.9291	0.3440	3.06279	0.02810	0.17310	0.00478	86.5	5.6310	0.0518	0.01886	0.00115	7.9962	1.3845	106.1	17.8
900	0.0164	13.3240	0.0496	3.43446	0.01854	0.02576	0.00292	55.3	6.3159	0.0342	0.01197	0.00072	5.9539	0.8641	79.6	11.3
950	0.0218	10.1616	0.0699	6.32966	0.05010	0.01387	0.00550	35.7	11.6621	0.0927	0.03072	0.00136	6.5379	1.6310	87.2	21.2
1000	0.0336	9.2011	0.0299	4.78268	0.01915	0.00488	0.00250	11.8	8.8030	0.0354	0.03830	0.00062	8.1162	0.7417	107.6	9.6
1050	0.0713	8.5869	0.0114	4.38995	0.00658	0.00323	0.00078	7.3	8.0780	0.0121	0.03970	0.00020	7.9568	0.2320	105.6	3.0
1075	0.1409	8.4716	0.0088	4.58887	0.00480	0.00281	0.00042	5.8	8.4452	0.0089	0.04195	0.00011	7.9797	0.1261	105.9	1.6
1100	0.2432	8.4427	0.0082	4.60541	0.00425	0.00249	0.00029	4.7	8.4757	0.0078	0.04649	0.00008	8.0469	0.0862	106.8	1.1
1125	0.3840	8.4315	0.0078	4.46661	0.00386	0.00270	0.00021	5.5	8.2195	0.0071	0.05101	0.00007	7.9630	0.0625	105.7	0.8
1150	0.4792	8.6219	0.0085	4.35492	0.00413	0.00328	0.00031	7.5	8.0134	0.0076	0.04955	0.00009	7.9730	0.0922	105.8	1.2
1200	0.7118	8.7430	0.0079	4.50108	0.00372	0.00334	0.00013	7.5	8.2831	0.0069	0.05079	0.00005	8.0886	0.0383	107.3	0.5
1400	0.9979	8.7010	0.0079	4.50706	0.00371	0.00313	0.00010	6.7	8.2942	0.0068	0.05483	0.00005	8.1109	0.0315	107.6	0.4
1600	1.0000	24.4407	0.4217	4.17210	0.09680	0.06562	0.01400	78.1	7.6761	0.1786	0.04932	0.00354	5.3489	4.1371	71.7	54.3
Integrated		9.0295	0.0036	4.48923	0.00171	0.00456	0.00010	11.2	8.2613	0.0032	0.04953	0.00003	8.0135	0.0305	106.3	0.8

Table 3. $^{40}\text{Ar}/^{39}\text{Ar}$ Analytical data

91DNS63A Hornblende																
Weighted average of J from standards = 7.575e-03 5.426e-05																
Temp.	Cum.	$^{40}\text{Ar}/^{39}\text{Ar}$	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$	+/-	% Atm.	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age	+/-
(Deg C)	39Ar	measured		measured		measured		^{40}Ar							(Ma)	(Ma)
700	0.0083	20.8692	0.0585	0.72418	0.01080	0.04647	0.00215	65.6	1.3294	0.0198	0.02671	0.00053	7.1653	0.6363	95.4	8.3
900	0.0260	9.2442	0.0142	1.13590	0.00524	0.00479	0.00101	14.4	2.0858	0.0096	0.01496	0.00025	7.8918	0.2980	104.8	3.8
950	0.0394	8.3201	0.0158	2.31006	0.00785	0.00279	0.00134	7.8	4.2450	0.0145	0.01083	0.00033	7.6525	0.3970	101.7	5.1
1000	0.0954	8.1434	0.0078	2.45638	0.00267	0.00103	0.00032	1.5	4.5143	0.0049	0.01440	0.00008	8.0064	0.0943	106.2	1.2
1050	0.3197	8.0721	0.0072	2.49430	0.00205	0.00099	0.00008	1.3	4.5841	0.0038	0.01606	0.00002	7.9511	0.0247	105.5	0.3
1075	0.6859	8.0835	0.0072	2.72103	0.00220	0.00100	0.00005	1.1	5.0016	0.0040	0.01710	0.00002	7.9766	0.0161	105.8	0.2
1100	0.8524	8.1107	0.0074	3.25181	0.00271	0.00124	0.00011	1.5	5.9793	0.0050	0.01790	0.00003	7.9770	0.0325	105.9	0.4
1125	0.8753	8.2229	0.0112	11.12873	0.01452	0.00406	0.00077	4.4	20.5687	0.0270	0.01648	0.00019	7.8870	0.2308	104.7	3.0
1150	0.9443	8.4664	0.0082	12.74050	0.01110	0.00519	0.00026	6.8	23.5726	0.0207	0.01841	0.00007	7.9263	0.0769	105.2	1.0
1200	0.9945	8.3846	0.0086	12.86991	0.01193	0.00457	0.00035	4.6	23.8140	0.0223	0.01804	0.00009	8.0383	0.1055	106.6	1.4
1600	1.0000	11.0377	0.0452	22.67440	0.09271	0.01840	0.00320	33.9	42.2277	0.1752	0.01885	0.00079	7.3844	0.9596	98.2	12.4
Integrated		8.2798	0.0035	4.20603	0.00155	0.00215	0.00006	3.9	7.7387	0.0029	0.01694	0.00002	7.9544	0.0178	105.6	0.8
91DNS45 Hornblende																
Weighted average of J from standards = 7.575e-03 5.426e-05																
Temp.	Cum.	$^{40}\text{Ar}/^{39}\text{Ar}$	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$	+/-	% Atm.	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age	+/-
(Deg C)	39Ar	measured		measured		measured		^{40}Ar							(Ma)	(Ma)
500	0.0015	266.2533	5.1809	5.36326	0.13730	0.85438	0.02290	94.7	9.8753	0.2537	0.07934	0.00418	14.2065	4.6837	184.4	57.8
700	0.0125	40.0941	0.1113	1.70032	0.01291	0.09871	0.00214	72.5	3.1233	0.0238	0.04753	0.00054	11.0358	0.6296	144.8	7.9
900	0.0414	25.2061	0.0342	1.95919	0.00527	0.05762	0.00082	67.0	3.5994	0.0097	0.03324	0.00020	8.3071	0.2412	110.1	3.1
950	0.0629	11.1706	0.0181	3.53592	0.00830	0.00962	0.00109	23.1	6.5029	0.0153	0.08068	0.00030	8.5835	0.3233	113.7	4.2
1000	0.1245	9.1035	0.0092	3.86260	0.00418	0.00406	0.00038	10.0	7.1052	0.0077	0.08670	0.00013	8.1864	0.1134	108.5	1.5
1050	0.2214	8.3796	0.0079	3.83060	0.00354	0.00216	0.00024	4.2	7.0462	0.0065	0.07542	0.00009	8.0212	0.0721	106.4	0.9
1075	0.2827	8.3717	0.0085	3.67263	0.00407	0.00253	0.00038	5.7	6.7549	0.0075	0.07163	0.00012	7.8894	0.1141	104.7	1.5
1100	0.3690	8.4156	0.0081	3.54896	0.00346	0.00240	0.00027	5.3	6.5269	0.0064	0.07320	0.00009	7.9619	0.0808	105.7	1.0
1125	0.4561	8.4585	0.0081	3.47589	0.00339	0.00232	0.00027	5.0	6.3922	0.0063	0.07435	0.00009	8.0239	0.0803	106.5	1.0
1150	0.4911	8.4810	0.0105	3.29695	0.00539	0.00241	0.00067	5.5	6.0625	0.0099	0.06562	0.00018	8.0053	0.1990	106.2	2.6
1200	0.6365	8.5918	0.0079	3.65752	0.00316	0.00260	0.00016	5.8	6.7271	0.0058	0.08242	0.00008	8.0876	0.0483	107.3	0.6
1600	1.0000	8.5610	0.0077	3.94293	0.00322	0.00276	0.00006	6.1	7.2534	0.0059	0.08075	0.00007	8.0341	0.0205	106.6	0.3
Integrated		9.8118	0.0037	3.68317	0.00144	0.00671	0.00008	17.5	6.7744	0.0027	0.07680	0.00004	8.0950	0.0243	107.4	0.8

Table 3. $^{40}\text{Ar}/^{39}\text{Ar}$ Analytical data

91DNS61E Hornblende																
Weighted average of J from standards = 7.575e-03 5.426e-05																
Temp.	Cum.	$^{40}\text{Ar}/^{39}\text{Ar}$	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$	+/-	% Atm.	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age	+/-
(Deg C)	39Ar	measured		measured		measured		^{40}Ar							(Ma)	(Ma)
700	0.1336	17.0284	0.0155	0.17967	0.00071	0.03130	0.00013	54.3	0.3297	0.0013	0.00190	0.00003	7.7657	0.0412	103.1	0.5
900	0.2580	10.6934	0.0097	0.28083	0.00077	0.00997	0.00014	27.4	0.5154	0.0014	0.00159	0.00003	7.7426	0.0428	102.8	0.6
950	0.3723	8.3796	0.0077	1.29565	0.00134	0.00211	0.00015	6.3	2.3794	0.0025	0.00722	0.00004	7.8309	0.0464	104.0	0.6
1000	0.5031	8.3291	0.0076	2.08838	0.00185	0.00211	0.00013	5.6	3.8371	0.0034	0.01272	0.00004	7.8441	0.0405	104.1	0.5
1050	0.6707	8.3714	0.0076	2.80870	0.00236	0.00246	0.00011	6.2	5.1630	0.0044	0.01508	0.00003	7.8406	0.0321	104.1	0.4
1100	0.7989	9.1043	0.0084	6.99784	0.00579	0.00576	0.00014	13.0	12.8988	0.0107	0.01261	0.00004	7.9342	0.0415	105.3	0.5
1150	0.9595	10.9794	0.0102	15.43323	0.01279	0.01388	0.00011	26.9	28.6053	0.0239	0.01144	0.00003	8.0895	0.0338	107.3	0.4
1200	0.9995	10.3316	0.0113	18.10971	0.01807	0.01222	0.00044	21.8	33.6253	0.0340	0.01605	0.00011	8.1481	0.1316	108.1	1.7
1400	0.9999	5.1717	0.2668	11.65139	0.62008	-0.01968	0.04079	-130.1	21.5421	1.1552	-0.00159	0.01010	11.9237	12.1585	156.0	152.4
1600	1.0000	105.2332	24.4525	7.10301	1.90408	0.52150	0.22431	146.0	13.0936	3.5263	-0.05774	0.04816	-48.5894	57.1765	-827.7	1236.5
Integrated		10.4105	0.0036	5.07914	0.00191	0.00985	0.00006	24.4	9.3504	0.0035	0.00956	0.00001	7.8785	0.0168	104.6	0.8
91DNS76 Hornblende																
Weighted average of J from standards = 7.575e-03 5.426e-05																
Temp.	Cum.	$^{40}\text{Ar}/^{39}\text{Ar}$	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$	+/-	% Atm.	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age	+/-
(Deg C)	39Ar	measured		measured		measured		^{40}Ar							(Ma)	(Ma)
500	0.0009	106.8570	2.4144	3.11474	0.11749	0.32325	0.01974	89.2	5.7267	0.2165	0.11781	0.00525	11.5649	5.4360	151.5	68.3
700	0.0068	16.4005	0.0582	0.72809	0.01448	0.02573	0.00278	46.1	1.3366	0.0266	0.05757	0.00071	8.8269	0.8218	116.8	10.5
900	0.0235	9.6012	0.0145	1.57736	0.00553	0.00971	0.00098	28.7	2.8972	0.0102	0.04213	0.00025	6.8293	0.2901	91.0	3.8
950	0.0318	9.1343	0.0239	4.55133	0.01548	0.00721	0.00198	19.6	8.3759	0.0286	0.13308	0.00060	7.3385	0.5869	97.6	7.6
1000	0.0695	8.7460	0.0090	3.20188	0.00380	0.00413	0.00043	11.2	5.8873	0.0070	0.12845	0.00017	7.7536	0.1289	103.0	1.7
1050	0.3149	7.9658	0.0071	2.38718	0.00197	0.00152	0.00007	3.4	4.3870	0.0036	0.10636	0.00009	7.6799	0.0210	102.0	0.3
1075	0.5974	7.8695	0.0071	2.34005	0.00194	0.00128	0.00006	2.6	4.3002	0.0036	0.10657	0.00009	7.6512	0.0186	101.6	0.2
1100	0.7587	7.8781	0.0071	2.32611	0.00199	0.00132	0.00010	2.8	4.2746	0.0037	0.10610	0.00009	7.6443	0.0309	101.6	0.4
1125	0.8348	7.9201	0.0075	2.32834	0.00229	0.00154	0.00022	3.5	4.2787	0.0042	0.10306	0.00011	7.6230	0.0643	101.3	0.8
1150	0.8835	7.9982	0.0080	2.38204	0.00279	0.00191	0.00034	4.8	4.3775	0.0051	0.09771	0.00012	7.5963	0.0999	100.9	1.3
1600	1.0000	8.3853	0.0077	3.11637	0.00268	0.00268	0.00014	6.7	5.7297	0.0049	0.10107	0.00009	7.8155	0.0424	103.8	0.6
Integrated		8.1760	0.0032	2.47022	0.00093	0.00229	0.00005	6.0	4.5398	0.0017	0.10479	0.00004	7.6694	0.0164	101.9	0.7

Table 3. $^{40}\text{Ar}/^{39}\text{Ar}$ Analytical data

91DNS89 Biotite																
Weighted average of J from standards = 7.575e-03 5.426e-05																
Temp.	Cum.	$^{40}\text{Ar}/^{39}\text{Ar}$	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$	+/-	% Atm.	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age	+/-
(Deg C)	39Ar	measured		measured		measured		^{40}Ar							(Ma)	(Ma)
400	0.0000	633.7014	508.3425	-7.39332	7.39213	3.19858	2.64731	149.2	-13.5008	13.4339	-0.02337	0.15961	-310.5678	313.3698	-107855.3	3166.2
600	0.0009	145.8503	4.3724	1.14550	0.16830	0.45877	0.02795	92.9	2.1034	0.3093	0.01259	0.00598	10.3495	7.2054	136.2	91.3
700	0.0165	7.7933	0.0163	0.25444	0.01027	0.01867	0.00152	70.8	0.4669	0.0189	0.00392	0.00037	2.2660	0.4479	30.7	6.0
800	0.0869	7.8726	0.0076	0.07720	0.00226	0.00413	0.00033	15.5	0.1417	0.0041	0.00338	0.00008	6.6292	0.0987	88.4	1.3
900	0.3535	7.7103	0.0071	0.02281	0.00061	0.00076	0.00009	2.9	0.0419	0.0011	0.00321	0.00002	7.4602	0.0274	99.2	0.4
1000	0.6587	8.3457	0.0073	0.02667	0.00052	0.00203	0.00008	7.2	0.0489	0.0010	0.00343	0.00002	7.7180	0.0237	102.5	0.3
1100	0.9461	7.5301	0.0067	0.03899	0.00055	0.00022	0.00008	0.8	0.0716	0.0010	0.00339	0.00002	7.4396	0.0250	98.9	0.3
1600	1.0000	8.5311	0.0090	0.20212	0.00295	0.00257	0.00043	8.8	0.3709	0.0054	0.00331	0.00011	7.7589	0.1287	103.0	1.7
Integrated		8.4923	0.0038	0.04718	0.00048	0.00351	0.00007	12.2	0.0866	0.0009	0.00336	0.00002	7.4314	0.0211	98.8	0.7
91RN229B Biotite																
Weighted average of J from standards = 7.575e-03 5.426e-05																
Temp.	Cum.	$^{40}\text{Ar}/^{39}\text{Ar}$	+/-	$^{37}\text{Ar}/^{39}\text{Ar}$	+/-	$^{36}\text{Ar}/^{39}\text{Ar}$	+/-	% Atm.	Ca/K	+/-	Cl/K	+/-	$^{40}\text{Ar}^*/^{39}\text{Ar}_K$	+/-	Age	+/-
(Deg C)	39Ar	measured		measured		measured		^{40}Ar							(Ma)	(Ma)
400	0.0005	28.6860	1.2562	0.30978	0.18692	0.10565	0.03596	108.9	0.5685	0.3431	0.00524	0.00871	-2.5410	10.5404	-35.1	146.9
600	0.0170	3.6762	0.0058	0.18540	0.00524	0.00901	0.00100	72.6	0.3402	0.0096	0.00559	0.00024	1.0004	0.2956	13.6	4.0
700	0.0408	8.8955	0.0109	0.14716	0.00362	0.00504	0.00069	16.7	0.2700	0.0066	0.00603	0.00017	7.3899	0.2044	98.3	2.6
800	0.1440	8.5497	0.0077	0.02471	0.00085	0.00221	0.00016	7.7	0.0454	0.0016	0.00670	0.00004	7.8688	0.0481	104.5	0.6
900	0.2827	7.9439	0.0071	0.01877	0.00063	0.00051	0.00012	1.9	0.0344	0.0012	0.00699	0.00003	7.7653	0.0360	103.1	0.5
1000	0.4689	8.1754	0.0077	0.03279	0.00049	0.00030	0.00009	1.1	0.0602	0.0009	0.00684	0.00002	8.0592	0.0281	106.9	0.4
1100	0.8496	7.8830	0.0070	0.04842	0.00024	0.00011	0.00004	0.4	0.0889	0.0004	0.00762	0.00001	7.8243	0.0146	103.9	0.2
1200	0.9797	7.8203	0.0071	0.07253	0.00067	0.00010	0.00013	0.3	0.1331	0.0012	0.00779	0.00003	7.7684	0.0381	103.2	0.5
1600	1.0000	8.0667	0.0112	0.30523	0.00429	0.00055	0.00082	1.7	0.5602	0.0079	0.00931	0.00020	7.8996	0.2415	104.9	3.1
Integrated		7.9746	0.0034	0.05203	0.00026	0.00074	0.00005	2.7	0.0955	0.0005	0.00728	0.00001	7.7309	0.0151	102.7	0.7

Interference corrections: $(^{39}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 6.51 \times 10^{-4}$, $(^{36}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 2.54 \times 10^{-4}$, $(^{40}\text{Ar}/^{39}\text{Ar})_{\text{K}} = 0.0287$