APPENDIX

The Bowers Ridge (Bering Sea): An Oligocene – Early Miocene Island Arc

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APPENDIX DR1

Analytical and experimental techniques

Major and trace elements in whole rocks

Rock chips were ground to flour in an agate mortar and agate mill. A predetermined amount of sample was roasted to determine the loss on ignition (LOI). The roasted sample was fused in a platinum-gold crucible with a commercial lithium tetraborate flux. The molten material was cast in a platinum mold. Major oxides (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O and P_2O_5) were analyzed by X-ray fluorescence spectroscopy (XRF) on the fused discs at Acme Analytical Laboratories (Vancouver). For further details of the analytic procedure see http://acmelab.com. For analytical quality control one international rock standard SY-4 and a prepared blank G1 were analyzed along with the sample series. Results are given in Tab. A2, A4 and A5.

Concentrations of 40 trace elements were analyzed by ICP mass spectrometry at the ICPMS Lab at Institute of Geosciences, University of Kiel (Germany), after pressurized HF-aqua regia dissolution of approximately 250 mg pulverized sample. At least 10% of samples were prepared in duplicate. Prior to analysis, sample digestion solutions were 10-fold diluted and spiked with 2.5 ng/ml beryllium (Be), indium (In), and rhenium (Re) for internal standardization. The instrument was calibrated using aqueous multi-element calibration standards without further matrix matching. All measurements were done using an Agilent 7500cs ICP-MS instrument under standard operating conditions with plasma shield on but no gas in the octopole reaction cell. Sample solution was introduced using a self-aspirating PFA micro-nebulizer (100 µl/min sample uptake) in combination with a standard Scott-type spray chamber maintained at 4 °C. The analytical results represent averages of 3 replicate measurements after subtraction of a laboratory reagent blank. For analytical quality control procedural blanks (“Blank”) and

international reference standards were prepared and analyzed along with the sample series. Results for the USGS rock standards AGV-2 (Andesite), BHVO-2 (Hawaiian Basalt) and BIR-1 (Icelandic Basalt) are reported in Tab. A4. Two samples (SO201-1b-DR25-1 and SO201-2-DR88-1) digested in duplicate (Tab. A5), yielded differences in the results below 2 % rel. for all elements. Instrument stability was monitored by re-analyzing one sample every 10 samples, and precision as calculated from 5 replicate analyses was better than 2 % RSD for all elements except Nb, Ta, W (3 - 11 % RSD). Further details of the sample preparation procedure and instrument calibration strategy can be found in Garbe-Schönberg, 1993.

Major element oxides in glass chips from Bowers Seamount have been determined by JEOL JXA 8200 electron microprobe at the Leibniz Institute of Marine Sciences IFM-GEOMAR in Kiel (Germany). The analytical conditions were 15 kV accelerating voltage, 6 nA current and 5 µm electron beam size. Counting time was 10/10 s (peak/background) for Na, 20/10s for (Si, Al, Fe, Mg, Ca), 30/15 s for K, Ti Cl, S and 40/20 s for Mn and F. Basaltic glass (USNM 113498/1 VG-A99) for Ti, Fe, Mg, Ca, P, rhyolitic glass (USNM 72854 VG568) for Si, Al, Na, K, scapolite (USNM R6600-1) for S and Cl, all from the Smithosonian collection of natural reference materials (Jarosevich et al., 1980), rhyolitic glass KN-18 (Mosbach et al., 1991) for F and synthetic rhodonite for Mn were used for calibration and monitoring of routine measurements. The INTAV intercomparison of electron-beam microanalysis of glass by tephrochronology laboratories (Kuehn et al., 2011), where the IFM-GEOMAR laboratory is referred to as Lab #12, revealed no systematic error for any of element and glasses compositions analyzed at IFM-GEOMAR. Presented here glass analyses are averaged from 6 microprobe points.

One glass sample was analysed by laser ablation – inductively coupled plasma – mass spectrometry (LA-ICP-MS) using a 193nm excimer laser with standard circular ablation cell (Coherent GeoLas Pro) coupled to a quadrupole-based ICP-MS (Agilent 7500cs) at the Institute of Geosciences, CAU Kiel, Germany. *In situ*-microsampling was done with 80 µm pit size and 10Hz pulse frequency at 15 Jcm^{-2} laser fluence. The generated aerosol was transported with 0.75 L min^{-1} He and mixed with 0.6 L min^{-1} Ar prior to introduction into the ICP. The ICP-MS was operated under standard conditions at 1500W and optimized for low oxide formation (ThO/Th <0.8%). The GLITTER software

package (Access Macquarie Ltd.) was used for data reduction of the time-resolved measurements. The blank signal was measured 20 s prior to each ablation and used for calculation of the actual detection limits. For sample data integration the time window of approx. 60 s was individually adjusted for each run. Calcium (44 m/z) was used for internal standardization utilizing pre-analyzed data from electron probe microanalysis (EPMA). The NIST 612 glass (preferred values from Jochum et al., 2011; Pearce et al., 1997) was used for calibration of the integrated raw data and re-analysed in triplicate with every batch of 20 sample acquisitions. In a second calibration step a series of international rock glass standards (MPI-DING glasses GOR-128G, GOR-132G, KL-2G, St.Hs. 6/80; Jochum et al., 2006) that had been analysed along with the unknown samples were used for matrix-matched calibration using external spreadsheet software. Final data represents background-subtracted averages of three individual sample acquisitions. Analytical precision of three runs was < 5 % for most elements.

Sr-Nd-Pb isotope ratios in whole rocks

Sr-Nd-Pb isotope analyses were carried out at the Leibniz Institute of Marine Sciences IFM-GEOMAR in Kiel (Germany). Prior to dissolution whole rock chips and fresh glass (DR29) were leached in 2N HCl at 70°C for 60 minutes and thereafter triple rinsed with 18.2MΩ water. Sample dissolution and Sr-Nd-Pb element chromatography followed standard procedures described in Hoernle K. et al., 2008. Isotopic ratios were determined by thermal ionization mass spectrometry (TIMS) on a TRITON (Sr-Nd) and MAT262 RPQ^{2+} TIMS (Pb) with both instruments operating in static multi-collection mode. Sr and Nd isotopic ratios are normalized within run to $^{86}Sr/^{88}Sr = 0.1194$ and $^{143}Nd/^{144}Nd = 0.7219$ respectively. Errors in Table A3 are reported as 2σ analytical errors (2σ/√n) whereas errors referring to the external reproducibility are reported as 2σ of the mean. Sr-Nd reference material measured along with the samples were normalized for each sample tourret (n = 3-5 Standard measurements) to allow for best possible, long-term comparison of sample data generated in this lab. In this respect NBS987 gave $^{87}Sr/^{86}Sr = 0.710250 \pm 0.000009$ (n=26) and La Jolla $^{143}Nd/^{144}Nd = 0.511850 \pm 0.000006$ (n=29). Pb isotope ratios were mass bias corrected using the Pb double-spike (DS) technique of Hoernle K. et al., 2011. The cumulative record of DS corrected NBS981 values (n = 107) in the period of the study (2009-2011) is $^{206}Pb/^{204}Pb = 16.9420 \pm 0.0029$, $^{207}Pb/^{204}Pb = 15.4999 \pm 0.0027$, $^{208}Pb/^{204}Pb = 36.7257$

± 0.0071, $^{207}Pb/^{206}Pb$ = 0.91488 ± 0.00005 and $^{208}Pb/^{206}Pb$ = 2.16773 ± 0.00009. Sr-Nd-Pb replicate analyses of sample DR118-1 - analyzed as separate digest - lies within the external errors of the reference material. Total chemistry blanks are <50 pg for Sr-Nd and Pb and thus considered negligible.

$^{40}Ar/^{39}Ar$ dating

Eight mineral and matrix separates from dredged rock samples (SO201-1b-DR25 to –DR29) were analyzed by $^{40}Ar/^{39}Ar$ laser step-heating. Amphibole and plagioclase crystals and matrix particles were hand-picked from crushed and sieved splits (250-500µm) and washed and cleaned using an ultrasonic disintegrator.

Separates were irradiated for 12 hrs in aluminum trays and capsules in the cadmium shielded RODEO tube of the HFR facilities (NRG, Petten, The Netherlands). The neutron flux was monitored using Taylor Creek Rhyolite Sanidine (TCR-2: 27.87 ± 0.04 Ma; Lanphere and Dalrymple, 2000). $^{40}Ar/^{39}Ar$ laser step-heating analyses were carried out at the IFM-GEOMAR Geochronology Lab using a 20W SpectraPhysics Argon-Ion laser and an MAP 216 series noble gas mass spectrometer. Ar isotope ratios from mass spectrometry were corrected for mass discrimination, background and blank values, J-value gradients, and interfering neutron reactions on Ca and K.

The step-heating data are evaluated in age spectra (apparent age and error vs cumulative ^{39}Ar) trying to detect plateaus (>3 consecutive steps comprising >50% of the ^{39}Ar released, with ages overlapping within 2Sigma errors), plateau ages representing the inverse-variance weighted mean of the plateau step ages and errors. Statistical robustness of plateaus and plateau ages are tested by calculating the MSWD (mean square weighted deviates; should be <<3) and POF (probability of fit; should be >0.05 at 2Sigma/95% confidence levels) (Baksi, 1999). Results are summarized in Tab. A6 (Appendix DR3). Age spectra and full analytical data are given in Tab. A7 and Fig. A2 (Appendix DR3).

APPENDIX DR1. TABLE A1. SAMPLE DESCRIPTION

Sample number	Location	Lat (°N)*	Long (°E)*	Depth (m)*	Rock type†
SO201-1b-DR25-1	Bowers Ridge, northern flank	54.967	176.415	1386	Basalt
		54.958	176.408	936	
SO201-1b-DR25-2	Bowers Ridge, northern flank	54.967	176.415	1386	Basalt
		54.958	176.408	936	
SO201-1b-DR25-3	Bowers Ridge, northern flank	54.967	176.415	1386	Basaltic andesite
		54.958	176.408	936	
SO201-1b-DR25-4	Bowers Ridge, northern flank	54.967	176.415	1386	Basaltic andesite
		54.958	176.408	936	
SO201-1b-DR25-5	Bowers Ridge, northern flank	54.967	176.415	1386	Basaltic andesite
		54.958	176.408	936	
SO201-1b-DR25-6	Bowers Ridge, northern flank	54.967	176.415	1386	Basaltic andesite
		54.958	176.408	936	
SO201-1b-DR25-7	Bowers Ridge, northern flank	54.967	176.415	1386	Basalt
		54.958	176.408	936	
SO201-1b-DR25-8	Bowers Ridge, northern flank	54.967	176.415	1386	Basaltic andesite
		54.958	176.408	936	
SO201-1b-DR25-9	Bowers Ridge, northern flank	54.967	176.415	1386	Basaltic andesite
		54.958	176.408	936	
SO201-1b-DR25-10	Bowers Ridge, northern flank	54.967	176.415	1386	Andesite
		54.958	176.408	936	
SO201-1b-DR25-16	Bowers Ridge, northern flank	54.967	176.415	1386	Basaltic andesite
		54.958	176.408	936	
SO201-1b-DR26-1	Bowers Ridge, northern flank	54.947	176.297	1420	Trachyandesite
		54.939	176.314	749	
SO201-1b-DR26-2	Bowers Ridge, northern flank	54.947	176.297	1420	Trachyandesite
		54.939	176.314	749	
SO201-1b-DR27-1	Bowers Ridge, northern flank	54.876	176.212	1206	Basalt
		54.860	176.207	763	
SO201-1b-DR27-2	Bowers Ridge, northern flank	54.876	176.212	1206	Basaltic andesite
		54.860	176.207	763	
SO201-1b-DR27-5	Bowers Ridge, northern flank	54.876	176.212	1206	Basalt
		54.860	176.207	763	
SO201-1b-DR27-8	Bowers Ridge, northern flank	54.876	176.212	1206	Basalt
		54.860	176.207	763	
SO201-1b-DR27-9	Bowers Ridge, northern flank	54.876	176.212	1206	Andesite
		54.860	176.207	763	
SO201-1b-DR28-1	Bowers Ridge, northern flank	54.912	176.276	1136	Basaltic trachyandesite
		54.903	176.275	710	
SO201-1b-DR29-1	Bowers Seamount, southern flank	54.202	174.431	2509	Basalt
		54.206	174.423	2018	
SO201-1b-DR29-2	Bowers Seamount, southern flank	54.202	174.431	2509	Basalt
		54.206	174.423	2018	
SO201-1b-DR29-3	Bowers Seamount, southern flank	54.202	174.431	2509	Basalt
		54.206	174.423	2018	
SO201-1b-DR29-4	Bowers Seamount, southern flank	54.202	174.431	2509	Basalt
		54.206	174.423	2018	
SO201-1b-DR29-13	Bowers Seamount, southern flank	54.202	174.431	2509	Basalt
		54.206	174.423	2018	
SO201-1b-DR29MP	Bowers Seamount, southern flank	54.202	174.431	2509	Trachybasalt
		54.206	174.423	2018	

Note: *Note: Coordinates and depths refer to dredge positions on bottom (first) and off bottom (second).
†Rock types according to TAS classification of Le Bas et al. (1986), see Figure A2.

APPENDIX DR1. TABLE A2. MAJOR AND TRACE ELEMENT COMPOSTION OF VOLCANIC ROCKS FROM THE BOWERS RIDGE

Sample number	SO201-1b-DR25-1	SO201-1b-DR25-2	SO201-1b-DR25-3	SO201-1b-DR25-4	SO201-1b-DR25-5	SO201-1b-DR25-6	SO201-1b-DR25-7	SO201-1b-DR25-8
Material	WR	WR	WR	WR	WR	WR	WR	WR
Method	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF
SiO_2, wt%	50.87	50.69	53.29	51.76	53.22	55.04	50.10	55.29
TiO_2	0.84	0.85	0.85	0.95	0.81	0.83	0.84	0.85
Al_2O_3	16.28	16.09	16.28	19.20	15.48	16.66	16.93	17.39
FeO*	8.31	8.31	8.27	7.94	8.13	7.19	8.37	6.48
MnO	0.11	0.11	0.16	0.13	0.15	0.12	0.15	0.11
MgO	6.83	6.62	5.46	3.10	5.99	4.36	5.59	3.78
CaO	10.41	10.08	8.93	9.77	8.94	9.22	11.30	9.51
Na_2O	2.86	2.92	2.97	3.56	2.97	3.41	2.77	3.56
K_2O	1.33	1.37	1.07	1.27	1.26	1.45	0.90	1.64
P2O5	0.24	0.25	0.22	0.32	0.25	0.27	0.22	0.31
LOI	1.20	1.30	1.20	0.70	1.40	0.10	1.20	<0.1
Total	100.24	99.49	99.67	99.63	99.53	99.53	99.32	99.78
Method	ICP-MS						ICP-MS	
Li, ppm	8.62						11.3	
Sc	37.5						35.8	
V	346						372	
Cr	170						167	
Co	32.6						27.4	
Ni	41.4						43.0	
Cu	164						66.5	
Zn	77.9						80.4	
Ga	19.8						20.2	
Rb	13.8						11.3	
Sr	766						617	
Y	14.5						18.7	
Zr	74.5						77.6	
Nb	0.951						0.739	
Mo	0.517						0.671	
Sn	0.683						0.714	
Sb	0.086						0.058	
Cs	0.116						0.178	
Ba	459						349	
La	12.9						8.92	
Ce	30.5						22.3	
Pr	4.73						3.71	
Nd	21.5						18.1	
Sm	4.67						4.59	
Eu	1.34						1.38	
Gd	3.84						4.21	
Tb	0.513						0.606	
Dy	2.66						3.34	
Ho	0.498						0.640	
Er	1.32						1.73	
Tm	0.181						0.249	
Yb	1.18						1.64	
Lu	0.172						0.246	
Hf	2.12						2.28	
Ta	0.063						0.055	
W	0.077						0.076	
Tl	0.068						0.037	
Pb	4.18						2.64	
Th	1.21						0.557	
U	0.651						0.693	

Note: *Total Fe expressed as FeO

APPENDIX DR1. TABLE A2 (CONT.) MAJOR AND TRACE ELEMENT COMPOSTION OF VOLCANIC ROCKS FROM THE BOWERS RIDGE

Sample number	SO201-1b-DR25-9	SO201-1b-DR25-10	SO201-1b-DR25-16	SO201-1b-DR26-1	SO201-1b-DR26-2	SO201-1b-DR27-1	SO201-1b-DR27-2	SO201-1b-DR27-5
Material	WR	WR	WR	WR	WR	WR	WR	WR
Method	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF
SiO_2, wt%	55.32	57.69	54.77	56.15	55.39	47.19	52.10	45.99
TiO_2	0.83	0.57	0.77	0.78	0.75	0.98	0.91	0.85
Al_2O_3	17.54	17.64	16.65	16.87	16.96	18.74	16.89	15.42
FeO*	6.42	5.95	7.12	6.91	7.68	8.67	7.69	8.56
MnO	0.13	0.11	0.14	0.11	0.11	0.12	0.15	0.13
MgO	3.79	3.04	4.95	3.06	3.16	4.04	5.33	5.38
CaO	9.61	7.82	8.71	7.17	7.00	10.92	9.70	13.67
Na_2O	3.54	3.77	3.30	4.09	4.19	3.11	2.64	2.39
K_2O	1.65	1.76	1.58	2.23	2.77	0.76	0.45	0.83
P2O5	0.32	0.30	0.32	0.31	0.30	1.03	0.13	2.03
LOI	0.20	0.50	0.70	0.70	0.90	3.20	2.70	3.00
Total	100.08	99.82	99.83	99.17	100.17	99.82	99.59	99.26
Method		ICP-MS	ICP-MS	ICP-MS			ICP-MS	
Li, ppm		16.5	17.0	10.2			6.66	
Sc		16.5	16.3	16.5			31.4	
V		213	210	277			246	
Cr		99.5	99.3	17.2			56.5	
Co		17.7	17.7	38.8			28.8	
Ni		37.0	37.5	26.4			14.2	
Cu		106	105	19.0			42.0	
Zn		67.5	67.7	70.4			71.3	
Ga		22.2	22.2	23.0			18.2	
Rb		23.4	23.8	33.6			4.87	
Sr		788	785	797			582	
Y		15.6	15.6	16.7			15.4	
Zr		96.2	95.7	140			62.9	
Nb		1.38	1.42	1.59			2.14	
Mo		0.632	0.619	3.54			0.427	
Sn		0.643	0.668	0.950			0.544	
Sb		0.099	0.101	0.820			0.131	
Cs		0.178	0.181	0.439			0.067	
Ba		594	592	674			146	
La		14.4	14.4	14.9			6.72	
Ce		33.0	33.0	36.2			15.9	
Pr		4.76	4.75	5.41			2.26	
Nd		20.5	20.5	24.1			10.1	
Sm		4.19	4.21	5.12			2.46	
Eu		1.19	1.20	1.44			0.918	
Gd		3.56	3.57	4.24			2.64	
Tb		0.494	0.496	0.574			0.434	
Dy		2.65	2.68	3.01			2.68	
Ho		0.516	0.524	0.569			0.550	
Er		1.42	1.44	1.53			1.52	
Tm		0.206	0.210	0.222			0.221	
Yb		1.41	1.43	1.50			1.47	
Lu		0.216	0.220	0.226			0.218	
Hf		2.65	2.67	3.67			1.81	
Ta		0.092	0.108	0.111			0.124	
W		0.112	0.128	0.124			0.143	
Tl		0.129	0.128	1.35			0.036	
Pb		4.84	4.87	5.38			2.57	
Th		1.19	1.20	1.17			0.978	
U		0.811	0.825	1.77			0.741	

APPENDIX DR1. TABLE A2 (CONT.) MAJOR AND TRACE ELEMENT COMPOSTION OF VOLCANIC ROCKS FROM THE BOWERS RIDGE

Sample number	SO201-1b-DR27-8	SO201-1b-DR27-9	SO201-1b-DR28-1	SO201-1b-DR29-1	SO201-1b-DR29-2	SO201-1b-DR29-3	SO201-1b-DR29-4	SO201-1b-DR29-13
Material	WR	WR	WR	WR	WR	WR	WR	WR
Method	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF
SiO_2, wt%	46.40	59.09	53.27	43.89	47.31	48.85	44.94	46.05
TiO_2	0.92	0.52	0.85	1.43	1.50	1.56	1.49	1.51
Al_2O_3	16.14	17.41	19.74	16.52	16.89	17.74	16.48	16.66
FeO*	9.60	4.72	6.22	6.15	6.45	6.47	6.08	5.97
MnO	0.10	0.11	0.11	0.58	0.52	0.26	0.26	0.30
MgO	4.73	2.47	2.21	3.43	4.10	3.60	2.88	3.73
CaO	13.04	6.05	8.42	13.40	11.63	9.68	13.31	12.90
Na_2O	2.89	4.08	4.30	2.98	3.29	3.42	3.26	3.16
K_2O	0.78	2.27	2.41	0.76	0.86	1.06	1.05	0.79
P2O5	1.84	0.16	0.37	3.75	2.05	1.35	3.94	2.93
LOI		2.30	1.00	5.00	4.20	4.40	4.40	4.40
Total	99.83	99.77	99.62	98.60	99.54	99.06	98.82	99.12
Method		ICP-MS	ICP-MS	ICP-MS		ICP-MS	ICP-MS	
Li, ppm		11.6	11.8	26.7		30.2	23.5	
Sc		19.1	20.2	26.2		28.8	27.8	
V		150	293	151		148	142	
Cr		31.2	10.8	259		214	177	
Co		12.2	16.2	40.4		59.1	23.8	
Ni		10.6	15.4	126		78.3	92.2	
Cu		42.1	55.5	61.4		56.2	58.9	
Zn		64.0	114	110		108	106	
Ga		16.9	24.5	15.9		18.2	16.5	
Rb		22.5	31.6	6.6		7.24	8.05	
Sr		587	891	561		479	566	
Y		13.8	21.6	98.4		25.7	101	
Zr		107	138	145		158	153	
Nb		1.14	1.49	12.7		14.2	13.5	
Mo		0.800	1.63	4.96		2.33	2.81	
Sn		0.506	0.80	1.08		1.18	1.10	
Sb		0.233	1.02	1.89		1.43	1.61	
Cs		0.227	0.224	0.284		0.208	0.324	
Ba		545	654	243		176	138	
La		11.2	15.1	48.8		12.6	46.8	
Ce		26.1	35.7	26.8		27.8	27.0	
Pr		3.80	5.55	7.07		3.72	7.72	
Nd		16.6	25.2	31.0		16.1	33.7	
Sm		3.62	5.54	6.30		3.93	7.05	
Eu		1.06	1.60	2.03		1.40	2.21	
Gd		3.11	4.82	8.60		4.26	9.20	
Tb		0.445	0.673	1.27		0.707	1.39	
Dy		2.43	3.64	8.12		4.35	8.83	
Ho		0.468	0.704	1.87		0.885	2.02	
Er		1.28	1.91	5.36		2.43	5.74	
Tm		0.185	0.276	0.765		0.359	0.812	
Yb		1.24	1.83	4.90		2.35	5.10	
Lu		0.190	0.280	0.796		0.351	0.794	
Hf		2.87	3.62	2.95		3.23	3.09	
Ta		0.103	0.101	0.792		0.860	0.818	
W		0.096	0.235	0.508		0.350	0.577	
Tl		0.136	0.096	0.162		0.104	0.525	
Pb		3.63	3.31	1.66		1.66	2.02	
Th		1.40	1.13	0.833		0.916	0.875	
U		0.872	1.43	3.41		1.61	4.27	

APPENDIX DR1. TABLE A2 (CONT.) MAJOR AND TRACE ELEMENT COMPOSTION OF VOLCANIC ROCKS FROM THE BOWERS RIDGE

Sample number	SO201-1b-DR29-1GL	SO201-1b-DR29-3GL	SO201-1b-DR29-9GL	SO201-1b-DR29MP	SO201-1b-DR29MP1	SO201-1b-DR29MP2	SO201-1b-DR29MP3
Material	GL	GL	GL	GL	GL	GL	GL
Method	EMPA	EMPA	EMPA	EMPA			
SiO_2, wt%	50.50	50.47	50.38	50.52			
TiO_2	1.72	1.85	1.82	1.86			
Al_2O_3	17.33	17.43	17.28	17.47			
FeO*	7.14	7.01	7.00	7.05			
MnO	0.15	0.13	0.11	0.08			
MgO	5.66	5.75	5.85	5.76			
CaO	9.99	9.99	10.03	10.03			
Na_2O	4.08	4.04	4.03	4.03			
K_2O	1.23	1.19	1.18	1.18			
P2O5	0.33	0.32	0.35	0.34			
LOI							
Total	98.28	98.33	98.18	98.47			
Method					LA-ICP-MS	LA-ICP-MS	LA-ICP-MS
Li, ppm					5.79	5.87	5.90
Sc					31.2	31.2	30.7
V					224	225	223
Cr					133	134	133
Co					25.5	25.8	25.7
Ni					45.1	45.5	46.9
Cu					54.5	55.0	54.4
Zn					65.5	64.4	63.3
Ga							
Rb					7.03	7.10	6.95
Sr					431	431	435
Y					26.9	26.7	26.2
Zr					186	186	183
Nb					16.5	16.6	16.3
Mo							
Sn							
Sb							
Cs					0.099	0.096	0.091
Ba					130	129	128
La					12.0	12.0	11.7
Ce					29.5	29.5	28.9
Pr							
Nd					18.3	18.3	18.0
Sm					4.42	4.40	4.36
Eu					1.55	1.55	1.50
Gd					4.88	4.87	4.85
Tb							
Dy					4.96	4.95	4.80
Ho							
Er					2.94	2.87	2.82
Tm							
Yb					2.61	2.62	2.52
Lu					0.400	0.387	0.384
Hf					3.85	3.84	3.75
Ta					1.08	1.06	1.04
W							
Tl							
Pb					1.93	1.85	1.82
Th					1.01	1.00	0.973
U					0.455	0.443	0.445

APPENDIX DR1. TABLE A3. ISOTOPE COMPOSITIONS OF VOLCANIC ROCKS FROM THE BOWERS RIDGE

Sample number	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	$^{87}Sr/^{86}Sr$	$^{143}Nd/^{144}Nd$
SO201-1b-DR25-1	18.261 ± 0.000*	15.462 ± 0.000	37.693 ± 0.001	0.703083 ± 0.000003	0.513126 ± 0.000003
SO201-1b-DR25-10	18.237 ± 0.001	15.454 ± 0.001	37.668 ± 0.003	0.703015 ± 0.000003	0.513127 ± 0.000002
SO201-1b-DR25-16	18.223 ± 0.001	15.453 ± 0.001	37.651 ± 0.001	0.703113 ± 0.000003	0.513136 ± 0.000003
SO201-1b-DR26-1	18.298 ± 0.002	15.460 ± 0.002	37.726 ± 0.007	0.703007 ± 0.000003	0.513123 ± 0.000002
SO201-1b-DR27-1	18.257 ± 0.001	15.460 ± 0.001	37.690 ± 0.001	0.702984 ± 0.000003	0.513138 ± 0.000003
SO201-1b-DR28-1	18.265 ± 0.001	15.455 ± 0.001	37.675 ± 0.002	0.702964 ± 0.000003	0.513132 ± 0.000003
SO201-1b-DR29-1	18.277 ± 0.001	15.448 ± 0.000	37.663 ± 0.001	0.702685 ± 0.000003	0.513113 ± 0.000003
SO201-1b-DR29GL	18.156 ± 0.001	15.435 ± 0.001	37.630 ± 0.002	0.702688 ± 0.000003	0.513123 ± 0.000003
SO201-1b-DR29-3	18.162 ± 0.001	15.433 ± 0.001	37.597 ± 0.002	0.702692 ± 0.000003	0.513135 ± 0.000002

Note: *Uncertainties reported as 2σ.

APPENDIX DR1. TABLE A4. STANDARDS FOR MAJOR AND TRACE ELEMENT DATA

Standard	SY-4		AGV-2		BHVO-2		BIR-1	
Values*	Recomm.	Analyzed	Recomm.	Analyzed	Recomm.	Analyzed	Recomm.	Analyzed
Method		XRF		ICP-MS		ICP-MS		ICP-MS
SiO_2, wt%	49.90	49.71						
TiO_2	0.29	0.28						
Al_2O_3	20.69	20.70						
FeO[†]	5.59	5.62						
MnO	0.11	0.11						
MgO	0.54	0.50						
CaO	8.05	7.94						
Na_2O	7.10	7.16						
K_2O	1.66	1.67						
P_2O_5	0.13	0.12						
Total		99.06						
Li, ppm			11.0	10.6	4.60	4.51	3.40	3.39
Sc			13.0	13.2	31.8	31.7	44.0	44.0
V			120	122	317	324	313	328
Cr			17.0	15.4	289	290	382	382
Co			16.0	16.2	45.0	46.1	51.4	54.3
Ni			19.0	18.7	119	122	166	171
Cu			53.0	52.4	127	131	126	121
Zn			86.0	89.7	103	106	71.0	69.5
Ga			20.0	21.2	21.7	21.9	16.0	15.9
Rb			68.6	67.8	9.20	9.02	0.212	0.182
Sr			658	652	395	385	104	108
Y			20.0	20.5	25.5	27.0	16.0	16.4
Zr			230	232	174	168	14.0	13.7
Nb			15.0	13.8	18.0	17.9	0.550	0.688
Mo			2.26	1.97	4.00	4.99	0.500	0.061
Sn			2.30	1.86	1.80	1.70	0.650	0.854
Sb			0.600	0.427	0.130	0.095	0.580	0.664
Cs			1.16	1.15	0.110	0.095	0.005	0.005
Ba			1140	1126	130	131	5.83	6.40
La			38.0	38.7	15.2	15.4	0.620	0.623
Ce			68.0	70.9	38.0	37.9	1.95	1.94
Pr			8.30	8.42	5.30	5.44	0.380	0.381
Nd			30.0	31.5	25.0	25.0	2.50	2.47
Sm			5.70	5.68	6.20	6.17	1.10	1.13
Eu			1.54	1.56	2.06	2.09	0.540	0.535
Gd			4.69	4.89	6.30	6.22	1.85	1.80
Tb			0.640	0.681	0.930	0.964	0.360	0.369
Dy			3.60	3.61	5.25	5.41	2.50	2.66
Ho			0.710	0.681	0.990	0.998	0.570	0.585
Er			1.79	1.82	2.50	2.47	1.70	1.67
Tm			0.260	0.257	0.340	0.329	0.260	0.252
Yb			1.60	1.69	2.00	2.04	1.65	1.68
Lu			0.250	0.253	0.280	0.281	0.260	0.252
Hf			5.08	5.09	4.07	4.32	0.581	0.584
Ta			0.890	0.802	1.13	1.10	0.035	0.045
W			0.540	0.524	0.250	0.249	0.070	0.055
Tl			0.270	0.288		0.020	0.010	0.002
Pb			13.0	12.7	1.70	1.36	3.08	3.90
Th			6.10	6.13	1.21	1.19	0.030	0.029
U			1.88	1.91	0.410	0.416	0.010	0.009

Note: *Recommended (Bowman, 2007; Garbe-Schönberg, 1993) and analyzed values, respectively.

[†] Total Fe expressed as FeO.

APPENDIX DR1. TABLE A5. REPRODUCIBILITY OF MAJOR AND TRACE ELEMENT DATA

Sample	G1	SO201-1b-DR27-9	SO201-1b-DR25-1	SO201-2-DR88-1
n	2*	5*	2†	2†
Method	XRF	ICP-MS	ICP-MS	ICP-MS
SiO_2, wt%	66.74 ± 0.07§			
TiO_2	0.48 ± 0.05			
Al_2O_3	15.98 ± 0.03			
FeO#	3.14 ± 0.11			
MnO	0.11 ± 0.01			
MgO	1.13 ± 0.01			
CaO	3.52 ± 0.07			
Na_2O	3.61 ± 0.04			
K_2O	3.91 ± 0.19			
P_2O_5	0.20 ± 0.01			
Total	99.87 ± 0.17			
Li, ppm		11.6 ± 0.10§	8.66 ± 0.093§	27.4 ± 0.47§
Sc		19.5 ± 0.76	37.3 ± 0.48	20.1 ± 0.28
V		155 ± 7.6	346 ± 0.4	113 ± 1.1
Cr		31.7 ± 0.83	170 ± 0.3	3.68 ± 0.067
Co		12.3 ± 0.12	32.5 ± 0.22	10.9 ± 0.10
Ni		10.6 ± 0.19	41.1 ± 0.46	3.83 ± 0.115
Cu		42.4 ± 0.61	163 ± 1.5	43.9 ± 0.49
Zn		63.9 ± 0.50	77.5 ± 0.86	96.6 ± 0.02
Ga		17.0 ± 0.11	19.7 ± 0.26	15.6 ± 0.25
Rb		22.6 ± 0.21	13.8 ± 0.11	17.3 ± 0.06
Sr		600 ± 21.7	759 ± 14.5	179 ± 2.1
Y		13.8 ± 0.11	14.4 ± 0.21	35.5 ± 0.08
Zr		107 ± 0.8	74.1 ± 0.75	161 ± 0.04
Nb		1.07 ± 0.074	0.942 ± 0.0185	2.51 ± 0.005
Mo		0.796 ± 0.0077	0.534 ± 0.0340	3.42 ± 0.064
Sn		0.509 ± 0.0131	0.689 ± 0.0124	1.34 ± 0.006
Sb		0.228 ± 0.0079	0.088 ± 0.0029	0.337 ± 0.0045
Cs		0.226 ± 0.0065	0.115 ± 0.0026	0.673 ± 0.0168
Ba		561 ± 29.7	456 ± 5.5	244 ± 7.5
La		11.3 ± 0.13	12.8 ± 0.20	9.31 ± 0.032
Ce		26.2 ± 0.25	30.3 ± 0.30	24.4 ± 0.17
Pr		3.83 ± 0.066	4.71 ± 0.055	3.79 ± 0.047
Nd		16.7 ± 0.22	21.4 ± 0.13	18.1 ± 0.20
Sm		3.64 ± 0.061	4.65 ± 0.032	4.94 ± 0.074
Eu		1.06 ± 0.013	1.34 ± 0.012	1.34 ± 0.013
Gd		3.15 ± 0.051	3.83 ± 0.013	5.43 ± 0.033
Tb		0.447 ± 0.0046	0.511 ± 0.0031	0.925 ± 0.0108
Dy		2.44 ± 0.026	2.66 ± 0.014	5.85 ± 0.055
Ho		0.469 ± 0.0034	0.498 ± 0.0004	1.22 ± 0.008
Er		1.28 ± 0.014	1.32 ± 0.005	3.43 ± 0.014
Tm		0.187 ± 0.0035	0.181 ± 0.0009	0.516 ± 0.0051
Yb		1.24 ± 0.019	1.18 ± 0.011	3.46 ± 0.008
Lu		0.189 ± 0.0015	0.172 ± 0.0003	0.521 ± 0.0036
Hf		2.87 ± 0.023	2.12 ± 0.003	4.36 ± 0.039
Ta		0.086 ± 0.0192	0.062 ± 0.0006	0.173 ± 0.0011
W		0.088 ± 0.0116	0.078 ± 0.0024	0.136 ± 0.0044
Tl		0.137 ± 0.0031	0.067 ± 0.0016	0.354 ± 0.0032
Pb		3.64 ± 0.042	4.06 ± 0.237	5.95 ± 0.001
Th		1.40 ± 0.019	1.21 ± 0.001	1.15 ± 0.003
U		0.876 ± 0.0119	0.651 ± 0.00001	1.22 ± 0.010

* Number of analyses of one sample.

† Number of duplicated samples.

§ Uncertainties reported as 2σ.

Total Fe expressed as FeO.

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APPENDIX DR2

Supplementary figures

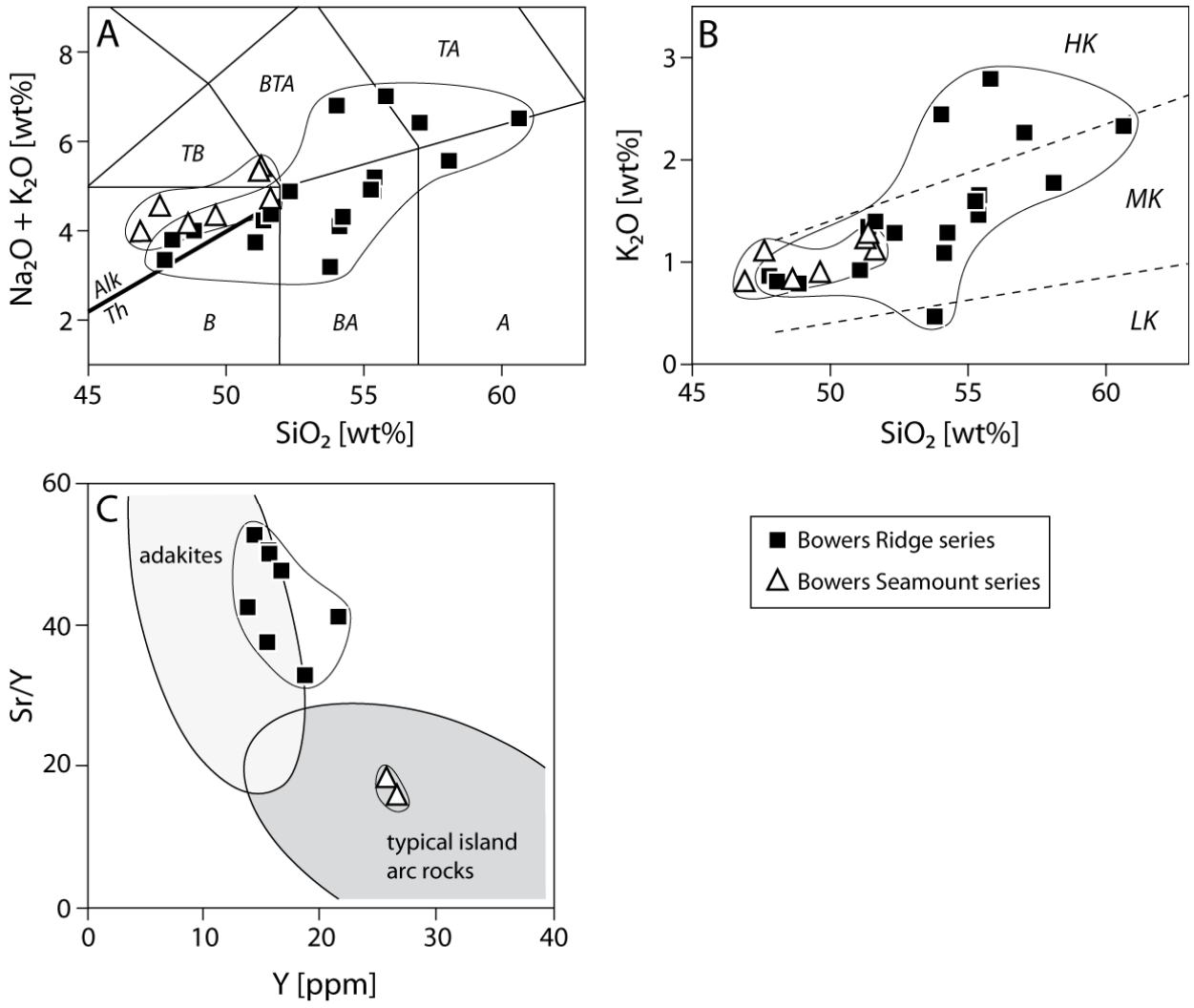

Figure A2. Major and trace element variations in volcanic rocks from the Bowers Ridge.
A: TAS classification diagram after Le Bas et al., 1986. Italicized letters indicate fields of basalt (*B*), basaltic andesite (*BA*), andesite (*A*), trachybasalt (*TB*), basaltic trachyandesite (*BTA*) and trachyandesite (*TA*). The thick solid line divides fields of alkaline basalt (*Alk*) and tholeiite (*Th*) after Macdonald and Katsura, 1964.
B: SiO_2 vs. K_2O diagram illustrating subdivision of rocks into high-K and middle-K groups. Dashed lines represent conventional boundaries between low-K (LK), middle-K (MK) and high-K (HK) rocks (Hart, 1984).
C: Sr/Y vs. Y diagram showing similarity of rocks from the Bowers Ridge series to adakites. Fields for adakites and classical island arc rocks after Defant and Drummond, 1990.

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APPENDIX DR3

Results from $^{39}Ar/^{40}Ar$ dating

APPENDIX DR3. TABLE A6. RESULTS FROM 40Ar/39Ar LASER STEP-HEATING

Sample	Rock type	Material	Vol ^{39}Ar	MSWD	Probability	Plate	Age (Ma)±2σ
Bowers Ridge							
SO201-1b-DR25-	Andesite	Amph	54.4	1.90	0.061	7 - 14	26.0 ± 0.7
SO201-1b-DR25-	Basaltic andesite	Amph	64.6	3.60	0.003	3 - 11	28.4 ± 1.7
SO201-1b-DR26-1	Trachyandesite	Amph	60.3	1.17	0.320	5 - 11	27.9 ± 0.5
SO201-1b-DR27-1	Basalt	Plag	81.5	1.50	0.110	2 - 11	32.3 ± 2.0
SO201-1b-DR28-1	Basaltic trachyandesite	Amph	80.9	1.60	0.110	4 - 14	29.0 ± 0.4
Bowers							
SO201-1b-DR29-1	Basalt	Plag	100	0.61	0.900	1 - 19	22.2 ± 2.7
SO201-1b-DR29-4	Basalt	Matrix	72	2.80	0.036	2 - 5	24.4 ± 0.8

APPENDIX DR3. TABLE A7. 40Ar/39Ar ANALYSIS DATA

25-10 amphibole
MASS = 2.154 mg

J =	3.21E-03	+/-	1.90E-06	(2 Sigma)			0.059 Percent			
Steps	POWER	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39ArK	Ca/K	% 40ArA	Cum 39ArK	Age [Ma]	2 Sigma
1	1.25E-01	6.99E+01	1.19E+00	2.32E-01	1.63E-16	2.34E+00	9.80E+01	1.69E-02	7.90E+00	1.77E+01
2	2.00E-01	3.22E+01	6.95E+00	9.77E-02	1.23E-16	1.37E+01	8.90E+01	2.96E-02	2.04E+01	1.09E+01
3	3.00E-01	8.19E+00	9.66E+00	1.33E-02	5.44E-16	1.91E+01	4.39E+01	8.60E-02	2.66E+01	1.24E+00
4	4.00E-01	6.65E+00	4.45E+00	4.77E-02	1.40E-18	8.75E+00	2.10E+02	8.62E-02	-	6.50E+02
5	5.00E-01	7.86E+00	8.67E+00	1.08E-02	8.28E-19	1.71E+01	3.68E+01	8.62E-02	2.86E+01	1.17E+03
6	6.00E-01	7.58E+00	1.02E+01	9.92E-03	1.54E-15	2.01E+01	3.41E+01	2.46E-01	2.88E+01	7.61E-01
7	7.00E-01	5.97E+00	9.99E+00	5.85E-03	1.17E-15	1.97E+01	2.33E+01	3.67E-01	2.64E+01	1.47E+00
8	8.00E-01	6.32E+00	9.95E+00	7.81E-03	8.08E-16	1.96E+01	3.12E+01	4.51E-01	2.51E+01	1.67E+00
9	9.00E-01	5.49E+00	9.86E+00	4.76E-03	6.10E-16	1.95E+01	1.95E+01	5.14E-01	2.55E+01	1.96E+00
10	1.00E+00	5.43E+00	9.75E+00	5.76E-03	4.18E-16	1.92E+01	2.52E+01	5.58E-01	2.35E+01	2.19E+00
11	1.10E+00	5.32E+00	9.77E+00	3.81E-03	8.24E-16	1.93E+01	1.49E+01	6.43E-01	2.61E+01	1.61E+00
12	1.20E+00	5.36E+00	9.71E+00	2.00E-03	4.62E-16	1.92E+01	4.85E+00	6.91E-01	2.94E+01	3.42E+00
13	1.35E+00	5.42E+00	9.57E+00	3.07E-03	4.84E-16	1.89E+01	1.08E+01	7.41E-01	2.79E+01	2.95E+00
14	1.50E+00	5.42E+00	9.60E+00	3.24E-03	4.70E-16	1.90E+01	1.16E+01	7.90E-01	2.76E+01	3.79E+00
15	2.00E+00	5.39E+00	1.03E+01	2.60E-03	1.15E-15	2.03E+01	7.79E+00	9.09E-01	2.87E+01	1.05E+00
16	3.00E+00	5.45E+00	9.71E+00	4.03E-03	3.95E-16	1.92E+01	1.58E+01	9.50E-01	2.65E+01	3.30E+00
17	8.00E+00	5.37E+00	8.89E+00	3.29E-03	3.72E-16	1.75E+01	1.25E+01	9.88E-01	2.71E+01	3.45E+00
18	1.00E+01	5.96E+00	9.36E+00	1.32E-03	1.12E-16	1.85E+01	1.20E+00	1.00E+00	3.39E+01	8.71E+00

Plateau age = 25.96±0.72 Ma
(2s, including J-error of .059%)
MSWD = 1.9, probability = 0.061
54.4% of the 39Ar, steps 7 through 14

APPENDIX DR3. TABLE A7 (CONT.) 40Ar/39Ar ANALYSIS DATA

25-16 amphibole
MASS = 1.611 mg
J = 3.21E-03 +/- 1.90E-06 (2 Sigma) 0.059 Percent

STEPS	POWER	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39ArK	Ca/K	% 40ArA	Cum 39ArK	Age [Ma]	2 Sigma
1	1.25E-01	7.74E+01	2.05E+00	2.62E-01	2.14E-16	4.02E+00	9.98E+01	2.80E-02	9.65E-01	1.68E+01
2	2.00E-01	5.64E+01	6.84E+00	1.82E-01	2.33E-16	1.35E+01	9.48E+01	5.86E-02	1.71E+01	1.33E+01
3	3.00E-01	6.09E+01	9.27E+00	1.87E-01	5.36E-16	1.83E+01	9.03E+01	1.29E-01	3.39E+01	6.05E+00
4	6.00E-01	8.45E+00	8.99E+00	1.24E-02	1.72E-15	1.77E+01	3.96E+01	3.55E-01	2.94E+01	1.03E+00
5	7.00E-01	6.68E+00	8.53E+00	6.88E-03	1.20E-15	1.68E+01	2.61E+01	5.12E-01	2.85E+01	1.34E+00
6	8.00E-01	6.30E+00	8.92E+00	6.82E-03	4.98E-16	1.76E+01	2.72E+01	5.77E-01	2.65E+01	2.01E+00
7	9.00E-01	6.09E+00	9.31E+00	6.01E-03	6.01E-16	1.84E+01	2.40E+01	6.56E-01	2.67E+01	2.19E+00
8	1.00E+00	5.68E+00	8.15E+00	5.37E-03	3.75E-16	1.61E+01	2.31E+01	7.05E-01	2.52E+01	2.93E+00
9	1.50E+00	5.74E+00	8.32E+00	2.35E-03	8.76E-16	1.64E+01	7.15E+00	8.20E-01	3.07E+01	7.42E-01
10	2.00E+00	5.76E+00	8.87E+00	3.03E-03	1.03E-15	1.75E+01	1.03E+01	9.54E-01	2.98E+01	8.38E-01
11	3.00E+00	5.94E+00	9.64E+00	3.25E-03	3.19E-16	1.90E+01	1.07E+01	9.96E-01	3.06E+01	3.35E+00
12	1.50E+01	1.52E+01	9.84E+00	4.67E-02	3.23E-17	1.94E+01	8.86E+01	1.00E+00	1.01E+01	3.67E+01

Plateau age = 28.4±1.7 Ma
(95% conf.), including J-error of .059%)
MSWD = 3.6, probability = 0.003
64.6% of the 39Ar, steps 3 through 8

APPENDIX DR3. TABLE A7 (CONT.) 40Ar/39Ar ANALYSIS DATA

26-1 amphibole
MASS = 1.797 mg
J = 3.21E-03 +/- 1.90E-06 (2 Sigma) 0.059 Percent

STEPS	POWER	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39ArK	Ca/K	% 40ArA	Cum 39ArK	Age [Ma]	2 Sigma
1	1.25E-01	4.56E+01	9.65E-01	1.48E-01	1.53E-16	1.89E+00	9.57E+01	1.38E-02	1.14E+01	1.14E+01
2	2.00E-01	1.76E+01	5.33E+00	4.61E-02	2.68E-16	1.05E+01	7.66E+01	3.79E-02	2.37E+01	3.89E+00
3	3.00E-01	6.93E+00	6.42E+00	7.14E-03	6.31E-16	1.26E+01	2.73E+01	9.49E-02	2.90E+01	1.42E+00
4	4.00E-01	8.02E+00	6.80E+00	1.04E-02	9.69E-16	1.34E+01	3.55E+01	1.82E-01	2.98E+01	7.51E-01
5	5.00E-01	5.93E+00	7.13E+00	4.74E-03	1.34E-15	1.40E+01	1.96E+01	3.03E-01	2.75E+01	7.30E-01
6	6.00E-01	5.55E+00	7.82E+00	3.07E-03	1.10E-15	1.54E+01	1.16E+01	4.02E-01	2.83E+01	1.22E+00
7	7.00E-01	5.67E+00	7.01E+00	3.08E-03	8.94E-16	1.38E+01	1.19E+01	4.83E-01	2.88E+01	1.22E+00
8	8.00E-01	5.73E+00	7.04E+00	3.67E-03	1.51E-15	1.39E+01	1.47E+01	6.19E-01	2.81E+01	1.07E+00
9	9.00E-01	5.38E+00	7.06E+00	2.96E-03	9.64E-16	1.39E+01	1.18E+01	7.06E-01	2.74E+01	1.30E+00
10	1.00E+00	5.49E+00	7.18E+00	3.07E-03	4.91E-16	1.42E+01	1.21E+01	7.51E-01	2.78E+01	2.51E+00
11	1.10E+00	5.42E+00	7.31E+00	1.35E-03	3.88E-16	1.44E+01	2.76E+00	7.86E-01	3.03E+01	3.17E+00
12	1.20E+00	5.36E+00	7.26E+00	5.39E-04	4.82E-16	1.43E+01	-1.64E+00	8.29E-01	3.14E+01	2.46E+00
13	1.35E+00	9.30E+00	7.15E+00	1.41E-02	2.92E-16	1.41E+01	4.21E+01	8.56E-01	3.10E+01	4.30E+00
14	1.50E+00	5.93E+00	6.88E+00	3.09E-03	4.63E-16	1.36E+01	1.15E+01	8.97E-01	3.02E+01	1.99E+00
15	2.00E+00	5.69E+00	7.43E+00	9.75E-05	3.23E-16	1.46E+01	-3.95E+00	9.26E-01	3.40E+01	3.65E+00
16	3.00E+00	5.68E+00	8.98E+00	5.66E-03	2.67E-16	1.77E+01	2.41E+01	9.51E-01	2.49E+01	4.04E+00
17	5.00E+00	6.77E+00	7.61E+00	7.83E-03	3.05E-17	1.50E+01	3.03E+01	9.53E-01	2.72E+01	4.26E+01
18	8.00E+00	6.55E+00	6.70E+00	5.25E-03	9.88E-17	1.32E+01	2.02E+01	9.62E-01	3.01E+01	9.97E+00
19	1.00E+01	2.79E+01	7.52E+00	6.72E-02	3.66E-17	1.48E+01	7.04E+01	9.66E-01	4.73E+01	2.64E+01
20	1.50E+01	1.06E+01	7.17E+00	1.92E-02	3.82E-16	1.41E+01	5.13E+01	1.00E+00	2.98E+01	3.42E+00

Plateau age = 27.93±0.45 Ma
(2s, including J-error of .059%)
MSWD = 1.17, probability = 0.32
60.3% of the 39Ar, steps 5 through 11

APPENDIX DR3. TABLE A7 (CONT.) 40Ar/39Ar ANALYSIS DATA

27-1 plagioclase
MASS = 2.018 mg

J =	3.21E-03	+/-	1.90E-06	(2 Sigma)				0.059 Percent		
STEPS	POWER	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39ArK	Ca/K	% 40ArA	Cum 39ArK	Age [Ma]	2 Sigma
1	1.25E-01	5.37E+01	1.13E+01	1.70E-01	3.28E-16	2.23E+01	9.27E+01	1.70E-01	2.26E+01	9.73E+00
2	2.00E-01	4.73E+01	3.67E+01	1.47E-01	3.36E-16	7.39E+01	8.91E+01	3.43E-01	3.04E+01	3.80E+00
3	3.00E-01	3.90E+01	4.38E+01	1.19E-01	3.42E-16	8.87E+01	8.65E+01	5.20E-01	3.11E+01	4.58E+00
4	4.00E-01	2.42E+01	6.64E+01	7.02E-02	1.63E-16	1.36E+02	7.64E+01	6.04E-01	3.42E+01	8.66E+00
5	6.00E-01	3.77E+01	7.39E+01	1.18E-01	2.19E-16	1.53E+02	8.55E+01	7.17E-01	3.30E+01	4.13E+00
6	8.00E-01	1.29E+01	8.67E+01	3.30E-02	1.15E-16	1.81E+02	5.29E+01	7.77E-01	3.69E+01	9.07E+00
7	1.00E+00	9.97E+00	9.81E+01	2.47E-02	7.90E-17	2.07E+02	3.96E+01	8.17E-01	3.70E+01	9.41E+00
8	1.20E+00	8.80E+00	9.15E+01	2.48E-02	1.08E-16	1.92E+02	4.79E+01	8.73E-01	2.81E+01	9.19E+00
9	1.50E+00	9.37E+00	1.15E+02	2.48E-02	4.80E-17	2.46E+02	3.62E+01	8.98E-01	3.72E+01	2.18E+01
10	2.00E+00	1.12E+01	1.23E+02	3.03E-02	6.38E-17	2.64E+02	4.27E+01	9.31E-01	4.01E+01	1.49E+01
11	2.50E+00	1.27E+01	1.31E+02	4.45E-02	3.90E-17	2.83E+02	6.82E+01	9.51E-01	2.56E+01	1.76E+01
12	3.00E+00	2.08E+01	1.36E+02	6.70E-02	2.27E-17	2.93E+02	7.29E+01	9.63E-01	3.57E+01	3.11E+01
13	6.00E+00	1.95E+01	1.20E+02	5.83E-02	4.30E-17	2.56E+02	6.75E+01	9.85E-01	3.95E+01	1.62E+01
14	8.00E+00	1.28E+01	1.45E+02	-2.32E-02	8.32E-18	3.17E+02	-9.23E+01	9.89E-01	1.52E+02	8.62E+01
15	1.00E+01	2.26E+01	9.53E+01	3.90E-02	4.59E-18	2.00E+02	3.66E+01	9.92E-01	8.68E+01	1.59E+02
16	1.20E+01	8.27E+01	9.88E+01	2.40E-01	6.39E-18	2.08E+02	8.17E+01	9.95E-01	9.17E+01	1.62E+02
17	1.50E+01	1.68E+01	1.18E+02	-4.85E-02	5.40E-18	2.53E+02	-1.09E+02	9.98E-01	2.09E+02	1.52E+02
18	2.00E+01	1.17E+01	2.09E+02	-5.73E-02	4.42E-18	4.79E+02	-2.06E+02	1.00E+00	2.27E+02	1.84E+02

Plateau age = 32.3±2.0 Ma
(2s, including J-error of .059%)
MSWD = 1.5, probability = 0.11
81.5% of the 39Ar, steps 2 through 14

APPENDIX DR3. TABLE A7 (CONT.) 40Ar/39Ar ANALYSIS DATA

28-1 amphibole
MASS = 1.784 mg

J =	3.21E-03	+/-	1.90E-06	(2 Sigma)				0.059 Percent		
STEPS	POWER	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39ArK	Ca/K	% 40ArA	Cum 39ArK	Age [Ma]	2 Sigma
1	1.25E-01	4.12E+01	9.11E-01	1.36E-01	2.82E-16	1.79E+00	9.72E+01	2.36E-02	6.55E+00	1.25E+01
2	2.00E-01	9.72E+00	2.53E+00	2.82E-02	1.64E-16	4.96E+00	8.49E+01	3.73E-02	8.47E+00	9.49E+00
3	3.00E-01	9.12E+00	5.20E+00	1.60E-02	6.86E-16	1.02E+01	4.99E+01	9.46E-02	2.63E+01	2.01E+00
4	4.00E-01	7.76E+00	5.84E+00	9.77E-03	1.13E-15	1.15E+01	3.47E+01	1.89E-01	2.92E+01	1.14E+00
5	5.00E-01	6.33E+00	6.29E+00	5.67E-03	1.31E-15	1.24E+01	2.31E+01	2.98E-01	2.80E+01	7.20E-01
6	6.00E-01	5.65E+00	6.40E+00	2.42E-03	1.28E-15	1.26E+01	8.79E+00	4.06E-01	2.97E+01	1.24E+00
7	7.00E-01	5.57E+00	6.69E+00	2.13E-03	1.07E-15	1.32E+01	7.21E+00	4.95E-01	2.97E+01	1.28E+00
8	8.00E-01	5.43E+00	6.37E+00	2.10E-03	1.05E-15	1.26E+01	7.43E+00	5.83E-01	2.89E+01	1.12E+00
9	9.00E-01	5.41E+00	6.39E+00	2.39E-03	7.97E-16	1.26E+01	9.03E+00	6.50E-01	2.83E+01	1.59E+00
10	1.00E+00	5.88E+00	6.49E+00	3.76E-03	6.07E-16	1.28E+01	1.52E+01	7.01E-01	2.87E+01	1.96E+00
11	1.10E+00	5.78E+00	6.41E+00	2.05E-03	4.53E-16	1.26E+01	6.70E+00	7.39E-01	3.10E+01	2.33E+00
12	1.20E+00	5.66E+00	6.42E+00	2.72E-03	5.77E-16	1.26E+01	1.03E+01	7.87E-01	2.92E+01	2.11E+00
13	1.35E+00	5.50E+00	6.44E+00	1.67E-03	6.57E-16	1.27E+01	5.01E+00	8.42E-01	3.01E+01	2.19E+00
14	1.50E+00	5.37E+00	6.64E+00	1.63E-03	7.41E-16	1.31E+01	4.76E+00	9.04E-01	2.94E+01	1.02E+00
15	2.00E+00	5.60E+00	7.16E+00	1.53E-03	8.30E-16	1.41E+01	3.74E+00	9.73E-01	3.10E+01	1.28E+00
16	3.00E+00	5.50E+00	8.06E+00	3.22E-03	2.98E-16	1.59E+01	1.23E+01	9.98E-01	2.78E+01	3.79E+00
17	5.00E+00	6.79E+00	6.29E+00	-6.17E-03	1.04E-17	1.24E+01	-3.00E+01	9.99E-01	5.05E+01	1.28E+02
18	8.00E+00	8.05E+00	9.99E+00	1.77E-02	1.28E-17	1.97E+01	6.09E+01	1.00E+00	1.82E+01	9.05E+01

Plateau age = 29.37±0.48 Ma
(2s, including J-error of .059%)
MSWD = 0.72, probability = 0.67
60.5% of the 39Ar, steps 6 through 14

APPENDIX DR3. TABLE A7 (CONT.) 40Ar/39Ar ANALYSIS DATA

29-1 plagioclase
MASS = 1.707 mg
J = 3.21E-03 +/- 1.90E-06 (2 Sigma) 0.059 Percent

STEPS	POWER	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39ArK	Ca/K	% 40ArA	Cum 39ArK	Age [Ma]	2 Sigma
1	1.25E-01	3.79E+01	3.70E+01	1.18E-01	4.40E-17	7.44E+01	8.84E+01	3.49E-02	2.60E+01	1.40E+01
2	2.00E-01	8.68E+00	4.01E+01	3.32E-02	3.00E-17	8.08E+01	9.75E+01	5.87E-02	1.31E+00	2.07E+01
3	3.00E-01	1.14E+01	4.76E+01	3.46E-02	5.77E-17	9.65E+01	7.55E+01	1.04E-01	1.66E+01	1.39E+01
4	4.00E-01	6.54E+00	6.27E+01	1.97E-02	7.10E-17	1.28E+02	5.64E+01	1.61E-01	1.71E+01	8.38E+00
5	6.00E-01	6.28E+00	7.23E+01	1.78E-02	1.13E-16	1.49E+02	4.48E+01	2.50E-01	2.10E+01	8.89E+00
6	8.00E-01	6.17E+00	7.77E+01	1.77E-02	6.13E-17	1.61E+02	4.21E+01	2.99E-01	2.17E+01	1.80E+01
7	1.00E+00	5.41E+00	7.88E+01	1.93E-02	6.32E-17	1.64E+02	5.57E+01	3.49E-01	1.46E+01	1.92E+01
8	1.20E+00	5.18E+00	7.79E+01	1.80E-02	3.24E-17	1.62E+02	5.14E+01	3.75E-01	1.53E+01	2.79E+01
9	1.50E+00	5.08E+00	7.46E+01	1.29E-02	7.33E-17	1.54E+02	2.49E+01	4.33E-01	2.31E+01	1.46E+01
10	2.00E+00	4.76E+00	7.32E+01	1.11E-02	1.90E-16	1.51E+02	1.66E+01	5.84E-01	2.40E+01	7.02E+00
11	2.50E+00	4.79E+00	7.59E+01	1.06E-02	9.88E-17	1.57E+02	1.13E+01	6.62E-01	2.57E+01	9.98E+00
12	3.00E+00	4.68E+00	7.98E+01	8.89E-03	3.13E-17	1.66E+02	-1.92E+00	6.87E-01	2.90E+01	2.77E+01
13	5.00E+00	4.69E+00	7.70E+01	1.16E-02	2.67E-16	1.60E+02	1.74E+01	8.99E-01	2.35E+01	4.40E+00
14	6.00E+00	4.98E+00	7.91E+01	1.30E-02	4.59E-17	1.64E+02	2.33E+01	9.35E-01	2.32E+01	1.78E+01
15	8.00E+00	5.41E+00	7.74E+01	2.15E-02	2.42E-17	1.60E+02	6.88E+01	9.54E-01	1.03E+01	5.24E+01
16	1.00E+01	8.53E+00	6.64E+01	-9.75E-04	1.62E-18	1.37E+02	-2.99E+01	9.55E-01	6.59E+01	6.08E+02
17	1.20E+01	4.84E+00	7.81E+01	1.58E-03	3.43E-17	1.62E+02	-4.53E+01	9.83E-01	4.25E+01	2.96E+01
18	1.50E+01	6.12E+00	5.81E+01	6.24E-02	1.95E-18	1.19E+02	2.69E+02	9.84E-01	-6.35E+01	6.70E+02
19	2.00E+01	5.35E+00	7.35E+01	1.37E-02	1.99E-17	1.52E+02	2.91E+01	1.00E+00	2.30E+01	5.35E+01

Plateau age = 22.2±2.7 Ma
(2s, including J-error of .059%)
MSWD = 0.61, probability = 0.90
100% of the 39Ar, steps 1 through 19

APPENDIX DR3. TABLE A7 (CONT.) 40Ar/39Ar ANALYSIS DATA

29-4 matrix
MASS = 1.629 mg
J = 3.21E-03 +/- 1.90E-06 (2 Sigma) 0.059 Percent

STEPS	POWER	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39ArK	Ca/K	% 40ArA	Cum 39ArK	Age [Ma]	2 Sigma
1	1.25E-01	8.97E+02	6.74E+00	2.99E+00	1.05E-15	1.33E+01	9.87E+01	9.06E-02	6.84E+01	1.10E+01
2	2.00E-01	4.72E+01	4.83E+00	1.44E-01	2.87E-15	9.50E+00	9.01E+01	3.39E-01	2.70E+01	3.01E+00
3	3.00E-01	1.87E+01	5.41E+00	4.94E-02	2.76E-15	1.06E+01	7.71E+01	5.77E-01	2.47E+01	1.45E+00
4	5.00E-01	1.03E+01	5.76E+00	2.19E-02	2.02E-15	1.13E+01	6.09E+01	7.51E-01	2.32E+01	1.25E+00
5	6.00E-01	9.81E+00	6.23E+00	1.88E-02	6.90E-16	1.23E+01	5.46E+01	8.11E-01	2.57E+01	1.87E+00
6	7.00E-01	1.09E+01	9.22E+00	2.03E-02	1.48E-16	1.82E+01	5.24E+01	8.24E-01	2.98E+01	5.41E+00
7	8.00E-01	1.10E+01	5.81E+00	2.28E-02	6.17E-16	1.14E+01	5.93E+01	8.77E-01	2.58E+01	2.03E+00
8	9.00E-01	1.69E+01	1.15E+01	3.71E-02	1.17E-16	2.27E+01	6.25E+01	8.87E-01	3.66E+01	1.33E+01
9	1.00E+00	1.35E+01	1.36E+01	2.28E-02	5.82E-17	2.69E+01	4.64E+01	8.92E-01	4.18E+01	1.36E+01
10	1.20E+00	2.43E+01	1.74E+01	7.18E-02	5.62E-17	3.44E+01	8.49E+01	8.97E-01	2.14E+01	2.59E+01
11	1.35E+00	2.39E+01	1.20E+01	5.89E-02	3.36E-17	2.36E+01	7.10E+01	9.00E-01	4.00E+01	3.50E+01
12	1.50E+00	4.21E+01	1.07E+01	1.32E-01	9.31E-17	2.11E+01	9.16E+01	9.08E-01	2.05E+01	1.13E+01
13	2.00E+00	1.39E+01	9.97E+00	3.54E-02	1.16E-16	1.97E+01	7.30E+01	9.18E-01	2.16E+01	1.16E+01
14	3.00E+00	2.16E+01	8.42E+00	5.86E-02	8.46E-17	1.66E+01	7.91E+01	9.25E-01	2.60E+01	1.25E+01
15	1.50E+01	1.90E+01	5.48E+00	5.17E-02	8.66E-16	1.08E+01	7.96E+01	1.00E+00	2.23E+01	2.97E+00

Plateau age = 24.41±0.81 Ma
(2s, including J-error of .059%)
MSWD = 2.8, probability = 0.036
72% of the 39Ar, steps 2 through 5

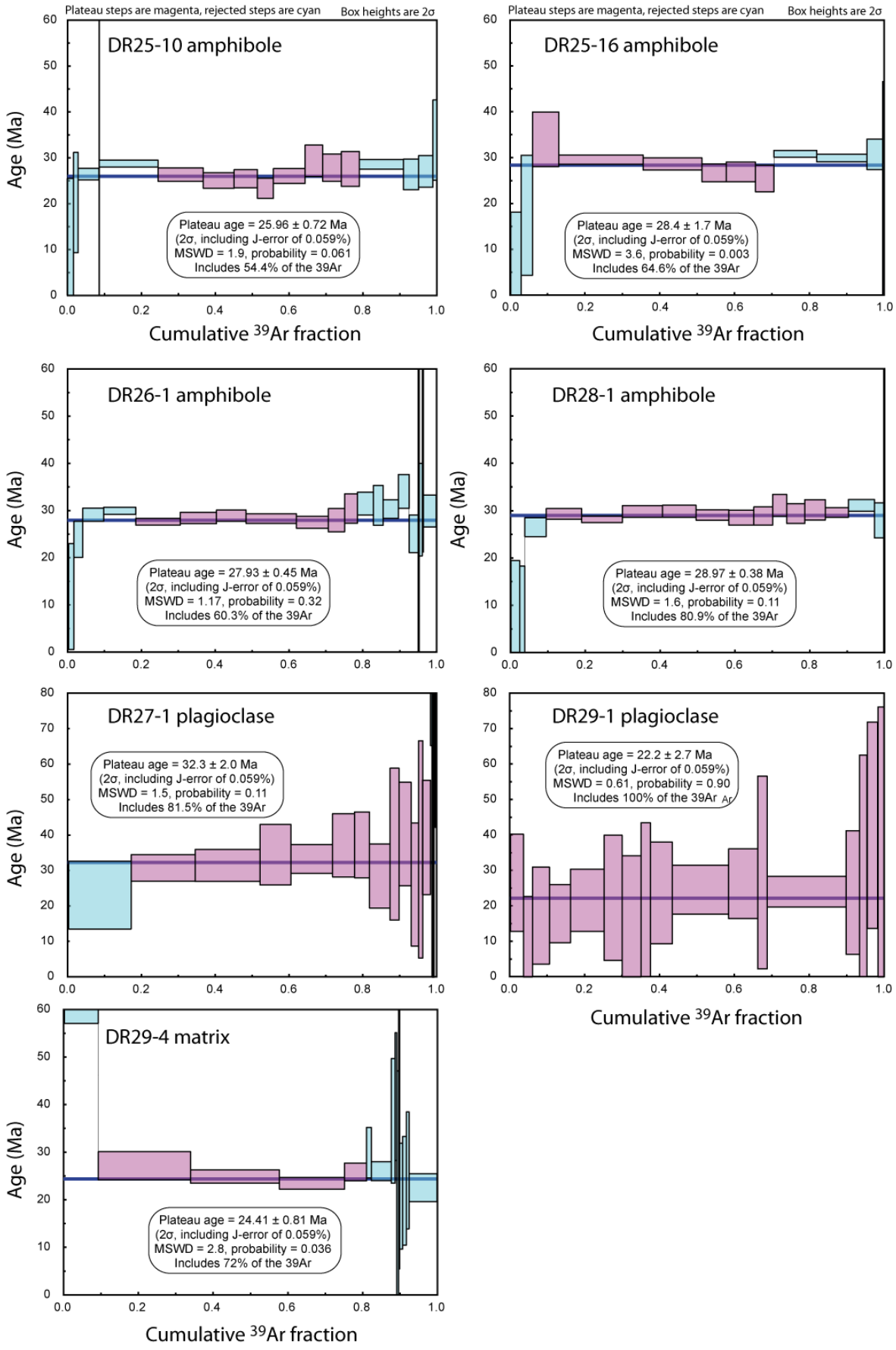

Figure A2. $^{40}Ar/^{39}Ar$ step-heating age spectra.