Tectonic dissection and displacement of parts of Shona hotspot volcano 3500 km along the Agulhas-Falkland Fracture Zone

Appendix DR1: $^{40}Ar/^{39}Ar$ analytical methods and age data.

Only the freshest cores of rock samples were used for the preparation of mineral separates. The samples were crushed, sieved, multiply washed in deionized water and dried at 50°C. Plagioclase separates from six rock samples were analyzed by $^{40}Ar/^{39}Ar$ laser step-heating analyses. Feldspars were etched in 5% HF acid for 8-12min and then sample material was cleaned in deionized water using an ultrasonic disintegrator.

Samples were irradiated for 12h in aluminum trays and capsules in the cadmium shielded RODEO tube of the HFR facilities (NRG, Petten, The Netherlands). The Taylor Creek Rhyolite Sanidine (TCR-2: 27.87 ± 0.04 Myr; Lanphere and Dalrymple, 2000) was used as neutron flux monitor. $^{40}Ar/^{39}Ar$ laser step-heating analyses were performed in the GEOMAR Geochronology Lab using a 25W Coherent Sabre Argon-Ion laser and MAP 216 series noble gas mass spectrometer. Measured Ar Isotope ratios were corrected for mass discrimination, background and blank values, and J-value gradients. Correction factors applied to interfering neutron reactions on Ca and K are ($^{40}Ar/^{39}Ar$)K: 0.00183, ($^{39}Ar/^{37}Ar$)Ca: 0.000699, and ($^{36}Ar/^{37}Ar$)Ca: 0.000270) (Wijbrans et al., 2007).

The step-heating data are evaluated in age spectra (apparent age and error versus cumulative ^{39}Ar) to detect plateaus consisting of more than three consecutive steps that comprise >50% of the released ^{39}Ar and ages overlapping within 2σ errors. Plateau ages represent the inverse-variance weighted mean of the plateau step ages and errors. MSWD (mean square weighted deviates; <3) and probability of fit (>0.05 at 2σ (95%) confidence levels; Baksi, 1999) serve as tests of the statistical validity of plateaus and plateau ages. The degree of alteration was monitored using the measured $^{36}Ar/^{37}Ar$ ratios for Ca-rich plagioclase (alteration index AI/37; normalized to J=0.01) (Baksi, 2007). Uncertainties are quoted as 2σ. Age results are summarized below in **Appendix DR1 Table A1**. Detailed analytical data are listed below in **Appendix DR1 Table A2**. Age spectra are shown below **Appendix DR1 Figures**.

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Appendix DR1 Table A1: $^{40}Ar/^{39}Ar$ step-heating results

Sample No.		Locality	Size fraction	Material	Mass (mg)	Lab No	%K	Result	Age (Ma)	±	2σ	MSWD	Prob.	39Ar fraction	Steps	Alteration assessment
MSM19/3	DR3-3	Richardson Guyot	< 0.5 mm	Plag	1.650	3-3fs2	0.23	plateau	82.60	±	1.70	0.79	0.61	51.7	10 to 18	plateau step AI/37 ≤6E-5 --- largely fresh
MSM19/3	DR18-1	Agulhas Ridge	< 0.5 mm	Plag	3.492	18-1fss	0.29	plateau	81.68	±	0.31	0.39	0.96	93.6	6 to 17	plateau step AI/37<6E-5 --- fresh
MSM19/3	DR30-1	Agulhas Ridge	< 0.5 mm	Plag	2.834	30-1fss	0.08	plateau	80.96	±	0.78	0.83	0.56	84.4	8 to 15	plateau step AI/37<6E-5 --- fresh
MSM19/3	DR35-1	Agulhas Ridge	< 0.5 mm	Plag	4.064	35-1fss	0.14	plateau	72.18	±	0.48	1.30	0.26	95.1	6 to 14	plateau step AI/37<6E-5 --- fresh
MSM19/3	DR39-2	Meteor Guyot	32-63 µm	Matrix Plag	6.764	39-2fss	0.91	low-mid-temperature plateau	75.12	±	0.29	1.90	0.06	56.8	2 to 10	plateau step AI/37 >1E-3 --- somewhat altered
								high-temperature plateau	76.00	±	0.30	3.00	0.00	62.0	6 to 18	high-t step AI/37 >1E-4 --- somewhat altered
MSM19/3	DR42-1	Meteor Guyot	<0.5, 0.5-1 mm	Plag	4.164	42-1fss	0.39	plateau	73.92	±	0.23	2.00	0.08	73.0	10 to 15	plateau step AI/37<6E-5 --- fresh

Appendix DR1 Table A2: 40Ar/39Ar analytical data

MSM19/3 DR3-3 feldspar

															Average 40*/39	2.027E+01	
Mass			1.65	mg	0.00165	g									Moles 40Ar*	5.505E-14	
															Moles 40Ar*/g	3.336E-11	
J =			2.69E-03	+/-	2.74E-06	(2 Sigma)		0.102 Percent	Reactor constants						%K in plag	2.275E-01	
Step		**J-value**	**Laser power (W)**	**40Ar/39Ar**	**37Ar/39Ar**	**36Ar/39Ar**	**Mol 39Ar**	**39Ar Fraction**	**36/37Ca**	**39/37Ca**	**40/39K**	**36c/39**	**F**	**Age [Ma]**	**2 Sigma [Ma]**	**Al/37**	**RAD%**
3-3	5 125	2.69E-03	1.25E-01	6.12E+02	1.46E+01	1.95E+00	3.83E-17	1.41E-02	0.000270	0.000699	0.001830	1.947973	36.562634	169.31	72.13	3.595E-02	*5.89*
3-3	5 200	2.69E-03	2.00E-01	2.29E+02	2.01E+01	7.40E-01	7.79E-17	4.28E-02	0.000270	0.000699	0.001830	0.734772	11.622740	55.56	35.56	9.817E-03	*4.99*
3-3	5 300	2.69E-03	3.00E-01	1.72E+02	1.53E+01	5.52E-01	1.25E-16	8.88E-02	0.000270	0.000699	0.001830	0.547748	10.462269	50.09	8.26	9.653E-03	*5.99*
3-3	5 400	2.69E-03	4.00E-01	3.19E+01	1.65E+01	7.80E-02	1.37E-16	1.39E-01	0.000270	0.000699	0.001830	0.073592	10.282575	49.24	7.73	1.203E-03	*31.72*
3-3	5 600	2.69E-03	6.00E-01	2.18E+01	1.26E+01	3.62E-02	2.95E-16	2.48E-01	0.000270	0.000699	0.001830	0.032760	12.223091	58.39	4.16	7.010E-04	*55.41*
3-3	5 800	2.69E-03	8.00E-01	1.73E+01	1.76E+01	1.75E-02	1.43E-16	3.01E-01	0.000270	0.000699	0.001830	0.012774	13.694860	65.29	6.05	1.954E-04	*77.83*
3-3	5 1000	2.69E-03	1.00E+00	1.59E+01	1.76E+01	8.37E-03	1.76E-16	3.65E-01	0.000270	0.000699	0.001830	0.003611	14.978043	71.29	4.93	5.513E-05	*92.85*
3-3	5 1200	2.69E-03	1.20E+00	1.86E+01	2.51E+01	1.40E-02	1.61E-16	4.25E-01	0.000270	0.000699	0.001830	0.007192	16.773154	79.65	7.08	7.716E-05	*88.01*
3-3	5 1500	2.69E-03	1.50E+00	1.60E+01	2.55E+01	1.13E-02	1.52E-16	4.81E-01	0.000270	0.000699	0.001830	0.004428	14.953599	71.18	5.36	4.666E-05	*91.22*
3-3	5 2000	2.69E-03	2.00E+00	1.67E+01	2.77E+01	8.24E-03	2.15E-16	**5.60E-01**	0.000270	0.000699	0.001830	0.000755	16.801293	**79.78**	**4.06**	7.330E-06	*97.97*
3-3	5 2500	2.69E-03	2.50E+00	1.73E+01	3.38E+01	9.04E-03	1.85E-16	**6.28E-01**	0.000270	0.000699	0.001830	0.000000	17.705302	**83.97**	**5.59**	0.000E+00	*99.14*
3-3	5 3000	2.69E-03	3.00E+00	1.85E+01	3.58E+01	1.34E-02	1.69E-16	**6.90E-01**	0.000270	0.000699	0.001830	0.003751	17.863267	**84.70**	**6.35**	2.819E-05	*93.16*
3-3	5 4000	2.69E-03	4.00E+00	1.77E+01	3.69E+01	1.15E-02	3.25E-16	**8.10E-01**	0.000270	0.000699	0.001830	0.001523	17.677537	**83.84**	**3.47**	1.112E-05	*96.54*
3-3	5 5000	2.69E-03	5.00E+00	1.68E+01	3.53E+01	7.76E-03	3.42E-16	**9.36E-01**	0.000270	0.000699	0.001830	0.000000	17.274530	**81.98**	**2.90**	0.000E+00	*99.10*
3-3	5 6000	2.69E-03	6.00E+00	1.85E+01	3.67E+01	-5.96E-04	5.83E-17	**9.57E-01**	0.000270	0.000699	0.001830	0.000000	19.028229	**90.09**	**14.61**	0.000E+00	*99.07*
3-3	5 8000	2.69E-03	8.00E+00	2.01E+01	3.82E+01	2.02E-02	6.25E-17	**9.80E-01**	0.000270	0.000699	0.001830	0.009899	17.631533	**83.63**	**16.47**	6.968E-05	*84.61*
3-3	5 10000	2.69E-03	1.00E+01	2.57E+01	3.98E+01	2.76E-02	2.65E-17	**9.90E-01**	0.000270	0.000699	0.001830	0.016818	21.289318	**100.51**	**47.64**	1.136E-04	*79.82*
3-3	5 12000	2.69E-03	1.20E+01	1.06E+02	7.14E+01	3.02E-01	2.07E-17	**9.98E-01**	0.000270	0.000699	0.001830	0.282516	23.332616	**109.86**	**46.27**	1.065E-03	*20.60*
3-3	5 15000	2.69E-03	1.50E+01	8.24E+02	9.70E+02	2.98E+00	2.95E-18	9.99E-01	0.000270	0.000699	0.001830	2.713762	69.655774	309.95	521.03	7.530E-04	*0.71*
3-3	5 20000	2.69E-03	2.00E+01	2.47E+01	5.21E+01	3.89E-03	3.79E-18	1.00E+00	0.000270	0.000699	0.001830	0.000000	25.606893	120.22	205.16	0.000E+00	*98.67*

Age = 82.6±1.7 Ma
(2σ, including J-error of .102%)
MSWD = 0.79, probability = 0.61
51.7% of the 39Ar, steps 10 through 18

MSM19/3 DR18-1 feldspar

															Average 40*/39	1.730E+01	
MASS=			3.492	mg	0.003492	g									Moles 40Ar*	1.474E-13	
															Moles 40Ar*/g	4.222E-11	
J =			2.69E-03	+/-	2.74E-06	(2 Sigma)		0.102 Percent	Reactor constants						%K in plag	2.901E-01	
Step		**J-value**	**Laser power (W)**	**40Ar/39Ar**	**37Ar/39Ar**	**36Ar/39Ar**	**Mol 39Ar**	**39Ar Fraction**	**36/37Ca**	**39/37Ca**	**40/39K**	**36c/39**	**F**	**Age [Ma]**	**2 Sigma [Ma]**	**Al/37**	**RAD%**
18-1	11 400	2.69E-03	4.00E-01	1.10E+02	3.35E+01	3.24E-01	2.68E-17	3.94E-03	0.000270	0.000699	0.001830	0.314486	17.090658	81.12	32.20	2.527E-03	*15.10*
18-1	11 500	2.69E-03	5.00E-01	7.55E+01	2.66E+01	2.07E-01	3.83E-17	8.43E-03	0.000270	0.000699	0.001830	0.199839	16.738150	79.49	18.15	2.024E-03	*21.62*
18-1	11 600	2.69E-03	6.00E-01	3.93E+01	2.94E+01	8.03E-02	6.87E-17	1.65E-02	0.000270	0.000699	0.001830	0.072337	18.297743	86.72	17.02	6.630E-04	*45.27*
18-1	11 800	2.69E-03	8.00E-01	2.39E+01	2.62E+01	2.85E-02	1.83E-16	3.79E-02	0.000270	0.000699	0.001830	0.021420	17.934014	85.03	7.08	2.203E-04	*73.07*
18-1	11 1000	2.69E-03	1.00E+00	1.87E+01	2.61E+01	1.33E-02	2.21E-16	6.39E-02	0.000270	0.000699	0.001830	0.006280	17.188948	81.58	5.77	6.481E-05	*89.50*
18-1	11 1200	2.69E-03	1.20E+00	1.77E+01	2.69E+01	9.99E-03	2.20E-16	**8.97E-02**	0.000270	0.000699	0.001830	0.002717	17.269271	**81.95**	**5.63**	2.715E-05	*94.82*
18-1	11 1500	2.69E-03	1.50E+00	1.80E+01	2.65E+01	1.00E-02	2.40E-16	**1.18E-01**	0.000270	0.000699	0.001830	0.002833	17.460061	**82.84**	**4.55**	2.873E-05	*94.70*
18-1	11 2000	2.69E-03	2.00E+00	1.89E+01	2.63E+01	1.35E-02	4.58E-16	**1.71E-01**	0.000270	0.000699	0.001830	0.006397	17.286833	**82.03**	**1.88**	6.539E-05	*89.38*
18-1	11 2500	2.69E-03	2.50E+00	1.72E+01	2.63E+01	7.85E-03	7.83E-16	**2.63E-01**	0.000270	0.000699	0.001830	0.000740	17.270420	**81.96**	**0.74**	7.558E-06	*98.07*
18-1	11 3000	2.69E-03	3.00E+00	1.71E+01	2.84E+01	8.25E-03	9.22E-16	**3.71E-01**	0.000270	0.000699	0.001830	0.000572	17.221650	**81.73**	**1.05**	5.411E-06	*98.30*
18-1	11 4000	2.69E-03	4.00E+00	1.71E+01	2.42E+01	7.04E-03	9.20E-16	**4.79E-01**	0.000270	0.000699	0.001830	0.000498	17.272581	**81.97**	**0.79**	5.527E-06	*98.53*
18-1	11 5000	2.69E-03	5.00E+00	1.71E+01	2.37E+01	6.21E-03	5.80E-16	**5.47E-01**	0.000270	0.000699	0.001830	0.000000	17.354230	**82.34**	**1.30**	0.000E+00	*99.40*
18-1	11 6000	2.69E-03	6.00E+00	1.69E+01	2.61E+01	7.29E-03	4.33E-16	**5.98E-01**	0.000270	0.000699	0.001830	0.000247	17.161434	**81.45**	**1.81**	2.545E-06	*98.91*
18-1	11 8000	2.69E-03	8.00E+00	1.71E+01	1.68E+01	5.22E-03	6.68E-16	**6.76E-01**	0.000270	0.000699	0.001830	0.000694	17.140833	**81.35**	**0.99**	1.113E-05	*98.38*
18-1	11 10000	2.69E-03	1.00E+01	1.74E+01	3.15E+01	1.06E-02	5.30E-16	**7.39E-01**	0.000270	0.000699	0.001830	0.002071	17.165565	**81.47**	**1.56**	1.770E-05	*95.71*
18-1	11 12000	2.69E-03	1.20E+01	1.71E+01	4.52E+00	1.36E-03	1.37E-15	**8.99E-01**	0.000270	0.000699	0.001830	0.000144	17.151466	**81.40**	**0.59**	8.560E-06	*99.63*
18-1	11 15000	2.69E-03	1.50E+01	1.72E+01	5.22E+00	1.76E-03	8.63E-16	**1.00E+00**	0.000270	0.000699	0.001830	0.000349	17.154414	**81.42**	**0.93**	1.800E-05	*99.26*

Age = 81.68±0.31 Ma
(2σ, including J-error of .102%)
MSWD = 0.39, probability = 0.96
93.6% of the 39Ar, steps 6 through 17

MSM19/3 DR30-1 feldspar

								Average 40*/39	1.573E+01
MASS=		2.834	mg	0.002834	g			Moles 40Ar*	3.306E-14
								Moles 40Ar*/g	1.166E-11
J =		2.69E-03	+/-	2.74E-06	(2 Sigma)	0.102 Percent	Reactor constants	%K in plag	8.116E-02

Step			J-value	Laser power (W)	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39Ar	39Ar Fraction	36/37Ca	39/37Ca	40/39K	36c/39	F	Age [Ma]	2 Sigma [Ma]	Al/37	RAD%
30-1	1	400	2.69E-03	4.00E-01	2.55E+03	3.04E+01	8.58E+00	9.18E-18	4.37E-03	0.000270	0.000699	0.001830	8.570944	20.510066	96.92	105.38	7.589E-02	*0.78*
30-1	1	500	2.69E-03	5.00E-01	4.83E+02	3.32E+01	1.58E+00	2.50E-17	1.63E-02	0.000270	0.000699	0.001830	1.573604	18.879283	89.40	67.69	1.275E-02	*3.78*
30-1	1	600	2.69E-03	6.00E-01	1.87E+02	4.22E+01	6.20E-01	3.33E-17	3.21E-02	0.000270	0.000699	0.001830	0.608988	7.711618	37.06	36.93	3.884E-03	*3.95*
30-1	1	800	2.69E-03	8.00E-01	7.69E+01	5.16E+01	2.31E-01	5.12E-17	5.65E-02	0.000270	0.000699	0.001830	0.217195	13.200723	62.98	13.72	1.133E-03	*16.33*
30-1	1	1000	2.69E-03	1.00E+00	5.10E+01	5.27E+01	1.38E-01	4.76E-17	7.92E-02	0.000270	0.000699	0.001830	0.123776	14.982804	71.31	19.71	6.321E-04	*27.91*
30-1	1	1200	2.69E-03	1.20E+00	2.48E+01	5.92E+01	5.07E-02	4.79E-17	1.02E-01	0.000270	0.000699	0.001830	0.034727	15.122266	71.96	12.11	1.578E-04	*57.66*
30-1	1	1500	2.69E-03	1.50E+00	1.84E+01	6.24E+01	3.21E-02	5.82E-17	1.30E-01	0.000270	0.000699	0.001830	0.015195	14.499643	69.06	11.15	6.548E-05	*74.32*
30-1	1	2000	2.69E-03	2.00E+00	1.72E+01	6.29E+01	2.32E-02	1.22E-16	**1.88E-01**	0.000270	0.000699	0.001830	0.006276	16.097479	**76.51**	**6.55**	2.687E-05	*87.80*
30-1	1	2500	2.69E-03	2.50E+00	1.62E+01	6.38E+01	1.91E-02	8.41E-17	**2.28E-01**	0.000270	0.000699	0.001830	0.001900	16.335410	**77.61**	**5.91**	8.011E-06	*94.94*
30-1	1	3000	2.69E-03	3.00E+00	1.64E+01	5.91E+01	1.29E-02	1.44E-16	**2.96E-01**	0.000270	0.000699	0.001830	0.000000	17.106151	**81.19**	**4.86**	0.000E+00	*98.48*
30-1	1	4000	2.69E-03	4.00E+00	1.63E+01	6.47E+01	1.67E-02	3.38E-16	**4.57E-01**	0.000270	0.000699	0.001830	0.000000	17.040232	**80.89**	**1.51**	0.000E+00	*98.33*
30-1	1	5000	2.69E-03	5.00E+00	1.65E+01	6.14E+01	1.70E-02	6.90E-16	**7.86E-01**	0.000270	0.000699	0.001830	0.000400	17.139558	**81.35**	**0.97**	1.753E-06	*97.71*
30-1	1	6000	2.69E-03	6.00E+00	1.62E+01	7.47E+01	2.23E-02	9.50E-17	**8.31E-01**	0.000270	0.000699	0.001830	0.002171	16.422932	**78.02**	**7.42**	7.824E-06	*94.18*
30-1	1	8000	2.69E-03	8.00E+00	1.63E+01	6.48E+01	1.95E-02	1.76E-16	**9.15E-01**	0.000270	0.000699	0.001830	0.002032	16.452746	**78.16**	**5.04**	8.439E-06	*94.71*
30-1	1	10000	2.69E-03	1.00E+01	1.60E+01	6.86E+01	1.88E-02	1.24E-16	**9.74E-01**	0.000270	0.000699	0.001830	0.000258	16.752116	**79.55**	**6.68**	1.011E-06	*97.76*
30-1	1	12000	2.69E-03	1.20E+01	1.59E+01	7.46E+01	3.12E-02	3.98E-17	9.93E-01	0.000270	0.000699	0.001830	0.011048	13.286789	63.38	15.00	3.985E-05	*77.87*
30-1	1	15000	2.69E-03	1.50E+01	1.66E+01	7.78E+01	2.63E-02	1.53E-17	1.00E+00	0.000270	0.000699	0.001830	0.005334	15.910631	75.64	47.87	1.846E-05	*88.68*

Age = 80.96±0.78 Ma
(2σ, including J-error of .102%)
MSWD = 0.83, probability = 0.56
84.4% of the 39Ar, steps 8 through 15

MSM19/3 DR35-1 feldspar

								Average 40*/39	1.537E+01
MASS=		4.064	mg	0.004064	g			Moles 40Ar*	7.402E-14
								Moles 40Ar*/g	1.821E-11
J =		2.69E-03	+/-	2.74E-06	(2 Sigma)	0.102 Percent	Reactor constants	%K in plag	1.429E-01

Step			J-value	Laser power (W)	40Ar/39Ar	37Ar/39Ar	36Ar/39Ar	Mol 39Ar	39Ar Fraction	36/37Ca	39/37Ca	40/39K	36c/39	F	Age [Ma]	2 Sigma [Ma]	Al/37	RAD%
35-1	3	600	2.69E-03	6.00E-01	4.24E+01	3.12E+01	9.00E-02	1.29E-17	3.17E-03	0.000270	0.000699	0.001830	0.081540	18.740396	88.76	57.94	7.037E-04	*42.87*
35-1	3	800	2.69E-03	8.00E-01	4.54E+01	3.02E+01	1.17E-01	2.69E-17	8.76E-03	0.000270	0.000699	0.001830	0.108460	13.646899	65.07	26.77	9.668E-04	*29.20*
35-1	3	1000	2.69E-03	1.00E+00	5.48E+01	2.98E+01	1.37E-01	2.05E-17	1.30E-02	0.000270	0.000699	0.001830	0.128957	17.037749	80.88	29.43	1.163E-03	*30.22*
35-1	3	1200	2.69E-03	1.20E+00	3.60E+01	3.45E+01	8.07E-02	2.40E-17	1.80E-02	0.000270	0.000699	0.001830	0.071379	15.308932	72.83	20.43	5.569E-04	*41.10*
35-1	3	1500	2.69E-03	1.50E+00	1.94E+01	2.86E+01	2.68E-02	9.63E-17	3.80E-02	0.000270	0.000699	0.001830	0.019106	13.992074	66.68	7.34	1.797E-04	*70.32*
35-1	3	2000	2.69E-03	2.00E+00	1.61E+01	3.29E+01	1.40E-02	2.84E-16	**9.68E-02**	0.000270	0.000699	0.001830	0.005103	14.891641	**70.89**	**2.10**	4.174E-05	*89.85*
35-1	3	2500	2.69E-03	2.50E+00	1.59E+01	3.37E+01	1.26E-02	4.02E-16	**1.80E-01**	0.000270	0.000699	0.001830	0.003498	15.243487	**72.53**	**1.67**	2.791E-05	*92.70*
35-1	3	3000	2.69E-03	3.00E+00	1.53E+01	3.41E+01	1.01E-02	4.24E-16	**2.68E-01**	0.000270	0.000699	0.001830	0.000933	15.341923	**72.99**	**1.64**	7.357E-06	*97.34*
35-1	3	4000	2.69E-03	4.00E+00	1.54E+01	3.25E+01	1.09E-02	1.02E-15	**4.80E-01**	0.000270	0.000699	0.001830	0.002153	15.081337	**71.77**	**0.77**	1.780E-05	*95.07*
35-1	3	5000	2.69E-03	5.00E+00	1.52E+01	3.44E+01	9.79E-03	3.94E-16	**5.62E-01**	0.000270	0.000699	0.001830	0.000503	15.384855	**73.19**	**1.98**	3.932E-06	*98.15*
35-1	3	6000	2.69E-03	6.00E+00	1.53E+01	3.78E+01	1.16E-02	5.12E-16	**6.68E-01**	0.000270	0.000699	0.001830	0.001369	15.266021	**72.63**	**1.74**	9.733E-06	*96.41*
35-1	3	8000	2.69E-03	8.00E+00	1.51E+01	3.60E+01	1.16E-02	3.71E-16	**7.45E-01**	0.000270	0.000699	0.001830	0.001872	14.930978	**71.07**	**1.57**	1.398E-05	*95.46*
35-1	3	10000	2.69E-03	1.00E+01	1.54E+01	3.38E+01	1.04E-02	7.83E-16	**9.08E-01**	0.000270	0.000699	0.001830	0.001254	15.387382	**73.20**	**1.20**	9.983E-06	*96.75*
35-1	3	12000	2.69E-03	1.20E+01	1.51E+01	3.46E+01	1.07E-02	3.93E-16	**9.89E-01**	0.000270	0.000699	0.001830	0.001300	15.073964	**71.74**	**2.23**	1.010E-05	*96.60*
35-1	3	15000	2.69E-03	1.50E+01	1.86E+01	3.51E+01	2.20E-02	5.25E-17	1.00E+00	0.000270	0.000699	0.001830	0.012550	15.251830	72.57	10.14	9.632E-05	*79.33*

Age = 72.18±0.48 Ma
(2σ, including J-error of .102%)
MSWD = 1.3, probability = 0.26
95.1% of the 39Ar, steps 6 through 14

MSM19/3 DR39-2 feldspar

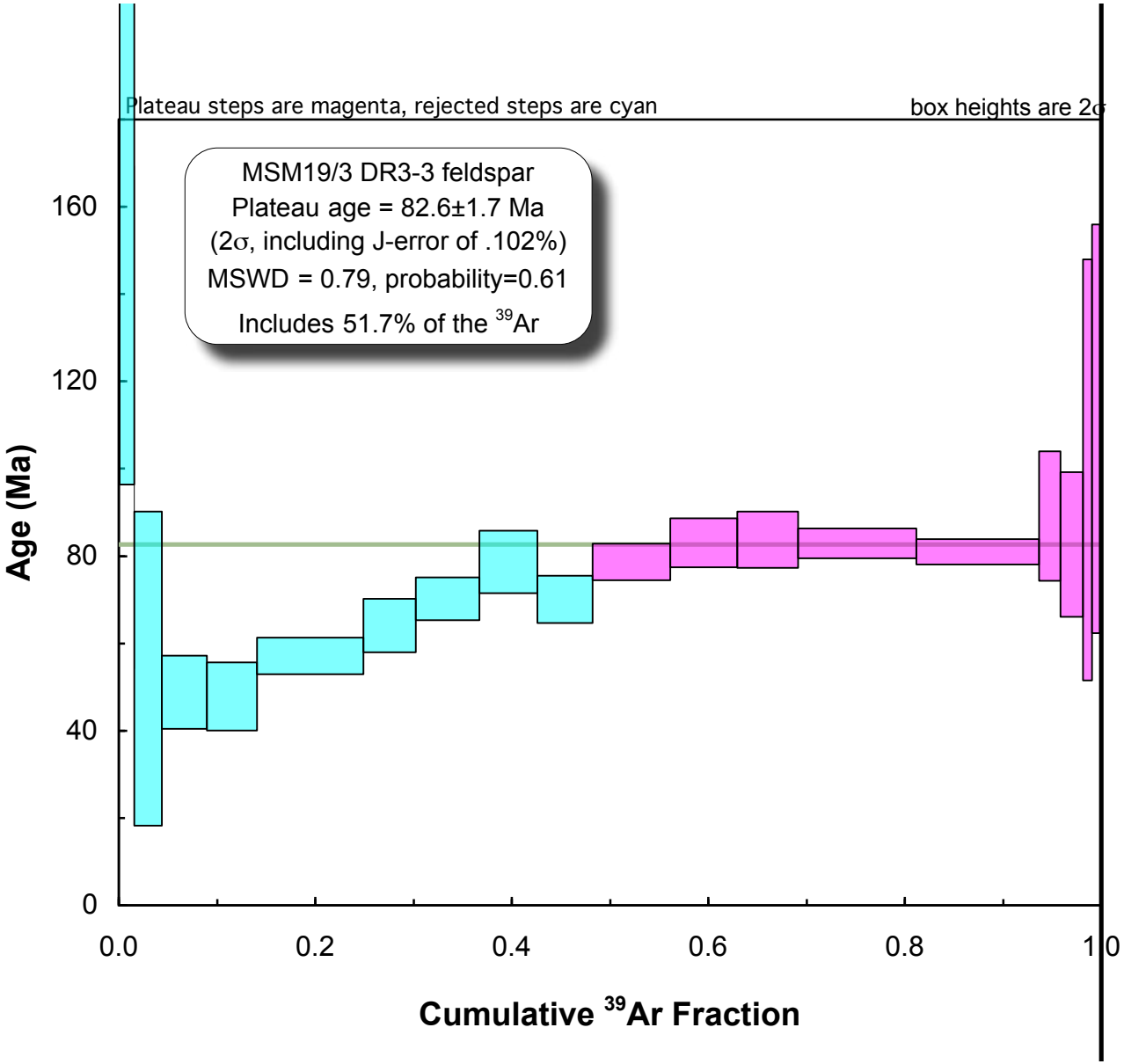
															Average 40*/39	1.559E+01	
MASS=			6.764	mg	0.006764	g									Moles 40Ar*	8.180E-13	
															Moles 40Ar*/g	1.209E-10	
J =			2.75E-03	+/-	2.04E-06	(2 Sigma)		0.074 Percent	Reactor constants						%K in plag	9.102E-01	
Step		**J-value**	**Laser power (W)**	**40Ar/39Ar**	**37Ar/39Ar**	**36Ar/39Ar**	**Mol 39Ar**	**39Ar Fraction**	**36/37Ca**	**39/37Ca**	**40/39K**	**36c/39**	**F**	**Age [Ma]**	**2 Sigma [Ma]**	**Al/37**	**RAD%**
39-2	6 100	2.75E-03	1.00E-01	5.80E+01	4.35E+00	1.43E-01	4.01E-15	7.64E-02	0.000270	0.000699	0.001830	0.142217	16.067435	78.00	1.00	8.984E-03	*27.57*
39-2	6 150	2.75E-03	1.50E-01	3.03E+01	4.56E+00	5.14E-02	3.91E-15	**1.51E-01**	0.000270	0.000699	0.001830	0.050178	15.551806	**75.55**	**0.80**	3.028E-03	*51.05*
39-2	6 200	2.75E-03	2.00E-01	3.15E+01	4.58E+00	5.59E-02	2.66E-15	**2.02E-01**	0.000270	0.000699	0.001830	0.054657	15.406979	**74.86**	**0.87**	3.284E-03	*48.68*
39-2	6 300	2.75E-03	3.00E-01	3.18E+01	5.03E+00	5.78E-02	4.12E-15	**2.80E-01**	0.000270	0.000699	0.001830	0.056437	15.183543	**73.80**	**1.03**	3.084E-03	*47.51*
39-2	6 400	2.75E-03	4.00E-01	3.03E+01	4.73E+00	5.26E-02	3.97E-15	**3.56E-01**	0.000270	0.000699	0.001830	0.051298	15.236122	**74.05**	**1.20**	2.979E-03	*49.98*
39-2	6 500	2.75E-03	5.00E-01	2.96E+01	4.50E+00	4.91E-02	3.68E-15	**4.26E-01**	0.000270	0.000699	0.001830	0.047875	15.480611	**75.21**	**0.74**	2.925E-03	*52.11*
39-2	6 600	2.75E-03	6.00E-01	2.85E+01	4.48E+00	4.52E-02	3.46E-15	**4.92E-01**	0.000270	0.000699	0.001830	0.043985	15.537209	**75.48**	**0.79**	2.702E-03	*54.31*
39-2	6 700	2.75E-03	7.00E-01	2.73E+01	4.30E+00	4.14E-02	2.87E-15	**5.47E-01**	0.000270	0.000699	0.001830	0.040283	15.426947	**74.95**	**0.79**	2.577E-03	*56.31*
39-2	6 800	2.75E-03	8.00E-01	2.62E+01	4.37E+00	3.75E-02	2.73E-15	**5.99E-01**	0.000270	0.000699	0.001830	0.036364	15.521100	**75.40**	**0.86**	2.287E-03	*58.95*
39-2	6 900	2.75E-03	9.00E-01	2.46E+01	4.41E+00	3.17E-02	2.39E-15	**6.45E-01**	0.000270	0.000699	0.001830	0.030547	15.621768	**75.88**	**0.99**	1.907E-03	*63.23*
39-2	6 1000	2.75E-03	1.00E+00	2.32E+01	4.26E+00	2.59E-02	2.15E-15	6.85E-01	0.000270	0.000699	0.001830	0.024754	15.951127	77.45	1.02	1.598E-03	*68.42*
39-2	6 1200	2.75E-03	1.20E+00	2.03E+01	4.62E+00	1.75E-02	3.60E-15	7.54E-01	0.000270	0.000699	0.001830	0.016215	15.575052	75.66	0.62	9.653E-04	*76.32*
39-2	6 1500	2.75E-03	1.50E+00	1.84E+01	4.64E+00	1.07E-02	2.97E-15	8.11E-01	0.000270	0.000699	0.001830	0.009476	15.612630	75.84	0.76	5.612E-04	*84.65*
39-2	6 2000	2.75E-03	2.00E+00	1.71E+01	5.68E+00	6.79E-03	2.97E-15	8.67E-01	0.000270	0.000699	0.001830	0.005256	15.656839	76.05	0.39	2.543E-04	*90.81*
39-2	6 3000	2.75E-03	3.00E+00	1.70E+01	6.96E+00	6.34E-03	2.42E-15	9.13E-01	0.000270	0.000699	0.001830	0.004463	15.713910	76.32	0.28	1.763E-04	*92.05*
39-2	6 4000	2.75E-03	4.00E+00	1.68E+01	8.02E+00	6.62E-03	1.25E-15	9.37E-01	0.000270	0.000699	0.001830	0.004451	15.615482	75.85	0.74	1.527E-04	*92.00*
39-2	6 6000	2.75E-03	6.00E+00	1.69E+01	8.45E+00	6.18E-03	1.36E-15	9.63E-01	0.000270	0.000699	0.001830	0.003895	15.832986	76.89	0.80	1.268E-04	*92.98*
39-2	6 8000	2.75E-03	8.00E+00	1.70E+01	8.39E+00	6.68E-03	7.29E-16	9.77E-01	0.000270	0.000699	0.001830	0.004418	15.787294	76.67	1.04	1.448E-04	*92.12*
39-2	6 10000	2.75E-03	1.00E+01	1.66E+01	9.98E+00	7.68E-03	7.66E-16	9.91E-01	0.000270	0.000699	0.001830	0.004987	15.265959	74.19	1.08	1.374E-04	*90.91*
39-2	6 15000	2.75E-03	1.50E+01	1.71E+01	9.68E+00	7.36E-03	4.54E-16	1.00E+00	0.000270	0.000699	0.001830	0.004749	15.785465	76.66	1.44	1.349E-04	*91.56*

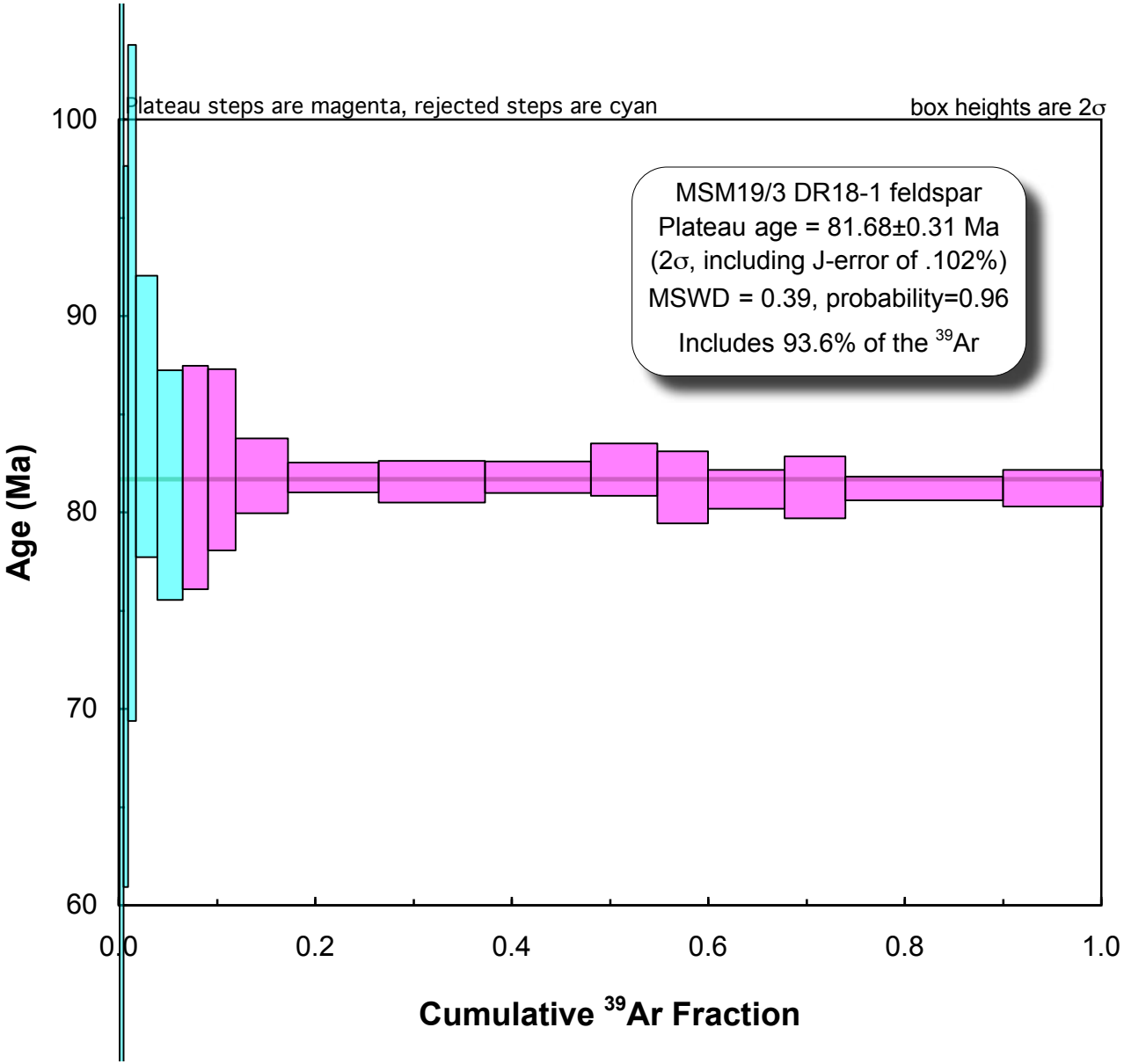
Age = 75.12±0.29 Ma
(2σ, including J-error of .074%)
MSWD = 1.9, probability = 0.055
56.8% of the 39Ar, steps 2 through 10

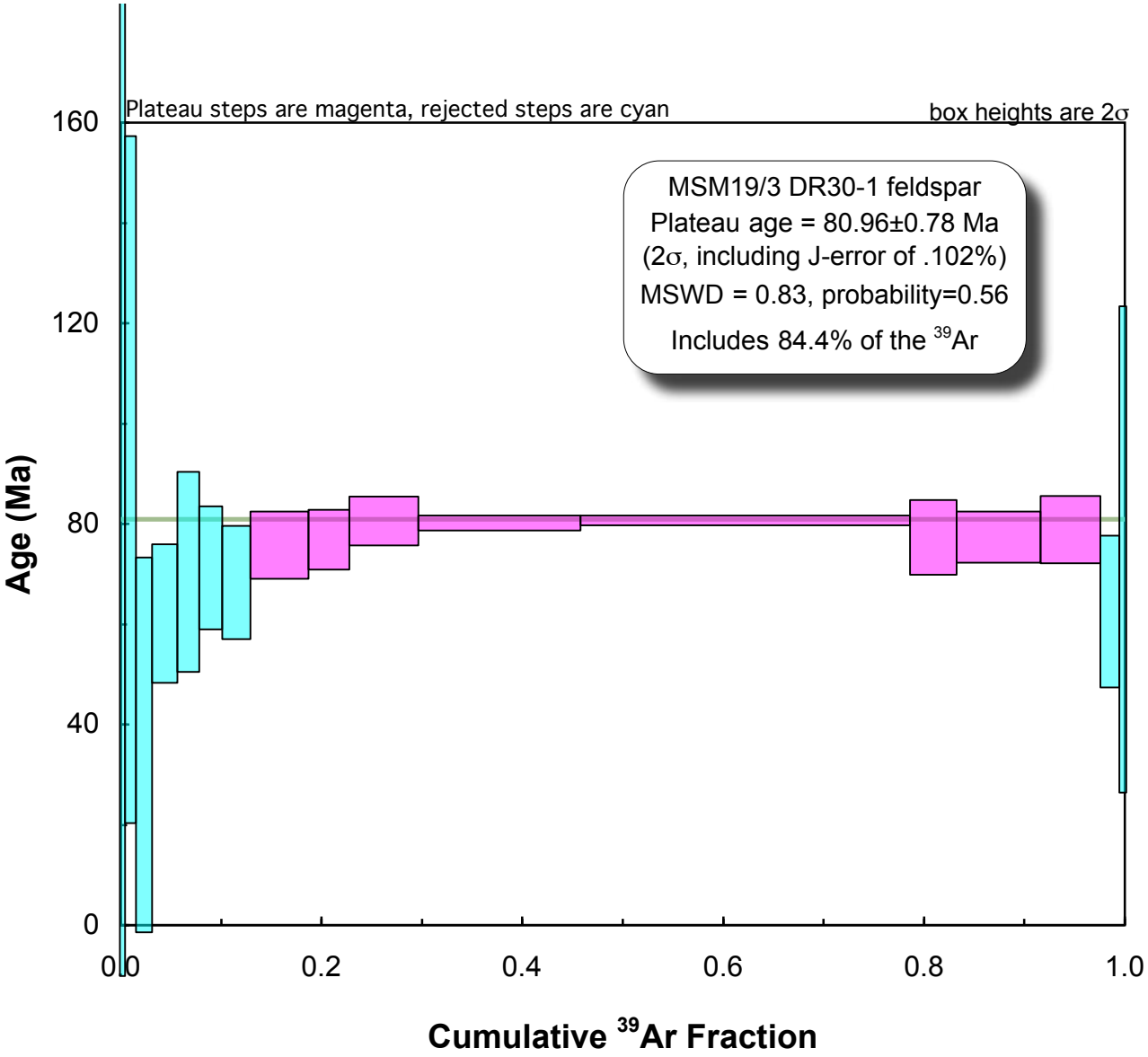
MSM19/3 DR42-1 feldspar

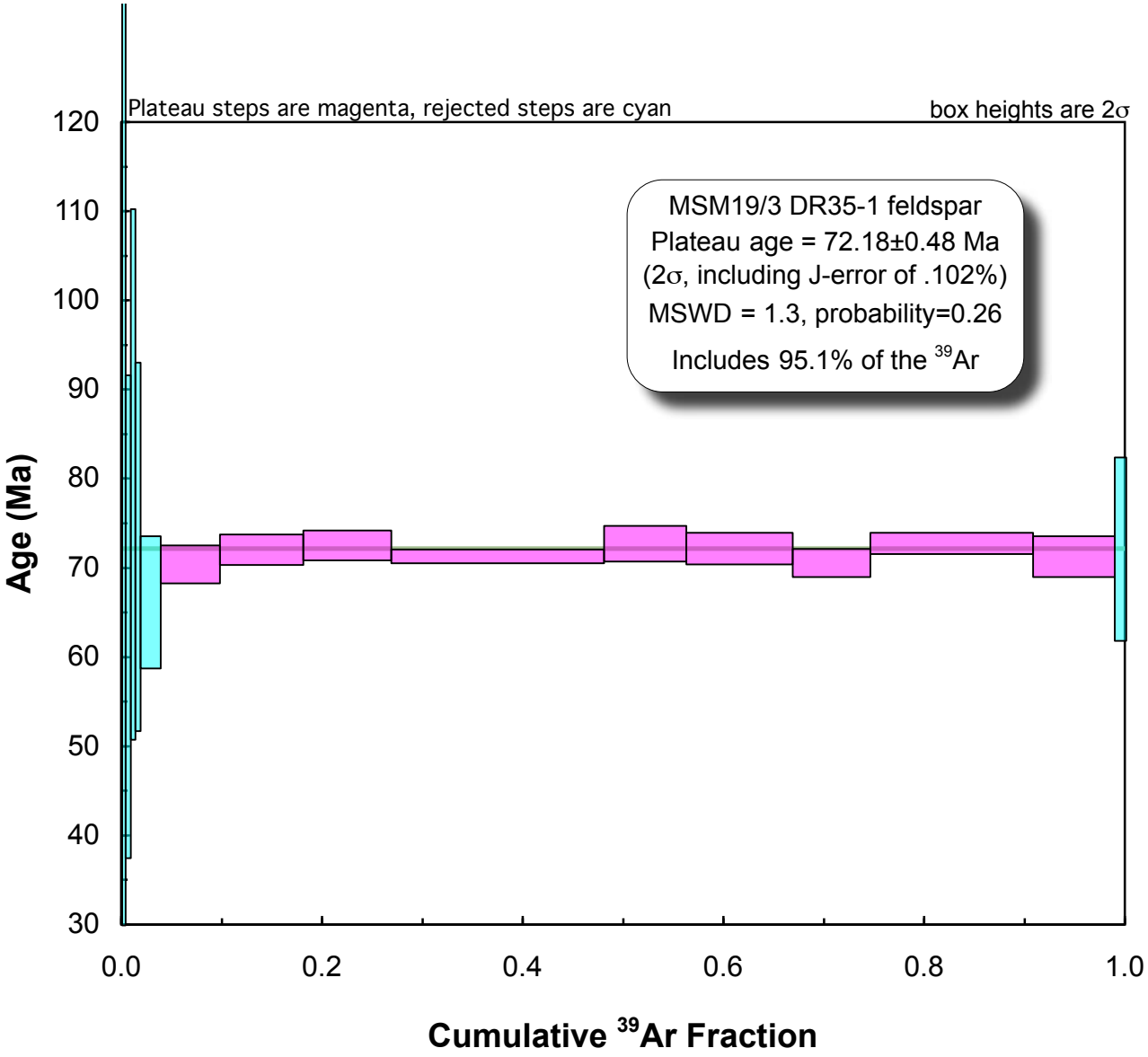
															Average 40*/39	1.627E+01	
MASS=			4.164	mg	0.004164	g									Moles 40Ar*	2.133E-13	
															Moles 40Ar*/g	5.123E-11	
J =			2.69E-03	+/-	2.74E-06	(2 Sigma)		0.102 Percent	Reactor constants						%K in plag	3.910E-01	
Step		**J-value**	**Laser power (W)**	**40Ar/39Ar**	**37Ar/39Ar**	**36Ar/39Ar**	**Mol 39Ar**	**39Ar Fraction**	**36/37Ca**	**39/37Ca**	**40/39K**	**36c/39**	**F**	**Age [Ma]**	**2 Sigma [Ma]**	**Al/37**	**RAD%**
42-1	5 400	2.69E-03	4.00E-01	3.80E+03	3.34E+01	1.27E+01	1.13E-17	1.51E-03	0.000270	0.000699	0.001830	########	53.571330	242.96	202.61	1.022E-01	*1.37*
42-1	5 500	2.69E-03	5.00E-01	9.46E+02	1.78E+01	3.15E+00	3.61E-17	4.26E-03	0.000270	0.000699	0.001830	3.147074	16.402008	77.92	37.56	4.757E-02	*1.70*
42-1	5 600	2.69E-03	6.00E-01	2.06E+02	1.49E+01	6.51E-01	8.16E-17	1.05E-02	0.000270	0.000699	0.001830	0.647364	14.715390	70.06	12.09	1.169E-02	*7.05*
42-1	5 800	2.69E-03	8.00E-01	9.19E+01	1.40E+01	2.59E-01	2.38E-16	2.86E-02	0.000270	0.000699	0.001830	0.255155	16.684782	79.24	5.35	4.913E-03	*17.91*
42-1	5 1000	2.69E-03	1.00E+00	3.94E+01	1.41E+01	8.12E-02	2.39E-16	4.68E-02	0.000270	0.000699	0.001830	0.077347	16.716705	79.39	3.60	1.471E-03	*41.85*
42-1	5 1200	2.69E-03	1.20E+00	3.33E+01	1.37E+01	6.48E-02	2.54E-16	6.62E-02	0.000270	0.000699	0.001830	0.061040	15.439198	73.44	3.01	1.195E-03	*45.72*
42-1	5 1500	2.69E-03	1.50E+00	4.16E+01	1.41E+01	6.72E-02	3.79E-16	9.51E-02	0.000270	0.000699	0.001830	0.063398	23.059618	108.62	3.19	1.213E-03	*54.74*
42-1	5 2000	2.69E-03	2.00E+00	2.18E+01	1.39E+01	1.79E-02	4.56E-16	1.30E-01	0.000270	0.000699	0.001830	0.014170	17.742617	84.15	1.90	2.741E-04	*80.47*
42-1	5 2500	2.69E-03	2.50E+00	1.78E+01	1.34E+01	1.10E-02	1.08E-15	2.12E-01	0.000270	0.000699	0.001830	0.007405	15.789035	75.07	0.76	1.486E-04	*87.43*
42-1	5 3000	2.69E-03	3.00E+00	1.56E+01	1.37E+01	4.43E-03	1.87E-15	**3.54E-01**	0.000270	0.000699	0.001830	0.000736	15.510234	**73.77**	**0.46**	1.447E-05	*98.26*
42-1	5 4000	2.69E-03	4.00E+00	1.61E+01	1.38E+01	5.78E-03	1.20E-15	**4.46E-01**	0.000270	0.000699	0.001830	0.002056	15.594876	**74.17**	**0.69**	4.016E-05	*95.88*
42-1	5 5000	2.69E-03	5.00E+00	1.56E+01	1.38E+01	4.09E-03	1.34E-15	**5.48E-01**	0.000270	0.000699	0.001830	0.000373	15.592651	**74.16**	**0.78**	7.277E-06	*98.94*
42-1	5 6000	2.69E-03	6.00E+00	1.54E+01	1.35E+01	3.97E-03	2.06E-15	**7.04E-01**	0.000270	0.000699	0.001830	0.000314	15.424849	**73.37**	**0.46**	6.244E-06	*99.05*
42-1	5 8000	2.69E-03	8.00E+00	1.55E+01	1.37E+01	3.65E-03	1.67E-15	**8.32E-01**	0.000270	0.000699	0.001830	0.000000	15.603401	**74.21**	**0.45**	0.000E+00	*99.65*
42-1	5 10000	2.69E-03	1.00E+01	1.55E+01	1.37E+01	3.75E-03	1.46E-15	**9.42E-01**	0.000270	0.000699	0.001830	0.000063	15.618696	**74.28**	**0.60**	1.236E-06	*99.53*
42-1	5 12000	2.69E-03	1.20E+01	1.53E+01	1.33E+01	4.54E-03	6.82E-16	9.94E-01	0.000270	0.000699	0.001830	0.000939	15.171970	72.19	1.02	1.896E-05	*97.85*
42-1	5 15000	2.69E-03	1.50E+01	1.65E+01	1.30E+01	8.02E-03	7.36E-17	1.00E+00	0.000270	0.000699	0.001830	0.004508	15.310917	72.84	9.25	9.328E-05	*91.62*

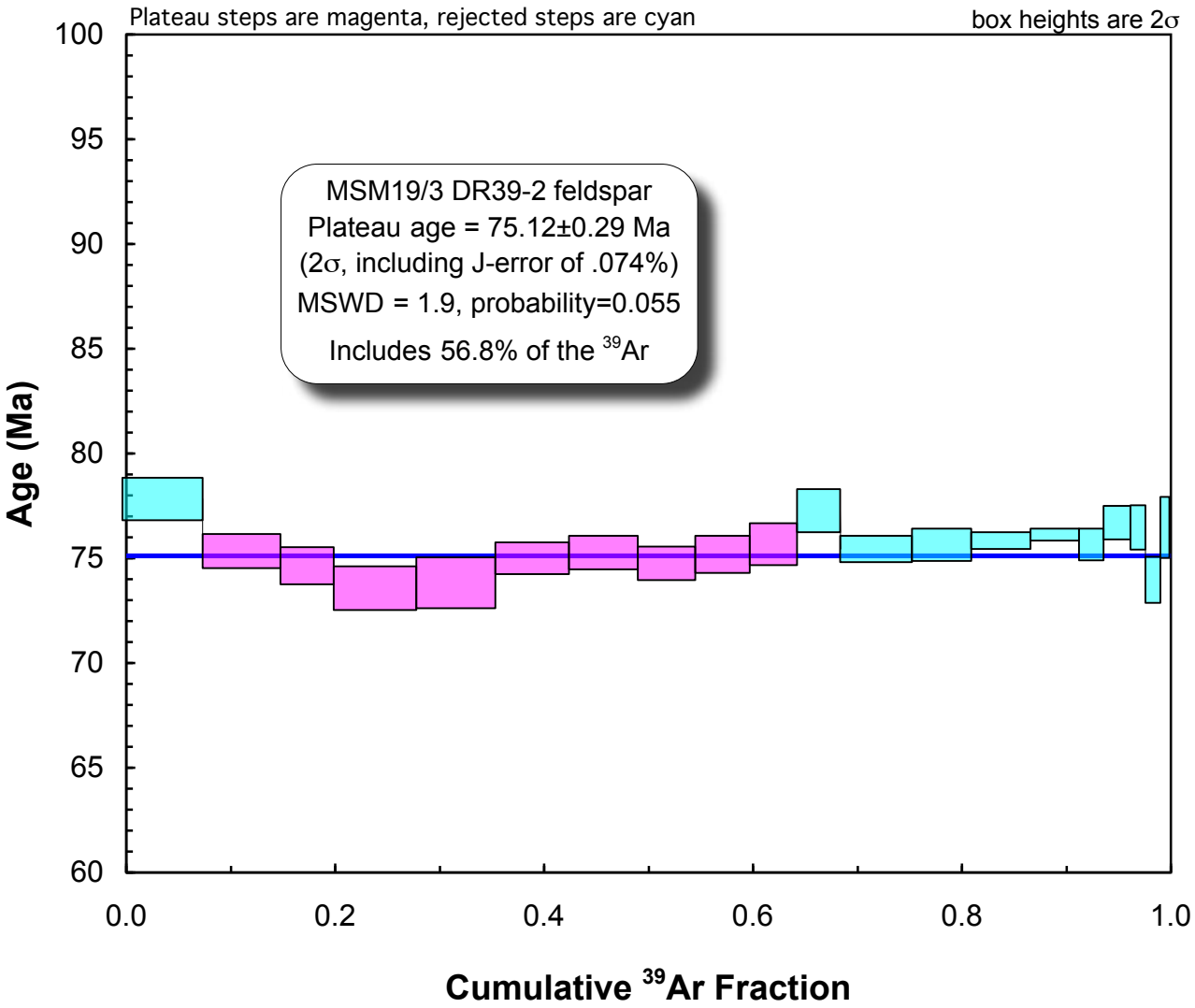
Age = 73.92±0.23 Ma
(2σ, including J-error of .102%)
MSWD = 2.0, probability = 0.080
73% of the 39Ar, steps 10 through 15

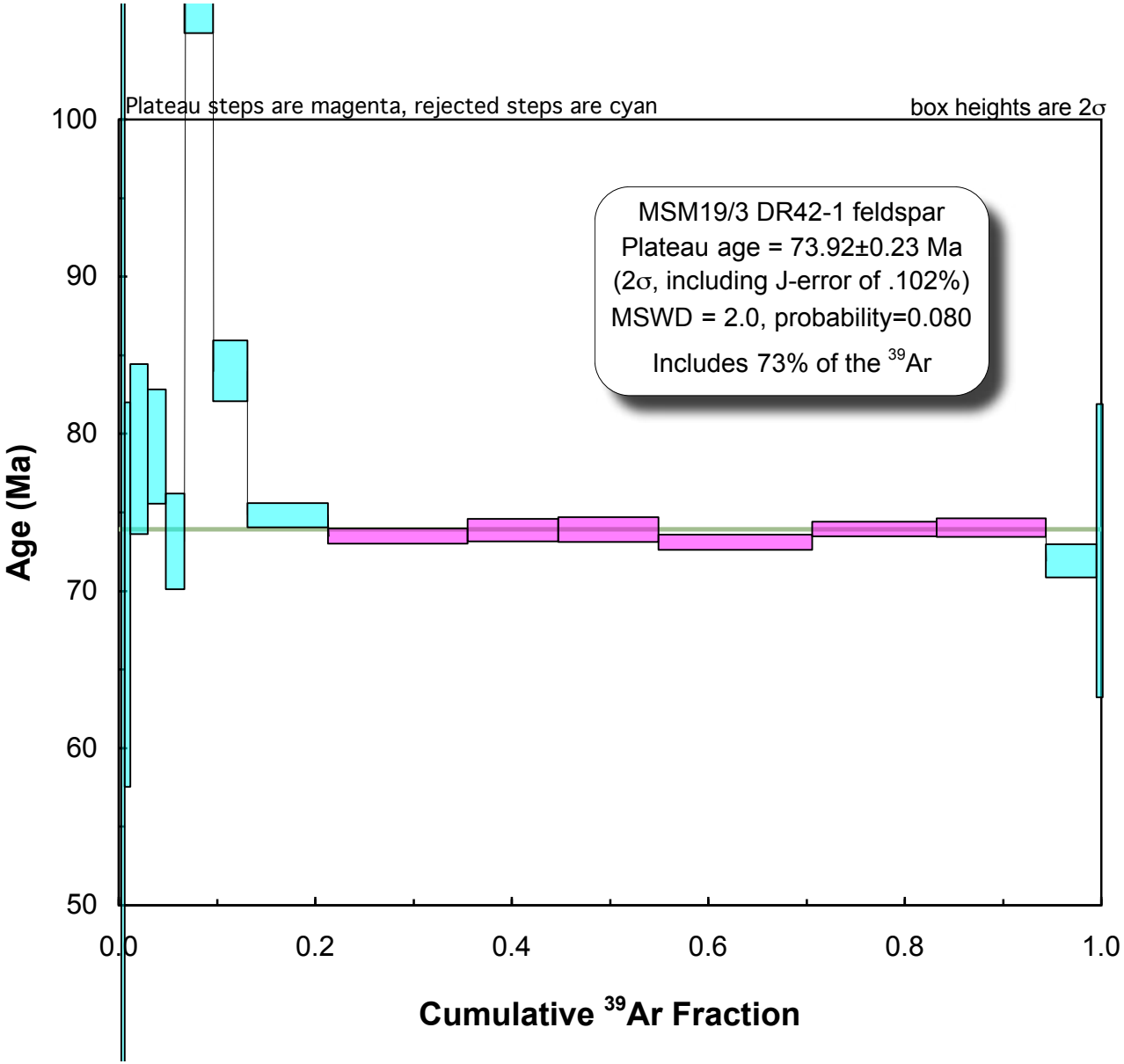

Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
MSM19/3 DR3-3 feldspar
Plateau age = 82.6±1.7 Ma
(2σ, including J-error of .102%)
MSWD = 0.79, probability=0.61
Includes 51.7% of the 39Ar
Age (Ma)
0
40
80
120
160
0.0
0.2
0.4
0.6
0.8
1.0
Cumulative 39Ar Fraction


Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
MSM19/3 DR18-1 feldspar
Plateau age = 81.68±0.31 Ma
(2σ, including J-error of .102%)
MSWD = 0.39, probability=0.96
Includes 93.6% of the 39Ar
Age (Ma)
100
90
80
70
60
0.0
0.2
0.4
0.6
0.8
1.0
Cumulative 39Ar Fraction


Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
MSM19/3 DR30-1 feldspar
Plateau age = 80.96±0.78 Ma
(2σ, including J-error of .102%)
MSWD = 0.83, probability=0.56
Includes 84.4% of the 39Ar
Age (Ma)
160
120
80
40
0
0.0
0.2
0.4
0.6
0.8
1.0
Cumulative 39Ar Fraction


Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
MSM19/3 DR35-1 feldspar
Plateau age = 72.18±0.48 Ma
(2σ, including J-error of .102%)
MSWD = 1.3, probability=0.26
Includes 95.1% of the 39Ar
Age (Ma)
120
110
100
90
80
70
60
50
40
30
0.0
0.2
0.4
0.6
0.8
1.0
Cumulative 39Ar Fraction


Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
MSM19/3 DR39-2 feldspar
Plateau age = 75.12±0.29 Ma
(2σ, including J-error of .074%)
MSWD = 1.9, probability=0.055
Includes 56.8% of the 39Ar
Age (Ma)
100
95
90
85
80
75
70
65
60
0.0
0.2
0.4
0.6
0.8
1.0
Cumulative 39Ar Fraction


Plateau steps are magenta, rejected steps are cyan
box heights are 2σ
MSM19/3 DR42-1 feldspar
Plateau age = 73.92±0.23 Ma
(2σ, including J-error of .102%)
MSWD = 2.0, probability=0.080
Includes 73% of the 39Ar
Age (Ma)
100
90
80
70
60
50
0.0
0.2
0.4
0.6
0.8
1.0
Cumulative 39Ar Fraction

Appendix DR2: Major element, trace element and isotope analytical methods and data.

Only the freshest cores of rock samples were used for the preparation of rock chips and powders. The samples were crushed, sieved, multiply washed in deionized water and dried at 50°C. The macroscopically freshest chips and minerals were subsequently picked under a binocular microscope. A part of the rock chips was further powdered using an agate mortar grinder and a planetary ball mill.

Major element compositions were measured by X-Ray Fluorescence Analysis (XRF) at the Institute of Mineralogy and Petrography at the University of Hamburg, and the analyses were conducted on fused pellets using a Magix Pro PW 2540 XRF. Six rock standards (JGB-1, JB-3, JB-2, JA-3, JG-3 and JG-2) were measured along with the samples. The reproducibility is typically better than 3% and the accuracy lies within 3% of the published reference values (Govindaraju, 1994) for most of the elements (**Appendix DR2, Table A1**). Major element data of the samples are provided in **Appendix DR2, Table A4**.

Trace element concentrations were determined by inductively coupled plasma mass spectrometry (ICP-MS) at the Institute of Geosciences, Christian-Albrechts-University of Kiel, on an AGILENT 7500cs ICP-MS. 100mg of sample powder was dissolved following the method described in Garbe-Schönberg (1993). Reference material BHVO-2 analyzed along with the samples agrees within 4% for most elements with the GeoReM reference values (**Appendix DR2, Table A2**). Precision for sample replicates by means of separate digestions is typically better than 2% (**Appendix DR2, Table A3**). The trace element data are included in **Appendix DR2, Table A5**.

Radiogenic isotope ratios were determined at GEOMAR Helmholtz Centre for Ocean Research Kiel by thermal ionization mass spectrometry (TIMS, Sr-Nd-Pb) and multicollector ICPMS (MC-ICPMS, Hf). The measured and initial data of the samples are included in

Appendix DR2, Table A6. 100-250mg leached whole-rock chips (2N HCl at 70°C for 1 hour followed by triple rinsing in 18.2 MΩ water) were used for Sr-Nd-Pb while Hf used 200-300mg of unleached powder. Additionally, Sr isotope ratios were measured on 100mg rock powder leached in 6N HCl at 150°C for 48h in an attempt to reduce further the effects of possible seawater alteration. The analyses show that the strong leaching does not always result in the least radiogenic Sr isotope ratios and thus the lowest Sr isotope ratio was used (see Appendix DR2, Table A6). Element chromatography followed established standard procedures (Blichert-Toft et al., 1997; Hoernle et al., 2008). Sr and Nd isotope ratios were measured on Thermo Fisher TRITON and TRITON+ instruments operating in static multi-collection mode. Within run mass-bias correction used $^{86}Sr/^{88}Sr = 0.1194$ and $^{146}Nd/^{144}Nd = 0.7219$. Measurement errors are reported as 2σ standard error (2SE), while the reproducibility of data is referred to as 2σ standard deviation (2SD). Sample data are reported relative to $^{86}Sr/^{88}Sr = 0.710250 \pm 0.000007$ (NBS987; n= 49; 2SD) and $^{143}Nd/^{144}Nd = 0.511850 \pm 0.000006$ (La Jolla; n = 89; 2SD) for both instruments. Pb isotopes were measured on a Finnigan MAT 262 RPQ^{2+} applying the Pb double-spike (Pb-DS) technique of Hoernle et al. (2011). Double-spike corrected NBS981 values are $^{206}Pb/^{204}Pb = 16.9432 \pm 0.0026$, $^{207}Pb/^{204}Pb = 15.5005 \pm 0.0026$ and $^{208}Pb/^{204}Pb = 36.7284 \pm 0.0062$ (n = 19; 2SD). Hf isotope ratios were measured on a Nu plasma MC-ICPMS in static mode. Our in-house SPEX Hf ICP standard solution (lot #9) was normalized to JMC475 with $^{176}Hf/^{177}Hf = 0.282163$ and generated an average standard bracketing normalized ratio of $^{176}Hf/^{177}Hf = 0.282170 \pm 0.000005$ (n = 85; 2SD). Total chemistry blanks for Sr, Nd, Pb and Hf were <100pg, <50pg, <35pg and <50 pg respectively and thus were considered negligible.

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Appendix DR2 Table A1.
Reproducibility and accuracy of major element data for several rock standards

Element (wt.%)	JGB-1 #1	JGB-1 #2	JGB-1 #3	Mean	Std. dev. (±1σ abs)	Std. dev. (±1σ %)	Ref. value[1]	Rel. dev. (%)
SiO_2	44.39	43.59	43.97	43.98	0.40	0.91	43.44	*1.3*
Al_2O_3	17.89	17.71	17.41	17.67	0.24	1.37	17.66	*0.1*
Fe_2O_3	15.56	15.38	15.07	15.34	0.25	1.62	15.16	*1.2*
MnO	0.19	0.19	0.19	0.19	0.00	0.00	0.17	*11.8*
MgO	8.29	7.71	7.72	7.91	0.33	4.20	7.83	*1.0*
CaO	12.12	11.79	11.72	11.88	0.21	1.80	11.98	*-0.9*
Na_2O	1.25	1.25	1.30	1.27	0.03	2.28	1.23	*3.0*
K_2O	0.23	0.23	0.23	0.23	0.00	0.00	0.24	*-4.2*
TiO_2	1.60	1.62	1.61	1.61	0.01	0.62	1.62	*-0.6*
P_2O_5	0.06	0.06	0.05	0.06	0.01	10.19	0.05	*13.3*

Element (wt.%)	JB-3 #1	JB-3 #2	JB-3 #3	Mean	Std. dev. (±1σ abs)	Std. dev. (±1σ %)	Ref. value[1]	Rel. dev. (%)
SiO_2	51.11	50.17	50.63	50.64	0.47	0.93	51.04	*-0.8*
Al_2O_3	17.27	17.10	16.89	17.09	0.19	1.11	16.89	*1.2*
Fe_2O_3	12.01	11.82	11.64	11.82	0.19	1.56	11.88	*-0.5*
MnO	0.18	0.17	0.17	0.17	0.01	3.33	0.16	*8.3*
MgO	5.42	5.01	5.05	5.16	0.23	4.38	5.2	*-0.8*
CaO	9.86	9.57	9.60	9.68	0.16	1.65	9.86	*-1.9*
Na_2O	3.12	3.11	2.77	3.00	0.20	6.64	2.82	*6.4*
K_2O	0.77	0.76	0.75	0.76	0.01	1.32	0.78	*-2.6*
TiO_2	1.40	1.42	1.43	1.42	0.02	1.08	1.45	*-2.3*
P_2O_5	0.29	0.28	0.29	0.29	0.01	2.01	0.29	*-1.1*

Element (wt.%)	JB-2 #1	JB-2 #2	JB-2 #3	Mean	Std. dev. (±1σ abs)	Std. dev. (±1σ %)	Ref. value[1]	Rel. dev. (%)
SiO_2	54.37	53.46	54.09	53.97	0.47	0.86	53.2	*1.5*
Al_2O_3	15.00	14.83	14.68	14.84	0.16	1.08	14.67	*1.1*
Fe_2O_3	14.56	14.45	14.23	14.41	0.17	1.17	14.34	*0.5*
MnO	0.22	0.21	0.22	0.22	0.01	2.66	0.2	*8.3*
MgO	4.88	4.53	4.57	4.66	0.19	4.11	4.66	*0.0*
CaO	10.08	9.83	9.78	9.90	0.16	1.62	9.89	*0.1*
Na_2O	2.08	2.08	2.11	2.09	0.02	0.83	2.03	*3.0*
K_2O	0.42	0.42	0.41	0.42	0.01	1.39	0.42	*-0.8*
TiO_2	1.17	1.19	1.19	1.18	0.01	0.98	1.19	*-0.6*
P_2O_5	0.10	0.09	0.09	0.09	0.01	6.19	0.1	*-6.7*

Appendix DR2 Table A1. continued

Element (wt.%)	JA-3 #1	JA-3 #2	JA-3 #3	Mean	Std. dev. (±1σ abs)	Std. dev. (±1σ %)	Ref. value[1]	Rel. dev. (%)
SiO_2	62.13	61.92	61.71	61.92	0.21	0.34	62.26	*-0.5*
Al_2O_3	15.60	15.75	15.20	15.52	0.28	1.83	15.57	*-0.3*
Fe_2O_3	6.47	6.56	6.33	6.45	0.12	1.80	6.59	*-2.1*
MnO	0.10	0.10	0.10	0.10	0.00	0.00	0.106	*-5.7*
MgO	3.88	3.66	3.58	3.71	0.16	4.19	3.65	*1.6*
CaO	6.27	6.27	6.11	6.22	0.09	1.49	6.28	*-1.0*
Na_2O	3.09	3.10	3.15	3.11	0.03	1.03	3.17	*-1.8*
K_2O	1.37	1.39	1.37	1.38	0.01	0.84	1.41	*-2.4*
TiO_2	0.67	0.70	0.68	0.68	0.02	2.24	0.68	*0.5*
P_2O_5	0.11	0.11	0.11	0.11	0.00	0.00	0.11	*0.0*

Element (wt.%)	JG-3 #1	JG-3 #2	JG-3 #3	Mean	Std. dev. (±1σ abs)	Std. dev. (±1σ %)	Ref. value[1]	Rel. dev. (%)
SiO_2	67.68	66.40	67.19	67.09	0.65	0.96	67.1	*0.0*
Al_2O_3	15.64	15.47	15.25	15.45	0.20	1.27	15.52	*-0.4*
Fe_2O_3	3.72	3.70	3.66	3.69	0.03	0.83	3.73	*-1.0*
MnO	0.07	0.07	0.07	0.07	0.00	0.00	0.072	*-2.8*
MgO	1.92	1.77	1.76	1.82	0.09	4.93	1.79	*1.5*
CaO	3.84	3.74	3.74	3.77	0.06	1.53	3.76	*0.4*
Na_2O	4.06	4.01	4.15	4.07	0.07	1.74	4.03	*1.1*
K_2O	2.62	2.61	2.62	2.62	0.01	0.22	2.63	*-0.5*
TiO_2	0.47	0.48	0.48	0.48	0.01	1.21	0.48	*-0.7*
P_2O_5	0.13	0.13	0.12	0.13	0.01	4.56	0.12	*3.8*

Element (wt.%)	JG-2 #1	JG-2 #2	JG-2 #3	Mean	Std. dev. (±1σ abs)	Std. dev. (±1σ %)	Ref. value[1]	Rel. dev. (%)
SiO_2	77.73	76.61	77.76	77.37	0.66	0.85	76.95	*0.5*
Al_2O_3	12.55	12.43	12.32	12.43	0.12	0.93	12.41	*0.2*
Fe_2O_3	0.93	0.92	0.90	0.92	0.02	1.67	0.92	*-0.4*
MnO	0.02	0.02	0.02	0.02	0.00	0.00	0.015	*33.3*
MgO	0.06	0.05	0.03	0.05	0.02	32.73	0.04	*16.7*
CaO	0.70	0.70	0.71	0.70	0.01	0.82	0.8	*-12.1*
Na_2O	3.59	3.61	3.67	3.62	0.04	1.15	3.55	*2.1*
K_2O	4.70	4.68	4.71	4.70	0.02	0.33	4.72	*-0.5*
TiO_2	0.04	0.05	0.04	0.04	0.01	13.32	0.04	*8.3*
P_2O_5	0.01	0.01	0.00	0.01	0.01	86.60	0.002	*233.3*

[1]Working values from Govindaraju, 1994, Geostandards Newsletter, Special Issue, v. 18, p. 1 - 158

Appendix DR2 Table A2.
Reproducibility and accuracy of trace element data for BHVO-2

# Analysis/ Element (ppm)	#1	#2	#3	#4	#5	#6	Mean	Std. dev. (±1σ abs)	Std. dev. (±1σ %)	Ref. Value[1]	Rel. Dev. (%)
Li	4.46	4.78	4.48	4.50	4.55	4.59	4.56	0.12	2.6	4.8	-5.0
Sc	31.8	31.3	31.5	31.1	31.0	33.1	31.6	0.78	2.5	32	-1.1
V	316	321	325	314	319	326	320	4.70	1.5	317	1.0
Cr	292	288	283	282	283	294	287	4.99	1.7	280	2.5
Co	44.4	44.6	43.8	44.2	44.2	46.4	44.6	0.94	2.1	45	-0.9
Ni	120	120	115	117	117	121	118	2.43	2.0	119	-0.5
Cu	127	128	126	129	129	130	128	1.30	1.0	127	0.9
Zn	104	107	109	101	100	104	104	3.43	3.3	103	1.3
Ga	21.2	21.4	22.0	21.3	21.2	22.2	21.5	0.43	2.0	22	-2.1
Rb	9.17	9.15	9.12	9.14	9.11	9.28	9.16	0.06	0.7	9.11	0.6
Sr	396	390	388	398	402	400	396	5.37	1.4	396	-0.1
Y	25.6	25.2	24.7	25.2	25.2	26.1	25.4	0.47	1.8	26	-2.5
Zr	174	172	165	165	163	177	169	5.65	3.3	172	-1.5
Nb	17.4	17.6	17.7	17.5	17.5	17.8	17.6	0.16	0.9	18.1	-2.9
Cs	0.105	0.101	0.124	0.112	0.113	0.116	0.112	0.01	7.3	0.1	11.9
Ba	133	129	135	134	135	140	134	3.76	2.8	131	2.6
La	15.3	15.4	15.2	15.0	15.0	16.0	15.3	0.36	2.4	15.2	0.7
Ce	37.9	38.1	37.2	36.8	36.7	38.7	37.6	0.79	2.1	37.5	0.2
Pr	5.43	5.43	5.28	5.25	5.24	5.49	5.35	0.11	2.0	5.35	0.0
Nd	25.1	25.0	24.7	24.5	24.4	25.7	24.9	0.49	2.0	24.5	1.7
Sm	6.26	6.22	6.22	6.16	6.15	6.36	6.23	0.08	1.3	6.07	2.6
Eu	2.09	2.08	2.10	2.09	2.10	2.17	2.11	0.03	1.5	2.07	1.7
Gd	6.28	6.19	6.20	6.10	6.08	6.41	6.21	0.12	2.0	6.24	-0.5
Tb	0.958	0.940	0.952	0.948	0.949	0.970	0.95	0.01	1.1	0.92	3.6
Dy	5.40	5.30	5.37	5.34	5.31	5.50	5.37	0.07	1.4	5.31	1.2
Ho	1.00	0.98	0.99	0.98	0.99	1.01	0.993	0.01	1.1	0.98	1.3
Er	2.48	2.43	2.49	2.49	2.46	2.52	2.48	0.03	1.1	2.54	-2.5
Tm	0.334	0.323	0.342	0.342	0.341	0.335	0.336	0.01	2.2	0.33	1.9
Yb	2.03	1.98	2.05	2.06	2.04	2.06	2.04	0.03	1.6	2	1.8
Lu	0.284	0.273	0.288	0.287	0.289	0.296	0.286	0.01	2.6	0.274	4.5
Hf	4.35	4.14	4.28	4.09	4.07	4.42	4.22	0.15	3.4	4.36	-3.1
Ta	1.03	1.06	1.09	1.08	1.08	1.11	1.07	0.03	2.5	1.14	-5.8
Pb	1.60	1.57	1.59	1.55	1.53	1.57	1.57	0.03	1.7	1.6	-2.0
Th	1.21	1.14	1.21	1.19	1.19	1.22	1.19	0.03	2.4	1.22	-2.1
U	0.426	0.392	0.423	0.400	0.403	0.438	0.414	0.02	4.3	0.403	2.7

[1]GeoReM reference values

Appendix DR2 Table A3.
Precision of trace element data for separate sample digests (Dup1 and Dup2)

Element (ppm)	DR07-1 Dup 1	DR07-1 Dup 2	Diff. (%)	DR29-11 Dup 1	DR29-11 Dup 2	Diff. (%)
Li	9.33	9.42	*1.0*	5.34	5.40	*1.1*
Sc	25.6	25.5	*0.5*	34.2	34.4	*0.7*
V	267	266	*0.2*	222	222	*0.1*
Cr	882	877	*0.6*	311	310	*0.1*
Co	63.7	63.2	*0.7*	34.5	34.8	*0.7*
Ni	643	641	*0.4*	110	111	*1.3*
Cu	112	111	*0.3*	6.56	6.73	*2.7*
Zn	129	107	*17.1*	35.9	38.2	*6.4*
Ga	15.0	14.9	*0.8*	15.8	16.0	*1.3*
Rb	10.4	10.2	*1.3*	5.11	5.01	*2.0*
Sr	530	527	*0.6*	192	192	*0.1*
Y	31.6	31.3	*0.8*	28.2	28.4	*0.8*
Zr	341	340	*0.1*	48.0	47.4	*1.4*
Nb	15.8	15.5	*2.0*	4.59	4.61	*0.4*
Cs	2.28	2.29	*0.1*	0.186	0.184	*1.3*
Ba	349	351	*0.6*	49.4	49.9	*1.0*
La	25.9	25.8	*0.5*	4.79	4.78	*0.2*
Ce	66.4	66.3	*0.0*	12.6	12.6	*0.1*
Pr	9.84	9.86	*0.2*	2.09	2.11	*0.6*
Nd	46.9	46.9	*0.1*	11.0	11.1	*0.8*
Sm	11.4	11.4	*0.0*	3.58	3.60	*0.7*
Eu	3.43	3.43	*0.2*	1.27	1.28	*1.2*
Gd	10.3	10.3	*0.1*	4.39	4.38	*0.3*
Tb	1.44	1.45	*0.3*	0.785	0.780	*0.6*
Dy	7.54	7.55	*0.1*	5.04	5.06	*0.4*
Ho	1.30	1.30	*0.1*	1.06	1.06	*0.1*
Er	3.08	3.08	*0.1*	2.90	2.91	*0.2*
Tm	0.393	0.391	*0.5*	0.435	0.433	*0.5*
Yb	2.30	2.31	*0.6*	2.75	2.73	*0.6*
Lu	0.309	0.307	*0.8*	0.402	0.398	*0.9*
Hf	8.46	8.50	*0.6*	1.47	1.44	*2.0*
Ta	1.03	0.985	*3.9*	0.300	0.296	*1.3*
Pb	3.64	3.63	*0.3*	0.470	0.472	*0.5*
Th	2.11	2.10	*0.5*	0.310	0.302	*2.7*
U	0.518	0.514	*0.8*	0.094	0.094	*0.2*

Appendix DR2 Table A4: Major element data.

Sample	Lat (°)	Long (°)	Depth (m.b.s.l.)	Rock type	SiO_2 wt.%	TiO_2 wt.%	Al_2O_3 wt.%	FeO* wt.%	MnO wt.%	MgO wt.%	CaO wt.%	Na_2O wt.%	K_2O wt.%	P_2O_5 wt.%	SO_3 wt.%	L.O.I. wt.%	Total wt.%
Richardson Guyot																	
MSM19/3 DR3-3	-40.26	14.40	2360-2780	Tholeiite	52.19	2.07	13.66	12.41	0.23	4.27	6.16	3.17	0.82	0.20	0.01	5.03	100.22
MSM19/3 DR7-1	-40.76	14.70	2440-3080	Tholeiite	48.88	4.00	7.86	11.56	0.16	14.97	8.63	1.68	0.70	0.40	0.00	0.98	99.82
MSM19/3 DR7-2	-40.76	14.70	2440-3080	Tholeiite	49.15	3.29	15.88	9.81	0.17	5.84	9.22	3.57	0.65	0.51	0.01	2.46	100.56
MSM19/3 DR8-1	-40.81	14.71	3910-4200	Tholeiite	49.72	2.17	15.82	9.67	0.09	4.11	4.88	4.87	3.20	0.31	0.01	5.22	100.07
MSM19/3 DR12-1	-41.23	13.69	3120	Tholeiite	47.44	2.63	16.50	10.14	0.10	5.77	7.42	3.49	1.09	0.48	0.01	5.40	100.47
MSM19/3 DR13-3	-41.23	13.70	2920-3330	Alkali Basalt	50.76	3.13	14.70	9.32	0.11	4.23	3.94	5.93	1.13	1.01	0.03	3.80	98.09
Agulhas Fracture Zone																	
MSM19/3 DR14-2	41.68	12.53	3670-4180	Tholeiite	44.87	3.46	14.55	12.17	0.39	5.34	3.39	2.81	3.60	0.93	0.03	7.05	98.59
MSM19/3 DR18-1	-41.96	11.73	2270-2800	Alkali Basalt	50.66	2.95	15.37	9.81	0.12	3.88	6.91	3.68	2.86	0.73	0.00	2.74	99.71
MSM19/3 DR18-10	-41.96	11.73	2270-2800	Tholeiite	47.61	1.27	14.40	9.43	0.16	8.59	10.39	2.05	0.71	0.11	0.00	4.37	99.09
MSM19/3 DR19-1	-42.36	11.37	3680-4130	Tholeiite	46.61	1.46	16.54	9.41	0.15	6.73	9.45	3.25	0.50	0.21	0.01	3.68	98.00
MSM19/3 DR29-1	-42.49	8.86	3940-4310	Tholeiite	52.85	1.40	16.03	7.71	0.12	7.43	9.78	3.38	0.54	0.21	0.00	1.10	100.55
MSM19/3 DR29-11	-42.49	8.86	3940-4310	Tholeiite	51.17	1.29	16.06	8.26	0.16	7.10	9.68	3.09	0.47	0.16	0.01	1.14	98.59
MSM19/3 DR30-1	-42.77	8.69	3230-3650	Tholeiite	49.83	1.94	17.68	9.20	0.13	3.79	10.42	3.31	0.85	0.58	0.01	2.88	100.62
MSM19/3 DR35-1	-43.29	8.35	2350-2940	Tholeiite	49.17	2.51	16.03	9.21	0.24	6.17	8.17	3.14	0.72	0.51	0.01	4.16	100.04
MSM19/3 DR35-16	-43.29	8.35	2350-2940	Alkali Basalt	47.52	2.04	15.30	7.97	0.22	7.49	10.57	2.71	1.11	0.33	0.01	3.49	98.76
MSM19/3 DR38-1	-44.06	5.95	3500-3930	Tholeiite	46.16	1.82	17.33	11.14	0.17	6.98	10.40	2.96	0.44	0.21	0.01	1.60	99.22
Meteor Guyot																	
MSM19/3 DR39-1	-44.36	4.99	1940-2460	Tholeiite	48.04	2.71	15.84	11.38	0.18	6.56	9.27	3.36	1.10	0.35	0.00	1.73	100.52
MSM19/3 DR39-2	-44.36	4.99	1940-2460	Tholeiite	47.67	2.72	15.68	11.09	0.17	5.40	9.11	3.40	1.11	0.36	0.00	1.57	98.28
MSM19/3 DR39-4	-44.36	4.99	1940-2460	Tholeiite	46.52	2.08	16.77	9.73	0.14	6.58	9.06	2.85	1.10	0.30	0.01	3.46	98.60
MSM19/3 DR40-1	-45.07	4.80	2720-3250	Tholeiite	49.10	1.93	18.47	8.82	0.10	2.52	11.43	2.99	0.85	0.68	0.04	3.36	100.29
MSM19/3 DR42-1	-45.45	5.08	2920-3280	Alkali Basalt	43.27	4.47	16.13	9.91	0.25	1.59	10.10	2.78	1.91	2.86	0.07	4.30	97.64
MSM19/3 DR42-3	-45.45	5.08	2920-3280	Alkali Basalt	45.98	2.36	14.09	12.52	0.18	9.04	8.15	3.54	1.59	0.57	0.03	0.04	98.09

L.O.I. = Loss on ignition

Appendix DR2 Table A5: Trace element data.

Sample	Li	Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Rb	Sr	Y	Zr	Nb	Cs	Ba	La
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Richardson Guyot																	
MSM19/3 DR3-3	14.9	28.2	303	153	23.9	32	44.0	144	23.5	41.2	449	26.2	195	16.9	1.66	130	19.0
MSM19/3 DR7-1	9.42	25.5	266	877	63.2	641	111	107	14.9	10.2	527	31.3	340	15.5	2.29	351	25.8
MSM19/3 DR7-1*	9.33	25.6	267	882	63.7	643	112	129	15.0	10.4	530	31.6	341	15.8	2.28	349	25.9
MSM19/3 DR7-2	21.0	22.9	270	147	47.7	155	74.2	174	24.6	4.32	475	36.8	297	28.2	0.072	300	28.7
MSM19/3 DR8-1	30.1	28.0	182	225	28.2	64	44.4	80	33.4	30.0	1009	17.6	121	9.57	0.538	218	11.7
MSM19/3 DR12-1	109	32.3	265	77.1	36.4	49	60.5	153	22.6	36.8	529	32.5	190	20.5	2.61	210	23.6
MSM19/3 DR13-3	79.0	22.7	223	24.3	23.1	17	26.4	157	21.8	18.2	392	41.6	301	34.3	0.315	189	40.9
Agulhas Fracture Zone																	
MSM19/3 DR14-2	72.9	25.3	304	30.4	34.6	24	40.5	170	26.9	28.2	333	50.2	359	38.0	0.614	382	48.0
MSM19/3 DR18-1	85.5	29.3	248	44.0	32.5	36	34.9	130	23.8	51.0	408	35.7	332	33.6	1.34	837	39.3
MSM19/3 DR18-10	57.3	50.7	330	362	47.9	166	173	212	16.2	22.3	114	23.8	62.8	3.77	1.71	18.7	4.17
MSM19/3 DR19-1	51.4	40.3	248	295	39.4	134	56.7	76	17.3	9.29	239	33.6	145	5.51	0.528	54.6	7.43
MSM19/3 DR29-1	5.43	29.7	212	194	29.1	101	10.7	34	14.7	3.71	217	29.9	62.6	8.55	0.099	86.4	9.32
MSM19/3 DR29-11	5.40	34.4	222	310	34.8	111	6.73	38	16.0	5.01	192	28.4	47.4	4.61	0.184	49.9	4.78
MSM19/3 DR29-11*	5.34	34.2	222	311	34.5	110	6.56	36	15.8	5.11	192	28.2	48.0	4.59	0.186	49.4	4.79
MSM19/3 DR30-1	11.4	31.1	218	230	24.6	57	80.9	117	19.8	10.8	369	29.5	179	11.1	0.252	149	13.8
MSM19/3 DR35-1	49.9	34.6	272	206	32.0	76	54.4	191	20.5	52.5	363	31.3	165	21.9	7.28	265	18.7
MSM19/3 DR35-16	52.9	36.3	279	324	38.8	191	106	151	18.5	25.5	482	24.6	139	27.8	1.01	326	19.5
MSM19/3 DR38-1	37.8	40.2	289	193	44.2	113	75.1	95	18.1	8.08	215	34.5	128	4.07	0.147	37.2	5.59
Meteor Guyot																	
MSM19/3 DR39-1	28.7	32.7	311	167	35.7	89	48.6	110	20.3	33.3	286	40.0	203	28.0	1.40	405	22.5
MSM19/3 DR39-2	27.3	33.4	342	193	42.6	107	51.0	119	23.6	43.0	299	43.3	215	27.8	2.15	382	21.2
MSM19/3 DR39-4	53.7	32.0	322	279	40.1	126	48.6	110	22.0	31.6	297	31.8	170	27.9	1.11	403	21.1
MSM19/3 DR39-4*	54.1	32.3	323	279	41.0	127	49.5	109	22.2	32.0	296	32.2	173	28.1	1.12	406	21.3
MSM19/3 DR40-1	18.1	34.8	224	435	43.4	140	69.0	135	19.9	14.9	402	31.4	132	14.3	0.422	161	13.1
MSM19/3 DR42-1	15.6	23.6	277	65.0	31.9	70	95.6	172	26.1	24.0	902	37.8	321	43.9	0.469	651	45.9
MSM19/3 DR42-3	8.25	22.2	221	353	58.4	180	55.2	124	23.0	10.8	660	20.9	224	36.8	0.315	133	29.8

*Trace element replicate analysis on separate sample dissolution

Appendix DR2 Table A5: Trace element data continued.

Sample	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Pb	Th	U
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Richardson Guyot																		
MSM19/3 DR3-3	42.7	5.92	27.1	6.65	2.27	6.49	1.00	5.54	1.02	2.53	0.350	2.08	0.290	4.44	1.06	2.23	1.81	0.765
MSM19/3 DR7-1	66.3	9.86	46.9	11.4	3.43	10.3	1.45	7.55	1.30	3.08	0.391	2.31	0.307	8.50	0.985	3.63	2.10	0.514
MSM19/3 DR7-1*	66.4	9.84	46.9	11.4	3.43	10.3	1.44	7.54	1.30	3.08	0.393	2.30	0.309	8.46	1.025	3.64	2.11	0.518
MSM19/3 DR7-2	67.1	9.06	40.9	9.73	3.14	9.33	1.43	7.85	1.43	3.56	0.491	3.01	0.417	6.60	1.65	3.68	2.75	0.580
MSM19/3 DR8-1	26.1	3.68	17.2	4.36	1.55	4.29	0.665	3.72	0.688	1.74	0.246	1.49	0.213	2.79	0.584	1.48	0.991	0.337
MSM19/3 DR12-1	45.6	6.25	27.9	6.79	2.30	6.80	1.05	5.91	1.12	2.87	0.397	2.40	0.343	4.33	1.21	2.30	2.10	0.751
MSM19/3 DR13-3	88.5	11.8	51.4	11.3	3.66	10.5	1.54	8.34	1.53	3.83	0.518	3.09	0.430	6.52	2.00	3.64	3.46	0.928
Agulhas Fracture Zone																		
MSM19/3 DR14-2	99.7	12.6	53.6	11.6	3.65	11.2	1.72	9.71	1.85	4.75	0.660	4.09	0.575	7.81	2.32	2.93	4.22	0.983
MSM19/3 DR18-1	85.2	10.8	46.4	9.67	3.70	8.87	1.32	7.29	1.36	3.47	0.482	2.98	0.418	7.07	1.87	2.98	3.35	0.732
MSM19/3 DR18-10	9.02	1.58	8.26	2.75	1.05	3.53	0.644	4.20	0.885	2.46	0.375	2.40	0.347	1.70	0.254	0.394	0.280	0.187
MSM19/3 DR19-1	20.1	3.03	14.7	4.17	1.48	4.88	0.878	5.78	1.24	3.54	0.548	3.64	0.543	2.96	0.345	1.55	0.598	0.171
MSM19/3 DR29-1	20.8	3.19	15.5	4.43	1.52	5.17	0.881	5.62	1.15	3.13	0.451	2.90	0.422	1.93	0.504	0.412	0.577	0.158
MSM19/3 DR29-11	12.6	2.11	11.1	3.60	1.28	4.38	0.780	5.06	1.06	2.91	0.433	2.73	0.398	1.44	0.296	0.472	0.302	0.094
MSM19/3 DR29-11*	12.6	2.09	11.0	3.58	1.27	4.39	0.785	5.04	1.06	2.90	0.435	2.75	0.402	1.47	0.300	0.470	0.310	0.094
MSM19/3 DR30-1	28.8	4.26	19.8	5.25	1.86	5.65	0.927	5.57	1.10	2.95	0.434	2.74	0.399	3.69	0.645	1.60	1.15	0.463
MSM19/3 DR35-1	39.9	5.24	23.7	5.99	2.11	6.27	1.00	5.96	1.18	3.14	0.459	2.90	0.421	3.65	1.23	2.52	1.97	0.565
MSM19/3 DR35-16	40.3	5.04	22.0	5.26	1.81	5.24	0.823	4.81	0.928	2.43	0.350	2.16	0.314	3.15	1.57	1.55	2.31	0.539
MSM19/3 DR38-1	16.1	2.69	14.1	4.45	1.68	5.57	0.979	6.36	1.32	3.64	0.536	3.52	0.523	3.23	0.262	0.796	0.441	0.180
Meteor Guyot																		
MSM19/3 DR39-1	46.7	6.03	26.0	6.44	2.08	7.16	1.21	7.63	1.55	4.26	0.631	4.13	0.611	4.65	1.56	2.35	2.84	0.677
MSM19/3 DR39-2	45.3	5.84	25.7	6.52	2.12	7.22	1.24	7.79	1.60	4.44	0.667	4.33	0.635	4.57	1.58	2.15	2.68	0.600
MSM19/3 DR39-4	42.5	5.24	22.9	5.44	1.86	6.07	1.00	6.30	1.26	3.43	0.498	3.23	0.497	3.97	1.67	1.81	2.77	0.627
MSM19/3 DR39-4*	42.8	5.29	23.0	5.50	1.87	6.11	1.01	6.32	1.27	3.45	0.499	3.27	0.500	3.96	1.68	1.79	2.81	0.628
MSM19/3 DR40-1	27.6	3.71	17.0	4.47	1.64	5.10	0.864	5.43	1.13	3.13	0.473	3.05	0.454	2.98	0.842	1.07	1.26	0.544
MSM19/3 DR42-1	85.6	10.9	45.6	9.35	2.98	8.51	1.26	6.89	1.30	3.33	0.465	2.89	0.418	6.68	2.58	4.19	3.95	1.38
MSM19/3 DR42-3	63.7	7.35	30.9	6.63	2.18	6.30	0.908	4.89	0.868	2.13	0.279	1.71	0.253	4.94	2.38	2.72	2.65	1.19

*Trace element replicate analysis on separate sample dissolution

Appendix DR2 Table A6: Isotope data.

Sample	Age (Myr)	±2σ	$^{87}Sr/^{86}Sr$§ least rad.	±2σ	$^{87}Sr/^{86}Sr$# chips	±2σ	$^{87}Sr/^{86}Sr$** powder	±2σ	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr_i$	$^{143}Nd/^{144}Nd$	±2σ	εNd	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd_i$	$εNd_i$
Richardson Guyot																
MSM19/3 DR3-3	82.6	1.7	0.704857	5	0.705145	6	0.704857	5	0.266	0.70483	0.512526	6	-2.19	0.148	0.51245	-1.68
MSM19/3 DR7-1	*80*		0.704456	5	0.704456	5	0.704510	5	0.056	0.70439	0.512593	4	-0.88	0.146	0.51252	-0.36
MSM19/3 DR7-2	*80*		0.704803	7	0.704817	6	0.704803	7	0.026	0.70479	0.512546	6	-1.79	0.143	0.51247	-1.25
MSM19/3 DR8-1	*80*		0.705685	6	0.705685	6	0.705930	7	0.086	0.70559	0.512479	5	-3.09	0.153	0.51240	-2.65
MSM19/3 DR12-1	*80*		0.704754	5	0.704944	5	0.704754	5	0.201	0.70472	0.512536	6	-1.98	0.146	0.51246	-1.47
MSM19/3 DR13-3	*80*		0.705166	5	0.705312	6	0.705166	5	0.134	0.70516	0.512485	6	-2.98	0.132	0.51242	-2.32
Agulhas Fracture Zone																
MSM19/3 DR14-2	*80*		0.704680	5	0.704876	6	0.704680	5	0.244	0.70460	0.512570	5	-1.33	0.130	0.51250	-0.65
MSM19/3 DR18-1	81.7	0.3	0.705632	5	0.705632	5	0.705911	7	0.362	0.70521	0.512481	5	-3.06	0.126	0.51241	-2.32
MSM19/3 DR18-10	*80*		0.703134	7	0.704218	5	0.703134	7	0.564	0.70358	0.512765	5	2.48	0.200	0.51266	2.45
MSM19/3 DR19-1	*80*		0.703240	5	0.703332	7	0.703240	5	0.112	0.70320	0.512937	6	5.83	0.171	0.51285	6.09
MSM19/3 DR29-1	*80*		0.704471	5	0.704471	5	0.704791	5	0.049	0.70441	0.512850	6	4.14	0.172	0.51276	4.39
MSM19/3 DR29-1†	*80*		0.704487	6	0.704487	6	0.704798	6	0.049	0.70443	0.512844	6	4.02	0.172	0.51275	4.27
MSM19/3 DR29-11	*80*		0.704312	6	0.704312	6	0.704634	5	0.075	0.70423	0.512892	6	4.95	0.195	0.51279	4.96
MSM19/3 DR30-1	81.0	0.8	0.703569	5	0.703650	6	0.703569	5	0.085	0.70355	0.512815	6	3.45	0.160	0.51273	3.83
MSM19/3 DR35-1	72.2	0.5	0.704580	7	0.704976	6	0.704580	7	0.419	0.70455	0.512683	6	0.88	0.152	0.51261	1.29
MSM19/3 DR35-1†	*80*		0.704582	6	0.704983	6	0.704582	6	0.419	0.70455	0.512687	5	0.95	0.152	0.51262	1.36
MSM19/3 DR35-16	*80*		0.703954	5	0.703954	5	0.703984	7	0.153	0.70378	0.512759	4	2.36	0.144	0.51268	2.89
MSM19/3 DR38-1	*80*		0.703593	6	0.703593	6	0.703950	7	0.109	0.70347	0.513000	3	7.05	0.190	0.51290	7.12
Meteor Guyot																
MSM19/3 DR39-2	75.1	0.3	0.704244	5	0.704244	5	0.704294	7	0.416	0.70380	0.512788	6	2.93	0.153	0.51271	3.36
MSM19/3 DR40-1	*80*		0.703319	8	0.703534	6	0.703319	8	0.107	0.70341	0.512873	6	4.59	0.159	0.51279	4.98
MSM19/3 DR40-1†																
MSM19/3 DR42-1	73.9	0.2	0.705570	6	0.705570	6	0.705577	7	0.077	0.70549	0.512510	6	-2.49	0.124	0.51245	-1.80
MSM19/3 DR42-3	*80*		0.702940	7	0.702960	5	0.702940	7	0.047	0.70291	0.512983	4	6.73	0.129	0.51292	7.42

†Isotope replicate analysis on separate sample dissolution

§least radiogenic $^{87}Sr/^{86}Sr$ from either leached chips or powder

#leached chips: 2N HCl at 70°C for 1h and then triple rinsed in 18.2 MΩ H_2O

**leached powder: 6N HCl at 150°C for 48h and then triple rinsed in 18.2 MΩ H_2O

±2σ internal errors are shown for the last significant digit(s)

Ages in italics are assumed ages for calculation of initial isotope ratios

Appendix DR2 Table A6: Isotope data continued 1.

Sample	$^{176}Hf/^{177}Hf$	±2σ	εHf	$^{176}Lu/^{177}Hf$	$^{176}Hf/^{177}Hf_i$	$εHf_i$	$^{206}Pb/^{204}Pb$	±2σ	$^{207}Pb/^{204}Pb$	±2σ	$^{208}Pb/^{204}Pb$	±2σ	$^{207}Pb/^{206}Pb$	±2σ	$^{208}Pb/^{206}Pb$	±2σ
Richardson Guyot																
MSM19/3 DR3-3							18.4071	13	15.6121	12	38.8466	34	0.84808	4	2.11038	9
MSM19/3 DR7-1																
MSM19/3 DR7-2							18.6255	19	15.6298	16	39.0763	42	0.83916	2	2.09800	4
MSM19/3 DR8-1	0.282632	5	-4.95	0.0109432	0.282615	-3.73	18.5551	15	15.6351	15	38.9397	43	0.84263	2	2.09860	9
MSM19/3 DR12-1	0.282760	6	-0.42	0.0113423	0.282743	0.78	18.2928	9	15.5916	10	38.7762	31	0.85233	2	2.11975	8
MSM19/3 DR13-3							18.2402	9	15.6045	10	38.7140	32	0.85550	2	2.12246	9
Agulhas Fracture Zone																
MSM19/3 DR14-2	0.282729	5	-1.51	0.0105527	0.282713	-0.27	18.5021	8	15.6256	7	39.1357	22	0.84453	1	2.11520	5
MSM19/3 DR18-1							18.4004	9	15.6164	8	38.9945	25	0.84870	1	2.11922	6
MSM19/3 DR18-10	0.283110	5	11.96	0.0293442	0.283065	12.17	18.2953	7	15.5828	6	38.6593	15	0.85174	1	2.11308	3
MSM19/3 DR19-1	0.283068	6	10.47	0.0263218	0.283027	10.85	18.0842	12	15.5303	13	38.0165	39	0.85878	2	2.10220	9
MSM19/3 DR29-1	0.283074	4	10.68	0.0313796	0.283025	10.78	18.4527	10	15.5704	10	38.3998	27	0.84380	2	2.08098	8
MSM19/3 DR29-1†							18.5239	11	15.5755	11	38.4445	30	0.84083	1	2.07540	6
MSM19/3 DR29-11							18.1911	10	15.5536	9	38.1735	21	0.85501	1	2.09848	2
MSM19/3 DR30-1	0.282940	5	5.94	0.0155067	0.282916	6.93	18.3702	17	15.5682	17	38.5622	49	0.84747	2	2.09917	11
MSM19/3 DR35-1	0.282887	5	4.06	0.0165413	0.282864	4.88	18.5144	11	15.6148	13	38.7415	40	0.84338	2	2.09251	10
MSM19/3 DR35-1†							18.5128	6	15.6155	6	38.7336	18	0.84350	1	2.09227	4
MSM19/3 DR35-16							18.9682	9	15.6313	10	38.9981	30	0.82408	2	2.05597	7
MSM19/3 DR38-1	0.283151	6	13.42	0.0232344	0.283115	13.96	17.9523	11	15.5052	12	37.9055	35	0.86369	2	2.11146	10
Meteor Guyot																
MSM19/3 DR39-2	0.282984	5	7.48	0.0199317	0.282955	8.17	18.3766	8	15.5663	9	38.5322	27	0.84707	2	2.09681	7
MSM19/3 DR40-1	0.283012	7	8.47	0.0218578	0.282978	9.09	18.6082	8	15.5779	9	38.6411	29	0.83715	2	2.07657	8
MSM19/3 DR40-1†	0.283010	5	8.40	0.0218578	0.282976	9.02										
MSM19/3 DR42-1							18.4328	10	15.6324	12	38.8900	39	0.84807	2	2.10983	11
MSM19/3 DR42-3	0.282990	5	7.72	0.0073269	0.282979	9.14	18.9531	16	15.5983	14	38.5261	35	0.82300	1	2.03271	5

†Isotope replicate analysis on separate sample dissolution

±2σ internal errors are shown for the last significant digit(s)

Appendix DR2 Table A6: Isotope data continued 2.

Sample	$^{238}U/^{204}Pb$	$^{235}U/^{204}Pb$	$^{232}Th/^{204}Pb$	$^{232}Th/^{238}U$	$^{206}Pb/^{204}Pb_i$	$^{207}Pb/^{204}Pb_i$	$^{208}Pb/^{204}Pb_i$	$^{207}Pb/^{206}Pb_i$	$^{208}Pb/^{206}Pb_i$	Δ7/4	Δ8/4
Richardson Guyot											
MSM19/3 DR3-3	21.95	0.16	53.70	2.45	18.12	15.60	38.62	0.8608	2.1315	12.6	96.5
MSM19/3 DR7-1											
MSM19/3 DR7-2	10.13	0.07	49.51	4.89	18.50	15.62	38.88	0.8446	2.1017	12.0	93.1
MSM19/3 DR8-1	14.57	0.11	44.25	3.04	18.37	15.63	38.76	0.8505	2.1098	13.3	88.0
MSM19/3 DR12-1	20.78	0.15	60.01	2.89	18.03	15.58	38.54	0.8639	2.1371	11.8	103.3
MSM19/3 DR13-3	16.23	0.12	62.54	3.85	18.04	15.59	38.47	0.8646	2.1326	13.6	103.5
Agulhas Fracture Zone											
MSM19/3 DR14-2	21.53	0.16	95.53	4.44	18.23	15.61	38.76	0.8563	2.1256	12.9	114.0
MSM19/3 DR18-1	15.69	0.11	74.26	4.73	18.20	15.61	38.69	0.8575	2.1260	13.1	112.1
MSM19/3 DR18-10	30.19	0.22	46.62	1.54	17.92	15.56	38.47	0.8687	2.1472	10.9	91.3
MSM19/3 DR19-1	6.91	0.05	24.98	3.62	18.00	15.53	37.92	0.8627	2.1068	7.9	52.6
MSM19/3 DR29-1	24.35	0.18	91.84	3.77	18.15	15.56	38.04	0.8571	2.0958	7.9	46.3
MSM19/3 DR29-1†	24.39	0.18	91.99	3.77	18.22	15.56	38.08	0.8541	2.0901	7.7	42.2
MSM19/3 DR29-11	12.54	0.09	41.68	3.32	18.03	15.55	38.01	0.8620	2.1075	9.1	55.4
MSM19/3 DR30-1	18.40	0.13	47.10	2.56	18.14	15.56	38.37	0.8578	2.1157	8.6	72.6
MSM19/3 DR35-1	14.31	0.10	51.60	3.61	18.35	15.61	38.56	0.8504	2.1008	11.7	73.1
MSM19/3 DR35-1†	14.31	0.10	51.60	3.61	18.35	15.61	38.55	0.8505	2.1006	11.8	72.5
MSM19/3 DR35-16	22.37	0.16	99.11	4.43	18.69	15.62	38.60	0.8357	2.0657	8.4	43.8
MSM19/3 DR38-1	14.18	0.10	35.86	2.53	17.78	15.50	37.76	0.8718	2.1245	6.8	57.4
Meteor Guyot											
MSM19/3 DR39-2	17.73	0.13	81.78	4.61	18.17	15.56	38.23	0.8562	2.1040	8.3	68.8
MSM19/3 DR40-1	32.30	0.23	77.21	2.39	18.20	15.56	38.33	0.8546	2.1058	7.0	51.7
MSM19/3 DR40-1†											
MSM19/3 DR42-1	21.01	0.15	62.31	2.97	18.19	15.62	38.66	0.8587	2.1254	14.3	97.8
MSM19/3 DR42-3	27.92	0.20	64.35	2.30	18.60	15.58	38.27	0.8375	2.0571	5.3	-1.5

†Isotope replicate analysis on separate sample dissolution

±2σ internal errors are shown for the last significant digit(s)

Δ7/4 and Δ8/4 = derivation of $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ from the Northern Hemisphere reference line (NHRL) as defined in Hart (1984)

Appendix DR3: Detailed map of the Shona hotspot track and additional geochemical diagrams.

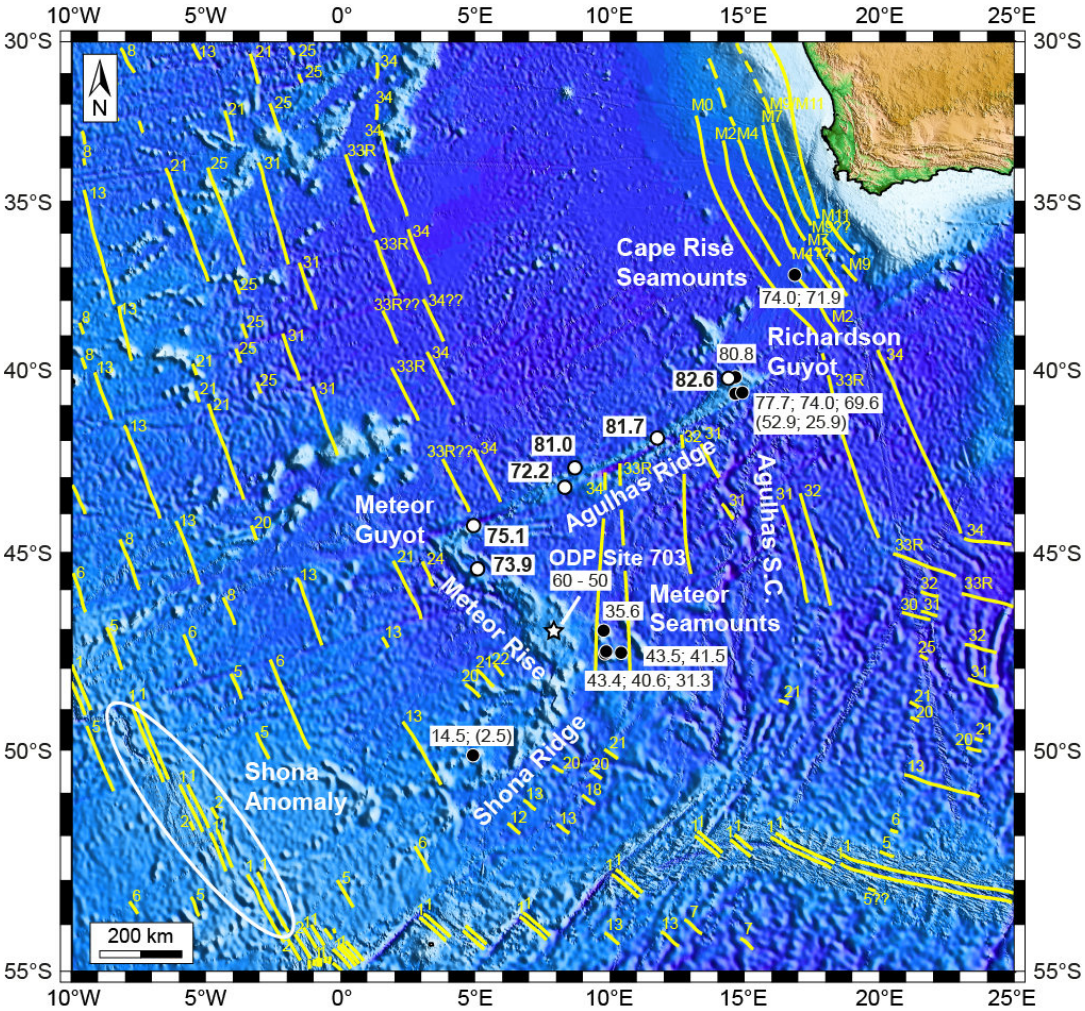

Figure A1. Detailed bathymetric map of the Shona hotspot track and surrounding regions. Included are ages in million years from this study (in bold) and from O'Connor et al. (2012). The age span for ODP Site 703 represents an assumption based on stratigraphic considerations and the deposition of the oldest marine sediments (Mueller et al., 1992; Raymond et al., 1991). Magnetic lineations, i.e. isochrons, and their ages are taken from O'Connor et al. (2012), Supplementary Information Fig. S1. The base map is from "The GEBCO_2014 Grid, version 20150318, http://www.gebco.net". Agulhas S.C. = Agulhas Spreading Center.

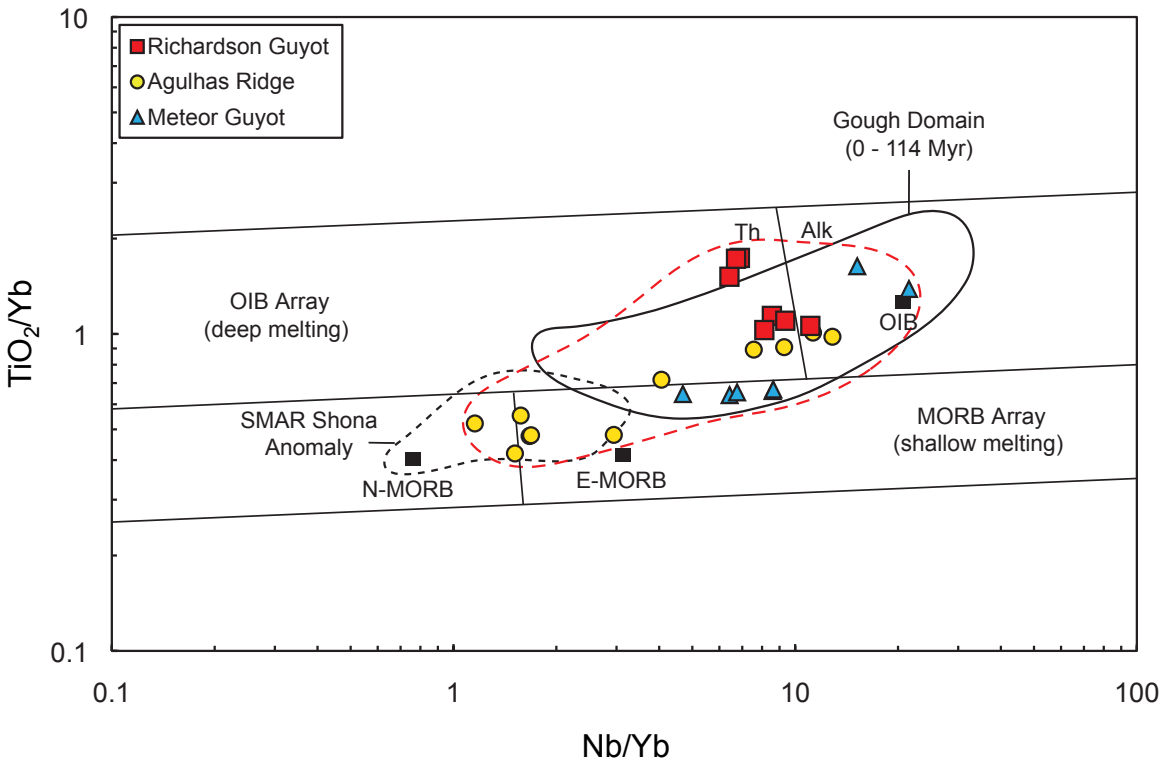

Figure A2. Nb/Yb versus TiO_2/Yb plot after Pearce (2008). Our data from Richardson Guyot, Agulhas Ridge and Meteor Guyot form an array extending from OIB to E-MORB and N-MORB. Included are fields for Gough Domain comprising data from Gough Island, Gough Guyot Province and Walvis Ridge (Hoernle et al., 2015; Rohde et al., 2013; Salters and Sachi-Kocher, 2010; GEOROC; http://georoc.mpch-mainz.gwdg.de/georoc/) and the Shona geochemical and bathymetric anomaly on the Southern Mid Atlantic Ridge (SMAR) (Le Roex et al., 2010).

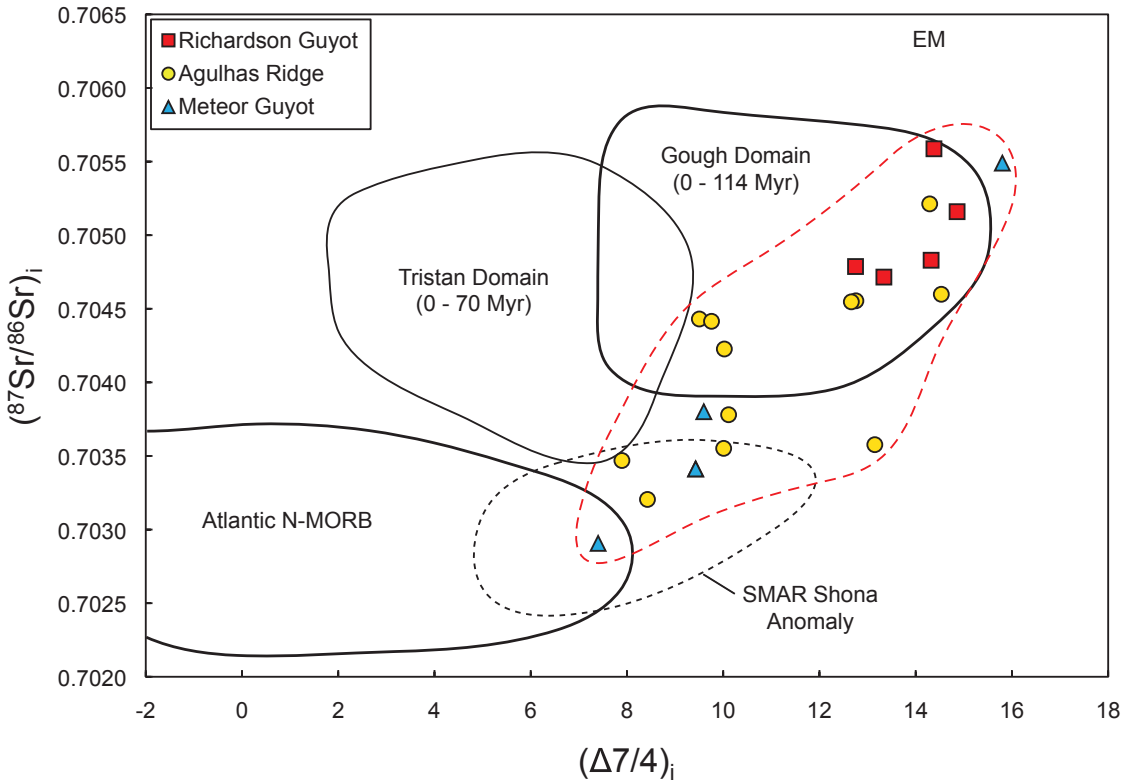

Figure A3. Initial Δ7/4 versus $^{87}Sr/^{86}Sr$ plot showing data from Richardson Guyot, Agulhas Ridge and Meteor Guyot. Fields for Gough and Tristan Domain (Hoernle et al., 2015; Rohde et al., 2013; Salters and Sachi-Kocher, 2010; GEOROC; http://georoc.mpch-mainz.gwdg.de/georoc/), the Shona anomaly of the SMAR (Douglass et al., 1999) and Atlantic N-MORB (PetDB; http://www.earthchem.org/petdb) are also shown. The Gough Domain includes data from Gough Island, Gough Guyot Province and Walvis Ridge and the Tristan Domain comprises data from Tristan da Cunha, Tristan Guyot Province and DSDP Sites 527 and 528 on the Walvis Ridge. Mantle end members are from Zindler and Hart (1986). Initial isotopic compositions for all data and fields are calculated at 80 Myr. Parent/daughter (P/D) ratios to project the OIB source of Tristan and Gough Islands to 80 Myr are from Stracke et al. (2003). Measured P/D ratios were used to correct measured isotope data from Walvis Ridge samples with ages of 70–96 Myr to 80 Myr. Average measured P/D ratios were used to calculate initial isotopic composition for Shona SMAR at 80 Myr. Average depleted MORB mantle (DMM) compositions of Workman and Hart (2005)

were used to calculate initial isotopic composition for N-MORB. Initial values for Tristan and Gough Guyot Province samples (<60 Myr) were calculated using measured P/D ratios and eruption ages, then the data were further corrected to 80 Myr using OIB source values from Stracke et al. (2003). Initial isotope values for Walvis Ridge samples older than 100 Myr were determined using measured P/D ratios and eruption ages and then the data were projected to 80 Myr using P/D ratios from Stracke et al. (2003) for OIB. Symbols are the same as in Figure A1.

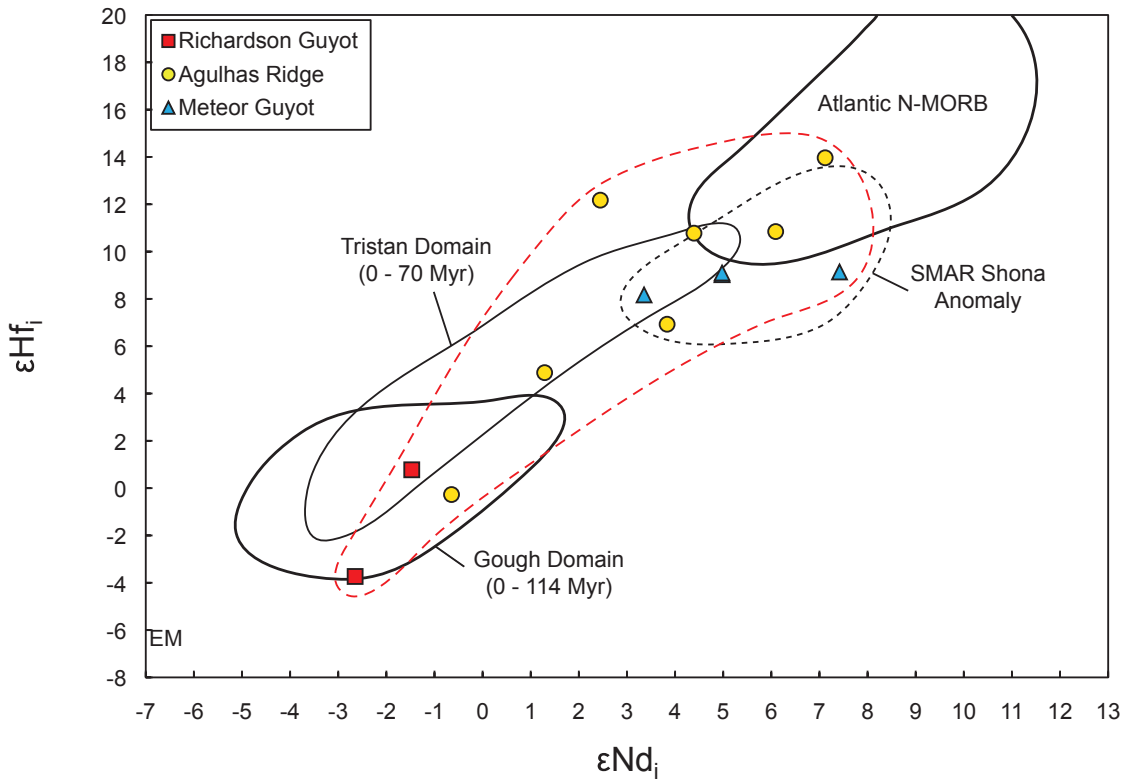

Figure A4. Initial εNd versus εHf plot. For more details see Figure A3.

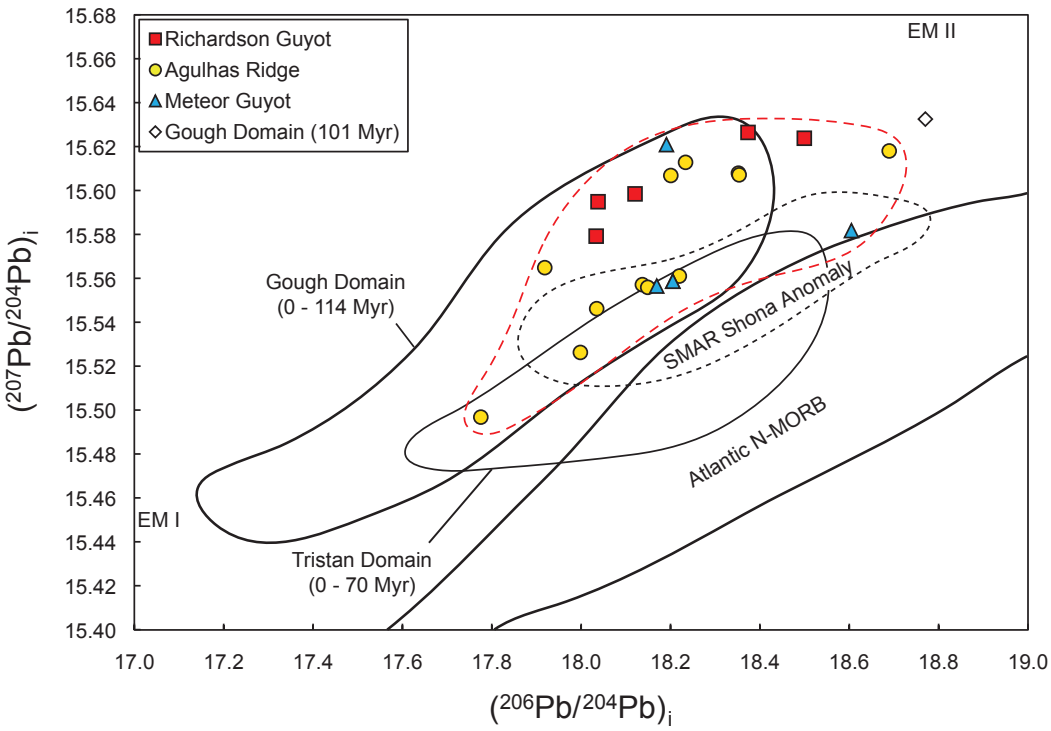

Figure A5. Initial $^{206}Pb/^{204}Pb$ versus $^{207}Pb/^{204}Pb$ plot. For more details see Figure A3.

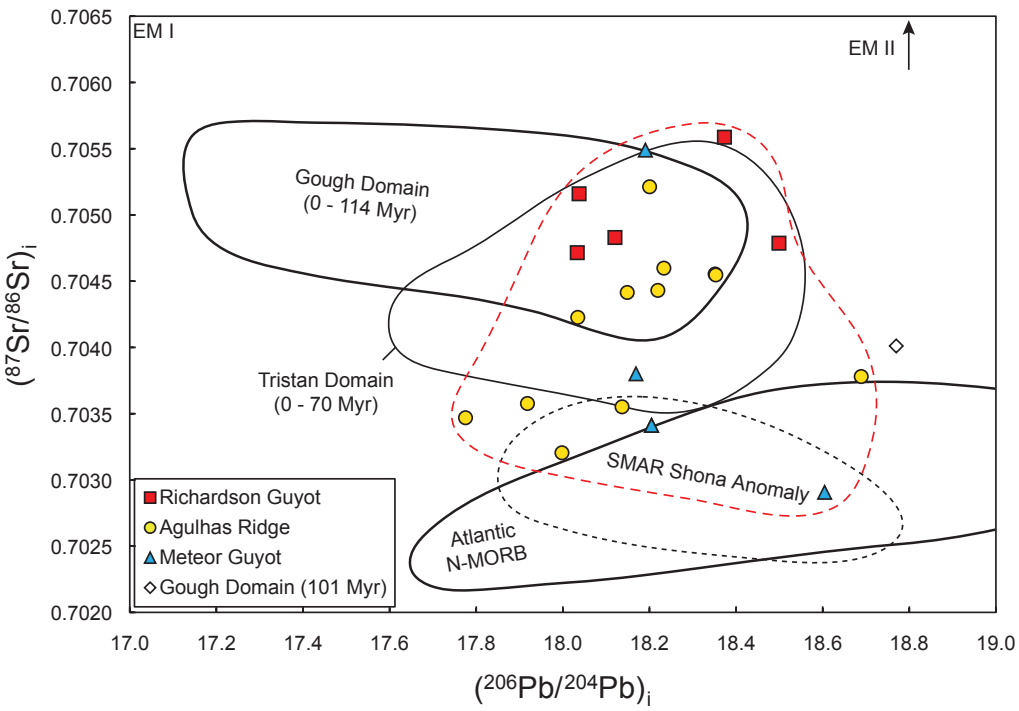

Figure A6. Initial $^{206}Pb/^{204}Pb$ versus $^{87}Sr/^{86}Sr$ plot. For more details see Figure A3.

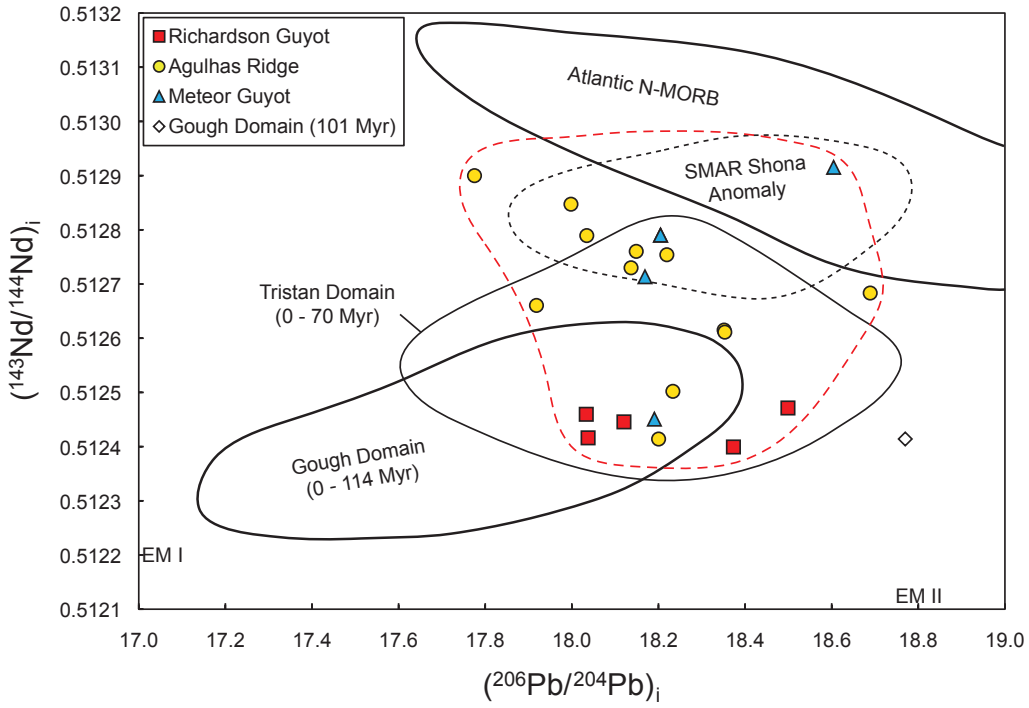

Figure A7. Initial $^{206}Pb/^{204}Pb$ versus $^{143}Nd/^{144}Nd$ plot. For more details see Figure A3.

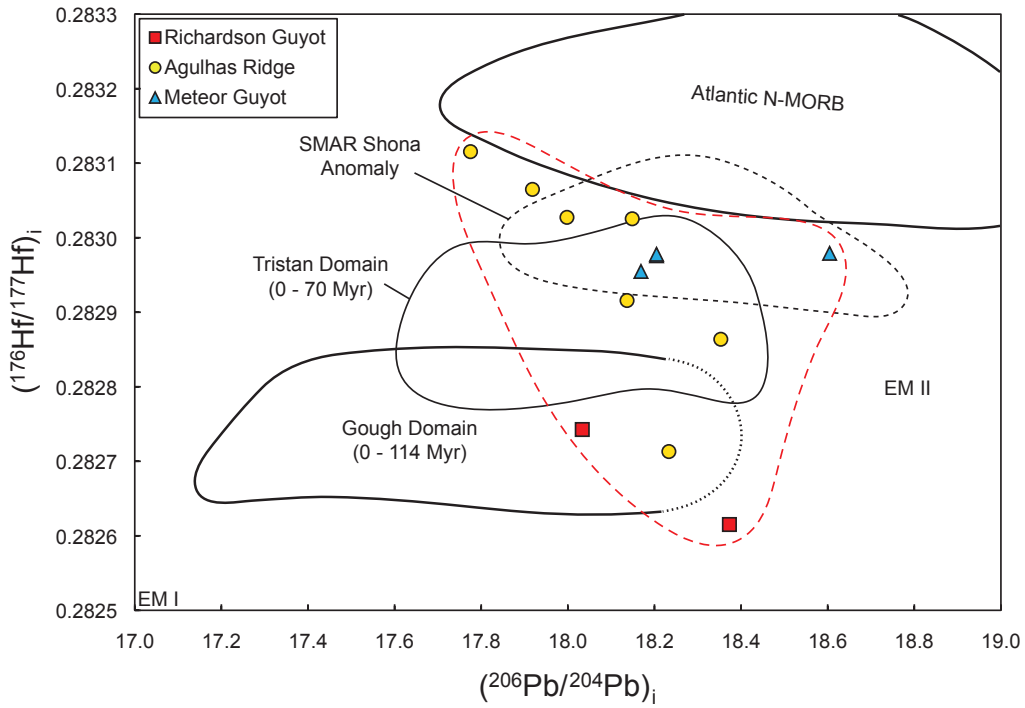

Figure A8. Initial $^{206}Pb/^{204}Pb$ versus $^{176}Hf^{177}Hf$ plot. For more details see Figure A3. The dotted part of the Gough Domain field indicates extrapolation of the field due to the lack of Hf isotope data.

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