DATA REPOSITORY ITEM: SUPPLEMENTAL MATERIAL

^{40}Ar-^{39}Ar METHODS

The incremental heating ^{40}Ar-^{39}Ar measurements were performed at Oregon State University on whole-rock disks (~100 mg) cut from fresh surfaces of drill core and using a low-blank, double-vacuum resistance furnace (temperature-controlled with thermocouple) combined with a MAP-215/50 mass spectrometer. Sample preparation and instrumental conditions are described by Duncan et al. (1997). The mass spectrometer is a 90° sector instrument with a Nier-type source and all-metal extraction system. It has an electron multiplier for high sensitivity and an electrostatic analyzer with adjustable collector slit for an effective resolution (~600) of Ar peaks from small hydrocarbon peaks. Gas cleanup was accomplished with a series of Zr-Al getters. All argon ages were measured relative to the flux monitor standard FCT-3 biotite (28.03 ± 0.16 Ma, 2σ; Renne et al., 1998) and calculated using the corrected Steiger and Jäger (1977) decay constant of $5.530 \pm 0.097 \times 10^{-10}$ yr^{-1} (2σ) as reported by Min et al. (2000). Incremental heating plateau ages and isochron ages were calculated as weighted means with $1/\sigma^2$ as weighting factor and as YORK2 least-squares fits with correlated errors (York, 1969) using the ArArCALC v2.2 software (Koppers, 2002) available from http://earthref.org/tools/ararcalc.htm).

To determine whether an incremental heating experiment yielded meaningful crystallization ages, we adopted the quality criteria proposed by Fleck et al. (1977) and Pringle (1993): (1) high temperature plateaus in the age spectra include more than three incremental heating steps and at least 50% of the total amount of ^{39}Ar released, (2) the plateau and isochron ages are concordant at the 95% confidence level, (3) the ^{40}Ar/^{36}Ar intercepts in the isochron diagrams are equal to the atmospheric value of 295.5 at the 95% confidence level, and (4) the mean square of weighted deviations (York, 1969; Roddick, 1978) for both the plateau ages (MSWD = SUMS/N-1) and isochron ages (MSWD = SUMS/N-2) is less than the critical value for significance (~2.5). The complete data set is available at http://www.earthref.org.

TABLE DR1. ^{40}Ar-^{39}Ar INCREMENTAL HEATING AGES FOR ODP HOLE 1213B BASALTS

Sample	Material	Total Fusion Age (Ma)	2σ error	Plateau Age (Ma)	2σ error	N	MSWD	Isochron Age (Ma)	2σ error	$^{40}Ar/^{36}Ar$ initial	2σ error	J
28R-2 (1-6)	whole rock	142.21	5.25	none developed				no isochron				0.001693
30R-3 (1-6)	whole rock	150.71	2.04	144.78	1.15	6/8	1.94	144.43	1.29	297.7	4.3	0.001706
33R-3 (115-120)	feldspar	143.39	3.33	143.74	3.02	7/7	0.33	142.73	3.48	298	4.8	0.001617

Note: N is the number of heating steps (defining plateau/total). MSWD is an F-statistic that compares the variance within step ages with the variance about the plateau age. J combines the neutron fluence with the monitor age. Note that ODP sample numbers indicate core (e.g. 28R), section (e.g. 2), and interval in centimeters within the section (e.g. 1-6). The complete data set is available at http://www.earthref.org.

TABLE DR 2. Nd-Pb-Sr ISOTOPE RATIOS AND ISOTOPE-DILUTION CONCENTRATIONS

Sample	*1213B* 28R-2 (6-11) U	28R-2 (6-11) L	31R-3 (113-119) U	31R-3 (113-119) L	33R-5 (52-57) U	33R-5 (52-57) L	*TN037* D9-1B L
$\in_{Nd}(0)$	+8.8		+8.6		+8.7		+10.0
$(^{143}Nd/^{144}Nd)_0$	0.513093		0.513081		0.513087		0.513152
$(^{87}Sr/^{86}Sr)_0$	0.70305	0.70277	0.70295	0.70277	0.70295	0.70276	0.70284
$(^{206}Pb/^{204}Pb)_0$	18.642		18.565		18.412		18.477
$(^{207}Pb/^{204}Pb)_0$	15.469		15.467		15.454		15.491
$(^{208}Pb/^{204}Pb)_0$	38.155		38.135		37.986		37.880
Nd (ppm)	10.12		9.332		9.370		2.779
Sm	3.308		3.004		3.007		1.251
Sr	154.4	136.1	161.0	155.9	159.8	158.6	179.0
Rb	0.797	0.217	1.41	0.387	1.17	1.296	4.75
Pb	0.3168		0.3224		0.5083		0.1970
U	0.0885		0.0777		0.07483		0.0574
Th	0.2699		0.2556		0.2340		0.0977
$(^{206}Pb/^{204}Pb)_t$	18.242		18.221		18.203		18.086
$(^{207}Pb/^{204}Pb)_t$	15.449		15.450		15.444		15.472
$(^{208}Pb/^{204}Pb)_t$	37.756		37.765		37.772		37.662
$(^{87}Sr/^{86}Sr)_t$	0.70302	0.70276	0.70290	0.70275	0.70290	0.70271	0.70269
$(^{143}Nd/^{144}Nd)_t$	0.512912		0.512903		0.512909		0.512910
$\in_{Nd}(t)$	+8.8		+8.6		+8.8		+8.7

TABLE DR2. CONTINUED

Sample	D14-1A	D14-1A	*464* 34R-CC	*1179D* 13R-3 (26-29)	20R-2 (96-100)	22R-05 (80-83)
	U	L	L	U	G	U
$\epsilon_{Nd}(0)$	+8.6		+9.1	+10.7	+10.3	+10.0
$(^{143}Nd/^{144}Nd)_0$	0.513085		0.513105	0.513189	0.513169	0.513155
$(^{87}Sr/^{86}Sr)_0$	0.70330	0.70307	0.70355	0.70314	0.70265	0.70286
$(^{206}Pb/^{204}Pb)_0$	18.449		18.597	18.130	18.308	18.233
$(^{207}Pb/^{204}Pb)_0$	15.468		15.504	15.439	15.458	15.448
$(^{208}Pb/^{204}Pb)_0$	37.959		38.053	37.588	37.807	37.742
Nd (ppm)	9.576		0.8661	4.42	10.28	10.57
Sm	2.136		0.3175	1.712	3.337	3.517
Sr	277.3	299.8	175.2	94.25	146.3	118.4
Rb	20.6	13.5	11.6	11.5	2.25	2.13
Pb	1.277		0.2520	0.4506	0.5029	0.7526
U	0.2772		0.1046	0.0698	0.0860	0.0896
Th	0.6694		0.1412	0.1380	0.2795	0.2834
$(^{206}Pb/^{204}Pb)_t$	18.140		18.145	17.935	18.091	18.081
$(^{207}Pb/^{204}Pb)_t$	15.453		15.482	15.430	15.447	15.441
$(^{208}Pb/^{204}Pb)_t$	37.715		37.853	37.462	37.576	37.586
$(^{87}Sr/^{86}Sr)_t$	0.70286	0.70280	0.70325	0.70249	0.70257	0.70276
$(^{143}Nd/^{144}Nd)_t$	0.512958		0.512946	0.512992	0.513003	0.512985
$\epsilon_{Nd}(t)$	+9.8		+8.7	+10.1	+10.3	+10.0

Note: G, glass; U, unleached, but acid-washed handpicked chips; L, strongly acid-leached after Mahoney (1987); for the D14 and D9 samples, preliminary leaching steps with hydrogen peroxide and hydroxylamine hydrochloride removed ferromanganese and organic material. Measured isotope ratios (subscript *0*) are age-corrected (*t*) to 144 Ma for Hole 1213B and D14-1A, to 136 Ma for D9-1B, to 110 Ma for Hole 464, and to 129 Ma for Hole 1179D. Measurements were made on the Hawaii VG Sector multicollector instrument. Data are reported relative to $^{87}Sr/^{86}Sr$ = 0.71024 for NBS 987 Sr and to $^{143}Nd/^{144}Nd$ = 0.511850 for La Jolla Nd; the total range measured for NBS 987 Sr over a three-year period was ±0.000018; for La Jolla Nd it was ±0.000010 (0.2 ϵ_{Nd} units). Pb isotope ratios for Hole 1213B and 1179D samples were measured with a double-spike method (Galer, 1999); mean values obtained for 5-ng loads of NBS 981 Pb over a three-year period were 16.937, 15.492, and 36.710 for $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$, with a total range of 220 ppm. Pb isotope ratios for D9-1B, D14-1a, and Site 464 are reported relative to Todt et al.'s (1996) values for NBS 981; the total range for non-double-spike measurements of NBS 981 is ±0.011, ±0.012, and ±0.038 for $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$, respectively. Within-run errors on the isotopic data above are less than or equal to the external uncertainties on the standards. Uncertainties on concentrations are less than 0.2% for Sm and Nd, 0.4% for Sr, 0.5% for Pb, 1% for U, and 2% for Th. Total procedural blanks are <40 pg for Pb, <35 pg for Sr, and <12 pg for Nd. Note that ϵ_{Nd} = 0 today corresponds to $^{143}Nd/^{144}Nd$ = 0.51264; values for older times assume present bulk-earth $^{147}Sm/^{144}Nd$ = 0.1967.

TABLE DR3. BULK-ROCK MAJOR AND TRACE ELEMENT DATA

	1213B	*1213B*	*1213B*	*1179D*	*1179D*	BHVO-1	BHVO-1
Sample	28R-2	31R-3	33R-5	20R-2	22R-05		
	(6-11)	(113-119)	(52-57)	(96-100) G	(80-83)	meas.	recomm.
SiO_2 (wt%)	49.65	49.25	48.88	48.99	50.01	49.89	49.59
TiO_2	1.61	1.47	1.45	1.52	1.68	2.74	2.69
Al_2O_3	14.41	14.78	14.64	15.93	16.91	13.71	13.70
Fe_2O_3*	13.07	12.66	12.45	11.17	9.30	12.44	12.39
MnO	0.20	0.17	0.17	0.17	0.30	0.17	0.17
MgO	7.64	7.72	8.31	8.04	7.66	7.26	7.22
CaO	12.01	12.46	12.25	12.02	12.23	11.42	11.32
Na_2O	2.06	1.92	1.87	2.31	2.16	2.24	2.24
K_2O	0.09	0.12	0.11	0.16	0.11	0.51	0.52
P_2O_5	0.15	0.15	0.14	0.14	0.17	0.27	0.27
Total	100.87	100.71	100.27	100.45	100.53	100.65	100.11
L.O.I.	2.29	1.74	1.30		4.38		
Cs (ppm)	0.022	0.026	0.029	0.046	0.013	0.13	0.10
Rb	0.74	1.5	1.3	2.5	0.75	9.8	9.5
Ba	14.8	16.1	15.5	34.9	31.8	133	133
Th	0.23	0.24	0.23	0.36	0.44	1.10	1.26
U	0.087	0.082	0.079	0.11	0.14	0.42	0.42
Nb	5.2	4.5	4.3	4.0	4.2	19.1	19.5
Ta	0.31	0.28	0.28	0.30	0.30	1.15	1.20
La	4.81	4.35	4.21	4.43	4.48	15.9	15.5
Ce	13.2	11.8	11.6	12.9	13.1	37.7	38.0
Pr	2.08	1.90	1.89	2.17	2.22	5.44	5.45
Pb	0.482	0.456	0.517	0.472	0.830	2.10	2.10
Sr	167	157	156	138	153	369	390
Nd	11.0	9.9	9.7	10.7	11.1	24.7	24.7
Hf	2.52	2.35	2.32	2.56	2.68	4.40	4.30
Zr	90.0	82.7	82.1	86.6	92.4	169	180
Sm	3.32	3.15	3.14	3.58	3.55	6.08	6.17
Eu	1.22	1.16	1.15	1.28	1.29	1.97	2.06
Gd	4.29	3.98	3.99	4.72	4.78	6.40	6.22
Tb	0.76	0.70	0.70	0.86	0.85	0.96	0.95
Dy	4.59	4.21	4.19	5.31	5.33	5.19	5.25
Y	28.0	25.4	24.7			27.3	28
Ho	1.01	0.94	0.92	1.17	1.15	0.99	1.00
Er	2.61	2.42	2.40	3.20	3.13	2.39	2.56
Tm	0.39	0.35	0.36	0.49	0.47	0.33	
Yb	2.55	2.32	2.27	3.19	3.10	2.02	1.98
Lu	0.39	0.35	0.34	0.52	0.49	0.29	0.28
Sc	51.5	42.5	46.5			32.5	31.8
Cr	285	287	316			292	289
Co	53	49	49			45	45
Ni	82	85	94			123	120

Note: Fe_2O_3*, total iron as Fe_2O_3; L.O.I., weight loss on ignition to 1100°C. G, glass. Measurements were made on the Hawaii Siemens 303-AS XRF spectrometer (major elements) and VG PQ-2S ICP-MS instrument (trace elements). Relative precision is ~0.5% for SiO_2, ~1% for other major elements; for trace elements it is <5% at levels above 0.5 ppm in the rock. Comparison of measured (mean of 15 analyses) and recommended (Govindaraju, 1994; Eggins et al., 1997) values for the BHVO-1 standard gives an indication of accuracy.

REFERENCES CITED

Duncan, R.A., Hooper, P.R., Rehacek, J., Marsh, J., and Duncan, A.R., 1997. The timing and duration of the Karoo igneous event, southern Gondwana: Journal of Geophysical Research, v. 102, p. 18,127-18,138.

Eggins, S.M., Woodhead, J.D., Kinsley, L.P.J., Mortimer, G.E., Sylvester, P., McCulloch, M.T., Hergt, J.M., and Handler, M.R., 1997. A simple method for the precise determination of ≥40 trace elements in geological samples by ICPMS using enriched isotope internal standardization: Chemical Geology, v. 134, p. 311-326.

Fleck, R.J., Sutter, J.F., and Elliot, D.H., 1977. Interpretation of discordant $^{40}Ar/^{39}Ar$ age-spectra of Mesozoic tholeiites from Antarctica: Geochimica et Cosmochimica Acta, v. 41, p. 15-32.

Galer, S.J.G., 1999. Optimal double and triple spiking for high precision lead isotopic measurement: Chemical Geology, v. 157, p. 255-274.

Govindaraju, K., 1994. Compilation of working values and sample descriptions for 383 geostandards: Geostandards Newsletter, Special Issue 18, p. 15-16.

Koppers, A.A.P., 2002. ArArCALC - software for Ar-40/Ar-39 age calculations: Computers & Geosciences, v. 28, p. 605-619.

Mahoney, J.J., 1987. An isotopic survey of Pacific oceanic plateaus: implications for their nature and origin: *in* Keating, B., Fryer, P., Batiza, R., and Boehlert, G., eds., Seamounts, Islands, and Atolls: American Geophysical Union Monograph 43, p. 207-220.

Min, K.W., Mundil, R., Renne, P.R., and Ludwig, K.R., 2000. A test for systematic errors in ^{40}Ar-^{39}Ar geochronology through comparison with U/Pb analysis of a 1.1-Ga rhyolite: Geochimica et Cosmochimica Acta, v. 64, p. 73-98.

Pringle, M.S., 1993. Age progressive volcanism in the Musicians Seamounts: a test of the hot spot hypothesis for the late Cretaceous Pacific: *in* Pringle, M.S., Sager, W.W., Sliter, W.V., Stein, S., eds., The Mesozoic Pacific: Geology, Tectonics, and Volcanism: American Geophysical Union Monograph 77, p. 187-216.

Renne, P.R., Swisher, C.C., Deino, A.L., Karner, D.B., Owens, T.L., and DePaolo, D.J., 1998. Intercalibration of standards, absolute ages and uncertainties in $^{40}Ar/^{39}Ar$ dating: Chemical Geology, v. 145, p. 117-152.

Roddick, J.C., 1978. The application of isochron diagrams in ^{40}Ar-^{39}Ar dating: a discussion: Earth and Planetary Science Letters, v. 41, p. 233-244.

Steiger, R.H., Jäger, E., 1977. Subcommission on geochronology: convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Todt, W., Cliff, R.A., Hanser, A., Hoffman, A.W., 1996. Evaluation of a ^{202}Pb-^{205}Pb double spike for high-precision lead isotope analysis: *in* Basu A., Hart, S., eds., Earth Processes: Reading the Isotopic Code: American Geophysical Union Monograph 95, p. 429-437.

York, D., 1969. Least squares fitting of a straight line with correlated errors: Earth and Planetary Science Letters, v. 5, p. 320-324.