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Influence of the Galápagos hotspot on the East Pacific Rise during Miocene superfast spreading

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APPENDIX

SAMPLE PREPARATION AND ANALYTICAL METHODS

Samples used in this study were obtained from DSDP and ODP drill cores stored at the Gulf Coast Repository at Texas A&M University (College Station, Texas, USA). At GEOMAR, the samples were wrapped in plastic foil and carefully manually crushed with a hammer, then sieved followed by repeated washing with deionized water in an ultrasonic bath to remove dust-sized particles by decantation until a clear solution was obtained. Subsequently, the material was dried overnight at 50 °C. Thereupon, the rock chips were handpicked under a binocular microscope in order to preclude the most altered parts (coatings, veinlets, filled vesicles) from further processing. Selected rock-chips and glass shards were then split into two fractions. Rock chips of one fraction were manually pulverized in an agate mortar for trace element analyses. The other subset of matrix and glass chips (0.5–2.0 mm) was used for isotope chemistry.

Trace elements of fourteen new and three re-processed samples (Table DR2) were analyzed by inductively coupled plasma mass spectrometry (ICP-MS) on an AGILENT 7500cs ICP-MS quadrupole instrument at the Institute for Geosciences, Kiel University (Garbe-Schönberg, 1993). About 100 mg of each sample powder were digested during a multi-step table-top procedure in sealed PFA vials (Savillex^{TM}) using, in a first step, a mixture of subboiled concentrated HF+HNO_3+HCl overnight at 160 °C. After evaporation of the digest solution, another dissolution step in a hot mixture of 2+1 HNO_3 and ultrapure DIW followed. Subsequent to a second evaporation step the residue was taken up with hot 1+3 HNO_3 and ultrapure DIW, and made up to a final volume of 50 ml. Prior to analysis, this solution was then 10-20fold diluted and spiked with 2.5 µg/l beryllium, indium, rhenium for internal standardization. More details of the analytical procedure, instrument setup, and calibration strategies can be found in Garbe-Schönberg (1993). Analyses of international rock standards (BIR-1, BHVO-1, and

BHVO-2) and duplicates of individually digested samples as well as results for replicate analyses during batch analysis are displayed in Table DR2. Results for BIR-1, BHVO-1 and BHVO-2 agree within <1-5 % of recommended values (GeoREM online data base; Govindaraju, 1994; Jochum et al., 1990) for most measured elements except for Zn being 6 % low and Ta being 24 % high in BIR-1, for Th and Nb being 14 % and 7 % high in BHVO-1 and for Li and Cr being 6 % low and 8 % high respectively in BHVO-2. Analyses of replicates of individual sample digestions are mostly within 2–3 %RSD. Based on reiterated runs of the identical sample solution ("replicate run" in Table DR2), instrumental data reproducibility is better than 1.0 % for all elements apart from Cs, and Pb which present values between 1 and 2 % (Table DR2). Additionally, trace element concentrations of thirteen fresh glass samples from ODP/IODP Site 1256 were determined by laser ablation ICP-MS at the same lab (labeled in Figs. 2 and 3 with crosses in symbol). A 193 nm excimer laser (GeoLas Pro, Coherent) coupled to a AGILENT 7500s ICPMS was operated at a repetition rate of 10 Hz with 80 μm spot size over an analysis interval of 90 s (peak) and 20 s (background), respectively. Helium was used as carrier gas in the ablation cell. Data integration of time-resolved signals was done externally using third party software (Glitter, Macquarie Univ., Australia). Results and details of precision and accuracy are given in Table DR3.

Nd and Pb (double-spike, DS) isotope analyses were obtained by thermal ionization mass spectrometry (TIMS) at GEOMAR. Both instruments, a Finnigan MAT 262 RPQ^{2+} (Sr, Pb) and a Thermo Finnigan TRITON-TI (Nd), operate in static multi-collection mode. The sample chips were leached in 2N HCl at 70 °C for one hour followed by a threefold cleaning in ELGA water prior to dissolution in a 4:1 HF-HNO_3 mixture at 150 °C for 48 hours. Nd and Pb chromatography followed the procedures outlined in Hoernle et al. (2008). Nd isotopic ratios were mass bias corrected within run to $^{146}Nd/^{144}Nd = 0.7219$, respectively. Within run errors are reported as $2\sigma / \sqrt{n-1}$ (n = number of scans passing the outlier test) and all external errors, such as the reproducibility of standards are reported as 2σ of the mean (Tables DR2 and DR4). Nd standards measured along with the samples were averaged and normalized for each sample turret (n = 3–5 standard measurements) and the normalization values applied to the sample data. This ensures best data comparison over the course of the project (2006–2011). According to this procedure, the La Jolla standard gave $^{143}Nd/^{144}Nd = 0.511850 \pm 0.000007$ (n = 41). Pb isotope ratios were determined using the Pb double-spike (Pb-DS) technique described in Hoernle et al. (2011). The long-term average double-spike corrected NBS981 values are $^{206}Pb/^{204}Pb = 16.9420 \pm 0.0029$, $^{207}Pb/^{204}Pb = 15.4999 \pm 0.0027$, $^{208}Pb/^{204}Pb = 36.7257 \pm 0.0071$, $^{207}Pb/^{206}Pb = 0.91488 \pm 0.00005$, $^{208}Pb/^{206}Pb = 2.16773 \pm 0.00009$ (n = 107). These values match up well with published NBS981 double- and triple-spike data (Baker et al., 2004; Baker et al., 2005; Galer, 1999; Thirlwall, 2000, 2002). Duplicate analysis of sample 67-495-48R4-71-74 cm was replicated within the external 2 sigma errors of the standards (Table DR2). Total Pb chemistry blanks were 40–90 pg and thus are considered to be insignificant.

Compared to the previously published conventional Pb data (Sadofsky et al. 2009), the re-processed samples from Leg 206 display higher $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios. We attribute these differences to: 1) application of Todt et al. (1996) NBS981 values for external fractionation correction of the conventionally measured data, and 2) analysis of leached powders instead of leached chips.

PALEOMAGNETIC CONSTRAINTS

Crustal ages shown in Fig. 1 and given in Table DR1 are based on magnetic anomalies. Ages of Sites 844, 845, 851, and 1256 (Table 1) can be determined fairly precisely from the profiles published by Wilson (1996). All are close to well-mapped reversals, with uncertainties of the order of 0.1 Myr. Sites 495 and 499 are in an area identified by Lonsdale (2005) as between anomalies C6Bn and C7. Based on inspection of publicly available profiles, we agree and assign a probable age of C6Cn. Site 83 is in a well-surveyed area of challenging magnetic geometry. Polarity reversals are clear and on the young side of the wide C5n.2n anomaly, though it is difficult to distinguish whether the site is within C4Ar or C5n.1. Site 82 is rather poorly surveyed, but is more than 100 km on the young side of anomaly C5n. Sites 846/1226 and 849 formed near the equator on the Nazca-Pacific EPR, with isochrons now parallel to magnetic north, so total-field magnetic anomalies are insensitive to polarity reversals. However, these sites formed within ~100 km of the triple-junction trace, and their ages can be judged with moderate precision from the clear anomalies mapped on the other side of the trace (Lonsdale, 2005; Wilson, 1996). In all cases, ages based on pelagic microfossils identified from oldest overlying sediments (see relevant DSDP/ODP cruise report volumes, references given in Table 1) overlap with or are slightly younger than the age inferred from magnetics.

DETAILS OF MODELLING IN FIGURE 2A

Since crucial parameters (exact source compositions and lithology, degrees of melting and melting processes) are unknown, we choose a simple fractional melting model (based on Johnson et al., 1990) for demonstrating the principal process that previous (deep) melt depletion of a more enriched source results in lower more versus less incompatible ratios and light versus heavy rare earth element ratios compared to the MORB source at the same degrees of ridge melting. For MORB source melting the elemental composition of McKenzie and O'Nions (1991) (Tb=0.08, Lu=0.05, La=0.21, Yb=0.35 ppm) is used with mineral proportions of 55 % ol, 25 % opx, 18 % cpx, 2 % sp and melting in the spinel lherzolite field with partition coefficients as shown below (selected from the GERM data base: earthref.org).

Phase/Part. Coeff.	**Tb**	**Lu**	**La**	**Yb**
Olivine	0.002	0.009	0.003	0.047
Opx	0.030	0.220	0.001	0.220
Cpx	0.310	0.560	0.105	0.601
Spinel	0.010	0.010	0.010	0.010
Garnet	0.750	8.054	0.016	6.600

For enriched source melting the elemental composition of "primitive mantle" according to Hofmann (1988) and mineral proportion of 55% ol, 20% opx, 15% cpx, and 10% gt are used. After deep melting of f =3% and melt removal, the residual matrix (with a composition of Tb =0.076, Lu =0.063, La =0.121, Yb =0.411 ppm) is then subjected to high degrees of melting in the spinel stability field under the same conditions as used for the MORB source melting. As can be seen in Fig. 2A, previous, deep source depletion of an initially more fertile, incompatible element enriched source results in lower ratios of more versus less incompatible elements and light versus heavy rare earth elements compared to the MORB source at the same degrees of shallow ridge melting. Deviations from the actual sample data (towards lower La/Yb ratios) is

caused by choosing element concentrations of published source compositions (see above) for simplicity. Including recycled material with e.g. higher La/Yb will improve the model but its exact compositions and proportions cannot be constrained.

REFERENCES OF LOCAL MORB IN FIGURES 2 and 3

For comparison of the analyzed 7-23 Ma drill core samples with local MORB, published MORB data from a ridge segment between 9°-10° N (see Fig. 1), which is believed to be unaffected by any hotspot (Sims et al., 2002) are used in Figure 2 and 3. At this location predominantly N-MORB is produced but enriched E-MORB can be found in off-axis settings (Waters et al., 2011). References for local (9°–10° N) N-MORB are from Sims et al. (2002; 2003), Goss et al. 2010, and for E-MORB from Waters et al. (2011). In addition, data for normal and transitional (T)-MORB from the next segment to the north (11°–15°N) from Castillo et al. (2000) is shown in Fig. 2.

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Table DR1. Site location, crustal ages based on magnetic lineations (in bold) and biostratigraphic age constraints of immediately overlying sediment (in italics). Nannofossil zone ages updated after Berggren et al. (1995). *Foraminiferal zone ages updated after Wade et al. (2011) [calibrated to the geomagnetic polarity time scale of Cande and Kent (1995)]. **Diatom zone age not updated.

Leg, Site, (Hole)	Coordinates	Approximate age	Reference for lithology and microfossil species
9-82	02º35.48'N; 106º56.52'W	**~7.0-8.5 Ma (C3B-C4)** *6.00-8.52 Ma* (Globorotalia plesiotumida zone, immediately above)*	Hays, Cook, Jenkins, et al.,1972
9-83	04º02.8'N; 95º44.25'W	**9.5-10.0 (older C4Ar or youngest C5n)** *9.79 Ma* (Globoquadrina altispira zone immediately above equates to Neogloboquadrina acostaensis)*	Hays, Cook, Jenkins, et al.,1972
138-844B	7º55.279'N; 90º28.846'W	**17.3 Ma (youngest C5Dn)** *17.5 Ma** (bottom of Crucidenticula nicobarica zone)*	Mayer, Pisias, Janecek, et al.,1992
138-845A	9º34.950'N; 94º35.448'W	**16.7 Ma (oldest C5Cn)** *14.8-16.0 Ma (CN3, NN4 zones*)	Mayer, Pisias, Janecek, et al.,1992
138-846B	3°5.696'S, 90°49.078'W	**16.7-17.5 Ma (C5Cr-C5Dn)** *14.8 - 16.01 Ma (Zone CN3)*	Mayer, Pisias, Janecek, et al.,1992
201-1226B	3°5.6686´S 90°49.0793´W	Same site as 846 above	D'Hondt, Jørgensen, Miller, et al., 2003
67-495	12°29.78'N; 91°02.26'W	**22.5-23.0 Ma (younger C6Cn)** *19.1-23.1 Ma (nannofossil Discoaster deflandrei subzone)*	Aubouin, von Huene, et al., 1982
138-849B	0º10.983'N; 110º31.183'W	***11.5-12.5 Ma (older C5r-younger C5A)*** *7.2-11.9 Ma (Subzone CN5b (Zone NN7)) based on the presence of common specimens of Discoaster kugleri and Dis- coaster musicus*	Mayer, Pisias, Janecek, et al.,1992
138-851B	2°46.223'N, 110°34.308'W	**11.9-12.0 Ma (oldest C5r)** *7.2-11.9 (nannofossil Subzone CN5b and foraminiferal Zone N14)*	Mayer, Pisias, Janecek, et al.,1992
206-1256C/ 206-1256D	6º44.163'N; 91º56.061'W	**15.2 Ma (youngest C5Br)** *14.5 Ma (based on extrapolated sedimentation rate and calcareous nannofossil record)*	Teagle, Wilson, Acton, et al., 2007

Table DR2. Whole-rock sample analyses (only alteration-resistent trace elements are given)

Sample ID	Li	Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Th	Nb	Ta	La	Ce	Pb	Pr	Nd	Sm	Hf	Zr	Eu	Gd	Tb	Dy	Ho	Y	Er	Tm	Yb	Lu	143Nd/144I	2 sigma	206Pb/204I	2 sigma	207Pb/204I	2 sigma	208Pb/204I	2 sigma	87Sr/86Sr	2 sigma
Leg 9-82-7R-1, 0-5 cm	7.47	47.8	396	139	57.9	64.4	76.6	125	18.8	0.29	3.65	0.23	5.32	15.7	1.84	2.67	14.3	4.92	3.38	134	1.70	6.66	1.22	8.33	1.78	50.3	5.01	0.76	5.07	0.76	0.513080	0.000003	18.4012	0.0013	15.4995	0.0015	37.9840	0.0047	0.703631	0.000005
Leg 9-82-7R-1, 28-32 cm	7.66	47.4	409	138	49.7	64.7	68.0	119	18.4	0.30	3.59	0.23	5.36	15.8	2.83	2.70	14.5	5.04	3.37	131	1.72	6.81	1.25	8.54	1.82	51.7	5.13	0.77	5.13	0.77	0.513126	0.000003	18.3593	0.0008	15.5041	0.0007	37.9621	0.0021	0.702765	0.000006
Leg 9-83-9R-1, 11-12 cm	11.8	45.6	422	66.2	41.4	40.5	54.5	120	18.8	0.69	3.61	0.24	5.73	16.7	3.60	2.82	15.0	5.15	3.94	150	1.74	6.81	1.25	8.51	1.81	52.0	5.11	0.77	5.13	0.77	0.513128	0.000003	18.4473	0.0011	15.5062	0.0011	38.0121	0.0029	0.703801	0.000005
Leg 9-83-9R-CC, 0-8 cm	13.1	48.4	455	99.6	60.3	59.0	59.9	127	19.1	0.51	3.56	0.23	5.52	16.3	4.04	2.77	15.0	5.16	3.76	137	1.77	6.94	1.28	8.66	1.86	53.2	5.26	0.80	5.32	0.79	0.513133	0.000002	18.4238	0.0007	15.5119	0.0006	38.0081	0.0015	0.703989	0.000005
Leg 67-495-48R-1, 65-68 cm	6.61	41.2	284	360	40.8	102	74.5	77.3	16.8	0.21	1.97	0.14	3.64	11.6	0.87	2.03	10.9	3.68	2.74	114	1.32	4.82	0.87	5.89	1.25	35.0	3.48	0.52	3.49	0.52	0.513113	0.000002	18.4778	0.0017	15.5079	0.0015	38.0985	0.0041	0.702630	0.000006
Leg 67-495-48R-4, 71-74 cm	7.89	42.8	293	344	40.7	99.9	73.6	77.9	17.1	0.13	1.94	0.14	3.50	11.4	0.64	2.01	11.0	3.73	2.75	115	1.35	4.87	0.89	5.98	1.26	35.5	3.55	0.53	3.53	0.53	0.513112	0.000003	18.4845	0.0012	15.5137	0.0013	38.1134	0.0042	0.702700	0.000005
Leg 67-495-48R-4, 71-74 cm (Duplicate for isotopes)																															0.513106	0.000002	18.4846	0.0010	15.5137	0.0009	38.1136	0.0021	0.702693	0.000005
Leg 138-844B-31X-CC, 44-47 cm	10.9	41.1	245	319	55.3	194	107	81.4	17.9	0.07	0.99	0.08	1.99	6.24	0.40	1.10	6.04	2.21	1.51	57.4	0.91	3.15	0.59	4.15	0.89	24.8	2.50	0.38	2.53	0.38	0.513009	0.000003	19.2932	0.0026	15.5815	0.0022	38.7865	0.0063	0.702825	0.000006
Leg 138-844B-31X-CC, 44-46 cm	10.0	41.3	247	325	58.2	210	111	86.7	18.3	0.12	1.04	0.08	1.96	6.19	0.71	1.08	5.97	2.18	1.58	60.7	0.92	3.10	0.59	4.03	0.87	23.9	2.43	0.36	2.38	0.36	0.513009	0.000003	19.1054	0.0017	15.5840	0.0017	38.7536	0.0051	0.702910	0.000005
Leg 138-845A-31X-CC, 39-41 cm	26.1	46.0	297	360	35.9	75.7	50.7	72.9	17.4	0.36	4.81	0.31	5.21	14.8	0.84	2.35	12.0	3.75	2.94	132	1.37	4.78	0.85	5.65	1.18	33.0	3.28	0.49	3.22	0.48	0.513082	0.000003	18.6856	0.0037	15.5323	0.0031	38.2726	0.0070	0.702663	0.000005
Leg 138-846B-45X-2, 39-45 cm	9.11	47.0	268	442	48.0	197	84.1	72.2	17.0	0.11	1.51	0.11	2.00	6.26	0.46	1.11	6.21	2.34	1.69	63.9	0.95	3.38	0.65	4.56	1.00	27.4	2.88	0.44	2.95	0.44	0.513097	0.000003	18.8024	0.0021	15.5175	0.0018	38.2123	0.0042	0.702911	0.000006
Leg 138-846B-45X-2, 39-45 cm (Replicate run)	9.21	46.9	269	444	47.7	197	84.0	72.4	16.9	0.11	1.49	0.11	2.00	6.28	0.48	1.12	6.27	2.33	1.70	64.1	0.95	3.37	0.65	4.58	1.00	27.4	2.87	0.44	2.98	0.45										
Leg 138-846B-45X-2, 39-45 cm (Replicate run)	9.12	47.4	270	450	48.1	199	84.3	72.9	17.0	0.11	1.49	0.11	2.00	6.26	0.47	1.11	6.25	2.34	1.71	64.3	0.96	3.37	0.65	4.56	1.00	27.6	2.87	0.44	2.97	0.45										
Relative standard deviation (%)	*0.5*	*0.4*	*0.4*	*0.8*	*0.4*	*0.4*	*0.2*	*0.4*	*0.4*	*0.9*	*0.7*	*2.0*	*0.1*	*0.2*	*1.3*	*0.3*	*0.4*	*0.1*	*0.5*	*0.3*	*0.3*	*0.1*	*0.6*	*0.1*	*0.1*	*0.4*	*0.1*	*0.3*	*0.5*	*0.2*										
Leg 201-1226B-47X-CC, 40-47 cm (Duplicate 1)	8.40	43.2	232	456	67.4	302	105	80.6	17.4	0.09	1.32	0.10	1.70	5.27	0.31	0.97	5.54	2.14	1.50	56.7	0.90	3.08	0.59	4.11	0.89	24.2	2.52	0.38	2.59	0.39	0.513098	0.000002	18.9115	0.0010	15.5285	0.0008	38.3833	0.0019	0.702955	0.000006
Leg 201-1226B-47X-CC, 40-47 cm (Duplicate 2)	8.20	42.3	225	454	65.6	296	103	77.1	17.0	0.08	1.28	0.09	1.66	5.16	0.29	0.95	5.40	2.09	1.47	55.3	0.88	3.00	0.58	4.02	0.87	23.7	2.48	0.38	2.53	0.38										
Difference (%)	*2.4*	*2.2*	*3.1*	*0.5*	*2.5*	*1.9*	*2.6*	*4.2*	*2.0*	*3.2*	*3.1*	*5.5*	*2.6*	*2.2*	*6.0*	*2.0*	*2.6*	*2.2*	*2.0*	*2.4*	*2.5*	*2.7*	*2.3*	*2.2*	*2.3*	*2.2*	*1.6*	*1.7*	*2.1*	*2.1*										
Leg 138-849B-37X-CC, 19 cm	6.97	47.2	381	206	44.2	67.3	66.2	95.1	17.8	0.23	2.64	0.17	3.60	10.8	0.76	1.88	10.5	3.71	2.69	101	1.33	5.10	0.94	6.45	1.38	38.9	3.92	0.59	3.95	0.59	0.513109	0.000004	18.5565	0.0018	15.5133	0.0016	38.1133	0.0038	0.702706	0.000006
Leg 138-849B-37X-CC, 25-28 cm	7.97	51.2	380	223	46.6	69.9	56.8	163	18.3	0.19	2.56	0.18	4.29	11.6	0.68	2.18	12.1	4.32	2.74	89.8	1.55	6.07	1.12	7.78	1.70	50.3	4.85	0.74	4.92	0.74	0.513117	0.000003	18.5687	0.0008	15.5154	0.0007	38.1174	0.0020	0.703258	0.000006
Leg 138-851B-34X-CC, 26-28 cm	6.24	47.1	361	235	39.8	75.4	73.0	91.1	17.3	0.18	2.67	0.18	3.47	10.3	0.63	1.80	9.86	3.48	2.46	91.7	1.26	4.78	0.88	6.03	1.30	36.5	3.67	0.55	3.69	0.55	0.513111	0.000003	18.5137	0.0048	15.5102	0.0041	38.1230	0.0105	0.703407	0.000005
Standards																																								
BIR-1_literature*	**3.20**	**43.00**	**319.00**	**391.00**	**52.00**	**166.00**	**119.00**	**72.00**	**15.30**	**0.032**	**0.55**	**0.0**	**0.615**	**1.92**	**3.10**	**0.37**	**2.4**	**1.12**	**0.58**	**14.0**	**0.53**	**1.87**	**0.36**	**2.51**	**0.56**	**15.6**	**1.66**	**0.25**	**1.65**	**0.25**										
BIR-1_measured	3.37	43.03	312.36	378.12	52.06	162.97	114.68	67.66	14.78	0.03	0.53	0.04	0.62	1.88	3.02	0.37	2.4	1.11	0.58	13.9	0.52	1.81	0.36	2.60	0.57	15.4	1.63	0.25	1.65	0.25										
BHVO-1_literature*	**4.60**	**31.80**	**317.00**	**289.00**	**45.00**	**121.00**	**136.00**	**105.00**	**21.00**	**1.08**	**17.11**	**1.10**	**15.80**	**39.00**	**2.08**	**5.70**	**25.20**	**6.20**	**4.38**	**179.00**	**2.06**	**6.40**	**0.96**	**5.20**	**0.99**	**27.60**	**2.40**	**0.33**	**2.02**	**0.29**										
BHVO-1_measured	4.71	31.21	319.15	286.19	45.24	120.35	135.97	104.42	21.20	1.23	18.3	1.10	15.7	38.5	2.11	5.46	25.3	6.20	4.38	176	2.09	6.32	0.95	5.43	0.99	26.1	2.47	0.33	2.02	0.28										
BHVO-2_literature**	**4.80**	**32.00**	**317.00**	**280.00**	**45.00**	**119.00**	**127.00**	**103.00**	**22.00**	**1.22**	**18.10**	**1.14**	**15.20**	**37.50**	**1.60**	**5.35**	**24.50**	**6.07**	**4.36**	**172.00**	**2.07**	**6.24**	**0.92**	**5.31**	**0.98**	**26.00**	**2.54**	**0.33**	**2.00**	**0.27**										
BHVO-2_measured	4.52	32.07	321.60	303.24	45.99	123.01	128.06	104.70	21.27	1.22	18.4	1.10	15.4	37.7	1.67	5.37	24.8	6.13	4.36	175	2.07	6.24	0.94	5.37	0.99	26.0	2.44	0.33	2.01	0.28										
Re-processed samples (previously published in Sadofsky et al., 2009)																																								
Leg 206-1256C-10R-2, 103-105 cm	4.30									0.27	3.65	0.24	4.28	12.8	0.20	2.25	11.9	4.19	2.96	107	1.55	5.77	1.08	7.34	1.58	43.6	4.51	0.68	4.60	0.68	0.513089	0.000003	18.6670	0.0011	15.5218	0.0009	38.2867	0.0023	0.702845	0.000005
Leg 206-1256C-11R-2, 76-78 cm																															0.513082	0.000005	18.6058	0.0008	15.5211	0.0007	38.2294	0.0020	0.702976	0.000005
Leg 206- 1256D-54R-2, 83-86 cm	3.66									0.18	2.25	0.15	2.30	7.56	0.30	1.39	7.69	2.83	1.99	69.6	1.10	3.97	0.75	5.15	1.10	30.1	3.16	0.48	3.23	0.49	0.513085	0.000003	18.7383	0.0009	15.5238	0.0008	38.2212	0.0019	0.702872	0.000005
Leg 206-1256D-74R-2, 102-111 cm	4.05									0.15	1.90	0.13	2.30	7.58	0.24	1.41	7.77	2.92	2.03	70.1	1.15	4.18	0.79	5.52	1.20	32.9	3.48	0.53	3.61	0.55	0.5131	0.000002	18.5457	0.0009	15.5119	0.0008	38.1729	0.002	0.703005	0.000006

*Jochum et al., 1990; Govindaraju, 1994

** GeoRem (Jochum et al. 2005)

Table DR3. Glass analyses (Site 1256) by Laser-ICP-MS

	1256C-06R1-50-53	±1σ	1256C-06R1-50-53 (Replicate)	±1σ	1256D-14R1-139-142	±1σ	1256D-17R1-65-68	±1σ	1256D-18R1-81-84	±1σ	1256D-20R1-33-37	±1σ	1256D-21R1 116-119	±1σ	1256D-23R2-16-20	±1σ	1256D-30R1-44-59	±1σ	1256D-38R1-121-124	±1σ	1256D-40R1-31-36	±1σ	1256D-43R1-9-12	±1σ	1256D-43R1-9-12 (Replicate)	±1σ	1256D-51R2-60-64	±1σ	1256D-62R1-10-12	±1σ
U	5.76	0.88	6.78	0.17	5.65	0.10	5.49	0.09	5.57	0.10	5.70	0.16	12.2	0.41	5.39	0.17	4.49	0.06	4.61	0.11	4.35	0.07	4.59	0.07	4.51	0.05	6.02	0.07	4.96	0.13
Sc	48.4	0.77	47.1	0.95	42.9	0.54	48.7	0.32	46.3	0.56	45.5	0.33	40.6	0.37	46.6	0.52	45.4	0.47	47.5	0.24	42.5	1.12	45.7	0.31	45.5	0.30	43.6	0.11	46.9	0.26
V	429	9.76	420	4.15	317	5.77	341	6.64	338	6.73	349	5.52	190	1.84	328	3.81	295	1.75	296	6.19	278	4.37	302	2.81	293	0.52	354	3.94	310	9.36
Mn	1643	23.8	1756	26.9	1481	22.8	1485	30.4	1620	31.4	1639	31.1	1725	20.5	1693	165	1473	8.91	1506	24.6	1441	38.8	1365	17.2	1454	11.5	1620	20.9	1410	22.6
Co	44.7	0.66	44.3	0.70	39.1	0.80	46.6	0.87	47.4	1.03	46.5	1.11	33.2	0.60	56.6	14.2	46.5	0.44	46.9	1.04	43.8	0.81	46.2	0.67	46.0	0.42	44.8	0.77	47.5	1.08
Ni	50.0	0.39	49.6	0.81	69.3	1.31	54.2	0.71	55.4	2.51	48.7	1.07	23.6	0.82	101	60.9	87.3	1.42	79.7	2.14	75.6	4.19	90.2	1.32	90.1	0.96	43.6	0.74	78.5	2.50
Cu	70.4	0.87	70.2	1.27	79.1	1.37	89.4	0.82	92.3	2.55	85.5	1.55	48.2	1.97	92.8	2.80	105	1.48	106	3.14	104	10.8	104	1.97	105	1.88	79.4	1.51	98.9	3.35
Zn	125	2.23	129	3.24	100	2.15	103	2.35	110	3.65	117	3.33	175	3.18	112	8.26	95.9	1.82	92.4	2.80	87.1	4.97	91.6	1.15	92.8	1.00	119	2.85	97.9	3.29
Ga	18.2	0.19	18.5	0.44	17.9	0.21	16.0	0.25	16.6	0.27	17.2	0.54	21.8	0.43	16.5	0.28	15.4	0.27	15.6	0.38	14.7	0.35	14.8	0.18	15.0	0.32	17.7	0.34	15.3	0.43
Rb	1.88	0.05	1.90	0.05	4.10	0.04	1.19	0.02	1.23	0.03	1.37	0.04	5.39	0.14	1.14	0.01	1.67	0.04	1.56	0.02	1.44	0.03	1.80	0.02	1.83	0.05	1.97	0.03	1.60	0.06
Sr	85.4	0.92	83.8	1.54	141	0.90	75.0	0.75	75.5	0.87	77.6	1.74	86.9	1.93	74.2	0.42	76.3	1.40	78.5	1.49	77.6	0.88	76.0	1.93	74.4	1.58	84.0	1.16	75.2	2.05
Y	43.6	0.69	40.6	1.31	32.4	0.61	30.8	0.68	27.8	0.25	29.1	0.70	102	2.80	27.1	0.45	22.4	0.51	24.5	0.50	20.8	0.55	23.9	0.73	23.1	0.51	31.8	0.41	26.5	0.99
Zr	111	1.77	106	2.99	120	2.13	68.0	1.52	64.0	0.66	68.5	1.49	298	7.47	61.9	1.03	52.1	1.17	57.0	1.22	49.9	1.24	55.2	1.59	54.3	1.30	82.6	1.06	59.9	2.45
Nb	3.91	0.08	3.94	0.08	7.93	0.06	2.30	0.03	2.39	0.04	2.65	0.06	10.5	0.22	2.21	0.02	2.95	0.05	2.80	0.05	2.77	0.05	3.26	0.09	3.18	0.12	3.64	0.05	2.89	0.10
Cs	0.03	0.01	0.03	0.00	0.05	0.00	0.02	0.00	0.02	0.00	0.01	0.00	3.06	0.00	0.01	0.00	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00
Ba	17.6	0.85	17.7	0.19	40.3	0.40	12.0	0.16	12.4	0.18	13.8	0.21	0.06	0.99	11.5	0.23	18.3	0.21	16.7	0.31	16.3	0.30	19.7	0.35	19.7	0.81	18.7	0.15	17.0	0.40
La	4.10	0.12	4.07	0.06	6.5	0.07	2.41	0.05	2.41	0.03	2.64	0.05	10.6	0.26	2.27	0.04	2.41	0.02	2.46	0.04	2.34	0.05	2.62	0.06	2.61	0.11	3.38	0.02	2.51	0.08
Ce	12.1	0.33	12.2	0.16	17.3	0.15	7.14	0.12	7.32	0.18	8.01	0.12	30.4	0.81	6.80	0.08	6.56	0.09	6.63	0.17	6.43	0.16	7.05	0.16	6.98	0.24	9.98	0.09	6.94	0.12
Pr	2.08	0.07	2.05	0.03	2.64	0.03	1.24	0.03	1.27	0.02	1.38	0.02	5.17	0.13	1.19	0.01	1.09	0.01	1.10	0.02	1.06	0.02	1.14	0.03	1.13	0.03	1.65	0.02	1.15	0.03
Nd	11.3	0.33	11.2	0.14	13.1	0.07	7.03	0.12	7.18	0.14	7.71	0.14	28.1	0.78	6.80	0.09	5.96	0.09	6.20	0.10	5.84	0.16	6.06	0.17	6.09	0.14	9.07	0.06	6.27	0.11
Sm	4.09	0.10	4.05	0.06	3.99	0.02	2.66	0.06	2.67	0.05	2.86	0.04	9.82	0.33	2.56	0.05	2.13	0.04	2.26	0.04	2.13	0.07	2.18	0.06	2.24	0.06	3.25	0.02	2.31	0.04
Eu	1.43	0.05	1.42	0.02	1.42	0.01	1.00	0.03	1.03	0.02	1.08	0.01	2.86	0.08	0.97	0.01	0.83	0.02	0.85	0.01	0.83	0.02	0.84	0.02	0.83	0.02	1.18	0.01	0.85	0.02
Gd	5.99	0.14	5.63	0.16	4.99	0.11	4.09	0.11	3.86	0.05	4.00	0.07	14.0	0.58	3.67	0.04	3.06	0.05	3.38	0.05	2.94	0.09	3.19	0.08	3.21	0.05	4.54	0.05	3.48	0.05
Tb	1.07	0.02	1.01	0.03	0.85	0.01	0.73	0.02	0.70	0.01	0.72	0.01	2.46	0.10	0.67	0.01	0.55	0.01	0.61	0.01	0.53	0.01	0.58	0.01	0.57	0.01	0.81	0.01	0.63	0.01
Dy	7.46	0.15	6.94	0.21	5.76	0.07	5.18	0.13	4.86	0.05	5.02	0.03	17.22	0.63	4.63	0.09	3.88	0.06	4.19	0.09	3.65	0.10	4.08	0.11	3.96	0.08	5.51	0.04	4.46	0.10
Ho	1.59	0.03	1.49	0.04	1.21	0.02	1.13	0.03	1.04	0.02	1.08	0.01	3.67	0.12	0.99	0.02	0.83	0.01	0.91	0.02	0.79	0.03	0.87	0.02	0.86	0.02	1.19	0.01	0.96	0.02
Er	4.82	0.11	4.45	0.13	3.52	0.08	3.43	0.10	3.13	0.04	3.24	0.04	11.1	0.33	2.96	0.03	2.48	0.04	2.72	0.04	2.30	0.05	2.61	0.07	2.56	0.06	3.56	0.06	2.90	0.09
Tm	0.75	0.02	0.68	0.01	0.53	0.01	0.53	0.01	0.49	0.01	0.49	0.01	1.73	0.04	0.46	0.01	0.38	0.01	0.41	0.01	0.35	0.01	0.41	0.01	0.40	0.01	0.54	0.01	0.45	0.01
Yb	4.83	0.14	4.52	0.06	3.58	0.04	3.45	0.05	3.23	0.05	3.34	0.07	11.2	0.44	3.03	0.06	2.53	0.02	2.75	0.06	2.41	0.06	2.67	0.07	2.65	0.04	3.60	0.03	2.90	0.08
Lu	0.74	0.02	0.69	0.02	0.52	0.01	0.53	0.02	0.50	0.01	0.50	0.01	1.70	0.05	0.46	0.01	0.39	0.00	0.43	0.01	0.36	0.01	0.41	0.01	0.40	0.00	0.55	0.01	0.45	0.01
Hf	3.08	0.07	2.84	0.04	2.78	0.07	2.00	0.04	1.81	0.04	1.88	0.04	8.05	0.29	1.69	0.03	1.41	0.03	1.60	0.02	1.34	0.02	1.54	0.03	1.50	0.02	2.25	0.02	1.71	0.04
Ta	0.23	0.01	0.25	0.00	0.47	0.01	0.14	0.00	0.15	0.00	0.17	0.00	0.61	0.01	0.14	0.00	0.18	0.00	0.18	0.00	0.16	0.01	0.18	0.01	0.20	0.01	0.23	0.00	0.17	0.00
Pb	0.52	0.02	0.48	0.00	0.75	0.04	0.35	0.03	0.33	0.01	0.38	0.01	1.07	0.03	0.30	0.01	0.03	0.00	0.36	0.05	0.31	0.02	0.28	0.01	0.27	0.00	0.43	0.02	0.42	0.05
Th	0.28	0.01	0.27	0.00	0.51	0.01	0.16	0.01	0.16	0.01	0.17	0.00	0.81	0.01	0.14	0.01	0.20	0.01	0.20	0.01	0.18	0.01	0.22	0.01	0.23	0.00	0.24	0.00	0.21	0.00
U	0.09	0.01	0.09	0.00	0.16	0.00	0.05	0.00	0.06	0.00	0.23	0.00	0.05	0.00	0.06	0.01	0.06	0.00	0.05	0.00	0.07	0.00	0.07	0.00	0.08	0.00	0.08	0.00	0.07	0.00
number of ana	*5*		*4*		*5*		*5*		*5*		*5*		*5*		*4*		*5*		*5*		*4*		*4*		*4*		*5*		*5*	

	NIST SRM 612	±1σ	±1σ% (relative standard deviation)	Reference value*	BCR-2G	±1σ	±1σ% (relative standard deviation)	Reference value**	GOR128-G	±1σ	±1σ% (relative standard deviation)	Reference value***	StHs6/80G	±1σ	±1σ% (relative standard deviation)	Reference value***	KL2-G	±1σ	±1σ% (relative standard deviation)	Reference value***
U	34.6	0.90		*2.60*	*40.2*	8.12	0.27	*3.37*	*10.0*	10.4	0.18	*1.90*	*10.4*	18.4	0.55	*2.98*	*20.7*	5.12	0.06	*1.26*	*5.10*
Sc	41.4	0.70		*1.68*	*39.9*	35.2	0.51	*1.46*	*33.0*	32.2	0.44	*1.49*	*32.1*	10.9	0.05	*0.43*	*11.5*	31.9	0.62	*1.93*	*31.8*
V	37.5	0.84		*2.23*	*38.8*	425	9.85	*2.32*	*425*	188	4.90	*2.85*	*189*	83.0	2.18	*2.62*	*90.3*	303	7.20	*2.38*	*309*
Mn	37.6	2.10		*5.57*	*38.7*	1524	68.9	*4.52*	*1550*	1463	56.8	*4.25*	*1390*	577	25.9	*4.50*	*610*	1258	52.0	*4.14*	*1290*
Co	33.4	0.78		*2.34*	*35.5*	36.4	1.01	*2.77*	*38.0*	92.2	1.70	*2.03*	*92.4*	12.8	0.34	*2.67*	*13.2*	41.3	0.93	*2.25*	*41.2*
Ni	38.4	0.94		*2.45*	*38.8*	11.9	0.50	*4.23*	*12.6*	1161	33.2	*3.13*	*1074*	20.2	0.50	*2.49*	*23.7*	112	2.23	*1.99*	*112*
Cu	41.7	1.10		*2.65*	*37.8*	16.6	0.97	*5.86*	*19.6*	67.0	2.80	*4.57*	*63.8*	40.4	0.70	*1.73*	*41.5*	87.9	1.79	*2.03*	*87.9*
Zn	39.3	1.23		*3.13*	*39.1*	147	5.92	*4.04*	*145*	76.3	3.46	*4.97*	*74.7*	67.2	1.15	*1.72*	*67.0*	104	2.45	*2.36*	*110*
Ga	33.7	0.99		*2.94*	*36.9*	21.6	0.76	*3.49*	*23.0*	9.13	0.18	*2.20*	*8.67*	20.1	0.32	*1.60*	*20.9*	20.0	0.30	*1.52*	*20.0*
Rb	30.6	0.84		*2.75*	*31.4*	47.7	1.69	*3.56*	*47.0*	0.41	0.01	*1.35*	*0.41*	29.8	0.85	*2.84*	*30.7*	8.63	0.16	*1.85*	*8.70*
Sr	80.2	1.73		*2.15*	*78.4*	339	6.09	*1.80*	*334*	29.3	0.56	*2.11*	*30.0*	493	9.04	*1.83*	*482*	359	6.38	*1.78*	*356*
Y	43.9	1.11		*2.54*	*38.3*	36.4	0.77	*2.12*	*35.0*	11.9	0.37	*3.37*	*11.8*	12.5	0.32	*2.57*	*11.4*	25.0	0.99	*3.96*	*25.4*
Zr	42.0	1.14		*2.72*	*37.9*	194	4.15	*2.14*	*184*	9.96	0.21	*2.35*	*10.0*	130	2.78	*2.14*	*118*	152	5.82	*3.84*	*152*
Nb	39.1	0.78		*2.01*	*38.9*	12.7	0.20	*1.59*	*12.5*	0.10	0.00	*1.99*	*0.10*	7.12	0.15	*2.07*	*6.94*	15.0	0.23	*1.53*	*15.0*
Cs	40.7	1.23		*3.04*	*42.7*	1.16	0.04	*3.65*	*1.16*	0.23	0.01	*2.68*	*0.24*	1.49	0.04	*2.37*	*1.75*	0.12	0.01	*4.74*	*0.12*
Ba	39.7	0.59		*1.49*	*39.3*	684	13.4	*1.96*	*683*	1.07	0.04	*4.00*	*1.06*	309	7.57	*2.45*	*298*	122	1.57	*1.29*	*123*
La	37.4	0.65		*1.73*	*36.0*	25.2	0.44	*1.76*	*24.7*	0.12	0.00	*3.96*	*0.12*	12.3	0.21	*1.72*	*12.0*	13.0	0.26	*2.03*	*13.1*
Ce	40.3	0.62		*1.54*	*38.4*	53.3	1.10	*2.06*	*53.3*	0.45	0.02	*3.73*	*0.45*	26.3	0.58	*2.22*	*26.1*	32.4	0.42	*1.31*	*32.4*
Pr	40.0	0.58		*1.46*	*37.9*	6.73	0.11	*1.64*	*6.70*	0.10	0.01	*5.16*	*0.10*	3.24	0.05	*1.53*	*3.20*	4.57	0.06	*1.21*	*4.60*
Nd	37.3	0.83		*2.22*	*35.5*	29.0	0.52	*1.80*	*28.9*	0.75	0.02	*3.26*	*0.78*	13.4	0.24	*1.81*	*13.0*	21.4	0.35	*1.61*	*21.6*
Sm	39.4	0.95		*2.41*	*37.7*	6.68	0.14	*2.12*	*6.59*	0.53	0.01	*1.69*	*0.53*	2.91	0.05	*1.56*	*2.78*	5.54	0.10	*1.85*	*5.54*
Eu	36.5	0.72		*1.98*	*35.6*	1.95	0.03	*1.73*	*1.97*	0.26	0.01	*2.59*	*0.26*	0.96	0.02	*2.13*	*0.95*	1.92	0.03	*1.73*	*1.92*
Gd	42.7	1.08		*2.54*	*37.3*	7.08	0.18	*2.48*	*6.71*	1.17	0.04	*3.41*	*1.17*	2.76	0.09	*3.29*	*2.59*	5.92	0.23	*3.90*	*5.92*
Tb	42.0	1.04		*2.49*	*40.0*	1.08	0.03	*2.35*	*1.02*	0.25	0.01	*2.49*	*0.25*	0.40	0.01	*2.19*	*0.37*	0.89	0.03	*3.23*	*0.89*
Dy	40.1	0.89		*2.21*	*35.5*	6.77	0.17	*2.46*	*6.44*	1.93	0.06	*3.45*	*1.98*	2.36	0.05	*2.09*	*2.22*	5.22	0.17	*3.31*	*5.22*
Ho	42.7	1.08		*2.53*	*38.3*	1.36	0.04	*2.57*	*1.27*	0.44	0.01	*1.76*	*0.44*	0.46	0.01	*1.82*	*0.42*	0.96	0.04	*4.59*	*0.96*
Er	42.9	1.09		*2.55*	*38.0*	3.88	0.10	*2.55*	*3.70*	1.34	0.03	*2.28*	*1.40*	1.27	0.03	*1.99*	*1.18*	2.54	0.07	*2.78*	*2.54*
Tm	44.8	1.08		*2.40*	*36.8*	0.57	0.02	*2.59*	*0.51*	0.21	0.01	*4.63*	*0.20*	0.19	0.01	*3.51*	*0.17*	0.35	0.01	*2.62*	*0.33*
Yb	43.7	1.05		*2.40*	*39.2*	3.63	0.08	*2.21*	*3.39*	1.35	0.03	*2.67*	*1.41*	1.19	0.03	*2.60*	*1.13*	2.10	0.04	*2.11*	*2.10*
Lu	44.3	1.19		*2.68*	*37.0*	0.56	0.02	*2.78*	*0.50*	0.21	0.01	*3.50*	*0.21*	0.19	0.01	*3.70*	*0.17*	0.30	0.01	*1.98*	*0.29*
Hf	41.0	1.07		*2.60*	*36.7*	5.13	0.12	*2.41*	*4.84*	0.33	0.01	*1.89*	*0.35*	3.21	0.06	*1.98*	*3.07*	3.93	0.12	*3.03*	*3.93*
Ta	40.2	2.41		*5.99*	*37.6*	0.81	0.04	*4.85*	*0.78*	0.02	0.00	*10.2*	*0.02*	0.45	0.03	*5.48*	*0.42*	0.93	0.05	*5.67*	*0.96*
Pb	39.5	0.74		*1.87*	*38.6*	11.1	0.40	*3.65*	*11.0*	0.33	0.01	*2.97*	*0.35*	11.4	0.28	*2.42*	*10.3*	1.95	0.06	*3.32*	*2.07*
Th	40.9	1.10		*2.69*	*37.8*	6.28	0.15	*2.39*	*5.90*	0.01	0.00	*15.1*	*0.01*	2.43	0.05	*2.10*	*2.28*	1.01	0.03	*2.65*	*1.02*
U	38.6	1.20		*3.11*	*37.4*	1.78	0.06	*3.53*	*1.69*	0.01	0.00	*14.9*	*0.01*	1.04	0.05	*4.88*	*1.01*	0.54	0.03	*5.18*	*0.55*
number of ana	*36*				*31*				*5*				*5*				*6*			

* Jochum et al. (2011): Determination of Reference values for NIST SRM 610-617 Glasses following ISO Guidelines. Geostandards and Geoanalytical Research, 1-33.

** USGS BCR-2G: GeoReM preferred Values, Jochum (MPCH Mainz, Germany), 1/2009, http://georem.mpch-mainz.gwdg.de.

*** Jochum et al. (2006): MPI DING reference glasses for in situ microanalysis: New reference values for element concentrations and isotope ratios. Geochemistry Geophysics Geosystems, 7: 1-44.

Table DR4.

Sample ID	87Sr/86Sr	2 SE(M)	143Nd/144Nd	2 SE(M)	206Pb/204Pb	2 SE(M)	207Pb/204Pb	2 SE(M)	208Pb/204Pb	2 SE(M)
Site 1256 glass samples (Leg 206)										
Hole C-6R1, 50-53 cm	0.703089	0.000003	0.513098	0.000003	18.5895	0.0014	15.5154	0.0012	38.2084	0.0034
Hole C- 14R1, 139-142 cm	0.702915	0.000003	0.513070	0.000003	18.8555	0.0006	15.6619	0.0006	38.8866	0.0018
Hole D-17R1, 65-68 cm	0.702900	0.000002	0.513100	0.000003	18.5443	0.0017	15.5088	0.0013	38.1574	0.0034
Hole D-18R1, 81-84 cm	0.702899	0.000003	0.513097	0.000003	18.5467	0.0026	15.5116	0.0023	38.1657	0.0061
Hole D-20R1, 33-37 cm	0.702862	0.000003	0.513096	0.000003	18.5599	0.0014	15.5146	0.0012	38.1861	0.0028
Hole D-21R1, 116-119 cm	0.702933	0.000002	0.513093	0.000003	18.6013	0.0007	15.5186	0.0006	38.2451	0.0015
Hole D-23R2, 16-20 cm	0.703047	0.000003	0.513093	0.000003	18.5519	0.0047	15.5044	0.0039	38.1560	0.0096
Hole D-30R1, 44-59 cm	0.702968	0.000003	0.513090	0.000003	18.6793	0.0088	15.5224	0.0074	38.3180	0.0190
Hole D-38R1, 121-124 cm	0.703400	0.000003	0.513088	0.000002	18.6535	0.0016	15.5252	0.0014	38.2747	0.0037
Hole D-40R1, 31-36 cm	0.702927	0.000003	0.513086	0.000003	18.6209	0.0017	15.5195	0.0014	38.2615	0.0038
Hole D-43R1, 9-12 cm	0.702964	0.000003	0.513087	0.000002	18.6882	0.0017	15.5265	0.0016	38.3380	0.0044
Hole D-51R2, 60-64 cm	0.702980	0.000003	0.513072	0.000003	18.5991	0.0011	15.5179	0.0009	38.2435	0.0023
Hole D-62R1, 10-12 cm	0.703072	0.000003	0.513109	0.000003	18.6293	0.0015	15.5181	0.0013	38.2582	0.0031