Supporting Information for

Size and composition of the residual and depleted mantle reservoir

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Figure Captions for Supplementary Figures

Fig. S 1. Log U vs log Nb and log Ta for global MORB data. Slopes have been calculated from two-error regression analysis assuming equal error on both axes (see also Table S1). The concentrations values are normalized to the Primitive Mantle values given by McDonough and Sun {, 1995 #16}. (a) Data for about 400 MORB segment averages from Gale et al. {, 2013 #12}. (b) MORB glass data from Jenner and O'Neill {, 2012 #25}. (c) MORB data given by Arevalo and McDonough {, 2010 #26}.

Fig. S 2a. Slopes of log-log regressions such as those shown in Fig. S1 for logarithms of Ba, Th, U, Ta, K, La versus log Nb (in the abscissa). The slopes are listed in Table S1. (2b) Same as (a), but using the logarithms of Ba, Th, Nb, U, K, La, versus log Ta. The plots show that all three data sets give remarkably similar results: The slope of log U vs. log Nb is slightly below 1.0, whereas the slope of log U vs. log Ta is slightly greater than 1.0. From these slopes we infer the following order of increasing compatibility; Ba < Th < Nb < U < Ta <K < La.

Fig. S3. Nb/Th vs Nb in MORB {Gale, 2013 #12}, oceanic plateaus, normal and HIMU-type OIBs, and EM-type OIBs, in addition to values for the primitive mantle {McDonough, 1995 #16} and average continental crust {Rudnick, 2003 #14}. This plot shows that, although Nb/Th ratios are not strictly "canonical" in that they vary systematically as a function of global enrichment/depletion, their ratios in OIBs and oceanic plateaus are similarly complementary to

the continental crust as MORB values. EM-type OIBs appear to deviate systematically from the general MORB-OIB-oceanic plateau array toward somewhat lower values, presumably because they contain small amounts of recycled continental material. The OIB data are listed in Table S4.

Fig. S4. Comparison of the ALL MORB average given by Gale et al. {, 2013 #12} with partial melts of the Depleted Mantle of Workman and Hart {, 2005 #20}, using equilibrium batch melting and aggregate fractional melting. A melt fraction F = 0.03 and a final enrichment of the melt by fractional crystallization, increasing the final trace element concentrations by a factor of 1.35, following Su and Langmuir {, 2002 #70}, generates a final melt closely resembling the ALLMORB average of Gale et al {, 2013 #12}. A melt fraction of F = 0.03 is substantially lower than any of the published estimates of melt fractions involved in generating MORB.

Fig. S5. Generating MORB (ALLMORB average of Gale et al,. 2013) by partially melting the Residual Mantle (RM) derived in this paper. The specific version of RM is based on the crustal average of Rudnick and Gao (2003), X(RM) = 0.974 (see Table 1). As shown in Fig. S4, batch melts and aggregate fractional melts yield similar results, but the melt fraction is significantly higher, F = 0.09 and a final factor of 1.35.

≈ 600 MORB Glasses

Jenner & O'Neill, 2012

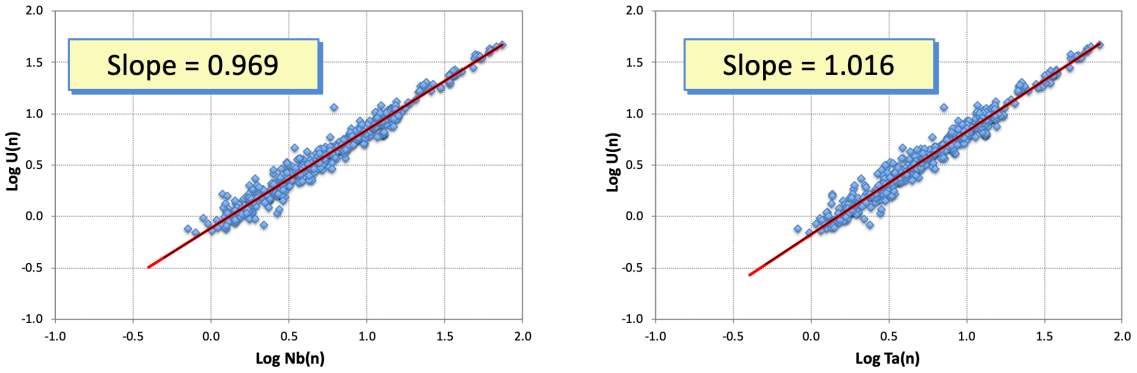

Fig. S1b

About 400 MORB segment averages

Gale et al. 2013

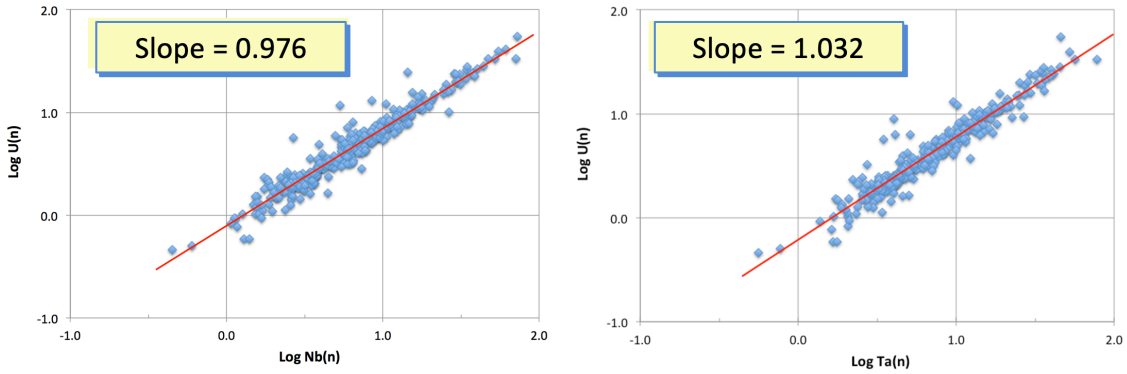

Fig. S1a

≈ 650 MORB Glasses

Arevalo & McDonough, 2010

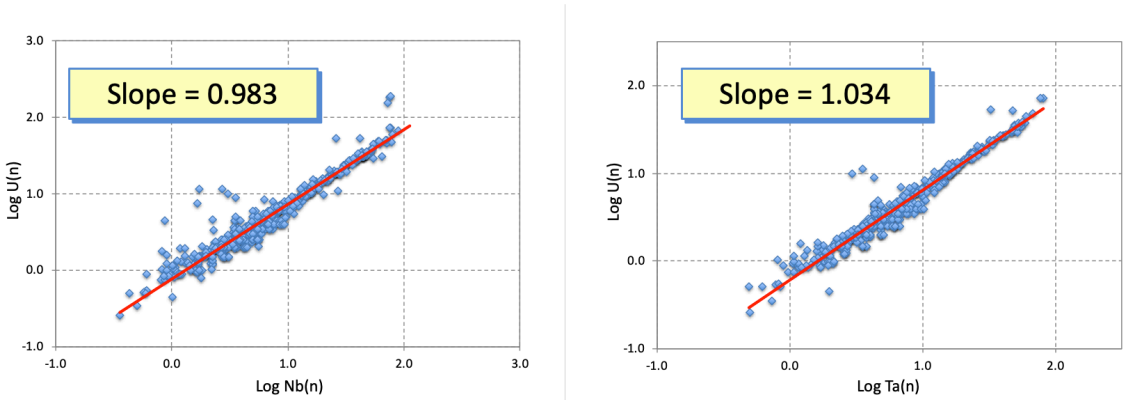

Fig. S1c

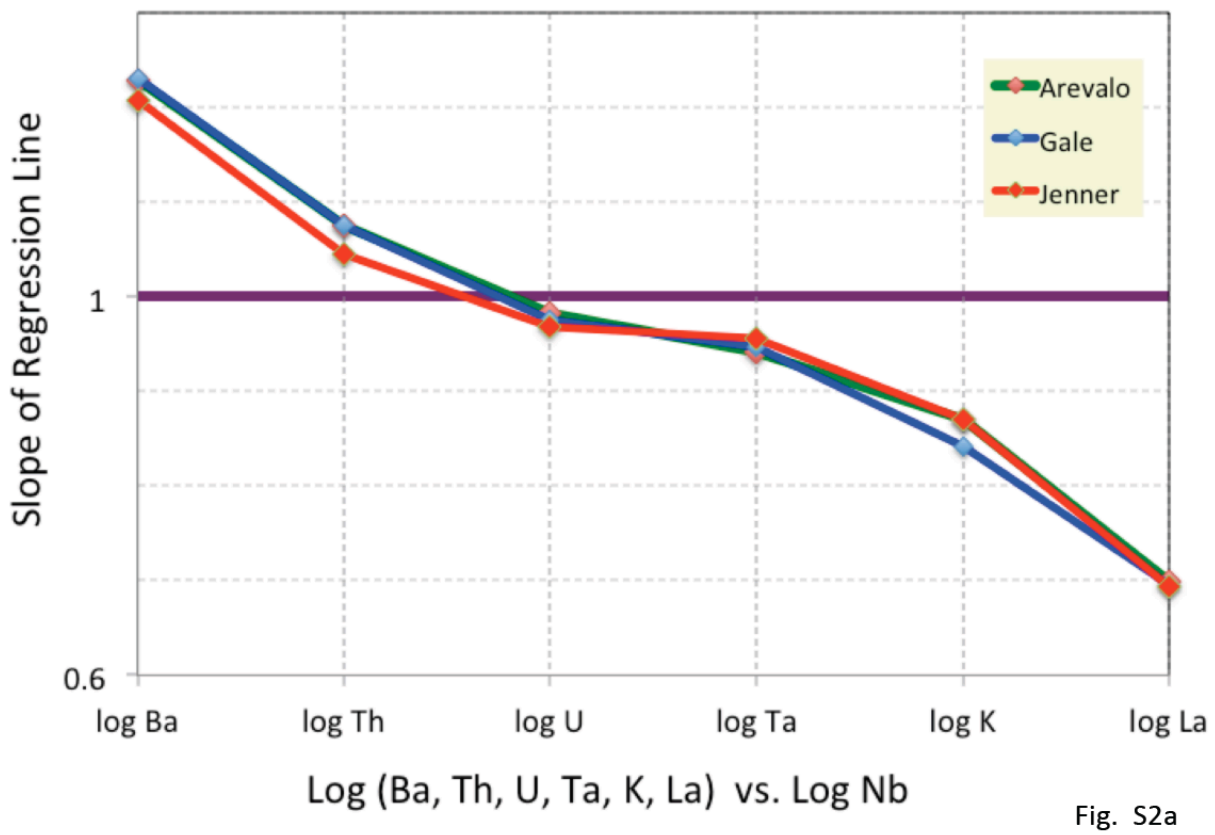

Fig. S2a

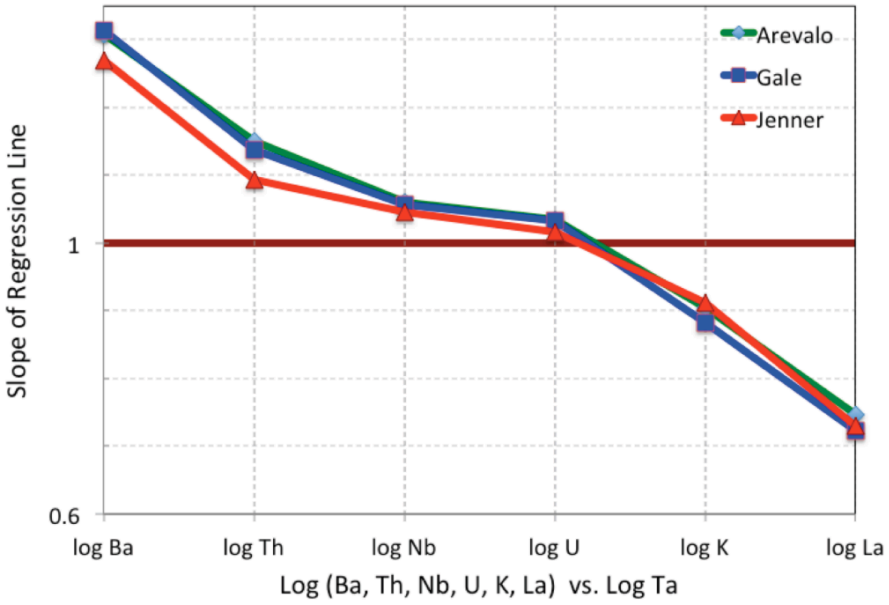

Fig. S2b

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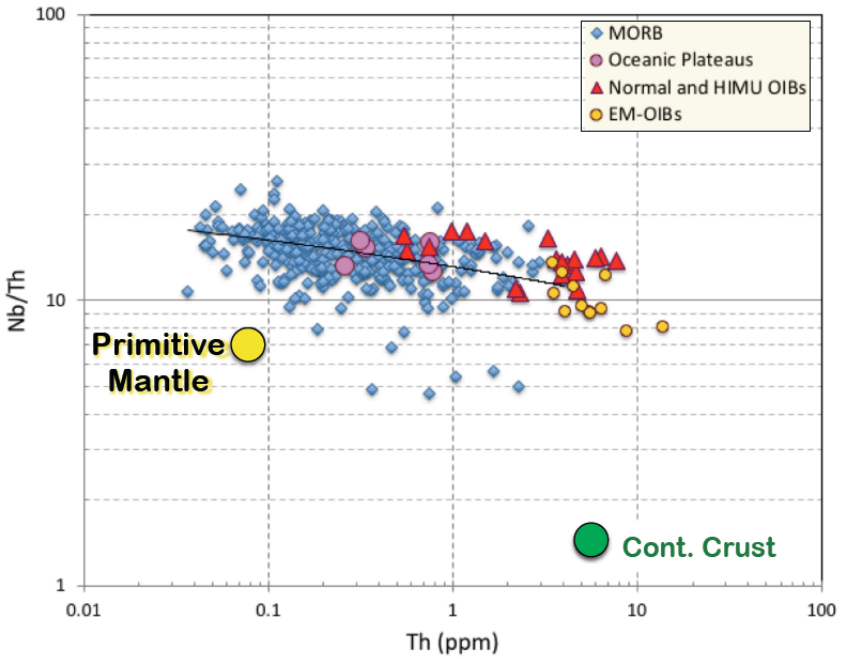

Fig. S3

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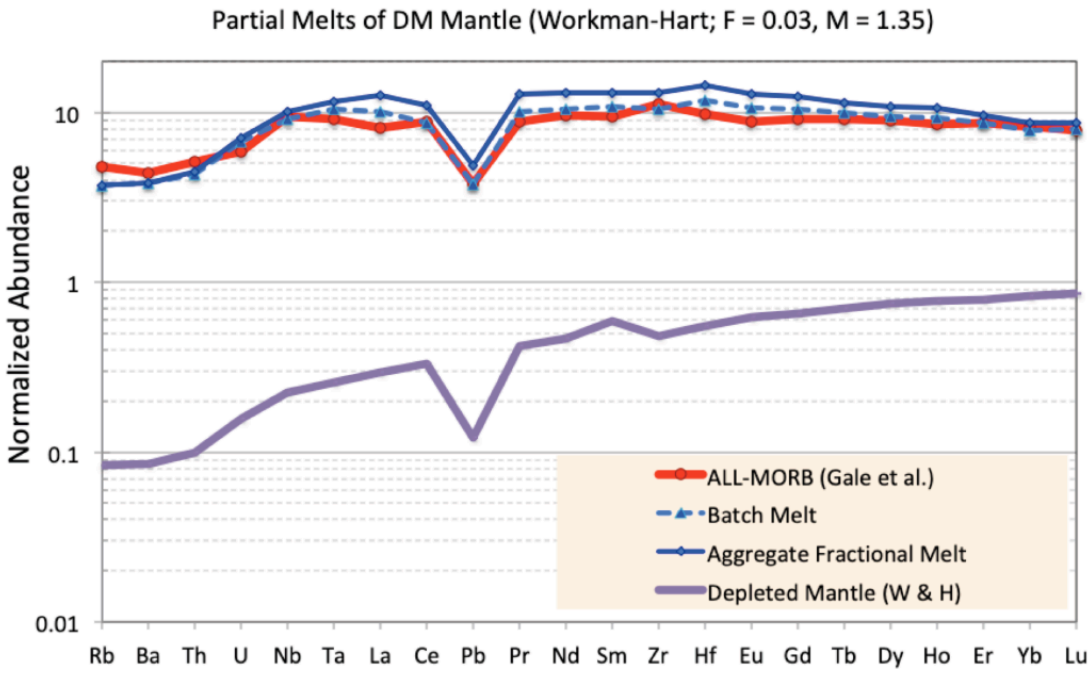

Fig. S4

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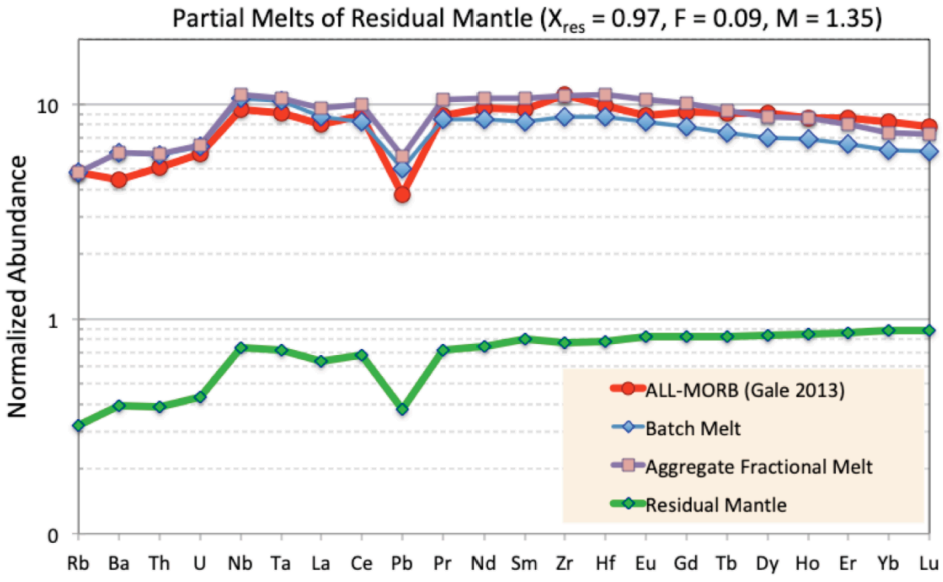

Fig. S5

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Table S1

MORB: Two-error regression results

Reference	X	Y	**Slope**	Error	Intercept	X	Y	**Slope**	Error	Intercept
Gale et al. 2013	log Nb	log Ba	**1.231**	0.023	-0.435	log Ta	log Ba	**1.314**	0.028	-0.603
Jenner-O'Neill. 2012	log Nb	log Ba	**1.208**	0.017	-0.445	log Ta	log Ba	**1.271**	0.018	-0.524
Arevalo-McDonough, 2010	log Nb	log Ba	**1.229**	0.014	-0.475	log Ta	log Ba	**1.309**	0.016	-0.627
Gale et al. 2013	log Nb	log Th	**1.076**	0.021	-0.303	log Ta	log Th	**1.137**	0.025	-0.437
Jenner-O'Neill. 2012	log Nb	log Th	**1.045**	0.015	-0.303	log Ta	log Th	**1.094**	0.016	-0.369
Arevalo-McDonough, 2010	log Nb	log Th	**1.075**	0.013	-0.303	log Ta	log Th	**1.151**	0.014	-0.463
Gale et al. 2013	log Nb	log U	**0.976**	0.020	-0.125	log Ta	log U	**1.032**	0.023	-0.246
Jenner-O'Neill. 2012	log Nb	log U	**0.969**	0.015	-0.124	log Ta	log U	**1.016**	0.016	-0.185
Arevalo-McDonough, 2010	log Nb	log U	**0.983**	0.012	-0.114	log Ta	log U	**1.034**	0.014	-0.220
Gale et al. 2013	log Nb	log Ta	**0.947**	0.026	0.115	log Ta	log Nb	**1.056**	0.023	-0.121
Jenner-O'Neill. 2012	log Nb	log Ta	**0.956**	0.014	0.058	log Ta	log Nb	**1.047**	0.015	-0.061
Arevalo-McDonough, 2010	log Nb	log Ta	**0.942**	0.012	0.102	log Ta	log Nb	**1.061**	0.014	-0.109
Gale et al. 2013	log Nb	log La	**0.695**	0.017	0.282	log Ta	log La	**0.724**	0.020	0.200
Jenner-O'Neill. 2012	log Nb	log La	**0.694**	0.013	0.270	log Ta	log La	**0.730**	0.013	0.225
Arevalo-McDonough, 2010	log Nb	log La	**0.699**	0.010	0.296	log Ta	log La	**0.748**	0.012	0.216

Table S1. Two error regression results of log-log plots for 3 datasets representing global MORB

Table 1 Footnote: Two-error regressions were calculated using ProFit software package, assigning equal errors to x and y values and no weighting of data.
The log-log slopes of Nb vs. U are slightly but consistently lower than 1.0 (= 0.969 to 0.983).
The log-log slopes of Ta vs. U are slightly but consistently greater than 1.0 (= 1.016 to 1.034).
An element having partitioning properties between Nb and Ta would yield a slope equal to 1.0

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Comparison of Averages, Std. Deviations, Variabilities of Nb/U, Ta/U, and Nb/Th

Average MORB ratios	Nb/U	Nb/U	Nb/U	Ta/U	Ta/U	Ta/U	Nb/Th	Nb/Th	Nb/Th	Calc Nb/Ta	Calc Th/U
	Ave	Std Dev	Variability	Ave	Std Dev	Variability	Ave	Std Dev	Variability		
Jenner & O'Neill, 2012	46.1162	7.4737	0.1621	2.7479	0.4360	0.1587	15.6981	2.5522	0.1626	16.78	2.94
Gale et al., 2013; segment aves	46.139	9.212	0.200	3.088	0.672	0.217	14.876	3.017	0.203	14.94	3.10
Arevalo & McDonough, 2010	44.852	10.302	0.230	2.909	0.625	0.215	16.187	4.241	0.262	15.42	2.77

Table S2. Average Nb/U, Ta/U, Nb/Th, Nb/Ta, and Th/U ratios for the three data sets indicated by the references and used in Table 1 and Figs. S1 and S2. Note that the Ta/U ratio (= 2.75) calculated from the data of Jenner and O'Neill (2012) appears to be systematically lower than the values given by the other two references. This low Ta/U value corresponds to a significantly higher Nb/Ta ratio of 16.78 compared with Nb/Ta = 14.94 and 15.42 obtained by the other two groups. Jenner and O'Neill (2012) also report a somewhat anomalously low Ta value for the standard reference glass BCR-2G (6.7% lower than the recommended GeoReM value). For reasons of internal consistency, we will not use the Ta/U value for average MORB given by Jenner and O'Neill (2012), but rely on the Ta/U value of Gale et al. (2013)

Table S2

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U	Th	Nb	Ta	Reference
0.91	4.20	11.0	1.00	Taylor and McLennan, 1985
1.40	5.6	8.0	0.70	Rudnick and Fountain, 1995
1.10	4.20	8.0	0.80	McLennan et al. 2006
1.30	4.20	8.0	0.70	Rudnick and Gao, 2003
1.13	4.29	7.4	0.54	Hacker et al., 2015
1.10	4.23	7.4	0.52	Hacker et al., 2015
1.09	4.20	8.1	0.52	Hacker et al., 2015
1.33	5.31	8.8	0.55	Hacker et al., 2015
1.14	4.29	8.1	0.53	Hacker et al., 2015

Table S3. Literature data for estimates of trace element concentrations for U, Th, Nb, Ta in the continental crust

Table S3

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