Samples and Methods

Sample Locations, Tectonics and Chemical Signatures

The back-arc basin samples examined in this study are from the Mariana Trough between latitudes 13° and 23°N, collected during the Sonne 69 (Gribble et al., 1996), R/V Thomas Washington TUNES (Gribble et al., 1998) and R/V Melville Cook7 expeditions (Pearce et al., 2005). These rocks are mostly basalts but show a wide range of compositions. North of 20° rifting takes place rather than true spreading and the lavas have strong arc affinities. Samples from south of 20°N are true BABB, formed by seafloor spreading. In this region, the MT has the morphology of a typical slow-spreading ridge and trace element and isotopic compositions tend toward MORB-like values (e.g., Gribble et al. 1998). We also report new Hf-isotope data for shoshonites of the Alkalic Volcano Province - AVP (Bloomer et al., 1989), as well as basalts from both the Northern Seamount Province - NSP (Bloomer et al. 1989) and Poyo seamount of the frontal arc (Lin et al. 1990) together with new Sr, Nd, and Pb isotopic data for NSP samples.

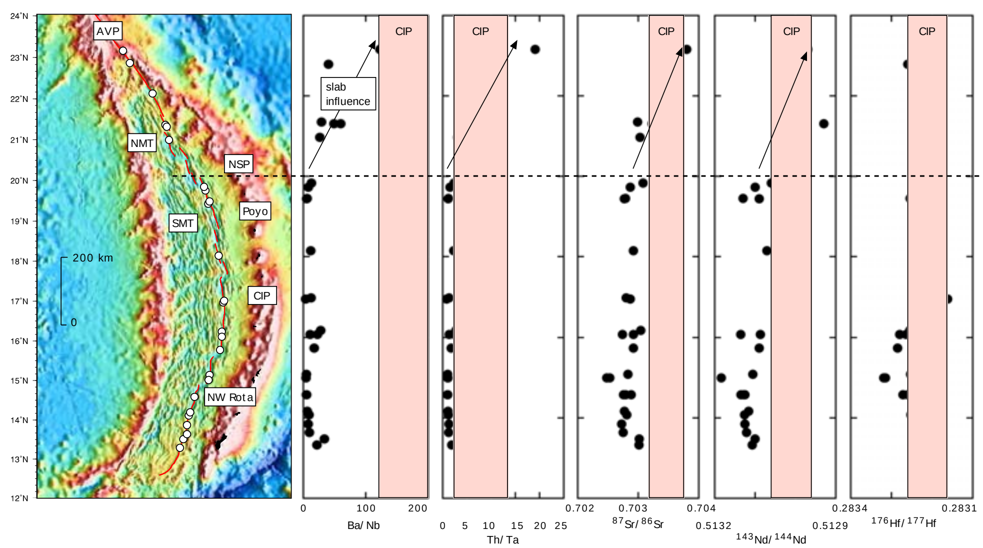

Figure DR1. Bathymetric map of the Mariana Arc-trench system showing locations of back-arc basin samples studied here. Abbreviations: SMT, Southern Mariana Trough; NMT, Northern Mariana Trough; AVP, Alkalic Volcano Province; NSP, Northern Seamount Province; CIP, Central Island Province; Poyo, Poyo seamount. Panels to the right show variations in Ba/Nb and Th/Ta, as well as Sr-, Nd-, Hf-isotopes in MT lavas (black circles) and ranges for the Mariana Arc Central Island Province lavas (pink shaded bands labeled CIP). Horizontal stippled line at 20°N marks the boundary between rifted arc BAB lavas to the north and BAB formed by true seafloor spreading to the south.). This map was compiled from available bathymetric data by Fernando Martinez (University of Hawaii), and includes the decimated 1-minute grid for the Mariana Trough (Kitada et al., 2006).

Analytical Methods

Hf-isotope data were acquired following the methods of Woodhead et al (2001) but employing the improved Hf separation chemistry of Munker et al 2001. New Pb-isotope data were obtained using the methods detailed in Woodhead (2002). All data are reported relative to $^{176}Hf/^{177}Hf$ = 0.282160 for JMC 475 Hf, $^{143}Nd/^{144}Nd$ = 0.511865 for La Jolla Nd, and $^{206}Pb/^{204}Pb$ = 16.935, $^{207}Pb/^{204}Pb$ = 15.489, $^{208}Pb/^{204}Pb$ = 36.701 for NIST SRM 981 Pb reference materials.

Throughout this study we have used the new ICPMS trace element data reported for these samples by Pearce et al (2005) as they were acquired during a single analytical program and thus eliminate possible analytical biases in the pre-existing data.

The Effects of Filtering

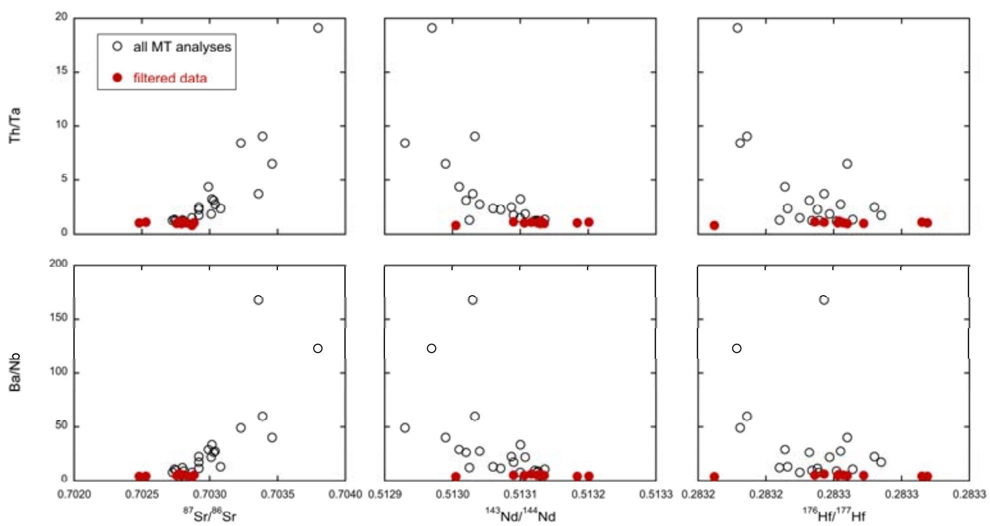

Figure DR2. Plots showing the filtering criteria, ratios of Th/Ta and Ba/Nb to remove 'deep subduction' and 'total subduction' components, after Pearce et al. (2005). In the unfiltered datasets clear correlations are observed between trace elements and some isotopic parameters (clearest for Sr). These are interpreted to reflect the influence of modern subducted slab components. Once filtered these significant correlations are no longer evident. In detail there are rare suggestions of correlations within the filtered dataset between some trace element ratios and Nd-Hf isotope compositions. It is unclear, given the limited number of samples in the filtered dataset, whether these correlations are statistically significant but, if real, we attribute them to remnants of older enrichment events i.e. pre-dating modern subduction.

Modeling Parameters

Mixing hyperbolae in Figure 2 were constructed using the following parameters. The three mantle end members (depleted, ambient, enriched) represent different points along the MT Nd-Hf array, D84 and D22 are samples numbers forming the extreme end of the array. Note: although these samples are isotopically diverse their trace element contents are very similar suggesting little source variation in Nd and Hf content. We have used a single estimated value of the latter for modeling purposes.

Table DR1.

	Sediment end-member	**Depleted mantle: D84**	**Ambient Mantle**	**Enriched mantle: D22**
Hf ppm	3.512	0.24	0.24	0.24
Nd ppm	26.636	0.9	0.9	0.9
$^{143}Nd/^{144}Nd$	0.512653552	0.513195	0.513121	0.513005
$^{176}Hf/^{177}Hf$	0.2828	0.283317	0.283257	0.283163

The sediment end-member itself is a 60:40 mix of Volcanogenic and Pelagic sediments as per:

	Volcanic sed	**Pelagic sed**	**60:40 mix**
Hf	4	2.78	3.512
Nd	28.14	24.38	26.636
$^{143}Nd/^{144}Nd$	0.5128	0.5124	0.512653552
$^{176}Hf/^{177}Hf$	0.2828	0.2828	0.2828

The sediment end member was chosen simply as a best fit to the data array in Figure 2A. Based upon our published (Vervoort et al., 2011) and unpublished data we have produced average values for typical Volcanogenic and Pelagic sediments (see above). These suggest that our preferred bulk sediment has an approximate composition of 60% volcanogenic: 40% pelagic components.

References

Bloomer, S.H., Stern, R.J., and Smoot, N.C., 1989, Physical volcanology of the submarine Mariana and Volcano arcs: Bulletin Volcanologique, v. 51, p. 210–224, doi:10.1007/BF01067957.

Kitada, K., N. Seama, T. Yamazaki, Y. Nogi, and K. Suyehiro, 2006, Distinct regional differences in crustal thickness along the axis of the Mariana Trough, inferred from gravity anomalies, Geochemistry Geophysics Geosystems 7, Q04011, doi:10.1029/2005GC001119.

Münker, C., Weyer, S., Scherer, E, and Mezger, K, 2001, Separation of high field strength elements (Nb, Ta, Zr, Hf) and Lu from rock samples for MC-ICPMS measurements: Geochemistry Geophysics Geosystems vol.2 doi: 10.1029/2001GC000183.

Vervoort, J.D., Plank, T., and Prytulak, J., 2011, The trace element and Hf-Nd isotopic composition of marine sediments. Geochimica et Cosmochimica Acta. vol. 75, p.5903–5926

Woodhead, J.D., 2002, A simple method for obtaining highly accurate Pb-isotope data by MC-ICPMS: Journal of Analytical Atomic Spectrometry vol.17, p.1381-1385.