SF	Mantle Inputs to the Subduction Factory: Assessing Scales of Spatial Variability along and Across the IBM Convergent Margin	
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	9/1/2001 – 8/31/2003	OCE 00-01827

Subduction Zones are complex physical and chemical systems where surficial Earth materials are dragged down to interact with asthenospheric mantle and generate melts. This interaction equilibrates Earth's mantle with its hydrosphere and atmosphere and produces continental crust, ore deposits, and explosive volcanism. Understanding how this interaction leads to melting, how these melts rise through downwelling mantle, and how melts evolve in the crust is a great scientific challenge, requiring multiple perspectives. One important perspective comes from understanding how the composition of magmas changes with depth to the Wadati-Benioff Zone (WBZ). From the earliest days of the plate tectonic revolution, systematic variations in magma chemistry—specifically, higher K contents with greater depth to the WBZ—were noted (Hatherton and Dickinson, 1969). In spite of this systematic behavior, it is still not clear what process is responsible. Hatherton and Dickinson (1969) were undecided as to its cause, suggesting that it could reflect either variations in the stability of K-bearing phases in the subducted slab (i.e., amphibole vs. phlogopite) or manifested differing ascent paths or melting processes.

This uncertainty persists. The 'K-h' relationship—since expanded to include more of the periodic table, including large ion lithophile (LIL) elements Rb and Ba and the light Rare Earths (LREE)—is still a robust constraint, but it is still not clear what this relationship reveals about subduction zone processes. We now know that the vast majority of major elements in arc melts come from partial melting of convecting asthenosphere in the mantle wedge, although incompatible element budgets may reflect distillation of subducted materials, especially sediments (Plank and Langmuir, 1993). Two attractive endmember possibilities are that the K-h relationship indicates that sediment melting becomes increasingly important with greater depth in the WBZ, or that lower degrees of melting of mantle peridotite occur as distance increases from the magmatic front.

Variations in sources and processes across the Subduction Factory can be most confidently addressed using volcanic cross-chains of intra-oceanic convergent margins (IOCM), those convergent margin systems that grow entirely within the ocean basins. IOCM magmatic systems may witness assimilation but it will be of relatively juvenile mantle lithosphere and thin mafic crust that are chemically and isotopically similar to the arc magmas that pass through, rather than the thicker, older, and more reactive crust and lithosphere associated with magmatic arcs on continents. IOCM cross-chains that extend rearward on to back-arc basin crust (like the Guguan Cross-Chain considered here) have minimal assimilation because these are built on crust that thins from ~20-30km along the magmatic front to ~5-10 km behind the arc. The Cook 7 expedition (March-April 2001) was funded by NSF-MARGINS for the purpose of addressing this issue. One of the best places to examine these variations is in a cross-chain associated with Guguan volcano in the Mariana arc system (Fig. 1).

The Guguan cross-chain extends west from the magmatic front, represented by Guguan island and a small submarine cone to the north (Cook 7 D50), which lie about 125 km above the WBZ. The West Guguan edifice (sampled by Cook 7 D49) lies on the western flank of Guguan, about 150 km above the WBZ. The Guguan 2 edifice lies over a part of the WBZ that is very steep, where we estimate a depth of 230km. Guguan is widely acknowledged to be the endmember example of magma generation at convergent margins where the 'Subduction Component' is carried in an aqueous fluid (Elliott *et al*., 1997). This interpretation agrees with observed high Ba/La and applies to N. Guguan as well (Fig. 2). Decreasing Ba/La and increasing La/Yb in lavas from W. Guguan and Guguan 2 could be interpreted as being due to the Subduction Component being carried as sediment melt, or could reflect low degrees of melting of the mantle. An explanation of sediment melting interpretation for the Guguan cross-chain is difficult to reconcile with Th/Nb and isotopic systematics. The isotopic variations reveal a mixing trend, but one which cannot simply be explained as a mixture between asthenospheric mantle and sediment melt. As is the case for the Izu cross-chains (Hochstaedter *et al*., 2000), the rear-arc volcanoes in the Guguan cross-chain have a range of Th/Nb that is similar to that of the magmatic front, but at a lower $^{87}Sr/^{86}Sr$. Also like the Izu cross-chains, the Guguan cross-chain trends towards lower εNd and lower $^{87}Sr/^{86}Sr$ with increasing depth to the subducted slab. The Guguan cross-chain also shows slightly lower εHf with inceasing depth to the subducted slab. None of the trajectories seen in the isotopic variations are consistent with an interpretation that the rear-arc volcanoes were derived from melting of an asthenospheric mantle that had been 'pickled' in sediment melts. Two interpretations are consistent with the trace element and isotopic data: 1) Rear-arc melts result from mixtures of a "Guguan-like" metasomatized mantle with a hybrid MORB-type mantle that has been metasomatized by 1-2% sediment melt; or 2) Rear-arc melts result from melting of an enriched asthenospheric mantle, but with a role for fluids sufficient to cause arc-like enrichments in LIL elements. Work is continuing to address these possibilities, including trace element studies of melt inclusions, and Li and O isotopic compositions.

This information will also provide valuable constraints on thermal structure for OBS studies of upper mantle structure now in progress (triangles in Fig. 1B).

Figures and Captions

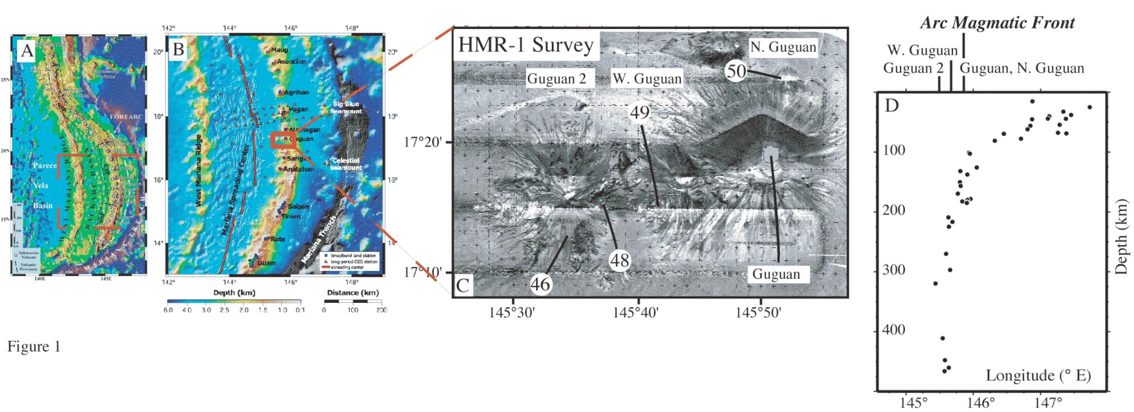

Figure 1

Figure 1: A) Locality map of the Guguan Cross Chain in the Mariana arc system (courtesy Bob Embley, NOAA). B) The Central Mariana Arc system and the location of the Guguan Cross-Chain. Red triangles show the location of the U.S.-Japan passive land-OBS deployment carried out Summer 2003. C) HMR-1 sonar backscatter image of the Guguan cross-chain, showing the location of dredge sampling carried out during Cook 7 expedition. Note location of Guguan island. D) Cross-sectional view of the central Mariana subduction system using the earthquake catalog of Engdahl *et al*. (1988). Black circles denote earthquake hypocenters in a 50 km wide volume centered along 17.33°N.

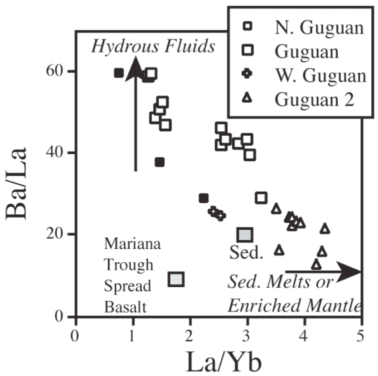

Figure 2: Ba/La vs. La/Yb for lavas from the Guguan Cross-chain. Note that lavas erupted along the magmatic front (Guguan, N. Guguan) have higher Ba/La and lower La/Yb than those from W. Guguan and Guguan 2. The high Ba/La, low La/Yb component is MORB-type mantle that has been metasomatized by hydrous fluids. The low Ba/La, high La/Yb endmember could be sediment melts or lower degrees of melting of relatively enriched mantle. The composition of bulk sediment is shown, as is the composition of relatively Mariana Trough basalt associated with seafloor spreading.

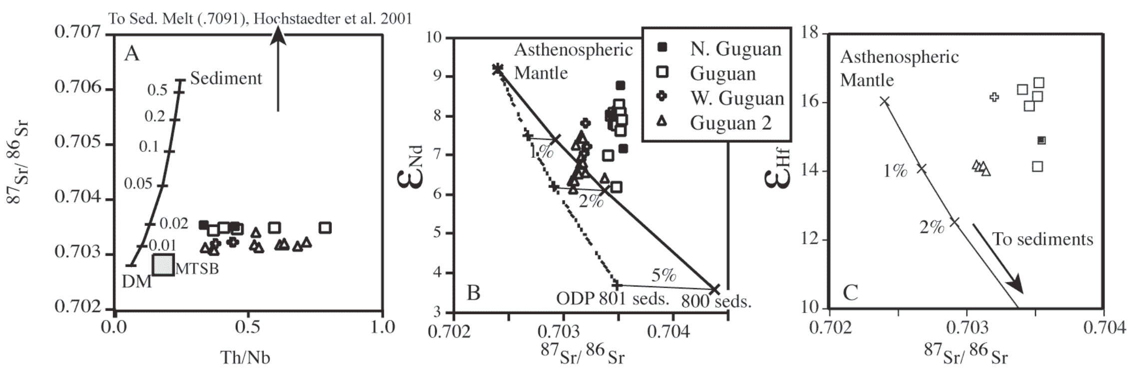

Figure 3: Isotopic systematics of Guguan cross-chain lavas. A) Plot of Sr istotopes vs. Th/Nb. Curve shows fraction of sediment mixed with MORB-type asthenospheric mantle. High Th/Nb is taken to indicate melting of subducted sediments (Elliott *et al*., 1997). Note that the range of Th/Nb encompassed by volcanoes along the magmatic front (Guguan and N. Guguan) is similar to that of the rear-arc volcanoes (W. Guguan and Guguan 2). These define parallel arrays but do not align along trajectories consistent with participation of sediment melts. B) Plot of Sr-Nd isotopes, with mixing trajectories for asthenospheric (MORB-type) mantle with bulk sediment compositions from ODP sites 800 and 801, east of the Mariana Trench (Plank and Langmuir, 1998). Note that the Guguan cross-chain samples are oriented perpendicular to the mixing trends. C) Plot of Sr-Hf isotopes (data for Guguan from Woodhead *et al*., 2001), with mixing trajectories for asthenospheric (MORB-type) mantle with bulk sediment compositions from sediments east of the Mariana Trench (Plank and Langmuir, 1998; Woodhead, pers. comm. 2003). Note that the Guguan cross-chain samples are oriented perpendicular to the mixing trends.

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