Nouveaux results from TN273 studies of the SE Mariana Forearc rift

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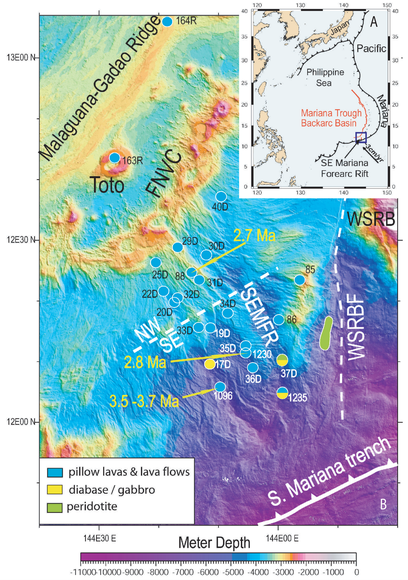
Summary:

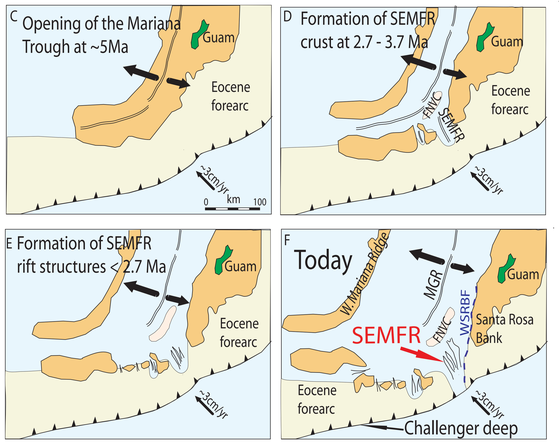
The SE Mariana forearc rift (SEMFR; Fig. 1A-B) is floored by Miocene oceanic crust that formed ~ 2.7 - 3.7 Ma ago to accommodate opening of the S. Mariana Trough (Fig.1C-F). SEMFR was investigated by the R/V Thomas Thompson from Dec. 22 2011 to Jan. 22 2012 (TN 273) by using deep-tow IMI 30 sonar and dredging. Investigations of serpentinite mud volcanoes demonstrate that forearcs are characterized by a more depleted mantle and higher inputs in fluid-mobile elements (FME: Rb, Cs, Ba; e.g. Savov et al., 2005, G-3) than arcs and backarc basins. The purpose here is to examine SEMFR lavas (i) to investigate forearc subduction and mantle processes,and (ii) to check if the above inferences are true for SEMFR. Compiled results show that :

* SEMFR lavas range from primitive low-K basalts to fractionated medium-K andesites (Fig. 2A); and their glassy rinds have variable volatile compositions (CO_2=16 - 578 ppm; H_2O =1.2 - 2.4 wt%; Fig. 2C).
* SEMFR is morphologically and geochemically divided into a SE and a NW sectors (Fig. 1B, 2B-D), where NW lavas and glass are more depleted in melt-mobile elements (Nb, Ti, La, Sm), and more enriched in fluid-mobile elements.
* SEMFR lavas were produced by a much depleted mantle source than typical forearc mantle source (Fig. 3A); and they captured a sediment melt (deep component) and a shallow component (Fig. 3B-C).

Tracking the mantle and the subduction inputs along the S. Mariana intraoceanic arc (Fig. 4A-C) show that the SEMFR subduction components increase towards the arc; while mantle depletion increases away from the trench (Fig. 4D). These observations suggest that (i) a new input of depleted mantle flowed from the trench along SEMFR (Fig. 5); (ii) Rb, Cs, Ba increase away from the trench, as they are mostly released from the subducting slab at ~ 50 - 100 km depth; (iii) occurrence of a deep component beneath SEMFR suggests that (i) subducted sediments melted beneath the forearc due to frictional heating, or (ii) this signature is inherited from the BAB mantle source.

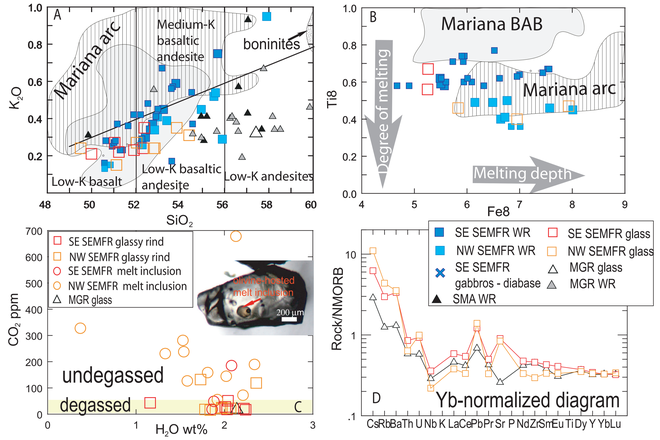
1- SEMFR formed 2.7 - 3.7 Ma ago to accomodate opening of the S. Mariana Trough backarc spreading center:





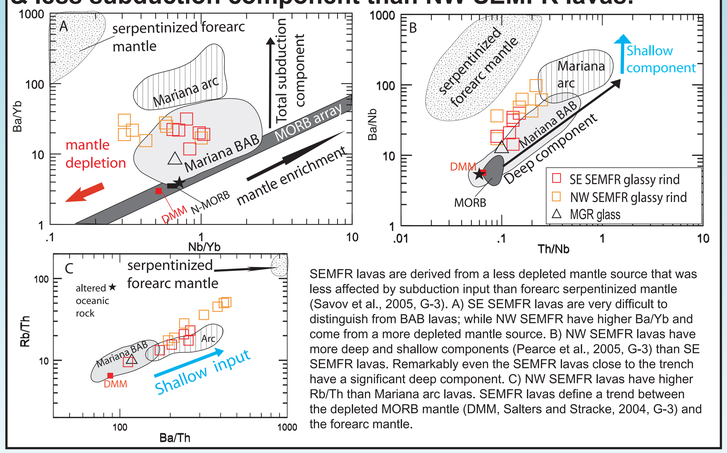
A) Location map of the southernmost Mariana convergent margin. The blue box highlights the area in B. B) Bathymetric map of the S. Mariana intraoceanic arc, with location of the dives - dredges performed during Yokosuka and Thomas Thompson cruises (TN273 dredges have a "D"). Panels C-F sketch the geodynamic evolution of SEMFR since the opening of the Mariana backarc Trough (the Malaguana-Gadao Ridge: MGR) ~ 5 Ma ago, resulting in stretching of the forearc lithosphere and forming the SEMFR ~ 3.7 - 2.7 Ma ago. Since < 2.7 Ma, magmatic activity stopped and SEMFR is dominated by post-magmatic rifting. FNVC: Fina-Nagu Volcanic Chain (extinct arc chain); WSRB: W. Santa Rosa Bank; WSRBF: Fault separating WSRB and SEMFR.

2- Depletion in melt-mobile elements & enrichment in fluid-mobile elements in NW SEMFR lavas:



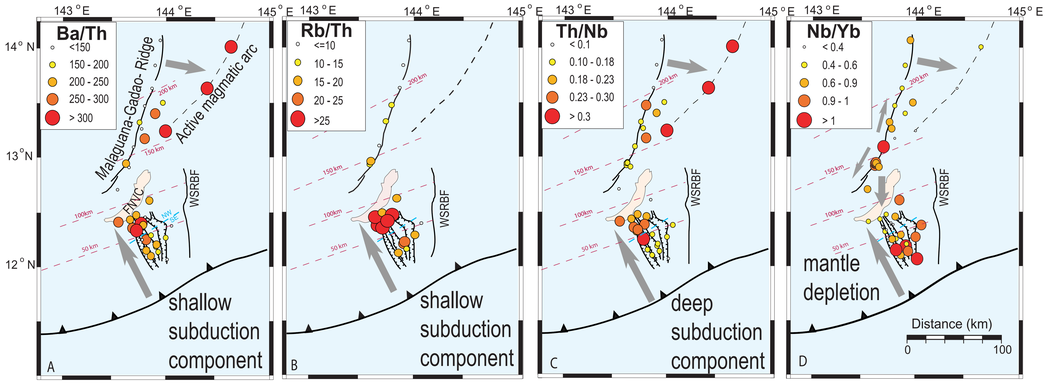
Composition of SEMFR whole rock (WR) and glasses. A) Characterizing the SEMFR lavas in Pecerillo and Taylor's diagram (1976, Contrib. Mineral. Petrol.); B) Ti8 vs Fe8 diagram highlighting the different mantle processes beneath SW and NE SEMFR; C) CO_2 and water contents of SEMFR glassy rinds and melt inclusions; D) Yb-normalized spider diagram (after Peace et al., 2005, G-3) of the glassy rinds averaged by sector (see Fig. 1B), and normalized to the N-MORB of Sun and McDonough (1989, Geol. Soc. Spec. Pub.).

3- SE SEMFR lavas were produced by a less depleted mantle & less subduction component than NW SEMFR lavas:



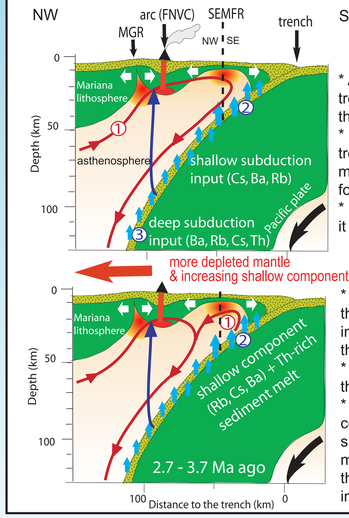
SEMFR lavas are derived from a less depleted mantle source that was less affected by subduction input than forearc serpentinized mantle (Savov et al., 2005, G-3). A) SE SEMFR lavas are very difficult to distinguish from BAB lavas; while NW SEMFR have higher Ba/Yb and come from a more depleted mantle source. B) NW SEMFR lavas have more deep and shallow components (Pearce et al., 2005, G-3) than SE SEMFR lavas. Remarkably even the SEMFR lavas close to the trench have a significant deep component. C) NW SEMFR lavas have higher Rb/Th than Mariana arc lavas. SEMFR lavas define a trend between the depleted MORB mantle (DMM, Salters and Stracke, 2004, G-3) and the forearc mantle.

4- Increasing mantle depletion and subduction inputs away from the trench:



Using geochemical proxies to map the subduction and mantle inputs along the S. Mariana Intraoceanic arc and SEMFR (after Pearce et al., 2005, G-3). Arrows point toward increasing subduction component and a more depleted mantle source. We used the whole rock composition to map Ba/Th, Th/Nb and Nb/Yb, as these elements are not affected by alteration; and the glassy rind composition to map Rb/Th. WSRBF is the expression in surface of a slab tear (Fryer et al., 2003, EPSL). The red dashed lines approximates the slab depth from Becker et al. (2005).

5- What did we learn so far?



What did we expect?

* A more depleted mantle toward the trench as BAB mantle flows towards the forearc after melt extraction (1);
* Higher Ba, Rb, Cs content toward the trench (2), as observed at serpentinite mud volcanoes (i.e serpentinized forearc mantle in Fig. 3);
* No deep subduction component, as it is released at slab depth ≥ 100 km (3).

What do we observe?

* Mantle depletion increases away from the trench, suggesting that new mantle input flowed beneath SEMFR toward the arc (1);
* Lower shallow component toward the trench (2);
* Occurrence of a BAB-like deep component, even in SE SEMFR lavas suggests that (i) subducted sediment melted by frictional heating beneath the forearc; or (ii) this feature is inherited from the BAB mantle.