Mission Immiscible or supercritical fluid?

Yoshihiko, Tamura[1], Osamu, Ishizuka[2], Robert, J., Stern[3]

[1] IFREE, JAMSTEC, Yokosuka, Japan; [2] GSJ, AIST, Tsukuba, Japan; [3]University of Texas at Dallas

tamuray@jamstec.go.jp

This is a white paper relating the research theme 3 entitled 'Fore-arc to back-arc volatile fluxes' of '2.5. Comparative and Thematic Studies' in the GeoPRISMS Draft Implementation Plan. We don't have specific volcanoes to study the across-arc variation in New Zealand, but ongoing surveys in the Mariana arc might give a model, which should be tested in the New Zealand primary site.

Finding and studying unfractionated arc basalt is fundamental to understanding the nature of the mantle source and the processes that yield primary magmas above subduction zones. Unfortunately, arc lavas are characteristically evolved, multiply saturated, and rich in phenocrysts and primitive basalts – representing magmas still nearly in equilibrium with mantle peridotite - are rare. New strategies – especially targeting the deep flanks of intra-oceanic arc volcanoes using submersibles such as ROVs – are allowing us to break through the crustal filter. Previous work in the Izu-Bonin-Mariana (IBM) arc in the Western Pacific shows that small parasitic cones on the submarine flanks of larger volcanoes often erupt more primitive lavas than does the main edifice, which may be an island or submarine (e.g., Ishizuka *et al.,* 2008; Tamura *et al.,* 2011).

Pagan and Northwest Rota-1 (NWR1) volcanoes are located at the volcanic front and 40 km behind the volcanic front of the Mariana arc, respectively. Two geochemical basalt groups can be distinguished in Pagan at similar (10-11 wt %) MgO; these erupted recently, 500 m apart. Both contain clinopyroxene and olivine phenocrysts and are referred to as COB1 and COB2. In contrast, there are two petrographic groups in NWR1, which are cpx-olivine basalt (COB) and plagioclase-olivine basalt (POB). The chemical differences between Pagan and NWR1 could be attributed to whether the subduction components (hydrous fluid and sediment melt) are immiscible or miscible. The subducting Pacific plate beneath the Mariana arc is old (~160 Ma), thick, cold and dense lithosphere, and its Wadati-Benioff zone dips steeply (Stern *et al.,* 2003). Thus, the depths to the top of the Mariana Wadati-Benioff zone just below Pagan and NWR1 are ~100 km and ~200 km, respectively (Pozgay *et al.,* 2009).

Pagan COB2 and NWR1 POB have systematically higher contents of High Field Strength elements (HFSE) and HREE than Pagan COB1 and NWR1 COB, respectively. However, in terms of fluid- and melt-mobile incompatible elements such as Rb, Ba, Th, U, K, light and middle REEs, Pagan and NWR1 lavas differ. In short, Pagan patterns don't cross, but those in NWR1 intersect. COB2 has higher abundances of sediment melt than do COB1. On the other hand, NWR1 COB have higher or similar contents of subducted sediment components compared to NWR1 POB. In contrast to Pagan suites, NWR1 COB and POB show a linear and simpler trend on Pb isotope diagrams (Tamura *et al.,* 2011), suggesting mixing between ambient mantle and sediment melt. In summary, observations from Pagan suggest that the subduction component responsible for more mantle melting of the COB1 source was mostly hydrous fluid. Both hydrous fluid and

sediment melt component may have unmixed in or above the subducting slab below the volcanic front, which might have added separately to the mantle wedge peridotite (mantle diapir) and resulted in two neighboring, but completely different primary magmas (COB1 and COB2) from the same diapir.

On the other hand, NWR1 COB has a greater subduction component, both hydrous fluid and sediment melt, than POB, perhaps reflecting that the subducting slab below NWR1 is > 100 km deeper than that beneath Pagan. At such higher pressures, hydrous fluid and sediment melt could have mixed into a uniform supercritical fluid (Mibe *et al.,* 2011; Kawamoto *et al.,* 2012), with different proportions yield distinct NWR1 COB and POB.

References:

Ishizuka, O., Geshi, N., Itoh, J., Kawanabe, Y. & TuZino, T., 2008. The magmatic plumbing of the submarine Hachijo NW volcanic chain, Hachijojima, Japan: Long-distance magma transport? Journal of Geophysical Research 113, doi:10.1029/2007JB005325.

Kawamoto, T., Kanzaki, M., Mibe, K., Matsukage, K. N. & Ono, S. (2012). Separation of supercritical slab-fluids to form aqueous fluid and melt components in subduction zone magmatism. PNAS doi: 10.1073/pnas.1207687109.

Mibe, K., Kawamoto, T., Matsukage, K. N., Fei, Y. & Ono, S. (2011). Slab melting versus slab dehydration in subduction-zone magmatism. PNAS 108, 8177-8182.

Pozgay, S. H., Wiens, D. A., Conder, J. A., Shiobara, H. & Sugioka, H. (2009). Seismic attenuation tomography of the Mariana subduction system: Implications for thermal structure, volatile distribution, and slow spreading dynamics. Geochemistry Geophysics Geosystems 10, doi:10.1029/2008/GC002313.

Stern, R. J., Fouch, M. J. & Klemperer, S. L. (2003). An overview of the Izu-Bonin-Mariana subduction factory. In: Eiler, J. (ed) *Inside the Subduction Factory.* Geophysical Monograph, American Geophysical Union 138, 175-222.

Tamura, Y., Ishizuka, O., et al., 2011. Two primary basalt magma types from Northwest Rota-1 volcano, Mariana arc and its mantle diapir or mantle wedge plume. Journal of Petrology, 52, 1143-1183.

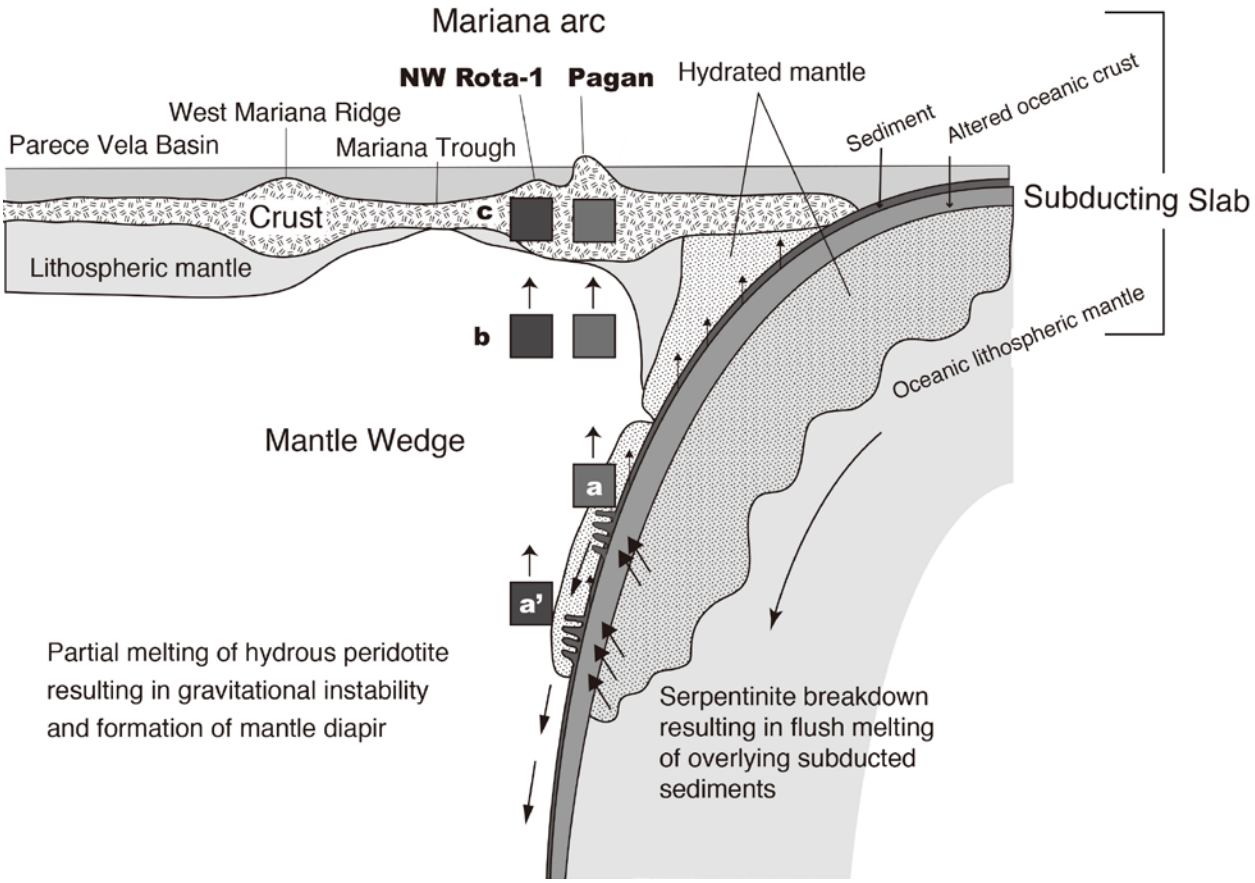

Figure 1. Section perpendicular to the Mariana arc-back-arc basin system, showing schematic upwelling of mantle diapirs. NW Rota-1 volcano is 40 km behind the volcanic front of the Mariana arc, which results in a significant difference Wadati-Benioff zone depth beneath NW Rota-1 and Pagan volcanoes. a) Mission Immiscible; a hydrous fluid coexists with a sediment melt, a') Mission miscible; a hydrous fluid mixes with a sediment melt to form a supercritical fluid.