Hydrous lithosphere and diffuse crustal accretion and tectonics in the southern Mariana margin: a possible analog for subduction zone infancy

Fernando Martinez1, Patricia Fryer1, Jonathan Sleeper1, Robert Stern2, Katherine Kelley3, Yasuhiko Ohara4,5 and Julia Ribeiro2.

1Hawaii Insititute of geophysics and Planetology, University of Hawaii at Manoa, 1680 East-West Rd., Honolulu, HI 96822
2 Geosciences Department, University of Texas at Dallas, 800 W. Campbell Rd., Richardson, TX 75083-0688, USA
3Graduate School of Oceanography, University of Rhode Island, Narragansett Bay Campus, 4Narragansett, RI 02882, USA.
Hydrographic and Oceanographic Department of Japan, Tokyo 135-0064, Japan
5Japan Agency for Marine-Earth Science and Technology
Yokosuka 237-0061, Japan

In subduction settings the mode of extension and crustal accretion may vary significantly during the evolution of the margin. A factor that likely has a strong control on this evolution is mantle water content. Water not only strongly affects the mantle solidus but also has strong effects on mantle rheology. Effects of mantle hydration on volcanism and tectonics may be examined in the southern Mariana margin because it is actively rifting sub-parallel to the trench forming new crust and lithosphere directly above the de-watering slab. Earthquake seismicity shows broadly distributed active deformation in the upper plate. Shallow-towed and near-bottom sidescan sonar data map a highly faulted terrain with distributed volcanic emplacements. The near-bottom sidescan sonar data also image an apparent corrugated core complex structure, the first such described from a convergent margin setting, indicating low-angle normal faulting during the extension. Water content in sampled volcanics are ~2 %, approaching that of the volcanic arc itself. The volcanic samples are mostly ~2-4 m.y. old, suggesting that active volcanism has now largely ceased. We hypothesize that the broadly distributed volcanism and tectonic activity is due to high mantle water content that weakens the margin lithosphere. Continual water addition from the subducting slab inhibits lithospheric dehydration and strengthening as has been proposed for lithosphere formed at mid-ocean ridges. A consequence of a broadening zone of rifting is that extensionally induced mantle upwelling rates will decrease with time. Surface cooling will thus progressively depress the mantle solidus, perhaps explaining the lack of current observed volcanism in the margin. The volcano-tectonic processes active today in the southern Mariana margin may be modern analogs of those inferred at subduction zone infancy where broadly distributed contemporaneous extension and volcanism above the initially subducting and de-watering slab have been proposed. If so, and if ophiolites are relicts of early crust formed at subduction settings, they may reflect crustal accretion processes that differ significantly from those at mid-ocean ridges.