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Geology of the Mariana Fore-arc near Guam

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The pattern of lithologies encountered during Shinkai 6500 manned submersible diving in the Mariana fore-arc southeast of Guam suggests that MORB-like tholeiitic basalts are the most abundant rock type in this region. Based on compositions of these lavas, 40Ar/39Ar and U-Pb dating of similar rocks further north in the IBM arc (Tani et al., 2009, EOS) and local minimum 40 Ar/39Ar ages, we concluded that these fore-arc basalts (FAB) were the first igneous rocks to be emplaced in the Izu-Bonin-Mariana arc after subduction initiated at about 51-52 Ma (Reagan et al., 2010, G-cubed, in press). Our research in this region also allows us to begin to illustrate the 4D geological relationships in the Mariana fore-arc, including the stratigraphic, structural, and geochronological relationships between FAB and other fore-arc lithologies. The sequence of rock types from the trench westward to Guam and from bottom to top is peridotite, gabbroic lithologies, diabase, FAB, transitional lavas, low-Ca boninites, high-Ca boninites, and tholeiitic to calcalkaline series arc lavas. Therefore, the overall stratigraphic and geographic pattern of lithologies is similar to those of some Tethyan ophiolites. Large northeasterly trending normal faults cause some repetition of section. Gabbroic rocks have FAB and boninitic affinities (Johnson et al., 2009, EOS), whereas diabase samples are exclusively FAB. Transitional lavas span compositional range from FAB to low-Ca boninites. The best geochronologic constraints at present suggest that this transition takes about 2 million, and the entire transition from FAB volcanism to arc volcanism takes 6-8 million years. The preservation of the subduction-initiation lithologies in the forearc indicates that subduction erosion (e.g. where the Pacific Plate abrades the Philippine plate) probably has not been very important over the history of the arc. Nevertheless, the presence of peridotites and intrusive rocks with FAB and boninitic affinities near the trench suggests that the upper part of the fore-arc crust in this area was removed either by slumping or large scale faulting. In either case, this material appears to have been removed to the trench and subducted. One mechanism that could have promoted this mass wasting is trenchward convection of peridotite, which could uplift the fore-arc and promote slumping.

Keywords: Mariana, fore-arc, basalt, geology, tectonics, subduction