Deap sea drilling at the Amami Sankaku Basin revealed wide distribution of fore-arc basalts across the Izu-Bonin-Mariana Arc: Evidence for spontaneous subduction initiation 52 million years ago

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In 2014, a triplet of IODP expeditions (Exp. 350-352) focused on the Izu-Bonin-Mariana (IBM) arc were conducted with the aim of comprehensively understanding the evolution of oceanic island arc and the origin of the continental crust. Exp.351 drilled at Site U1438 in the Amami Sankaku Basin (ASB), about 100 km west of the Kyushu-Palau Ridge, a remnant of the IBM arc.
A Cretaceous age (ca. 120 Ma) island arc system now preserved around the ASB (Amami Plateau, Daito Ridge and Oki-Daito Ridge) suggests that the oceanic crust beneath the ASB had existed before subduction initiation ca. 52 Ma. The primary objectives of Exp.351 were to constrain the geochemical nature of the mantle when the oceanic crust was formed, to identify and model the processes of subduction initiation, and to reconstruct the evolution of the IBM arc during the Paleogene.
Exp.351 cored a 1611-m-long cores composed of 1461-m of sediments and 150-m of igneous basement rocks from the seafloor at a depth of 4711 m. The age for the bottom of the sedimentary layers is estimated to be ca. 50 Ma, based on biostratigraphic and paleomagnetic studies; therefore, igneous basement below the sedimentary layers should be equivalent or only slightly older than 50 Ma. The measured heat flow at Site U1438 is 73.7 mW/m^2, implying that the thermal age for the underlying lithosphere is 40-60 Ma. This age range is consistent with that constrained based on biostratigraphic and paleomagnetic studies (50 Ma or older), which is much younger than the Cretaceous age (ca.120 Ma), as estimated before the expedition.
We then analyzed the chemical composition of the uppermost igneous basement rocks on board. We found that they are not mid-ocean ridge basalts, but are very similar to fore-arc basalts (FABs) commonly found in the adjacent IBM fore-arc region that erupted ca. 52 Ma when subduction of the Pacific plate beneath the Philippine Sea plate was initiated. The igneous basement beneath the ASB should be FAB itself formed at the onset of subduction ca. 52 Ma. FABs are distributed not only in the IBM fore-arc region but also in the ASB, which is at the rear-arc side of the IBM arc. This unexpected widespread distribution of FABs suggests that the subduction zone was under an extensional environment across the arc, and that the igneous basement of the IBM arc was formed over a much wider area during the subduction inception in a mode consistent with “spontaneous” subduction. The results of our analysis will provide significant insights into the process of subduction initiation in this area, as well as into the subsequent evolution of the IBM arc.
After Exp.351, we analyzed major and volatile elements (S and Cl) of melt inclusions collected from the top to the bottom of sedimentary Unit III (30-40 Ma based on onboard biostratigraphy) using electron probe micro-analyzers. Most of the host minerals of the melt inclusions are clinopyroxene and plagioclase. The compositions of the melt inclusions are diverse, ranging from basalt through rhyolite, and also ranging from low-K through medium-K series. In terms of major elements, low-K melt inclusions are consistent with the melt compositions reported from the volcanic front of the IBM arc. Major element composition of medium-K melt inclusions overlaps with the melt composition

reported from the IBM rear-arc, such as volcanoes on the KPR and/or near the ASB. These observations suggest that the turbidites accumulated at the ASB originate not only from the IBM rear arc, but also from the IBM frontal arc. We will further investigate the temporal evolution of arc volcanism by analyzing the trace elements and isotopes in the melt inclusions.

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