Discovery of low-Ca, high-Si boninites from the northern Zambales Ophiolite: Doubly-vergent subduction initiation along Philippine Sea Plate margins

*Americus Perez[1], Susumu Umino[1], Graciano Yumul Jr.[2], Osamu Ishizuka[3]

1. Kanazawa University, 2. Apex Mining Company Inc., 3. Geological Survey of Japan

We report the discovery of low-Ca, high-Si boninite from the middle Eocene Zambales Ophiolite in Luzon Island, Philippines. Boninite occurs as lapilli fall deposit and pillow lava flows in the upper volcanic unit of the juvenile arc section (Acoje Block) in northern Zambales Ophiolite. Following the classification of Kanayama et al. (2013) and Reagan et al. (2015), high-Si and low-Si subtypes are recognized in the upper unit together with boninitic basalts of Hawkins and Evans (1983). This upper volcanic unit in turn overlies a lower volcanic unit consisting of basaltic andesite to andesitic lavas and explosive eruptives (subaqueous pahoehoe and lobate sheet flows, tuff breccia, agglutinate, scoria and spatter deposits) forming a low-Si boninite series. Zambales high-Si boninites, mostly of the aphyric type, consist of subhedral olivine microphenocrysts (Mg#=0.88-0.91), abundant elongate enstatite microphenocrysts (Mg#=0.86-0.87) with augite±pigeonite overgrowth and chromian spinel (Cr# =0.7-0.8) set in glassy groundmass with quench clinopyroxene. This assemblage corresponds to Type II and III of Umino (1985) in samples described from the boninite type locality. Enstatite microphenocrysts with spongy cores and reverse zoning, together with embayed quartz xenocrysts are also recognized. Whole-rock composition of Zambales high-Si boninite, with 55.9-58.5 wt% SiO_2, 0.25-0.35wt% TiO_2, 8.5-13.8 wt% MgO and FeO*/MgO ratios less than 1, is akin to that of a typical Ogasawara boninite. Ni and and Cr contents are remarkably high as well. MORB-normalized trace element pattern of Zambales high-Si boninites show enrichment in LILEs (Rb, Ba, Th, K, Pb, Sr) and depletion in HFSEs (Nb, Ta) with positive Hf anomaly relative to Sm and negative Ti anomaly relative to Y. In contrast with samples from Ogasawara, Zambales high-Si boninites exhibit spoon-shaped REE pattern with strong LREE depletion relative to less depleted HREEs. Trace element ratios also distinguish Zambales boninites, having lower Zr/Ti and higher Ba/Yb ratios than Ogasawara boninites and are comparable with samples from Troodos and Oman Ophiolite. The presence of boninite and boninite-series volcanics in Acoje Block (44 Ma) and protoarc basalt (PAB)-like transitional MORB in Coto Block (45 Ma) indicate that the distinct subduction initiation chemostratigraphy is present in Zambales Ophiolite, albeit supplied by separate magma plumbing systems with stratigraphic relationships obfuscated by post-emplacement tectonic deformation. The occurrence of a massive sulfide deposit in the lower volcanic unit and possibly up to lowermost section of the upper unit is consistent with massive sulfide-bearing horizons in Troodos and Oman as well as on the Bonin Ridge.
Unfolding of subducted slabs beneath southern Eurasia reveals that the Philippine Sea Plate at 44Ma is bordered by Cretaceous oceanic crust (the East Asian Plate of Wu et al., 2016) in its western margin. Coupled with available paleomagnetic data from Zambales and Luzon, we make the case for a subduction initiation origin of the Zambales Ophiolite in the western margin (leading edge) of the northwestward moving, clockwise rotating Philippine Sea Plate. In addition, the complementary nature of Cretaceous ophiolites in eastern Philippines and the Amami-Daito region implies a common history prior to the onset of spreading in the overriding plate.

Keywords: Zambales Ophiolite, boninite, Philippine Sea Plate, subduction initiation

