Deep Crystallization of Tholeiitic Melt: Insights from Manguao Basalt, Palawan, Philippines

*James Cesar Avisado Refran[1], Tsukasa Ohba[1], Carlo Arcilla, Takashi Hoshide[1], Ma. Ines Rosana Balangue-Tarriela

1. Akita University

Manguao Basalt is a basalt-basaltic andesite lava flow field found on the northeast end of Palawan Island, Philippines. The relatively-stable nature of the Palawan Continental Block seemingly contradicts the presence of the geomorphologically-young lava flow field. This study investigates the occurrence and origin of Manguao Basalt, and its relation to evolution of the Palawan microcontinent.

Good exposures of the Manguao Basalt lava flow field are found nearshore; with flow structures and features (i.e. levees, channels, and tumuli) still intact and observable in several locations. The lava flow is generally blocky and vesicular, with perceptible phenocrysts and chert xenoliths. Macroscopic observations of obtained samples show identifiable olivine and pyroxene phenocrysts. Petrographic observations show olivine dominance in phenocryst and plagioclase dominance in groundmass. Pyroxenes are found both in phenocryst and groundmass assemblages. Mineral textures observed from petrography shows precedence of pyroxene phenocrysts from olivine. Plagioclase laths in groundmass also show precedence from anhedral groundmass pyroxenes. Volcanic glass fills the interstices between plagioclase and pyroxene; forming intersertal textures. A general overview of the crystallization sequence (pyroxenes àolivine àplagioclase àgroundmass pyroxenes), from petrography, is presented.

Major element chemistry from bulk-rock compositions characterizes the Manguao Basalt as subalkaline and tholeiitic. Bivariate diagrams show fractionation in ferromagnesians (i.e. olivine and pyroxenes) but limited fractionation in later-formed minerals (i.e. plagioclase). Total iron over magnesium (FeOt/MgO) versus silica (SiO_2) plots (Miyashiro, 1974) of Manguao Basalt shows 'straddling' tholeiite and calc-alkaline character. AFM ternary plots show diagnostic early iron enrichment, reflecting a tholeiitic trend. Trace element chemistry confirms the early ferromagnesian fractionation from nickel, chromium, and cobalt trends. Tectonic discrimination diagrams of Manguao Basalt show resemblance with different basalts from other known tectonic settings (i.e. continental flood basalts, island-arc basalts, continental-arc basalts, and within-plate basalts). However, association of Manguao Basalt with ocean-island basalts (OIB) or mid-ocean ridge basalts (MORB) appears inconclusive; plotting outside MORB-OIB array defined by Pearce (2008). These inconsistencies that accompany trace element discrimination diagrams have been pointed out by Li et al. (2015). Nevertheless, their utility is in constraining possible tectonic processes that influence melt generation and evolution. Trace element patterns in MORB- and OIB-normalized spider diagrams show enriched melt character of Manguao Basalt (i.e. more enriched than any MORB, but depleted compared to OIB). Characteristic Nb-Ta depletion is absent for Manguao Basalt, indicating possible non-subduction influence. Positive anomalies in continent-derived trace elements (e.g. K, Th, and Ba) are observable and consistent in any spider diagram presented (MORB-, NMORB-, EMORB-, and OIB-normalized).

Mineral chemistry data (olivine, orthopyroxene, clinopyroxene, and plagioclase) confirm crystallization sequence inferred from petrography. The most magnesian mineral species are orthopyroxene and clinopyroxene phenocrysts (Mg# > 80). Calculations using orthopyroxene barometer shows highest pressure (~5 kbar) and thermometers (i.e. opx-liquid) show highest temperatures (~1260 ˚C). Obtained

pressure and temperature conditions were used as benchmarks for simulations of source melting and crystallization.

Simulations of melting of different mantle sources (e.g. fertile and depleted mantle) were done using the MELTS program. Equilibrium and fractional melting from depressurization (15 kbar à5 kbar) of any mantle source produce liquids that are saturated in pyroxene components. Subsequent crystallization of melt, while being at equilibrium with source and at elevated pressures (~5 kbar) produce orthopyroxenes with similar compositions to orthopyroxenes in Manguao Basalt. The formation of olivine and the rest of the groundmass requires significant evolution of melt prior to its removal; as both components show 'evolved' melt origin. The model for magmatic underplating is presented here as a possible setup for the origin of Manguao Basalt.

Keywords: MELTS Program, Crystallization, Tholeiitic Melt

