Early subduction processes recorded by the metamorphic sole of the Palawan Ophiolite, Philippines

*Gabriel Theophilus Vinalay Valera[1], Tetsuo Kawakami[1], Betchaida Duetes Payot[2]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2. National Institute of Geological Sciences, University of the Philippines

Metamorphic soles are slivers of the subducted oceanic lithosphere which were welded at the base of ophiolite sequences during the early stages of subduction. They are composed primarily of metamafic rocks and record inverse *P-T* gradients (Soret et al., 2017). In this work, the petrological signatures of the Dalrympole amphibolites underlying the Late Eocene Palawan Ophiolite is investigated. Earlier works suggest that this ophiolite represents the obducted forearc region of a nascent arc formed following the subduction of the proto-South China Sea (e.g. Encarnacion et al., 1995).

The metamorphic sole consists from structurally lower sections of epidote amphibolites, amphibolite pods surrounded by epidote amphibolites and garnet amphibolites near the contact with basal peridotites. Synmetamorphic fluid movement is signified by foliation-parallel quartz veins. Raman spectrometry and preliminary microthermometry of primary fluid inclusions in one deformed quartz vein revealed that they are aqueuous with salinity of 3.3 –6.9 wt.% NaCl equivalent.

The epidote amphibolites are generally composed of hornblende, epidote, quartz and sodic plagioclase (An_{2-18}) with minor chlorite, sphene and rutile. The amphibolites are composed almost exclusively (~90%) of coarse hornblende and some sphene, rutile and albite. The garnet amphibolites are composed of garnet porphyroblasts set in a matrix of hornblende, epidote, oligoclase (An_{10-26}) and rutile. Inclusions of quartz, amphibole, epidote, albite and muscovite were also found in some garnets.

Hornblendes in the epidote amphibolite and amphibolite are mostly magnesiohornblende and edenite. They show prograde zonation marked by higher concentrations of Na, Al and Ti and lower Si at the rim relative to the core. Hornblende in the garnet amphibolites mostly classify as pargasite to tschermakite. Hornblende in garnet amphibolite have higher total Al (= 1.97-2.98 a.p.f.u) compared to other lithologies (= 0.20-2.73 a.p.f.u). Garnets in the garnet amphibolites also show prograde growth marked by decreasing Mn and increasing Mg content towards the rim. These garnet grains have high Fe (X_{Mg} =0.15-0.40) and Ca content (= Grs_{15-23}).

Pressure-temperature estimates calculated for the Dalrympole amphibolites suggest high-*P* amphibolite facies metamorphism consistent with their mineralogy and mineral chemistry (Wei and Duan, 2019). *T* was estimated using Zr-in-rutile thermometry (Tomkins et al., 2007) of rutile grains which occur in the matrix and as inclusions in amphibole and garnet. The epidote amphibolites and amphibolites generally have lower *T* values (=616-680 ˚C) compared with garnet amphibolites (=698-710 ˚C). *T* estimates using pairs of garnet and hornblende rims (Ravna, 2000) in the same samples are slightly lower (=659-704˚C). Only garnet-hornblende thermometry was applied to a garnet amphibolite (=727 ˚C) which lacks rutile. *P* was estimated for the epidote amphibolites (=10.3-12.9 kbars) and amphibolites (=10.4-12.6 kbars) by calculating the TZARS equilibria using the rim composition of the matrix assemblage following Kapp et al. (2009). The GHPQ barometer (Kohn and Spear, 1990) was applied to the garnet amphibolites using the garnet rims and matrix assemblage. Average *P* values for the garnet amphibolites (=12.7-13.2 kbars) are slightly higher but within the range of those obtained for the other lithologies.

The *T* values obtained for the Dalrympole amphibolites are lower compared to other ophiolites (e.g. Semail) while the *P* values are significantly higher. Although high-*P* can be attributed to low-crossing angle of Zr-in-rutile thermometer and TZARS equilibria, the apparent paleogeothermal gradient preserved in the Dalrympole amphibolites (~16 ˚C/km) are comparable to hot subduction zones (e.g. Penniston-Dorland et al., 2015). These suggest that in Palawan, subduction might have been initiated by forcing a young oceanic lithosphere to subduct beneath a relatively colder and thicker oceanic crust.

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