

Water content variation in lower-grade eclogite inferred from pseudosection and modal analysis from the Sesia Zone, Western Alps

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H₂O derived from dehydration in a subducted slab has important roles in causing various geological/geophysical processes in the subduction zone, such as the enhancement of serpentinization of mantle wedge, the induction of intraslab earthquake and the island arc magmatism (e.g., Kawahara et al., 2003; Ohtani, 2005). However, the systematics of fluid activity in the subduction zone has not been unraveled yet, such as how much fluid subducts into the upper/lower mantle or is released from the subducted slab, what kinds of reactions control the dehydration, and how the released fluid migrates toward the Earth's surface. Recently, several water content variation diagrams, which cover the wide range of P-T conditions observed in the subduction zone, have been proposed mainly based on the high-pressure experiment using synthetic minerals (e.g., Schmidt & Poli, 1998). These variation diagrams have been widely used for the computer modeling of the subduction zone. However, the synthetic studies carried out at low temperature condition (typically less than 600 C) have a crucial weak point, because these experiments commonly have yielded metastable phases (Hacker et al., 2003). For example, chlorite is commonly found in the run-product synthesized under equivalent P-T conditions with the low-temperature eclogite-facies or further lower grade rocks, although 'primary' chlorite is scarce in the natural eclogite. The petrological study of peculiar natural high-pressure metamorphic rocks, which are free from the retrograde stage overprinting/rehydration, has a potential to testify the validity of the proposed water content variation diagrams. Eclogitic Micaschist Complex (EMC) of the Sesia Zone is one of the best candidates to evaluate the water content variation in the subduction zone using natural rocks, because of the wide occurrence of less retrogressed high-pressure rocks.

The phase relationships of eclogite and glaucophanite in the Orco Valley of the southern EMC of the Sesia Zone are investigated. The main mineral parageneses of eclogite/eclogitic are Grt-Omp-Gln-Pg-Phn-Qtz-Rt in the St.Maria subarea and Grt-Omp-Gln-Pg-Czo-Phn-Qtz-Rt/Ttn in the Frassinetto, the Pont Canavese-Alpette and the Cuorgne subareas. Glaucophanite mainly consists of Gln-Czo-Grt-Phn-Qtz-Rt/Ttn in the Pont Canavese-Alpette subarea. Lawsonite is only found in the glaucophanite of the Cuorgne subarea. The application of the conventional geothermobarometry for eclogite/eclogitic rock yields ca. 512 ± 21 C and 16.8 ± 0.7 kbar in the Pont Canavese subarea, 559 ± 10 C and 17.9 ± 0.9 kbar in the St.Maria subarea and 503 ± 17 C and 18.4 ± 3.1 kbar in the Frassinetto subarea, suggesting that a regional metamorphic gradient (ca. 9 C/km) exists in the Orco Valley area. The water content variation was determined based on the modal analysis and/or the pseudosection modeling in system NCKFMASH for eclogite and glaucophanite. This analysis shows that prograde lawsonite decomposition can supply a significant amount of H₂O from the subducting slab by overstepping the lawsonite-decomposition reaction [Lws + Jd(or Ab) = Czo + Pg + H₂O] at 450 C and 12-13 kbar. The pseudosection modeling predicts that the water content in the eclogite continuously decreases with increasing metamorphic temperature from ca. 500 to 700 C. Therefore, we conclude that a prograde dehydration caused by the lawsonite-decomposition is a potential fluid supplier at ca. 35-45 km depth in subducting slab with moderate temperature.

The peak P-T conditions of the Orco Valley area are well concordant with the inferred thermal structure of the Philippines Sea plate beneath Chugoku-Shikoku in SW Japan. This suggests that lawsonite will be decomposed at 35-45 km depth and will release a significant amount of fluid beneath SW Japan. The fluid derived from the lawsonite decomposition is one of the candidates for causing the deep low-frequency earthquakes and tremors observed in ca. 25-40 km depth.