Thermal structure near the continental Moho of subduction zone: Natural example of the Asemigawa region of the Sanbagawa metamorphic belt, SW Japan

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Metamorphic rocks in subduction-type metamorphic belts record the metamorphic history from subduction to exhumation in subduction zones. Temperature, which is one of the most important variables in controlling the dynamics of subduction zones, has traditionally been estimated from mineral assemblage and chemical compositions. However, the temperature information recorded in metamorphic rocks is usually overprinted by retrograde metamorphism during exhumation. Such issues with the preservation potential for this information may be important in understanding the commonly observed difference in the thermal structure predicted from model calculations and the metamorphic temperature obtained from natural rocks (e.g., Uehara & Aoya, 2005_Tectonics; Penniston-Dorland et al., 2015_EPSL). In this study, we focus on the Sanbagawa metamorphic belt, a well-known example of a subduction-type metamorphic belt, and discuss the meaning of the petrologically obtained temperatures.

The peak metamorphic temperatures of 126 samples of pelitic schists collected along three routes in an area with dimensions 11 km north-south and 7 km east-west in the Asemigawa region in central Shikoku were estimated by using the Raman carbonaceous material geothermometer. The obtained temperatures show an overall continuous increase from 288 to 553℃ from south to north in the study area. The temperature range is consistent with the thermal structure of the metamorphic zonation reported in previous studies. A temperature discontinuity is observed at all three studied routes, with a jump between about 380℃ to 440℃. Close to the boundary of this temperature discontinuity, several large recumbent folds are present that deform both the compositional layering and the metamorphic isograds.

The temperature of 400℃ coincides closely the area where the downgoing slab comes into contact with the continental Mohorovičić (Moho) discontinuity in warm subduction zones as shown by thermal modelling. This result suggests that the temperature discontinuity identified in the Asemigawa region corresponds to the Moho depth, and that the lower and higher temperature sides of the discontinuity were overlain by continental crust and wedge mantle, respectively. The difference in the coupling strength with the slab and contact materials (serpentinite or continental crust material) may create a contrast in the ease of exhumation, and as a result, the exhumation-related deformation may become concentrated in the lower part which then accumulates close to the depth of the continental Moho. This tectonic scenario can account for the development of the observed temperature discontinuity and large-scale foldings.

In this study, we clarified the relationship between the thermal structure and deformation structure in the Sanbagawa metamorphic belt during the exhumation period. The derived thermal structure will help refine thermal models for the Sanbagawa subduction. In addition, the depth corresponding to the continental Moho boundary coincides with the region where the slow earthquakes are occurring in

present day SW Japan, and the temperature discontinuity proposed in this study has potential as a guide to trace the location of past slow earthquakes in the field.

Keywords: Thermal structure, Sanbagawa (Sambagawa) metamorphic belt, Raman carbonaceous material geothermometer, Mohorovičić discontinuity, Slow earthquake