High-pressure subduction-type metamorphism of the Sanbagawa belt, SW Japan associated with approach of a spreading ridge

Simon Wallis[1]; Mutsuki Aoya[2]

[1] Earth and Planetary Sci., Nagoya Univ.; [2] Institute of Geology and Geoinformation, AIST

Convergent plate boundaries are commonly marked by the presence of high P/T metamorphism including blueschist and eclogite. The formation of the unusually cool conditions required to form such rocks is quantitatively well-explained by the inflow of cold lithosphere due to subduction. However, quantitative thermal modeling presents a dilemma: thermal models predict generally much colder conditions than those estimated by application of petrological methods to high P/T metamorphic rocks. The subduction-type Sanabgawa metamorphic belt of SW Japan is a particularly clear example of this discrepancy between the results of thermal modeling and petrology. The peak metamorphic conditions of the Sanbagawa belt can be formed only when the subduction zone was unusually hot; either shortly after the initiation of subduction before steady-state or associated with subduction of a young slab implying a nearby spreading ridge. The subduction-related P-T paths are vital in distinguishing these possibilities. Such P-T paths in the Sanbagawa belt are not straight, but strongly curved with increasing P/T ratios with increasing P. Thermal modeling suggests such paths are only satisfactorily reproduced by considering the approach of a spreading ridge and that these conditions were attained a few million years before the arrival of the ridge at the convergent margin. This model can be tested using plate reconstructions and radiometric dating.

Kinematic and radiometric age data from the Sanbagawa belt suggest a Cretaceous formation age and an associated plate movement vector with a large sinistral oblique component with respect to the East Asian convergent margin. An examination of plate reconstructions for the Cretaceous to Tertiary for this region shows that the only plausible candidate plate compatible with such motion is the Izanagi plate. Plate reconstructions imply that subduction was associated with approach to the Cretaceous East Asian convergent margin of a spreading ridge located between the Izanagi plate and Pacific plate located to the south. The spreading ridge continued to approach until the remaining part of the Izanagi plate became fused to the Pacific plate and ceased to move independently at 85 - 83 Ma. This period represents a major reorganization of plates and associated changes in movement vectors in the Pacific realm and is likely to be the age of large-scale interaction between the ridge and convergent margin. The P-T paths of the Sanbagawa belt are predicted to develop within the subduction zone a few million years before ridge interaction. This prediction can be tested using high-precision geochronology. The most important rocks to date are the eclogite facies. These preserve some of the oldest deformation fabrics in the Sanbagwa belt and their formation age puts an older limit on the formation age of most of the Sanbagwa belt. Lu-Hf dating of garnet and omphacite from eclogite has a high closure temperature above the peak T recorded in the rocks and gives garnet growth ages of 88 - 89 Ma. This is in excellent agreement with the model prediction lending strong support to the hypothesis that the Sanbagawa metamorphism is the result of ridge approach.

Combining the estimate for the peak age of metamorphism with other thermochronological results implies vertical exhumation rates of cm/yr. These results show the Sanbagawa metamorphism and associated orogenesis was largely complete within a few million years. This implies that the Sanbagawa metamorphism represents a snap shot when the subduction zone is particularly warm and is not representative of normal steady-state. These results also imply hot conditions are a necessary condition for exhumation of high-pressure rocks. Also, rocks that arrived before hot conditions were achieved, do not seem to be preserved and were presumably cycled into the mantle.