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Composite metamorphic history recorded in garnets of Sambagawa metapelites in the Besshi region, central Shikoku, Japan

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Sedimentary rocks are one of the main components of subducted slabs, in which dehydration and recrystallization processes significantly control the chemical compositions of metamorphic fluids, and consequently driving the geochemical evolution of the wedge-mantle in trench-arc systems. As such, the elucidation of metamorphic history of metapelites or metapsammite is important to help reveal mass transfer processes in the subduction zones. In the Besshi region of the Sambagawa belt, the eclogite assemblage of garnet + omphacite + quartz occurs sporadically in metabasalt-metagabbro complexes of the high-grade zone. On the other hand, the evidence of high-pressure (e.g., omphacite) from the metasedimentary rocks is rare, and it has been assumed that the sedimentary rocks had not subducted deep underground. However, there is a possibility that most evidence for high-pressure metamorphism was recrystallized and disappeared during the retrograde metamorphism because metasedimentary rocks contain abundant hydrous minerals. Therefore, we focused on garnets, which are expected to preserve information from prograde metamorphism. We analyzed the chemical zoning of garnet grains, and measured the residual pressure of quartz inclusions in garnets by Raman spectroscopy.

In the metapelites in the Besshi region, garnet grains commonly show "composite zoning", defined by a slight increase in spessartine in the mantle part and an increase in grossular in the rim part. Garnet grains showing "Mn bell-shaped normal zoning", which is the most common garnet zoning type of Sambagawa metapelites are less common in the Besshi region. These data imply that the metapelites in the Besshi region had experienced different metamorphic histories compare to those in other areas. In addition, some quartz inclusions in the core to mantle part of the composite zoned garnets preserve high residual pressures, corresponding to those of eclogite samples. This high residual pressure is converted into metamorphic pressure of around 1.5-2.0 GPa in the temperature range of 300-600 ^{o}C, following the numerical calculation of the quartz Raman barometer. This pressure condition is significantly higher than those of the common Sambagawa metapelites, estimated using a conventional geothermobarometer, and this pressure corresponds to the estimation for eclogitic metabasites. In addition, omphacite rarely occurs as inclusions in the composite zoned garnets; equilibrium condition was estimated at 1.7-1.9 GPa/470-530 ^{o}C using the garnet-clinopyroxene-phengite geothermobarometer. These results indicate that most metapelites containing composite zoned garnet in the Besshi region had been subducted to the high-pressure corresponding to the eclogite facies with metabasic rocks. On the other hand, quart grains preserving a lower residual pressure than those in the core part were found in the rim part of the garnet. This low residual pressure corresponds to a metamorphic pressure of around 0.8-1.2 GPa in the temperature range of 300-600 ^{o}C. This garnet rim part probably grew at the epidote-amphibolite facies metamorphism that recrystallized the Sambagawa metamorphic rocks and formed the regional thermal structure of the Sambagawa belt.

The prograde metamorphic history of the Sambagawa metapelites in the Besshi region was discussed, through comparison of the chemical zoning of garnet and the distribution of residual pressure of quartz inclusions. These data suggest that (1) more sedimentary lithologies had been subducted deep underground corresponding to the eclogite facies condition than conventionally expected, and (2) sedimentary rocks are an important source to supply fluids and/or light elements to the mantle in past and also present subduction zones.

Keywords: Sambagawa belt (Sanbagawa belt), metapelite, Raman spectroscopy, garnet, quartz, residual pressure