Dating ductile deformation in a high-temperature/low-pressure type metamorphic terrane (Ryoke belt, Japan)

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High-temperature/low-pressure (high-T/low-P) type metamorphic belts are often considered to have formed below the volcanic arc in the subduction zone setting, and to represent a cross-section of ancient active continental crust. Detailed study on the evolution of high-T/low-P type metamorphic belts thus provides information on how continental crust replied to the abundant magmatic intrusions into the middle to lower crust. In this study, timing of ductile deformation that formed gneissosity of the migmatites in the high-temperature metamorphic terrane (Mikawa area, Ryoke belt, Japan) was dated utilizing pegmatite veins that crosscut the gneissosity and affected/not-affected by the gneissosity-forming ductile deformation.

Based on Takatsuka et al. (2018), three plutono-metamorphic stages are recognized in the Mikawa area: (1) 99-84 Ma: intrusion of granitoids (99-95 Ma pulse) into the upper crust and high-temperature regional metamorphism reaching sillimanite-grade (97.0 ±4.4 Ma to 88.5 ±2.5 Ma) in the middle crust, (2) 81-75 Ma: intrusion of gneissose granitoids (81-75 Ma pulse) into the middle crust at ~19-24 km depth, and (3) 75-69 Ma: voluminous intrusions of massive to weakly-foliated granitoids (75-69 Ma pulse) at ~9-13 km depth and formation of contact metamorphic aureoles (Takatsuka et al., 2018). Kazuratachi et al. (2019) obtained several zircon rims of metamorphic origin (Th/U<0.03) with ~81 Ma age from the vicinity of the 81-75 Ma pulse granitoids. They considered that this could represent the recrystallization of zircon during contact metamorphism by the 81-75 Ma pulse granitoids (Kazuratachi et al., 2019).

In this study, three pegmatite veins from northern part of the Mikawa area (Dando-san area) and one pegmatite vein from southern part of the Mikawa area (Hongu-san area) were dated. Zircon grains were extracted from the pegmatite veins and utilized in U-Pb dating performed by LA-ICPMS. In the Dando-san area, zircon from one pegmatite vein that crosscuts the gneissosity and shows a pinch-and-swell structure gave weighted average age of 70.0 ±1.8 Ma (2σ, MSWD = 2.0). Sillimanite and biotite define the gneissosity. Zircon from two non-deformed pegmatite veins that crosscut the gneissosity showed weighted average age of 70.5 ±2.3 Ma (2σ, MSWD = 1.0) and 70.2 ±2.3 Ma (2σ, MSWD = 1.2). The vein nearest to the Inagawa granite (~75-69 Ma) alone showed syn-kinematic nature. In the Hongu-san area, zircon from one pegmatite vein that shows gneissosity-oblique boudin trains gave weighted average age of 78.5 ±1.9 Ma (2σ, MSWD = 0.4). The gneissosity of this sample is also defined by the arrangement of sillimanite and biotite. Based on these data, we consider that final stage of ductile deformation that formed the penetrative gneissosity took place at ~70 Ma in the Dando-san area (corresponding to the ~70 Ma upper crust), whereas it was ~79 Ma in the Hongu-san area (corresponding to the ~80 Ma middle crust). Thermal input into the host metamorphic rocks by granitoid intrusions helped ductile deformation to take place at least locally in the vicinity of the intrusions utilizing the penetrative gneissosity even after the peak regional metamorphism (~97-89 Ma in the middle crust).

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