Using the alteration of magmatic monazite to constrain the thermal history of the Ryoke metamorphic belt (SW Japan)

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The Ryoke plutono-metamorphic belt exposed in SW Japan is the type locality for low-Pressure/high-Temperature (LP/HT) metamorphism. The Ryoke metamorphic field gradient is, however, a complex object shaped by several deformation phases, multiple magmatic pulses and protracted metamorphism. In the western part of the Ryoke belt (Iwakuni-Yanai area), a petrological and geochronological study of two plutons emplaced before metamorphism is used to explore the behaviour of magmatic monazite along the LP/HT gradient and constrain the thermal history of the belt. We compare a massive granite adjoining schistose rocks affected by greenschist facies metamorphism with a gneissose granite adjoining migmatitic gneiss affected by upper-amphibolite facies conditions. Despite contrasting textures, the granite samples have similar mineral modes and compositions. Monazite in the massive granite is dominated by primary domains with limited secondary recrystallization, and is variably replaced by allanite+apatite+ xenotime+Th–U–rich phases. Primary domains yield an average 206Pb/238U date of 102 ± 2 Ma while Th–U phases show Th–U–Pb dates of ca. 58 and 15–14 Ma. Monazite in the gneissose granite preserves sector- or oscillatory-zoned primary domains cross-cut by inclusion-rich secondary domains enriched in Ca, Y, U, P. Primary domain analyses are commonly discordant (116−101 Ma) while secondary domains preserve concordant 206Pb/238U dates spreading from 102 ± 3 to 91 ± 2 Ma.

Despite alteration, primary monazite domains preserve the age of magmatic crystallization for both plutons (102 ± 2 Ma and 106 ± 5 Ma). In the massive granite, monazite replacement is ascribed to the influx of aqueous fluid enriched in Ca+Al+Si±F during hydrothermal alteration below 500 °C. The oldest date (58 ± 5 Ma) obtained from the Th–U–rich alteration products is regarded as a minimum age for chloritization during final exhumation of the granite. In the gneissose granite a small amount of anatectic melt was responsible for a pseudomorphic recrystallization of monazite by dissolution-reprecipitation above 600 °C. The spread in 206Pb/238U dates for the secondary domains is attributed to incomplete isotopic resetting during dissolution-reprecipitation, and the youngest date of 91 ± 2 Ma is considered as the age of monazite recrystallization during a suprasolidus metamorphic event. These results reveal a diachronous, ca. 10 Ma-long HT history and an overall duration of about 15 Ma for the metamorphic evolution of the western part of the Ryoke belt.