

Petrochronology of the high temperature metamorphic rocks in the Higo metamorphic complex and Kontum Massif

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THESIS SUMMARY

Title: Petrochronology of the high temperature metamorphic rocks in the Higo metamorphic complex and Kontum Massif

The Higo metamorphic complex in Japan and the Kontum Massif in Vietnam are well-known high temperature (HT)–ultrahigh temperature (UHT) metamorphic areas in the world (e.g., Kelsey and Hand, 2015; Osanai et al., 2017). They play an important role in revealing tectonic evolution related with the large-scale growth of the Asian continent throughout a geological time (Osanai et al., 2008). Though the pressure–temperature (P – T) evolution and timing of the HT–UHT metamorphism in these areas were well reported (e.g., Hamamoto et al., 1999; Osanai et al., 2001a, 2001b, 2004, 2006; Maki et al., 2004; Nakano et al., 2007b, 2013), the timeline of the metamorphic evolution such as the timing of prograde, peak and retrograde stages is still obscured due to the lack of detail petrochronological studies. This study carried out U–Pb dating for both separated and in-situ zircon using laser ablation inductively coupled plasma mass spectrometry (LA–ICP–MS) and U–Th–Pb monazite dating by field-emission electron probe microanalyzer (FE–EPMA) for some representative high-grade metamorphic samples from these two mentioned study areas. Additionally, the X-ray chemical mapping and major element composition of garnet grains and rare earth elements (REE) geochemical analyses of zircon, monazite and garnet grains were also conducted. The combination the petrological context provided by garnet with geochronological ones from monazite and zircon allows to precisely constrain on the timings of the specific metamorphic stages for the HT to UHT metamorphism in the Higo metamorphic complex and Kontum Massif.

As the results, the timings of the HT–UHT metamorphism in the Higo metamorphic complex (*ca.* 105–120 Ma) and Kontum Massif (*ca.* 230–265 and *ca.* 430–450 Ma) are consistent with those of previous studies. However, compiling with previous P – T evolution, this study provided critical chronological information about the metamorphic evolution in each study area as follows. Firstly, in the Higo metamorphic complex the prograde metamorphism occurred at *ca.* 120 Ma immediately after precursor deposition at *ca.* 130 Ma and peak metamorphic conditions were attained during the period between 110 and 120 Ma. The *ca.* 110

Ma age might be indicative of the retrograde stage which promoted new zircon crystallization from melts and garnet breakdown. Finally, the hydration stage involved granitic intrusion into pelitic gneisses at *ca.* 105 Ma, which was characterized by the abundance of secondary chlorite, prehnite or even xenotime.

In case of the Kontum Massif, the results investigated that the pelitic granulites in the western Kannak Complex might have undergone the prograde M0 metamorphic stage at *ca.* 265 Ma, reached up to peak UHT condition of M1 stage between *ca.* 265 and 250 Ma by the continental collision in the Trans Vietnam Orogenic Belt (e.g., Osanai et al., 2004). The subsequent decompression relating to the M2 stage during retrograde stage and granite emplacement occurred at *ca.* 250 Ma, then followed by the later intense hydration involved the appearance of andalusite, muscovite and chlorite at *ca.* 230 Ma during its exhumation at the upper crust level. On the other hand, two high-grade metamorphic events were recorded at Permian–Triassic and Ordovician–Silurian in the western Ngoc Linh Complex. Evaluating the equilibrium between zircon, monazite and garnet proposed the first prograde HT metamorphism at *ca.* 440–450 Ma, overprinted by the second one at *ca.* 240–250 Ma under the granulite-facies condition with following decompression on retrograde stage after *ca.* 240 Ma. The decompression texture was indicated by the breakdown of garnet and sillimanite to form cordierite and spinel in the pelitic gneiss or garnet into orthopyroxene and plagioclase in the mafic granulite. Pelitic gneisses in the Kham Duc Complex recorded medium pressure metamorphism at *ca.* 230–240 Ma without any traces of early metamorphic event. There is no growth of zircon during this metamorphic condition. The timing of metamorphism at *ca.* 450 Ma was detected from two pelitic gneisses in the Dai Loc Complex, which is *ca.* 20 million years older than the magmatism event at *ca.* 420–430 Ma (Hieu et al., 2016).

Revealing the behavior of zircon–monazite–garnet during the HT to UHT metamorphism in these areas allows to verify the driving force or factor which control their behavior, and provides the critical information to understand the tectonic evolution. The interaction of internal and external fluid as well as melt plays an important role as the driving force for the formation or deduction of these three minerals. The most likely reasons to decide whether they can be formed or not during each metamorphic stage are the REE competition by the evolution (growth, breakdown or dissolution) and amount of other REE and Y-bearing minerals (xenotime and apatite), the local bulk rock composition as well as the formation of Zr-bearing phases such as ilmenite for the case of zircon.