

Exhumation processes in the Sambagawa metamorphic rocks inferred from their P-T-D-t path

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Our research group has been investigating exhumation processes and mechanisms in the Sambagawa metamorphic rocks of central Shikoku, southwest Japan, based on their P-T-D-t paths. In order to accomplish these purposes, the following three methods have been adopted: (1) microstructures in deformed and recrystallized quartz, (2) compositional zoning of amphibole, and (3) phengite K-Ar ages. Deformation microstructures in quartz (1) is a good indicator of deformation conditions (i.e. differential stress, strain rate and temperature). Quartz is ductile under temperature conditions above 300 C at natural strain rates, and the quartz-rich Sambagawa schists, which suffer a peak-metamorphism at 600 C in their highest grade part, greatly deform during the exhumation and cooling stages. In quartz from the Sambagawa metamorphic rocks of central Shikoku, a change in the recrystallization regime from subgrain rotation (SGR) to grain boundary migration (GBM) occurs with increasing deformation temperature. While quartz from the chlorite and garnet zones of the lower structural level (LSL) deforms and recrystallizes in SGR, that from the LSL albite-biotite, oligoclase-biotite, and the albite-biotite and garnet zones of the upper structural level (USL) in GBM recrystallization regimes. The recrystallized grain size of quartz from the quartz schist monotonously increases from 40 to 160 micron with the increasing the structural level. The important fact here is that the grain sizes of the LSL garnet (40-100 micron) and albite-biotite (120-130 micron) zones are finer than those of the corresponding USL garnet (140-160 micron) and albite-biotite (120-150 micron) zones. These facts not only indicate that the recrystallized grain size is not controlled by the peak-metamorphism, but by deformation during the exhumation and cooling stages, but also the exhumation-related deformation continues further in the LSL than in the USL, as temperature decreases.

Itaya and Takasugi (1988) show that phengite K-Ar ages are 85-80 Ma, around 80 Ma and around 75 Ma in the biotite, garnet and chlorite zones, respectively, indicating that these become older with increasing the peak-metamorphic grade. We have attributed these facts to the hypothesis that the rocks were cooled more rapidly with increasing structural level, as these 3 metamorphic zones were united and exhumed in the form of overturned P and T structure. The inference conforms to the fact that the deformation temperatures become higher with increasing the structural level as mentioned above (the higher the structural level, microstructures indicating the higher deformation temperatures are frozen-in). I tentatively have a scenario for the structural development that the structure, in which the garnet and albite-biotite zones are repeated, forms after the acquisition of phengite K-ar ages, and then only the LSL deforms strongly, as the temperature further decreases with increasing exhumation.

Yagi and Takeshita (2002) conclude that the southern part (Asemi-River area) is exhumed more rapidly than the northern part (Saruta-River area), based on the compositional zoning of amphibole from the basic schist in the albite-biotite zone. They interpret that the difference in the exhumation rate can be attributed to the activation of north-dipping normal faults, which are generated between the two area. The existence of the normal faults is evidenced by the existence of structurally disturbed area, and a few gaps in the spatial distribution of phengite K-Ar age and recrystallized grain size of quartz. This normal faulting, which is perhaps related with the formation of the duplex structure mentioned above, plays an important role in extracting the rocks in the southern part (Asemi-River area) toward the surface of the Earth, and hence can be very important in the exhumation tectonics of the Sambagawa metamorphic rocks.