Faulting during exhumation of the Sambagawa metamorphic rocks and fluid-assisted grain-boundary diffusion creep

Toru Takeshita[1]

[1] Dept. Earth and Planet. Sys. Sci., Hiroshima Univ

Recently, a model of channel flow has been developed, where metamorphic rocks at depth (in the middle crust) travel for a long distance, and finally extrude into the upper crust (Beaumont et al., 2004, JGR, 109, B06406). An important aspect of this model is that it is considered to be difficult that metamorphic rocks in the middle crust are elevated to the surface of the Earth, and hence some unroofing mechanism by which metamorphic rocks are brought to the surface of the Earth is necessary. Various unroofing mechanisms such as rapid erosion, thrusting and doming due to extension in the upper crust have been proposed. In any case, the formation of faults in the upper crust is essential for the exhumation of metamorphic rocks. Furthermore, faulting in metamorphic rocks itself facilitates their exhumation, and in fact must have occurred because rocks cooled below ca. 300 degrees are no longer ductile, but brittle. Note that at the temperature conditions of brittle-ductile transition (ca. 300 degrees), rocks are still situated at the depth of 15 km for a geothermal gradient of 20 degrees/km, and hence must be further elevated, assisted by faulting.

Extensive faulting during the exhumation of the Sambagawa metamorphic rocks was first recognized by the present author, 10 years ago along a logging road near Mt. Shiraga, central Shikoku (Takeshita and Yagi, 2004, Geological Society, London, Special Publications, 227). Later, the structural disturvance characterized by NNE-SSW trending lineation (or down-dip lineation), which trends WNW-ESE otherwise, was found in a narrow zone along the albite-biotite zone in the Kamio-Saruta-Dozan Rivers (northern area). Furthermore, the large difference in P-T paths in the albite-biotite zone between the Asemi River (southern) and northern areas, which has been found based on the compositional zoning of amphibole, suggests a long-lived faulting, which bounded the two areas (Yagi and Takeshita, 2002, JMG, 20).

In central Shikoku, the thickness of each metamorphic zone of the Sambagawa schist is not uniform, but fairly variable. I have recently found that the thickness change is not due to the spatial variation in ductile strain, but faulting, possibly normal faulting because some of the stratigraphy is missing. The thickness of high-grade zones (garnet, albite-biotite and oligoclase-biotite zones) is most narrow, south of Niihama-City, Ehime- Prefecture (Kokuryou-River area), where the thickness of each of the high grade zones is 1/3 to 1/5 of the corresponding one along the Asemi River.

I have obtained two kinds of evidences for that faulting was very intense in the Kokuryo-River area. One is that the extensive development of late-stage fold and faults. The late-stage faults are often marked by the precipitation of actinolite along the fault plane. The other evidence is the extensive development of micro-shear zones, and destruction of existing strong c-axis fabrics in quartz schist samples collected from this area (El Fakharani and Takeshita, 2004, 111th Ann. Meet. Geol. Soc. Japan, 270). Among analyzed four quartz schist samples, one shows strong type I, and another shows weak type I crossed girdle quartz c-axis fabrics. In the other samples, quartz c-axis fabrics are completely random. The mechanism for the late-stage deformation, which led to the destruction of the existing strong quartz c-axis fabrics, is under investigation. This is perhaps dissolution-precipitation creep, based on the irregular shape of apparently recrystallized grains (Takeshita and Hara, 1998, JSG, 20). However, grain-boundary sliding accommodated by grain-boundary diffusion with aid of fluid may be also a possible mechanism.