Tectonics of the Ryoke metamorphic belt: constraints from the Nukata area

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The Nukata area of Aichi Prefecture exposes medium to high-grade metamorphic rocks of the Ryoke high-T/low-P metamorphic belt. In the east of the area the metamorphic rocks are intruded by a major post-kinematic Cretaceous granitoid, the Shinshiro Granite. The mesoscopic foliation and stretching lineation shows an almost uniform trend throughout the whole study area suggesting the main ductile deformation in this area can be explained as the result of a single phase of deformation, Dmain or (Dm). Several structures indicate the shear sense during Dm was uniformly top-to-the-west. An older schistosity Sc is also preserved in the cores of intertectonic porphyroblasts.

Andalusite microstructures show both intertectonic (I-type) and post-tectonic (P-type) relationships with respect to Dm and some porphyroblasts have a composite or C-type microstructure with an intertectonic core and a post tectonic rim. I-type porphyroblasts are found only at distances greater than 4 km from the granite intrusion whereas P and C-type porphyroblasts are found close to the intrusion. These microstructures show that andalusite grew in two stages before and after Dm. The spatial distribution and post kinematic nature of the second stage andalusite miscrostructures suggests control by the intrusion of the Shinshiro granite. It is not self-evident, however, why there are two andalusite textures showing post-tectonic growth: the P-type and the rim part of the C-type. XRF analyses of samples with different microstructures show that the differences in microstructure are due to differences in bulk rock composition. Using the A'KF diagram, the compositions of the rocks including I-type or C-type andalusite plot in the muscovite-biotite-Al2SiO5-quartz paragenesis field. In contrast, rocks containing the P-type andalusite plot in the Al2SiO5-free paragenesis field if muscovite and quartz are assumed to be stable. We deduce, therefore, that the P-type andalusites were produced under static post-Dm conditions by the breakdown of muscovite, while the I-type and the core of the C-type developed before Dm under lower temperature conditions, perhaps as a result of the breakdown of pyrophyllite. The rim of the C-type formed at the same time as the P-type and represents a late stage overgrowth on an earlier formed core.

The above information on metamorphism and deformation can be combined with existing CHIME monazite geochronological data to give the following tectono-metamorphic history for the Nukata area: (1) Formation of the first foliation, Sc; (2) ca.100Ma Ryoke regional metamorphism and growth of first-stage andalusite; (3) main ductile deformation, Dm, postdating the peak of regional metamorphism associated with formation of Sm and west-directed shear; and (4) ca.86Ma intrusion of the Shinshiro granite causing a broad region of contact metamorphism and growth of the second-stage andalusite. The widespread development of the zone of second-stage andalusite implies a relatively high background geothermal gradient at the time of intrusion. A two-dimensional thermal model that takes into account constraints on the geometry of the Shinshiro granite body suggests that geothermal gradient at the time of intrusion should be approximately 35 degrees C/km. This represents a cooling from around 60 degrees C/km during peak regional metamorphism that must have taken place on a time scale less than 14 m.y.