Tectono-metamorphic evolution of the Higo metamorphic terrane in Kyushu, southwest Japan

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The Higo metamorphic terrane in west-central Kyushu Island, southwest Japan is sill investigated recently by many workers (e.g. Osanai et al., 2001, 2006, Kamei, 2004, Sakashima et al., 2003, Maki et al., 2004), consists of the Manotani (MMC), Higo (HMC) and Ryuhozan metamorphic complexes from north to south, which are intruded by the Higo plutonic complex (Miyanohara tonalite: MYT, Shiraishino granodiorite: SIG and Manzaka tonalite: MAT).

The HMC and MMC indicate an imbricate crustal section in which a sequence of metamorphic rocks with increasing metamorphic grade from high (northern part) to low (southern part) structural levels is exposed. The metamorphic rocks in these complexes can be divided into five metamorphic zones (zone A to zone E) from top to base (i.e. from north to south) on the basis of mineral parageneses of pelitic rocks. Greenschist-facies mineral assemblages in zone A (MMC) give way to amphibolite-facies assemblages in zones B, C and D, which in turn are replaced by granulite-facies assemblages in zone E of the HMC. The highest-grade part of the complex (zone E) indicates a peak P-T conditions of ca. 720 MPa and ca. 870 C. In addition highly-aluminous Spr-bearing granulites and related high-temperature metamorphic rocks occur as blocks in peridotite intrusions and show UHT-metamorphic conditions of ca. 900 MPa and ca. 950 C. The prograde and retrograde P-T evolution paths of the HMC and MMC are estimated using reaction textures, mineral inclusion analyses and mineral chemistries, especially in zones A and D, which show a clock-wise P-T path from Lws-including Pmp-Act field to Act-Chl-Epi field in zone A and St-Ky field to And field through Sil field in zone D.

Late Permian to Triassic ages of the HMC (260-230 Ma) are considered to reflect the main metamorphic stage associated with the progressive metamorphic field gradient from zone A to zone E. In zones D and E, where partial melting took place during the main metamorphic stage and produced anatectic melt-pods, segregation veins and S-type tonalite masses (258 Ma by SHRIMP). Hbl-gabbro situated in the basal part of zone E would be a possible heat source for the prograde metamorphism and anatexis, and has an age of 258 Ma by Sm-Nd internal isochron. Therefore we assume that the Late Permian to Triassic ages from the HMC are the most acceptable ages of the main metamorphic event. The SIG and MAT intruded into the HMC at around 120-110 Ma, when regional contact metamorphism and re-heating took place. In zones D and E, the temperature rises up to ca. 750-730 C with a Crd-bearing melt produced by low-pressure partial melting. Both the metamorphic and plutonic rocks underwent retrograde cooling after the SIG intrusion, and they passed ca. 300 C at 100-107 Ma, simultaneously. The upper crustal parts of zones A and B would have passed these low-closure temperatures earlier than the lower crustal zones C-F during up-thrusting, for example zone A passed through this temperature at around 210-170 Ma.

The HMC has been traditionally considered to be the western-end of the Ryoke metamorphic belt in the Japanese Islands or part of the Kurosegawa-Paleo Ryoke terrane in southwest Japan. However, recent detailed studies including Permo-Triassic age (ca. 250 Ma) determinations from the Higo metamorphic complex indicate an intense relationship with the high-grade metamorphic terranes in eastern-most Asia (e.g. north Dabie terrane, Imjingang belt) with similar metamorphic and igneous characteristics, protolith assembly, and metamorphic and igneous ages. The HMC and MMC as well as the Hida-Oki terrane in Japan would also have belonged to this type of collisional terrane and then experienced a top-to-the-south displacement with forming a regional nappe structure before the intrusion of younger SIG and MAT (ca. 120 Ma). The northern extension of the nappe is also found at the Raizan mountain in northern-end of Kyushu Island.