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The Hida metamorphic belt developed near the triple junction among the Sino-Korea, Yangtze and Proto-Pacific plates

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The eastward extension of the suture zone between the Sino-Korea and Yangtze cratons in the Korean Peninsula and Japanese islands remains debatable (Hiroi, 1981; Cluzel et al., 1991; Yin and Nie, 1993; Sohma and Kunugiza, 1993; Isozaki, 1997; Arakawa et al., 2000), and is related to our understanding of the continent-continent collision orogeny. The collision orogeny varies in tectono-metamorphic processes and the timing differs from place to place, as exemplified by the absence of coesite and micro-diamond in the Korean Peninsula and Japanese islands, because it is a long-lived process of more than several tens of million years from subduction to exhumation in the Wilson cycle, and because the suture zone extends more than several thousand kilometers with a curved shape from the Qinling area of China to the Hida highland area of Japan. Hiroi (1981) is the first paper to correlate the Unazuki metamorphic rocks of the Hida metamorphic belt in Japan with the Ogcheon belt in the Korean Peninsula based on the presence of 240 Ma medium P/T metamorphic rocks in both belts, but there is a lack of recent studies on this correlation.

To resolve the correlationship, there are two approaches: 1) petrological studies characterizing the origin and P-T history of rocks and 2) in-situ micro-dating of fine-grained, zoned minerals of zircon, monazite, uraninite and thorite using the EPMA (U-Th-Pb chemical dating or CHIME depending on calibration method) and the SHRIMP (Sensitive High-resolution Ion Microprobe) to decipher the timing of geological events. As a first step of these approaches, micro-dating was undertaken to rocks of the Hida metamorphic belt and its Mesozoic cover (Tetori Group) in the Hida highland area, central Japan.

1. Lithology of the Hida metamorphic belt - Petrological constraints

The Hida metamorphic belt consists of Paleozoic hornblende gneiss, amphibolite, calcareous gneiss, meta-granite and limestone with subordinate amount of pelitic gneiss. In contrast to the Korean Peninsula, no Archean to Proterozoic gneiss and granite occur. Lithologically, the Hida metamorphic belt is characterized by calcareous gneiss, which is intercalated with limestone and amphibolite, and composed mainly of salite, plagioclase and titanite with small amounts of K-feldspar, calcite and quartz. Such a calcareous gneiss, denoted as clinopyroxene gneiss, formed through a reaction, tremolite + 3 calcite + 2 quartz = 5 diopside + 3 CO_2 + H_2O. This reaction was induced not by changes in P-T conditions but by mechanical mixing of amphibolite and limestone under P-T conditions higher than those of the reaction probably at the amphibolite facies during the tectonic movement of collision-type orogeny (Goto et al., 1994; Kunugiza et al., 1994).

2. Protoliths and Tectono-metamorphic events of the Hida metamorphic rocks

The U-Th-Pb chemical and SHRIMP ages indicate following protolith ages and tectono-metamorphic events:

(1) Rounded cores of zircon of greater than 1000 Ma, mostly clustered around 1800 Ma, are found in pelitic gneisses and granitoids, and are of detrital or relict origin. The absence of ca. 1800 Ma monazite is noted in the Hida metamorphic rocks.

(2) High temperature metamorphism at the time of the Gondwana breakup is suggested by zircons of 350-300 Ma occurring as mantles of zoned grains and as discrete grains. These ages are also represented by the Rb-Sr isochron ages of metagabbros and migmatites (Arakawa, 1984) and by the K-Ar hornblende ages from some gneisses (Ota and Itaya, 1989). Protoliths of the Unazuki metamorphic rocks that are impure limestones of Carboniferous, rhyolite, basaltic sandstones and pelites are interpreted as rift zone sediments. Plant fossils of the Sino-Korea craton suggest its northward movement after the Carboniferous breakup of the Gondwana land.

(3) Collisional metamorphism proceeded from ca. 270 to 210 Ma. The SHRIMP ages of zircon and U-Th-Pb chemical ages of monazite from meta-granites and migmatites indicate an initiation of subduction at ca. 270 Ma. Major population of U-Th-Pb chemical ages of zircon and monazite at around 250 Ma corresponds to the peak of the Hida metamorphism. The U-Th-Pb chemical ages of uraninite define two distinct ages of ca. 240 and 200 Ma. The former represents the age for the precipitation of uraninite from hydrothermal fluids accompanied by the breakdown and recrystallization of zircon and monazite. Rb-Sr and K-Ar ages of younger than ca. 240 Ma (Ota and Itaya, 1989) were attributed to retrogressive metamorphism upon the exhumation of the Hida metamorphic belt.

(4) Granite activities took place during ca. 220-190 Ma. The 200 Ma uraninite age of Hida metamorphic rocks corresponds to hydrothermal stage of the granite activities. The name "Jurassic Funatsu granitoids" may be found in some papers written by Japanese and French researchers. The Jurassic age, based upon Rb-Sr and K-Ar dates, is not supported by new U-Th-Pb chemical and SHRIMP dates of this study. More than half of so-called Funatsu granitoids intruded before the Hida metamorphism (270-210 Ma) and are considered to be the metamorphosed granites.

(5) Uplift of the Hida metamorphic belt led to the formation of Jurassic accretionary complex (Mino belt) and then Cretaceous molasse sediment (Tetori Group), in which zircon and monazite grains showing the ages of ca. 1800, 250 and 200 Ma are common.

3. Collision process near the triple junction among the Sino-Korea, Yangtze and Proto-Pacific plates

The major part of the Japanese island except the Hida metamorphic belt consists of subduction-accretion-type orogenic belts developed at the periphery of the Yangtze craton with the Proto-Pacificward younging polarity from the early Paleozoic to the

Cenozoic (Isozaki and Maruyama, 1991; Isozaki, 1997). The Hida marginal belt is a Permian accretionary complex including more than 300 Ma blueschist and eclogite, and Paleozoic sediments, and did not suffer the Hida metamorphism at ca. 250 Ma. The paleomagnetic study (Hirooka et al., 1983) and the Xenoxylon fossils (Tsunada et al., 1985; Tsunada and Yamazaki, 1987) of the early Jurassic fore-arc sediments, Kuruma Group, covering the Hida marginal belt indicate the northward movement of the Yangtze plate during that time. Thus, the tectonic juxtaposition of the Hida metamorphic belt and the Hida marginal belt took place upon the continued subduction of the Yangtze plate near the triple junction among the Sino-Korea, Yangtze and Proto-Pacific plates. The early Cretaceous Tetori Group covers these belts, and marks the completion of the collision (the Hida nappe movement).

4. The geographic relationship between the Korean Peninsula and the Hida metamorphic belt

Detrital zircon and monazite grains of ca. 1800, 250 and 200 Ma of both the Mino belt and the Tetori Group were eroded away from some places in the Himalaya-sized mountains of the suture zone. The Hida metamorphic belt, the basement of the Tetori Group, is not a main provenance area of the Tetori Group, because of the absence of ca. 1800 Ma monazite in the Hida metamorphic rocks. In contrast, monazite of 1900 to 1600 Ma is rather common throughout the Korean Peninsula. In addition to the absence of Archean to Proterozoic rocks and the presence of clinopyroxene gneiss in the Hida metamorphic belt, the age distribution of detrital grains in the sediments suggests that the triple junction among the Sino-Korea, Yangtze and Proto-Pacific plates, where the Hida metamorphic belt developed, was thus situated far from the Korean Peninsula.