Significance of high-Ti biotite and anatectic conditions of paragneiss in the Oki-Dogo Island, Japan

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The Oki Gneiss exposed on the eastern side of the Oki-Dogo Island in SW Japan consists mainly of paragneiss and subordinate orthogneiss. These lithologies were originated from Paleoproterozoic (~1800 Ma) clastic rocks and granitoids, and subjected to low-P/T type metamorphism associated with anatexis at around 240 Ma (Tsutsumi et al., 2006; Cho et al., 2012). The Oki Gneiss must be a key to understand the correlation with Precambrian basements in the Korean Peninsula and Permo-Triassic tectonic framework of East Asia. In the present study, we conducted field survey in the entire areas of the Oki Gneiss and examined the spatial extent and P–T conditions of high-grade metamorphism and anatexis. Although structures of the Oki Gneiss were affected by intensive Cenozoic volcanic activities, the main foliation (gneissosity) largely strikes E–W and dips to the south or north. Migmatitic gneiss shows complex ptigmatic folding, but outcrops showing polyphase deformation are uncommon and the main foliation probably represents a single deformation phase. Migmatitic pelitic gneiss consists of biotite- and sillimanite-rich melanosome and plagioclase- and quartz-rich leucosome parallel to the main foliation, and is commonly cut by discordant leucogranite dikes. The peak mineral assemblage of aluminous pelitic gneiss is garnet + biotite + sillimanite + cordierite + plagioclase + quartz + spinel (hercynite-gahnite) + ilmenite + rutile + graphite or its partial assemblages. Spinel only occurs in southern areas. Occasionally, euhedral andalusite enclosing sillimanite occurs in the leucosome, and they might be cotectic minerals crystallized during cooling. Garnet grains are chemically homogeneous except for the reverse-zoned (i.e., increase in Mn and decrease in Mg) grain margins. However, some garnet in northern localities faintly preserves growth zoning characterized by high Mn, Ca and Y contents at the core of garnet grains. To estimate peak-T conditions, we used Ti-in-biotite and Zr-in-rutile geothermometers for biotite and rutile in equilibrium with quartz and zircon. High-Ti biotite (up to 5.9 wt% TiO_2) is found as inclusions in garnet and tiny rounded grains completely enclosed within single crystals of matrix quartz or plagioclase. These high-Ti biotite grains imply high-T metamorphism (up to 760°C), but high-Ti biotite in garnet shows significantly higher Mg#, suggesting Fe-Mg exchange with the host garnet during cooling. Coarse-grained platy biotite aligned in the gneissosity shows low Ti and is associated with low-Zr rutile and sillimanite, suggesting re-equilibration (~550–650°C) and pervasive ductile deformation during an early retrograde stage. High-Zr rutile (1200–1700 ppm Zr) only occurs as inclusions in garnet with no any associated cracks, and implies high-T conditions of ~750–780°C. Presuming high-Ti biotite in quartz/plagioclase and homogenous core of garnet are in equilibrium at the thermal peak, combination of conventional geothermobarometers gives peak P–T conditions of ~0.42–0.60 GPa and 760–780°C for samples from widely-spaced localities. Samples from southern localities tend to show lower P conditions. Calculated phase equilibria verify the coexistence of cordierite, garnet and spinel during anatexis at the estimated peak conditions for the southern samples. The ubiquitous occurrence of high-Ti biotite implies the Oki Gneiss entirely underwent high-grade metamorphism (transitional upper amphibolite to granulite facies). Taken together, the Oki Gneiss represents a Paleoproterozoic basement that was overprinted by a 240 Ma thermal event associated with ductile flow, low-P/T metamorphism and anatexis at mid-crustal levels (~15–20 km).

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