

## Magma process of the Ushikiri-yama granodiorite, north Kyusyu, SW Japan: Implications for formation of middle crust

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Continental crust comprises mafic lower crust and felsic middle crust in terms of seismic refraction and reflection date (Ansorge et al. 1992). Northern Kyusyu is widely underlain by the granitoid batholiths due to subduction of an oceanic plate during Cretaceous time. The Ushikiri-yama granodiorite intruded at the early stage of igneous activity of the batholiths, and emplaced in the middle crust (Eshima and Owada, 2015). In this study, we address magma processes, emplacement depth, K-Ar mineral ages of the Ushikiri-yama granodiorite, and discuss the formation process of middle crust in the active continental margin.

The Ushikiri-yama granodiorite intrudes limestone, various kinds of metamorphic rocks derived from the Permian accretionary complex. The granodiorite is divided into North and South bodies separated by fine-grained facies granodiorite. It shows hypidomorphic granular texture and consists mainly of plagioclase, biotite, hornblende, quartz, K-feldspar, and trace amounts of euhedral magmatic epidote with  $\text{Fe}^{3+} / (\text{Fe}^{3+} + \text{Al}^{3+})$  values between 25% and 27%. The granodiorite shows flow structure defined by preferred orientation of mafic minerals and plagioclase along the outline of the granodiorite body, and locally contains fine-grained mafic magmatic enclaves (MME).

We estimate the emplacement depth of the Ushikiri-yama granodiorite using the hornblende geobarometer (Schmidt, 1992) with solidus temperature using hornblende-plagioclase geothermometer (Holland and Blundy, 1994). Accordingly, the granodiorite yields emplacement conditions ~720 to 640 °C and ~ 0.45 to 0.35 GPa that are equivalent to middle crust conditions. In addition, the granodiorite contains magmatic epidote. It means that the granodiorite magma was produced at the depth of lower crust conditions because the magmatic epidote in granitic magmas can be stable at pressure 0.6-0.8 GPa (Zen and Hammarstrom, 1984; Schmidt and Poli, 2004). The emplacement depth of the Cretaceous granitoids from north Kyushu resemble those of the Ushikiri-yama granodiorite, e.g. Itoshima granodiorite (Yada and Owada, 2003). In other words, the granitoid batholiths of north Kyushu would be dominated by the middle crust along the active continental margin during Cretaceous time.

Keywords: middle crust, active continental margin, emplacement depth, magmatic epidote, ushikiri-yama granodiorite