

Petrological, geochemical, and geochronological characteristics of the Oritate travertine from Unazuki area, Toyama, Japan: possibility of U-Pb geochronology of carbonates with high common Pb.

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U-Pb dating of carbonate minerals can be widely applied to understand the timing of vein-type mineralization, fault movements, and other geological events forming calcites, which are difficult to be dated by other methods. Reference materials for U-Pb dating of calcite, such as WC-1 (254.4 ± 6.4 Ma, Roberts *et al.*, 2017) and ASH-15D (3.001 ± 0.012 Ma, Mason *et al.*, 2013; Vaks *et al.*, 2013), are available from several laboratories. However, it is often difficult to obtain reliable estimated ages of calcite because calcite usually contains high common Pb content.

In this study, we present the petrological, geochemical, and geochronological characteristic of the Oritate travertine from Unazuki area, Toyama, Japan. Typically, travertines are formed by a precipitation of carbonate minerals from hot spring. Thus, the U-Pb dating of calcite provides the timing of hydrothermal fluid activity. The Oritate travertine is called as 'Onyx Marble' by its texture. It shows layered texture with different colors from gray, white, to brown. It consists of aragonite and calcite. The chondrite normalized REE patterns of travertines show the flat and positive Eu anomalies which are different characteristics from oceanic limestones.

High initial $^{238}\text{U}/^{204}\text{Pb}$ (μ) content is requirement for precise U-Pb dating of calcite (Rasbury & Cole, 2009), because calcite generally contains significant amount of common Pb. It is also better to contain high U in the order of several tens of ppm for U-Pb dating. U/Pb ratio of the Oritate travertines range from 1.1 to 2.2. The U and Pb concentration of Oritate travertines are very low which is less than 1 ppm. The brownish colored layers in travertines contain relatively high U concentrations. Although the chemical compositions of Oritate travertine imply the difficulty to apply U-Pb method, we examined U-Pb dating of calcite with high common Pb. We analyzed travertines with relatively high U/Pb ratio and U contents parts of the travertines for U-Pb dating. U-Pb dating was attempted with the solution ICP-MS as well as the LA-ICP-MS utilize a New Wave Research 193UC excimer laser ablation system, coupled to a Nu Instruments Nu Plasma II multi-collector ICP-MS or Agilent 7700 quadru-pole ICP-MS at Akita University. We discuss and evaluate the U-Pb dating method for calcite with high common Pb.

Keywords: U-Pb dating, carbonate mineral, travertine, ICP-MS, Oritate