Estimation of thermal history of Toki granite over 0.1Myr timescale by Multi-OSL-thermochronometry

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Estimation of denudation history is important for geological disposal of high-level radioactive waste because denudation influences underground water flow and distance between the surface and underground facility. Terrestrial cosmogenic nuclide (^{10}Be, ^{26}Al) dating is used to evaluate denudation rate in a few meters, whereas low-temperature thermochronology, such as fission-track and (U-Th)/He methods, is applied to estimate denudation histories for a few to several kilometers in the last 10^6-10^8 years. However, the middle-term (10^4-10^5 years) denudation history over several hundred meters is more important for geological disposal because it takes tens of thousands of years to reduce the radioactivity of radioactive waste to the level of that of natural uranium ore.
Recently, multi- OSL-thermochronometry has been proposed as a tool that offers the potential for tight constraint of cooling histories in the low-temperature domain (< 75℃) over recent (0.1-0.2 Myr) timescales. This method determines the timing and rate at which electrons are trapped and thermally released in minerals, in response to in situ radiation and rock cooling. The technique of OSL thermochronometry is able to be used to unravel denudation histories.
Application of OSL thermochronometry is currently limited to regions that have experienced denudation rates higher than 3 mm/year, assuming a general geothermal gradient and surface temperature; luminescence signals saturate before the rocks are exhumed to the surface in a slowly-denuded region. Given such limitations on the cooling/denudation rate, previous researches on OSL themochronometry has focused on tectonically active mountain ranges, such as the Himalayas, the Southern Alps of New Zealand and Hida range in Japan.
We attempt to apply multi-OSL-thermochronometry to the tectonics that have experienced slowly denudation rate using long borehole. We used the borehole MIZ-1 which was drilled at Mino plateau, Gifu, Japan. The denudation rate in this area is expected to be around 0.1 mm/year or less from the denudation rate since ~40 Ma estimated by the apatite fission track method and uplift rate between MIS6 and MIS2 based on elevations and emergent ages of the fluvial terraces. This borehole consists mainly of the Cretaceous Toki granite pluton which is located at the Sanyo Belt in the Inner zone of the South west Japan Arc. The total length of MIZ-1 is about 1,300 mabh (meter along borehole) and Toki granite ranges from 110 to 1,300 mabh. We collected the samples at 159, 449, 751 mabh for multi-OSL-thermochronometry.
Cooling histories of all samples are similar. Their temperatures decreased to the present ambient temperature at each depth before 0.1 Ma and have then been stable. These results correspond to the expected slow denudation rate. Our results indicate that, by using long borehole, multi-OSL-thermochronometry can be applied to slowly-denuded regions.
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