Uplift and denudation history of the South Fossa Magna region revealed by low-temperature thermochronometric methods

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The South Fossa Magna region is located at the junction of the Japan and Izu-Bonin arcs. In this region, multiple blocks, which are four at maximum (Kushigatayama, Misaka, Tanzawa, Izu), collided and formed crustal structures after the middle Miocene[1, 2]. When these blocks collided are estimated by sediments between each block and the Japan arc, whereas what influences given emerge as the deformation of the Japan arc to which the Izu-Bonin arc are collided. However, these questions remain unresolved.

Today geodetic techniques, such as GPS observation, make progress to better understand the uplift rates quantitatively, but the technique is restricted to measure crustal motions of short timescale (less than a few decades). Then, we used low-temperature thermochronometric methods to estimate uplift-denudation histories of geological time scale. Thermochronology is a discipline to determine the timing and temperature of past thermal events on basis of radiometric ages, which may be reset by past heating[3]. This method has been applied to various geological phenomena.

In this study, we performed apatite fission track (AFT) thermochronometric methods to resolve the uplift and denudation history of the Japan Arc side that mainly suffers tectonically from the collision in the South Fossa Magna region. The AFT was used because of its lower closure temperature (~ 100 ˚C) than other thermochronometries such as U-Pb and zircon fission track methods[4].

The AFT age for Okuchichibu area is 14.7 ±4.7 Ma, the ages for Kanto Mountains are 1.0±0.4 Ma, 8.7 ± 2.0 Ma, and 6.3 ±1.1 Ma, and the age for Minobu area is 3.6 ±2.5 Ma. These granitic blocks were formed in the middle Miocene. In the Okuchichibu area, the AFT age is almost same to the age of rock formation (i.e., 10.5 ±1.5 Ma, based on the K-Ar method for hornblende[5]). In the Kanto Mountains and Minobu area, the AFT age is younger than the age of rock formation (i.e., the Kanto Mountains: 10.5 ±0.4 Ma, based on the K-Ar method for biotite[6]). Assuming a general geothermal gradient of 40 ℃/km, the average denudation rate for the Okuchichibu area is 0.23 ±0.07 mm/yr, the rates for Kanto Mountains are 3.6 ± 1.4 mm/yr, 0.36 ±0.08 mm/yr, and 0.49 ±0.09 mm/yr, and the rate for Minobu area is 1.6 ±1.1 mm/yr. The denudation rates for Tanzawa granites are ~ 2 mm/yr at 3.3 - 2.0 Ma, and ~ 0.8 mm/yr at 2.0 - 0 Ma[7]. The rates of Tsuburai granites range from 0.16 to 0.21 mm/yr after 16.4 Ma, as calculated from the previously reported AFT ages[8]. Therefore, the denudation rates of Kanto Mountains and Minobu area are faster than those of Okuchichibu area and Tsuburai granites, and almost same to that of Tanzawa granites. These results may reflect the tectonic effects of the collisions, such as doming or thrusting.

The subjects for a future study are as follows: 1) improvements for thermochronometric mapping by increasing the number of counting tracks and starting analysis for other sampling localities/areas, 2) more reliable thermal history inversion analysis by considering a cooling process using track length distributions, 3) revealing crustal movements at even shallower levels by the apatite (U-Th)/He method.

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