ジルコンFT熱年代計の現状と展望

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The present and future of zircon FT thermochronometry

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Fission track (FT) thermochronometry using zircon has widely been applied to unravel geological records of terrestrial materials, particularly in orogenic belts to reconstruct uplift-denudation-cooling of mountains, thermal processes of fault zones, etc. Thermal annealing characteristics of FTs in zircon has primarily been studied using spontaneous FTs. This is because (a) in contrast to apatite, the mean length of spontaneous FTs in zircon from rapidly cooled volcanics are indistinguishable from that of induced FTs, suggesting the absence of natural shortening and (b) thermochronologic analyses of geological samples are carried out using spontaneous FTs in natural zircons, for which thermal annealing behaviors should be described. Hence, the thermal annealing kinetics was first determined on spontaneous FTs of the Nisatai Dacite (NST) zircon.

Yet, it is not well known about how the kinetics can vary among natural zircons, for example, as a possible consequence of radiation damage accumulation. Confined track length reductions during 1 hr isochronal laboratory annealing were measured for both spontaneous and induced FTs in zircons (Kauya and Naeser, 1988), and found that (a) induced FTs in pre-annealed zircons are more resistant to thermal annealing than spontaneous FTs, (b) annealing behaviors of spontaneous FTs are indistinguishable between four samples of Paleogene to Miocene ages, with the range of spontaneous track densities of 10 to 0.9 x 10^6 cm^{-2}, and (c) induced FTs in non pre-annealed zircons behave like spontaneous tracks. Confined track length reductions during 1 hr isochronal laboratory annealing were also compared between the spontaneous and induced FTs in the NST zircon (Yamada et al., 1995). The experimental procedures were improved by applying analytical criteria and measuring crystallographic orientation of confined tracks. It was found that the induced FTs are more resistant to thermal annealing than spontaneous tracks at the advanced stage of annealing, even after the correction of track length anisotropy that reflects the anisotropic etching and annealing.

On these basis, laboratory annealing experiments were performed using nine zircon samples of different ages and spontaneous track densities, in order to better constrain the possible variation of annealing behaviors among natural zircons (Tagami and Matsuura, 2019). Confined track lengths in the nine natural zircons, separated from rapidly cooled volcanic rocks, showed consistent and systematic reductions against annealing temperature after 1 hr isochronal heating. No systematic difference of FT annealing characteristics was found among natural zircons of ~70 to ~0.6 Ma age (and spontaneous track density of 7 to ~0.05 x 10^6 cm^{-2}). Coupled with previous data, it implies that an identical annealing kinetics can work for many of the late Mesozoic to Cenozoic zircons.

References

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