Elucidating uplift/denudation histories of NE Japan by using low-temperature thermochronology

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The NE Japan is well-known as a typical arc-trench system. The tectonic setting of NE Japan arc is supposed to be controlled by the plate subduction, and the E-W compressive stress caused by the subduction formed mountains and geological structures. Since NE Japan has experienced massive and frequent changes of the stress field, the complex tectonic histories are inferred. Most of the geomorphic reliefs in NE Japan has been formed from Pliocene to Quaternary (Yonekura et al. 2001), whereas the onset of mountain uplift may be different at each region, the fore-arc, the Ou Backbone range and the back-arc side in NE Japan.
The methodologies of estimation of uplift/denudation in upper crust vary in timescale or target area. However, the uplift rate observed by GPS survey does not always agree with the uplift rate on 10^6–10^7 yrs timescale. Furthermore, the number of methods for estimation of uplift/denudation rate on >10^6 yrs timescale is not abundant, so few studies were conducted as to the quantitative evaluation of uplift/denudation rate on >10^6 yrs timescale in NE Japan.
In this study, low-temperature thermochronology was performed for a quantitative evaluation of vertical deformation in NE Japan, and interpretation of complicated tectonic effect on the proceedings of the mountain buildings. This method is used to estimate thermal histories of a mountain region on 10^6–10^7 yrs timescale, conducted across the southern part of the NE Japan arc, the fore-arc, the Ou Backbone range and the back-arc side. To estimate accurate thermal histories at each region, apatite fission-track (AFT) method was performed in south part of NE Japan where Sueoka et al. (2016) obtained apatite and zircon (U–Th)/He (respectively, AHe, ZHe) ages.
AFT ages were estimated at 79.5–66.0 Ma on the fore-arc side, 29.8–5.5 Ma in the Ou Backbone range, and 21.0–17.6 Ma on the back-arc side, respectively. These AFT ages were generally consistent with the previous FT ages and He ages. On the basis of the thermal inverse analysis results, the onsets of the last cooling episodes were determined from ages of nick points of the time-temperature paths. The results were as below: slow cooling pattern since ca. 80–60 Ma on the fore-arc side, rapid cooling pattern since ca. 1 Ma in the Ou Backbone range, and rapid cooling pattern since ca. 6–5 Ma on the back-arc side. The estimated thermal histories of each region were compared with previous tectonic/geologic information.
1) On the fore-arc side, the amount of denudation since 50 Ma was estimated at ca. 2 km, suggesting a tectonically stable setting over the Cenozoic. Therefore, the tectonics after the opening of the Sea of Japan have a slight influence on the fore-arc side. On the other hand, the uplift/denudation rates estimated by thermochronology (~0.04 mm/yr) and the other methods on 100 kyrs timescale (>0.1 mm/yr) have one order of discrepancy. However, this observation can be explained if the denudation rate increased since the Pliocene or Quaternary.
2) The Ou Backbone range was supposed to be uplifted because of the E-W compression since ~6 Ma or the strong E-W compression since 3–2 Ma (Sato 1994; Nakajima 2013). At the center of the Ou Backbone range, younger AHe ages of 2–1 Ma and AFT ages of 6–5 Ma were obtained. In addition, the result of thermal inverse analysis indicates the rapid cooling since ca. 1 Ma, consistent with the onset of uplift and rapid cooling since 3–2 Ma. On the other hand, the AFT and ZHe ages older than ~30 Ma were obtained

at the margins of the Ou Backbone range. The interpretation of the older ages is difficult because the apparent ages may be partially reset by volcanic activities on late Cenozoic as well as burial and/or volcanism related to the opening of the Sea of Japan. Although these ages may be useful to reconstruct cooling/denudation histories of the NE Asian continental margin prior to ~30 Ma.
3) On the back-arc side, AHe ages of <~10 Ma are obtained, and a nick point of cooling paths obtained by thermal inverse analysis lies around ca. 6–5 Ma. Considering these results, the uplift on back-arc side may be started since at least ~10 Ma. AFT and ZHe ages around 30 Ma, however, may be influenced by the volcanic activities attributed to the Green tuff tectonics or subsiding by the transgression, similar to the Ou Backbone range. The interpretation of the older ages is difficult.

Keywords: thermochronology, (U-Th)/He method, Fission Track method, NE Japan Arc

