Uplift and denudation history of the Akaishi Range based on low-temperature thermochronology and thermo-kinematic model

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The Akaisahi Range is a thrust block distributed in the collision zone between the Izu-Bonin and Honshu arcs, as well as the collision zone between the NE and SW Japan arcs. Thus, elucidation of uplift process and mechanism of the Akaishi Range can be a key to understand tectonics in and around arc-arc collision zones. We carried out thermo-kinematic modeling based on thermochronometric ages across the northern Akaishi Range for revealing: 1) relations between uplift of the northern Akaishi Range and activity of the Itoigawa-Shizuoka Tectonic Line fault zone (ISTL-FZ), 2) subsurface geometry and slip rate of ISTL-FZ, and 3) uplift and denudation history of the northern Akaishi Range.
The age data were reported by Sueoka et al. (2012, abst. AGU); apatite fission-track (AFT), zircon (U-Th)/He (ZHe), zircon fission-track (ZFT), and zircon U-Pb ages were obtained. AFT, ZHe, and ZFT ages generally decrease to the east, suggesting a westerly tilted uplift of the range. The youngest AFT and ZHe ages of ~3 Ma agree with onset of the uplift at ~3.3 Ma which was estimated from deposition age of the Akebono Conglomerate (Kano, 2002). The youngest ages were obtained at the western side of the Hakushu and Ho-osan faults (HHFs). Thus, thrusting of HHFs is thought to be the primary factor of the northern Akaishi Range uplift. In contrast, to the east of HHFs, no ages were significantly younger than the granitic formation age at ~16 Ma, then the total denudation since ~16 Ma is 2-3 km or less. The Ichinose and Shimotsuburai faults to the east of HHFs might be formed later than onset of the uplift due to migration of thrust front (Tajikara, 2002).
Thermo-kinematic calculations were conducted to verify if uplift of the northern Akaishi Range is attributable to thrusting of HHFs. We computed theoretical ages resulted from given tectonic scenarios to compare with the observed ages. HHFs were simplified to be a flat-ramp thrust composed of two rectangular fault plains. The calculation results suggest that the age pattern observed can be explained by 5–10 mm/yr reverse slip on HHFs that dip 27–45° west and sole onto detachment at a 20–25 km depth. The bedrock uplift rate was estimated at ~4 mm/yr from the slip rate and dip. The denudation rate was also inferred at ~4 mm/yr assuming a steady-state condition of bedrock uplift and denudation; this assumption seems adequate as the denudation rate is comparable with the shorter-term denudation rates obtained by cosmogenic nuclides methods (Korup et al., 2014) and sediment volumes of catchments (Fujiwara et al., 1999). The estimated fault parameters are also consistent with previously reported data, e.g., reverse slip rate of ISTL-FZ estimated from deformation of fluvial terraces (Ikeda et al., 2009), dip of ISTL-FZ obtained by seismic array observations (Panayotopoulos et al., 2010), and the lower limit of the seismic layer in this region (e.g., Asano et al., 2010). Consequently, uplift of the northern Akaishi Range is attributable to thrusting of HHFs since ~3.3 Ma.
Taking into account the results above, the uplift and denudation style of the northern Akaishi Range is well explained as a simple tilted thrust block model of Sueoka et al. (2012); due to tilted uplift derived from faulting on one side of the mountain, the mountain presents asymmetric topographic cross-sections as well as bedrock uplift and denudation rates increasing toward the fault side. However, considering both the difference in apatite FT age (Yamagiwa, 1998MS) and active fault distribution, the northern and southern Akaishi Range might be different in origin and timing of uplift. The inferred total denudation is larger than several km and likely exceeds 10 km since the onset of the northern Akaishi Range uplift,

suggesting that the low-relief surfaces on the ridges and relatively constant elevations of the summits reflect post-uplift denudation rather than pre-existing low-relief landforms.

Keywords: Akaishi Range, Itoigawa-Shizuoka Tectonic Line fault zone, low-temperature thermochronology, thermo-kinematic modeling, arc-arc collision zone

