Multichronometer thermochronologic modeling of migrating spreading ridge subduction in southern Patagonia

Andrea L. Stevens Goddard1, and Julie C. Fosdick2
1Department of Geology, Rowan University, 201 Mullica Hill Road, Glassboro, New Jersey 08028, USA
2Department of Geosciences, University of Connecticut, 354 Mansfield Road, Storrs, Connecticut 06269, USA

In Stevens Goddard and Fosdick (2019), we use thermal history modeling of a composite thermochronological data set to identify northward-migrating accelerated rock cooling ($t_{cool}$) from 20 to 5 Ma in the southern Patagonian Andes (47°–54°S) that systematically predates subduction of the Chile Ridge by ~2–5 m.y. We propose that this signal reflects northward migration of the Chile Ridge and associated cooling caused by lithospheric thickening along the leading edge of the obliquely subducting ridge that drives topographic uplift and exhumation—herein the crustal welt model (CWM; Furlong and Govers, 1999). Husson et al. (2019) raise two points for consideration: (1) that north-south crustal shortening required to explain the magnitudes of rock exhumation inferred from thermochronology are not evident in the field geology of Patagonia, and (2) that an alternative mechanism, transient dynamic topography—hereafter, the dynamic uplift model (DTM)—better fits the spatiotemporal distribution of $t_{cool}$ in southern Patagonia.

We agree that the CWM requires crustal thickening to drive exhumation, but disagree with Husson et al. about the magnitude of crustal shortening necessary to initiate the observed rock cooling. Husson et al. state that up to ~6.5 km of lithospheric thickening (and a corresponding 20%–25% crustal shortening) is needed to generate ~3 km of exhumation and reset apatite fission-track (AFT) ages. Here we re-emphasize that the migrating record of accelerated cooling, $t_{cool}$, is not evident by individual thermochronometric dates in any single system (zircon U-Th/He, AFT, and apatite (U-Th)/He) alone. Instead, thermal history modeling of multichronometer data sets resolves the onset of $t_{cool}$ along the Patagonian Andes at temperatures as low as 50 °C in some cases (Stevens Goddard and Fosdick, our figure DR2), indicative of <3 km exhumation. Residual cool, across all tectonic domains (modified from Stevens Goddard and Fosdick, 2019) poorly fit the timing and rate of predictions made by the dynamic uplift model (DTM) shown by the red line (Husson et al., 2018), but are consistent with the timing of terrace deformation (Guillaume et al., 2009).

Specifically, the predicted onset of dynamic uplift predates $t_{cool}$ at latitudes 54°S to 49°S and postdates $t_{cool}$ at latitudes 47.5°S to 46.5°S (Fig. 1). Additionally, thermal history models identify a deceleration of cooling, interpreted as slowed exhumation that follows $t_{cool}$ and occurs during or after the passage of the ridge (Stevens Goddard and Fosdick, our figure DR2) at the same time that the DTM predicts maximum exhumation and cooling. Finally, there is a discrepancy between the migration rate of uplift predicted by the DTM (~266 km m.y.−1, 54°–48°S) and rock cooling (94 ± 23 km m.y.−1), which is within the error of kinematic reconstructions of Chile Ridge subduction (Fig. 1; Breitsprecher and Thorkelson, 2009).

Although dynamic forces most certainly act on the lithosphere of southern Patagonia in variable ways, the DTM alone cannot fully explain the systematic northward signal of cooling resolved by thermochronometric modeling on an orogen scale. Our primary contribution (Stevens Goddard and Fosdick) is a resolvable orogen-scale migrating signal of rock cooling associated with ridge subduction. The CWM offers a consistent fit with the composite record of rock cooling and passage of the ridge segments, and we welcome future contributions that resolve the combined effects of isostatic and dynamic drivers in Patagonia.

REFERENCES CITED


