An Integrated Approach to Determining the Crustal Thickness History of Southern Tibet

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A full understanding of the evolution of a plate margin through the transition from convergence to collision requires knowledge of time-dependent boundary conditions at both the surface and depth. Remote imaging via geophysical studies can tell us about the present structure of the lithosphere but few strategies have been advanced to assess crustal-thickness variations through time. Indeed, post-collisional thrusting and strike-slip faulting typically modify suture zones to such an extent that little can be learned about syn-collisional crustal structure from direct observation.

The Lhasa Block offers the opportunity to combine results from seismology, isotope geochemistry, and thermochronology to gauge crustal thickness variations through time. High-resolution receiver-function analyses are providing an increasingly accurate image of present variations in crustal thickness and structure across southern Tibet. Using a combination of thermochronometry and isotope geochemistry, we have obtained preliminary model crustal thickness estimates for a series of snapshots in time from 120 Ma to present. For example, Nd isotopic data from ca. 50 Ma granitoids along a N-S traverse near Lhasa show a pronounced gradient in ε_{Nd}, with mantle-like values adjacent to the suture zone (+5) rising to $\varepsilon_{Nd} \approx -12$ at ~120 km north of the suture. This spatial gradient in ε_{Nd} is interpreted as reflecting decreasing mantle input/increasing crustal assimilation due to progressively thickened crust continentward (i.e., higher lower-crustal temperatures enhance crustal assimilation). Using a calibrated crustal thermal model, our initial results suggest that this strong northward gradient in assimilation is due to gradually decreasing northward mantle magma flux coupled with increasing crustal thickness, from ≤20 km immediately north of the suture to ≥50 km in the northern portion of the Gangdese Batholith where the granitoids are essentially pure crustal melts. Exhumation studies using continuous thermochronology applied to pre-120 Ma plutons document the quantity and timing of removal of material from the surface boundary of the Lhasa Block and record time-varying paleo-geothermal gradients. Thus, projecting back from the present reference, we can in principle use these three data sets to determine crustal thickness, exhumation, and petrogenesis through time and possibly assess potential feedbacks between tectonics and topography.

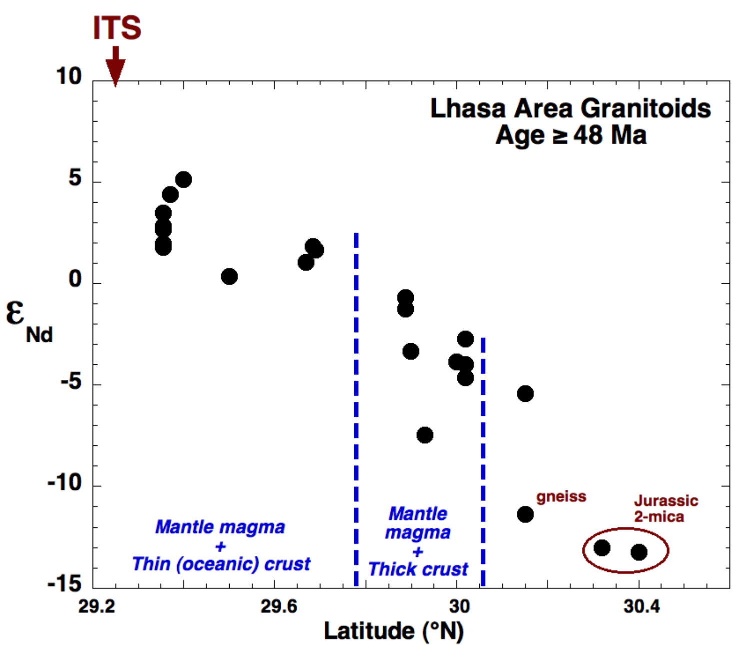

Figure 1. Plot of ε_{Nd} of SE Tibetan granitic rocks vs. latitude. (left) Pre-collisional (>48 Ma) granitoids show a classic continentward decrease in ε_{Nd}. High ε_{Nd} values south of ~29.8°N suggest that this area was underlain by oceanic crust at the time of magmatism. Between 29.8° and 30.1°N there may have been thicker Precambrian basement. North of 30.1°N, melting appears to have been intracrustal. Crustal thickness can be related to wallrock temperature, basement Sm-Nd model ages, and young granitoid initial ε_{Nd} through heat flow models.

Understanding the evolution of southern Tibet has significance well beyond its key role in recording events of the Indo-Asian collision. Knowledge of the pre-collisional geometries of India and Asia is vital to assessing when collision began and how much convergence was accommodated by thickening, extrusion, lower crustal flow, or delamination. The integrated approach described here offers a way to 'image' the pre- and syn-collisional crustal structure of southern Tibet to help address these fundamental issues.

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