The Moho after 100+ Years of Research: What, Where, When, & Why Do We Care?

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Where is the Moho? Is This a Big Problem?

TWTT

– P-wave reflection profile over ~1,000 km

What obvious features do you see?

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Need a Reliable, Consistent Yardstick for Crustal Thickness

Virtual Deep Seismic Sounding (VDSS)

Wide-angle reflection from SsPmp
  – Virtual source
  – Deep-penetrating
  – Large signal
  – Physically averaged position of crust-mantle transition

Gradual, northward thinning of crust
  – Deviation from Airy isostasy starts near S. end of disrupted Moho
  – Up to ~12 km difference
  – ~2 km in residual topography

Thermal or dynamic support from the mantle

Current Configuration of Colliding Lithosphere:

T-T Tomography

Finite-frequency (“banana-doughnut”) kernels (effects of wave-front healing)

New, multi-scale expansion of model space

Data adaptive, no a priori smoothing

Mantle: Sub-horizontal, high-speed anomaly
  – Interpreted as underthrust Indian mantle lithosphere

IMF emerge early in the expansion, appearing already at level 1 (longest wavelengths)
Regional Extent of Indian Mantle Lithosphere ("Greater India")

30 – 15 Ma
- IMF advanced beneath Lhasa terrane
- IMF impinged upon S. edge of Qiangtang terrane
- Rayleigh-Taylor instability
  - Thermal Rayleigh # $Ra = g \alpha (\Delta T) h^3 / \kappa \nu$
  - Convective removal of thickened root
  - Making space for IMF

15 Ma – present
- Indian mantle lithosphere advanced N. beyond BNS
- Detached mantle lithosphere resting above the lower mantle
  - Elevation of Qiangtang terrane was only 3 km

Reconstruction of LM to -15 Ma

Best of both Views
- RF: Moho highly variable in nature
  - Sharp
  - Transitional
  - Distinct lower crust below Conrad
- VDSS: insensitive to details
  - Self-consistent way of measuring & comparing crustal thickness
  - Reliable

Source vs. Receiver-Side Scattering

New Development: Using All Sources of Illumination

- Deep eqks are the best sources
  - No interferences
  - Rich in high-frequency contents
  - Avoiding going through highly attenuative upper mantle twice
  - Limited quantity of data
  - Poor azimuthal coverage & moveout analysis (e.g., no selective detection)
- All strong sources are good
  - Particle motion analysis
  - Subsequent deconvolution
  - Synthetic seismograms validated by Hi-CLIMB data
Conclusions

• Large-scale, subhorizontal underthrusting of cratonic lithosphere hides, but not necessarily destroys, cratons
  – Current collision not recycling cratonic crust into the mantle
• Two case studies of crustal thickness based on new method
  – Large deviations from Airy isostasy
  – Contrasting tectonic settings
    • Tibet: Gradual northward thinning of crust → delicate balance between crustal isostasy and thermal buoyancy of the mantle
    • Ordos: Mafic lower crust beneath the Conrad discontinuity → Pratt isostasy → proxy of starting materials for lower crust foundering
  – Moho can be a dynamic feature (e.g., re-lamination, tectonic disturbance)
• VDSS to complement global map of crustal thickness
  – With a single, consistent & reliable yardstick
    • Improved coverage & resolution
    • Current volume of continental crust
    • Crustal isostasy
    • Dynamic topography due to mantle convection
    • Interpretation of heat flow data
    • Crustal corrections for seismic investigations of the deep interior

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