The Tectonic Model beneath the Northwest Himalaya Region Analyzed by Seismic Data

Speaker: Yeh Ren-Jie

Reference

- S. S. Rai, K. Priestley, V. K. Gaur, S. Mitra, M. P. Singh, M. Searle, 2006. Configuration of the Indian Moho beneath the NW Himalaya and Ladakh. Geophysical Research Letters, Vol. 33, L15308, 2006.

- Warren B. Caldwell, Simon L. Klemperer, Shyam S. Rai, Jesse F. Lawrence, 2009. Partial melt in the upper-middle crust of the northwest Himalaya revealed by Rayleigh wave dispersion. Tectonophysic, Vol. 477, 58-65, 2009.

Outline

- Introduction
- Methods
- Results
- Discussion
- Conclusions

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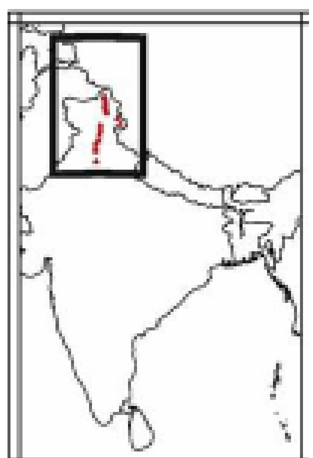
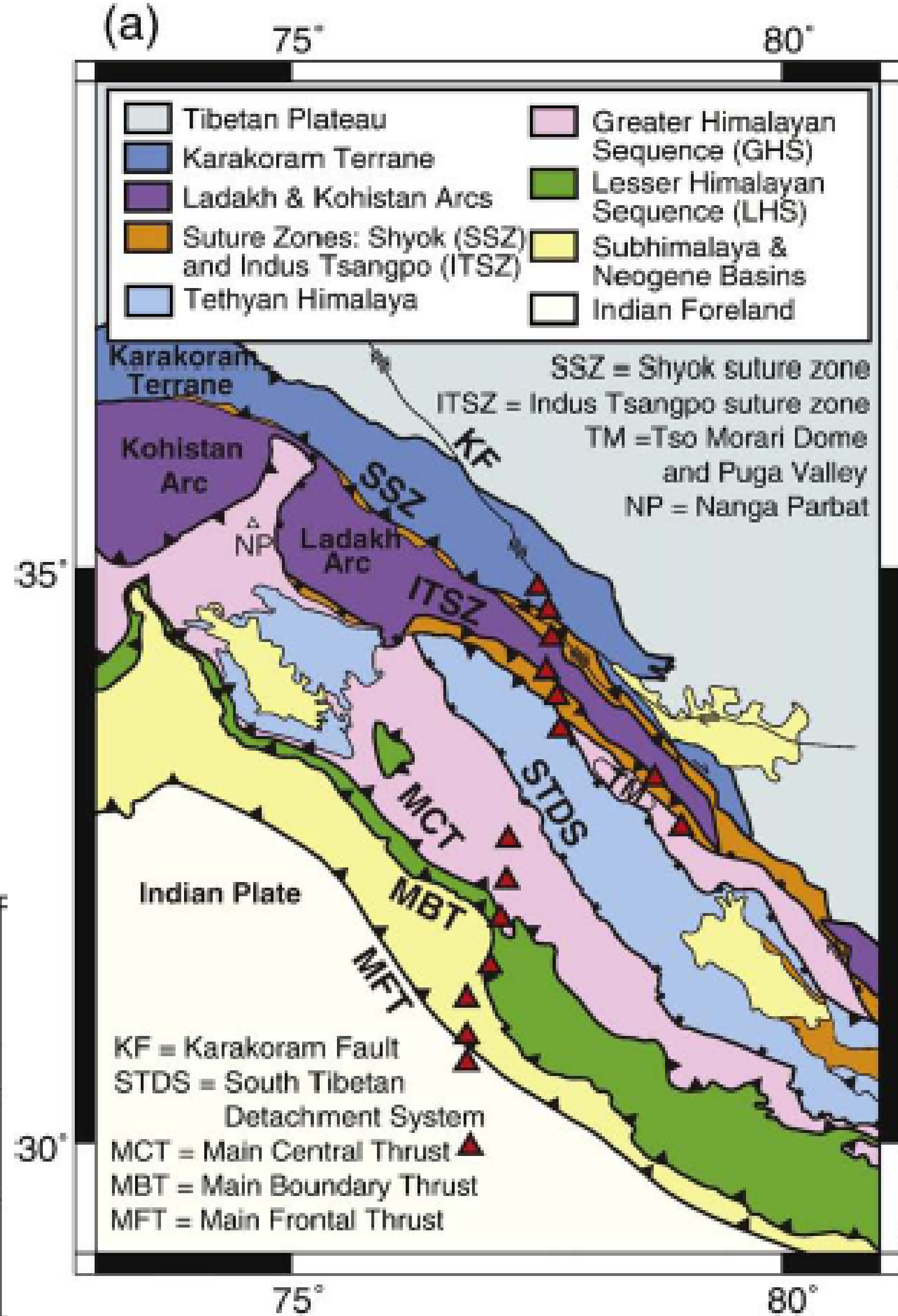
Introduction

Geologic setting





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Methods

- Dispersion Data
- Receiver Functions
- Inverted Models

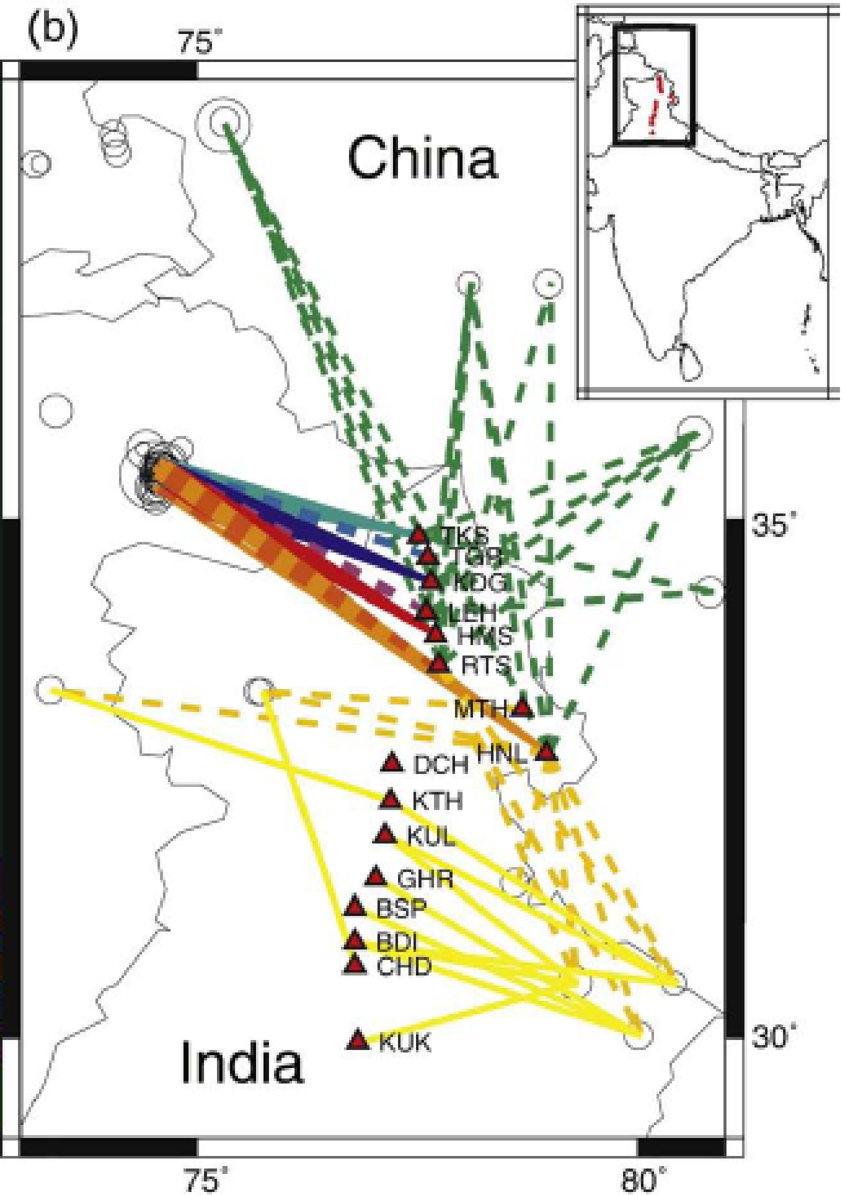
Methods

Dispersion curve calculation

- Using MFT (Dziewonski et al., 1969; Herrmann and Ammon, 2002)

- MFT consists of bandpass filtering each seismogram around a set of frequencies, calculating the envelope function for each of the filtered signals, and manually picking the time of maximum energy arrival for each frequency.

Methods

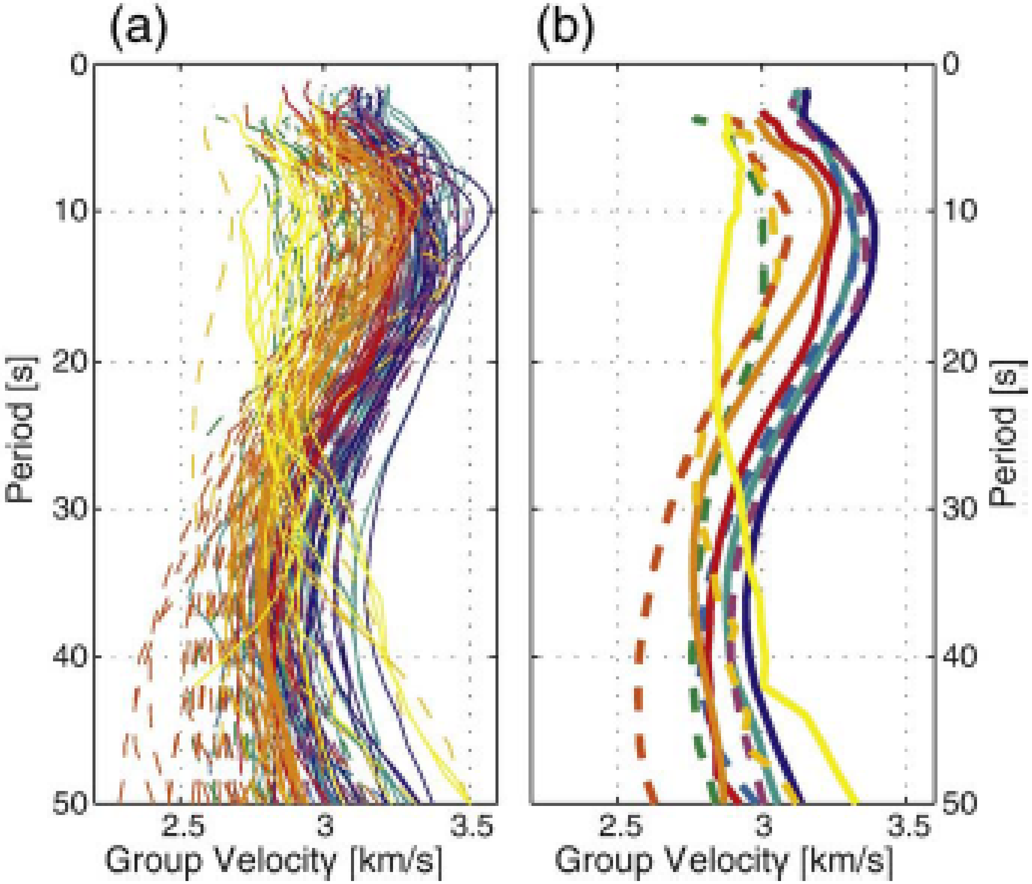


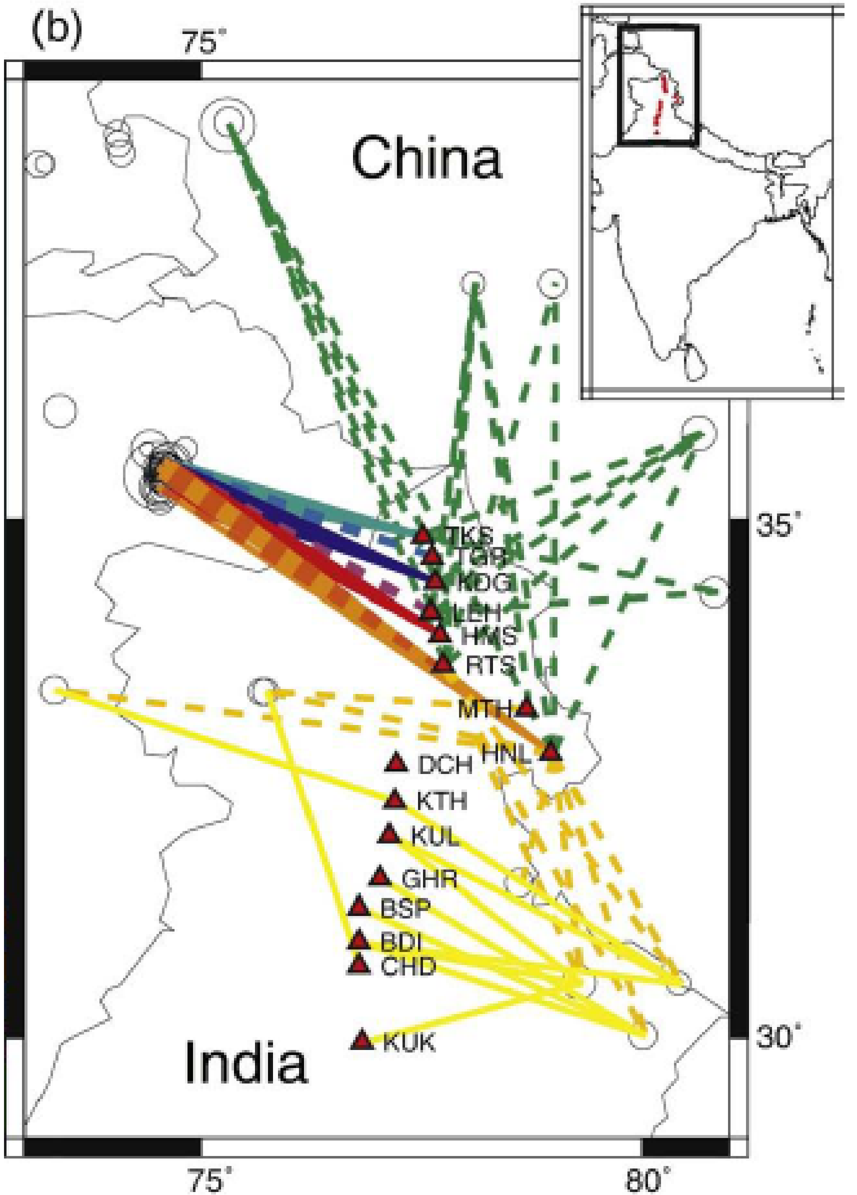
Data

- HIMPROBE transect
- 3-component broadband array
- 12 months (2002-2003)
- 36 earthquakes
  (~300-900km from stations)

Methods

- 10 sets
- 140 curves





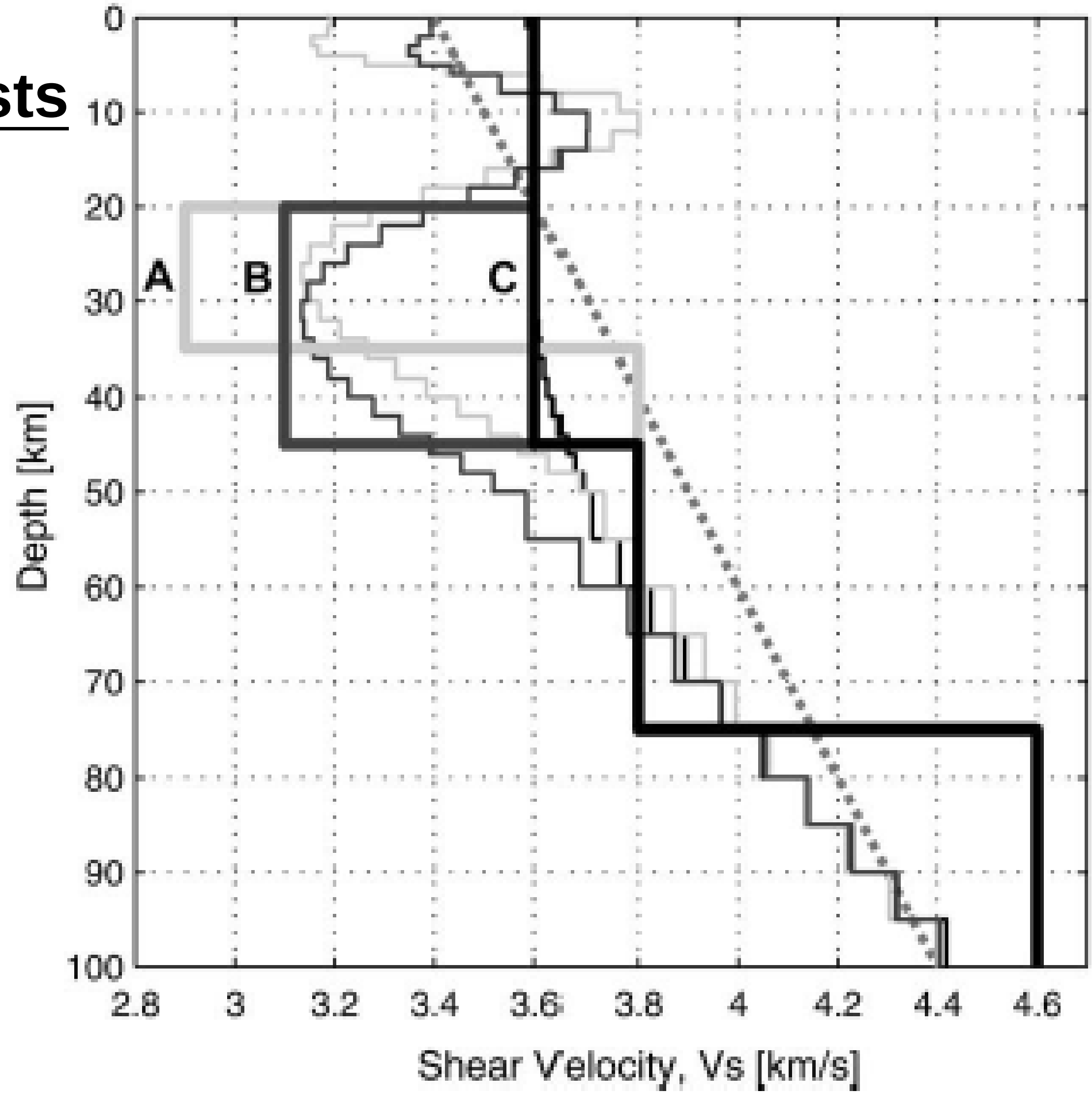
Methods

Inversion

- The earth model: layer thicknesses of 1 km in the upper 6 km, 2 km in 6-50 km, and 5 km in 50-100 km depth.
- For each 10 sets of data, ran 110 inversions in a grid search with all combinations of 5 damping factors and 22 starting models.
- Weighting: $w = 1/\sigma^2$

Methods

Synthetic tests



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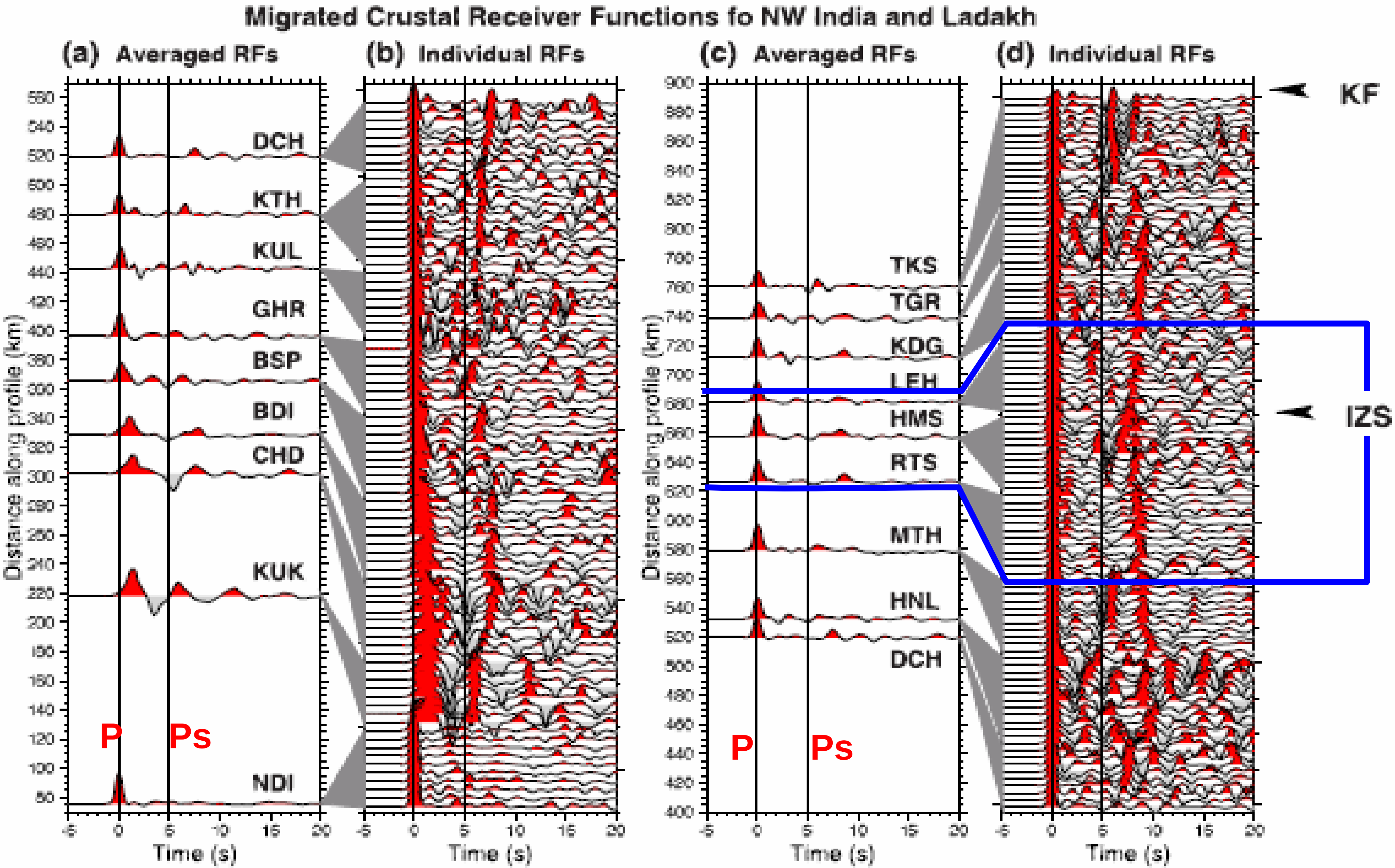
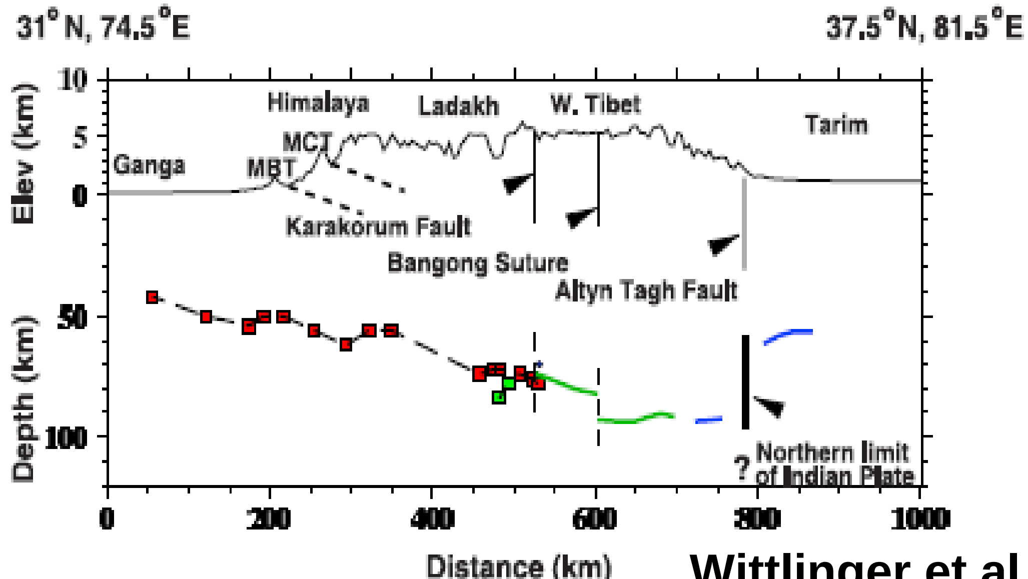
Results

Receiver Functions

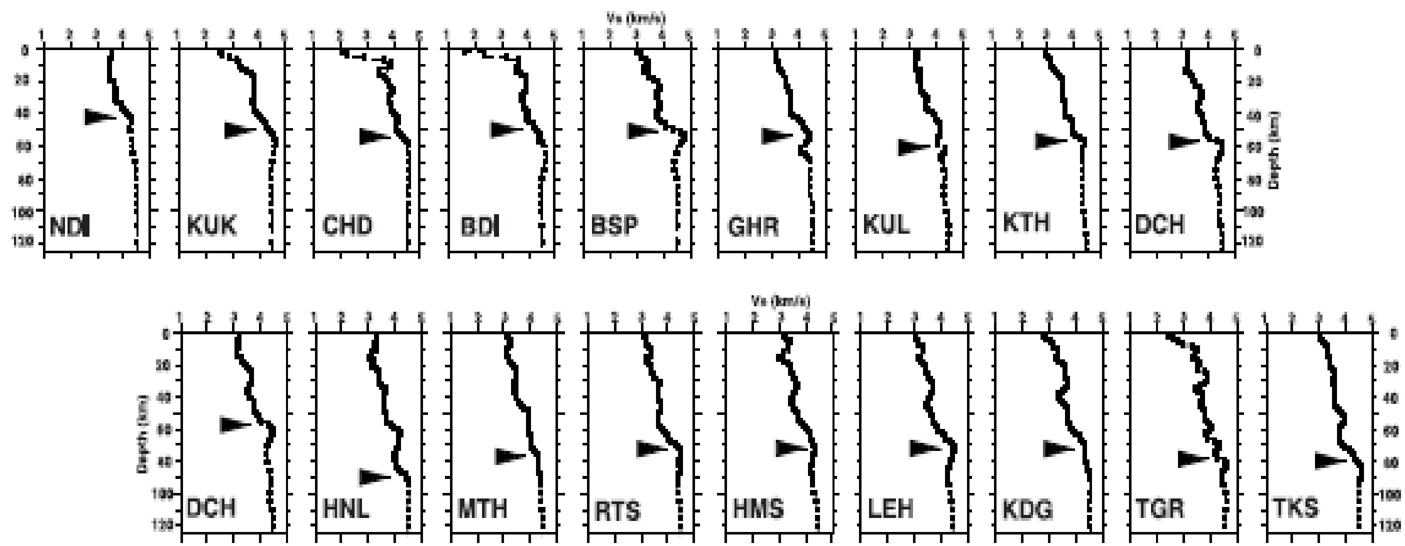


Results

Inverted Models

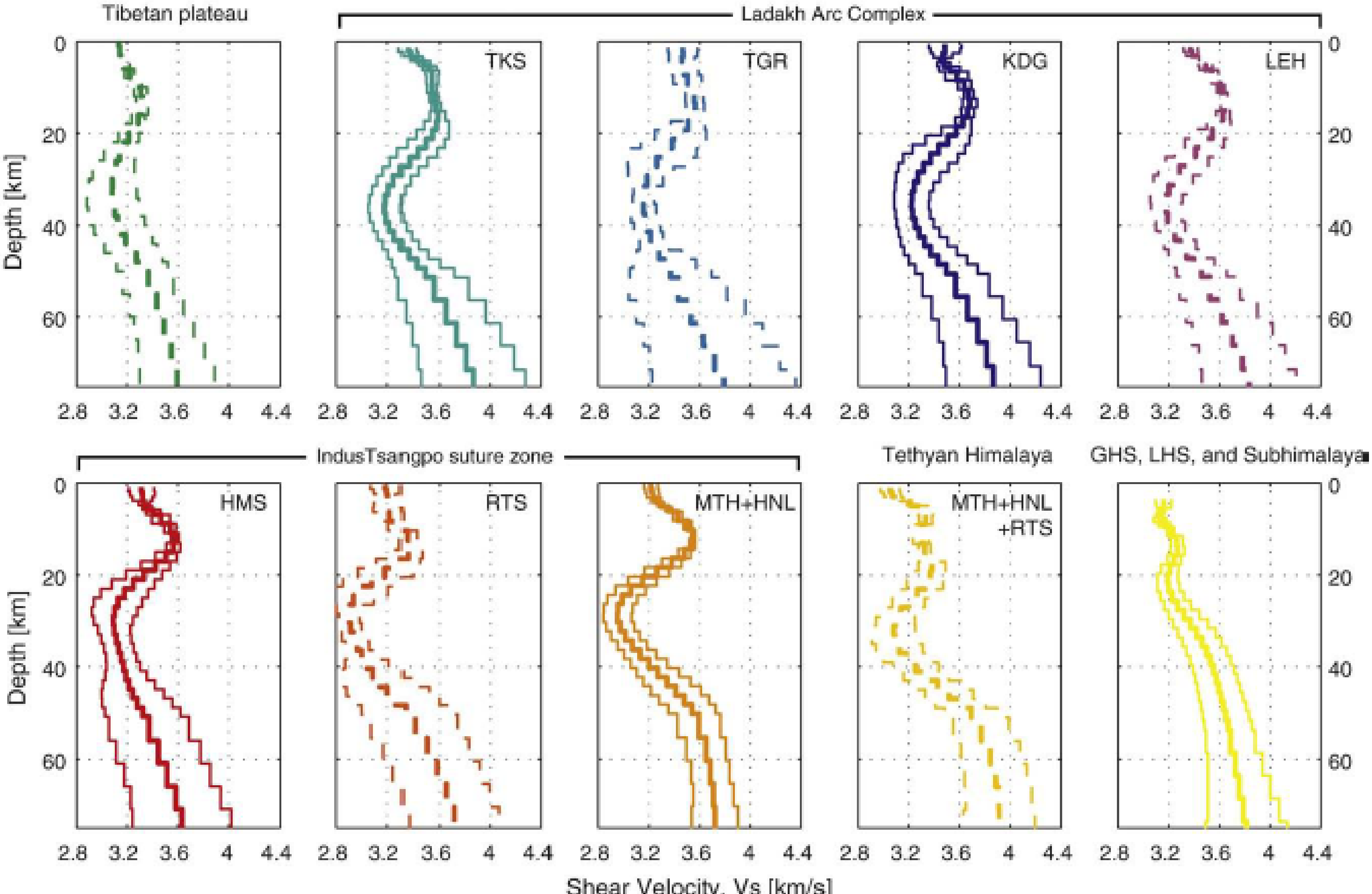


Wittlinger et al. (2004)

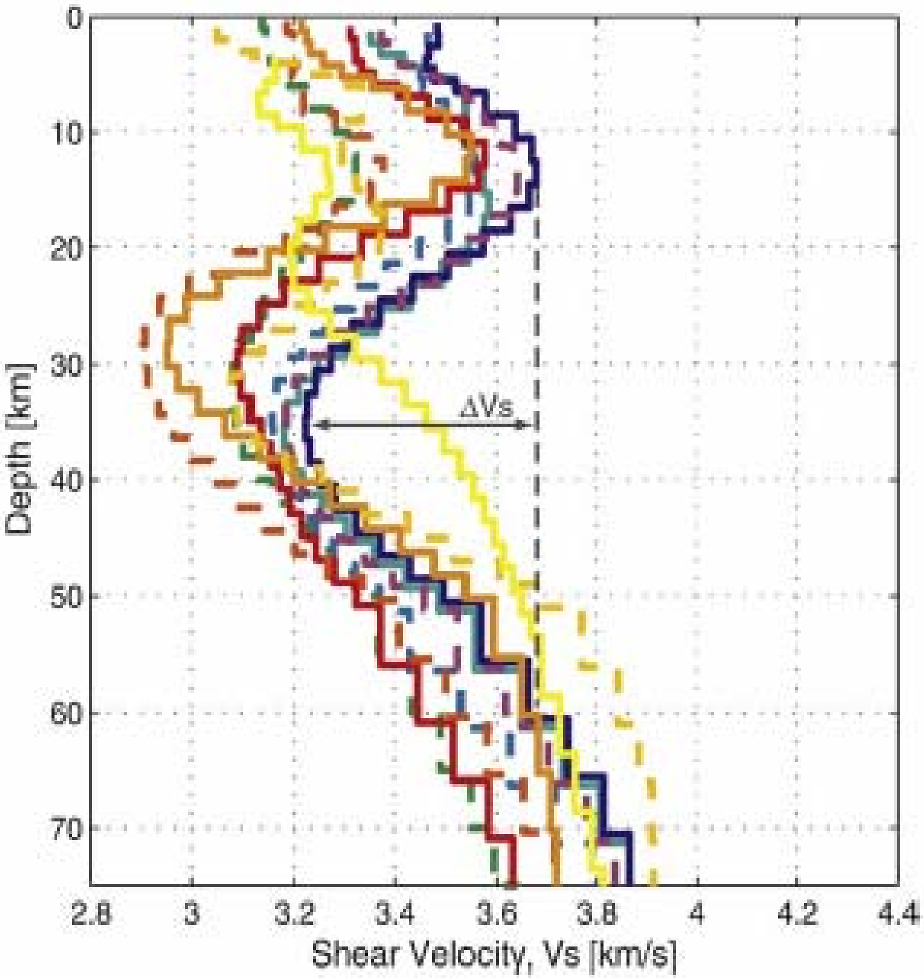


Results

Inverted Models



Results



Inverted Models

- Southernmost (Himalaya thrust belt, yellow line)
- V_s reduction (ΔV_s) range:
  - 7% (Tibetan plateau)
  - 17% (Tethyan Himalaya)

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Discussion

- Magnetotelluric (MT) studies in NW Himalaya reveal a low-resistivity layer in the mid-crust, which can be explained by partial melts, aqueous fluids or graphite. (Gokarn et al., 2002; Harinarayana et al., 2004, 2005; Arora et al., 2007)

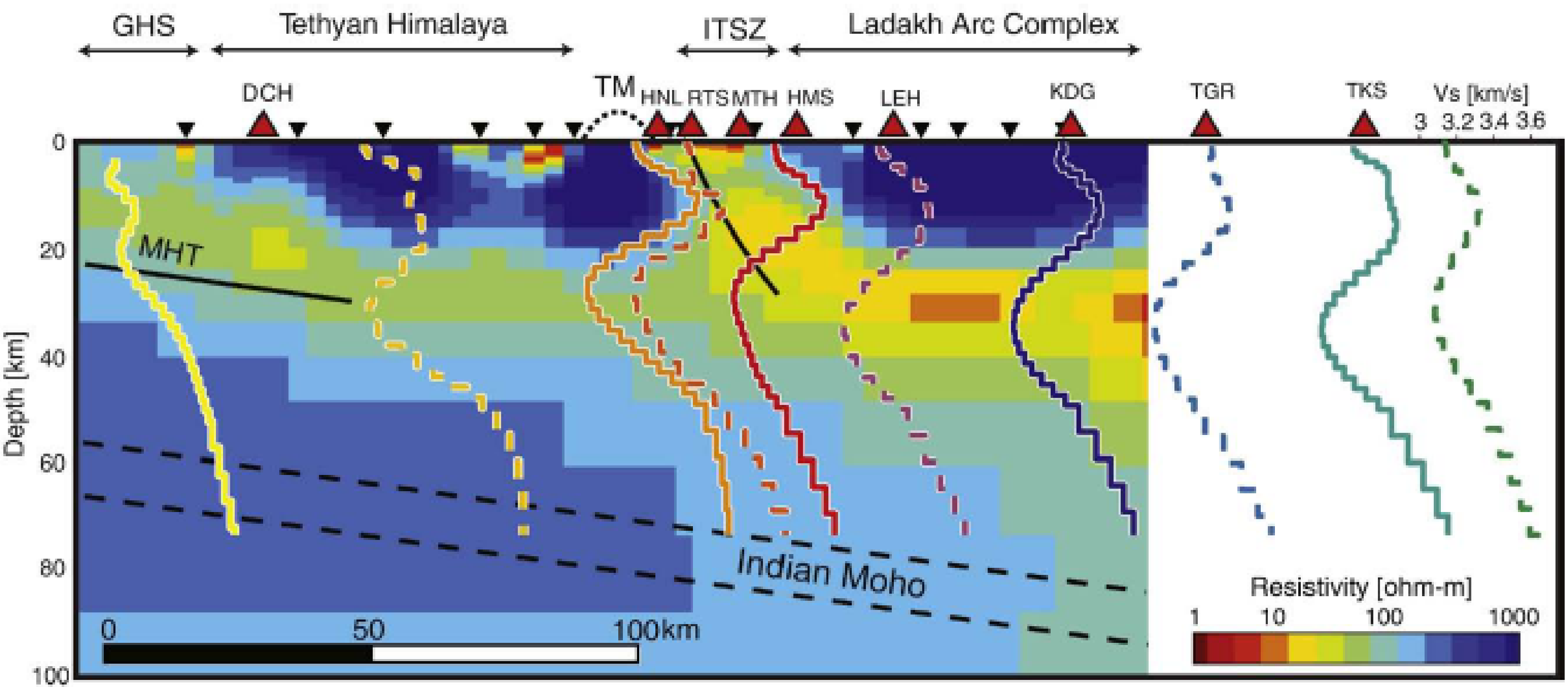
- Christensen (1996): the metamorphic rocks with the lowest shear-wave velocities were 3.51 km/s at room temperature and 1000 MPa (the pressure at 30 km depth), so that the low velocities observed (2.9-3.3 km/s at 30 km depth) couldn’t be dry crustal rocks.

Discussion

- Wang (2001) estimated a regional heat flow for the southern Tibet of c. 82 mW/m^2, equivalent to the ‘character Basin and Range’ heat flow of Lachenbruch and Sass (1977), for which they calculated temperatures of 650-850℃ at 30 km depth.

- The most plausible explanation for the LVL is therefore the presence of partial melts, aqueous fluids, or both, since the observed velocity decrease of 7-17%, low-velocity, low-resistivity, high-reflectivity geophysical anomalies in Tibet and the Himalaya.

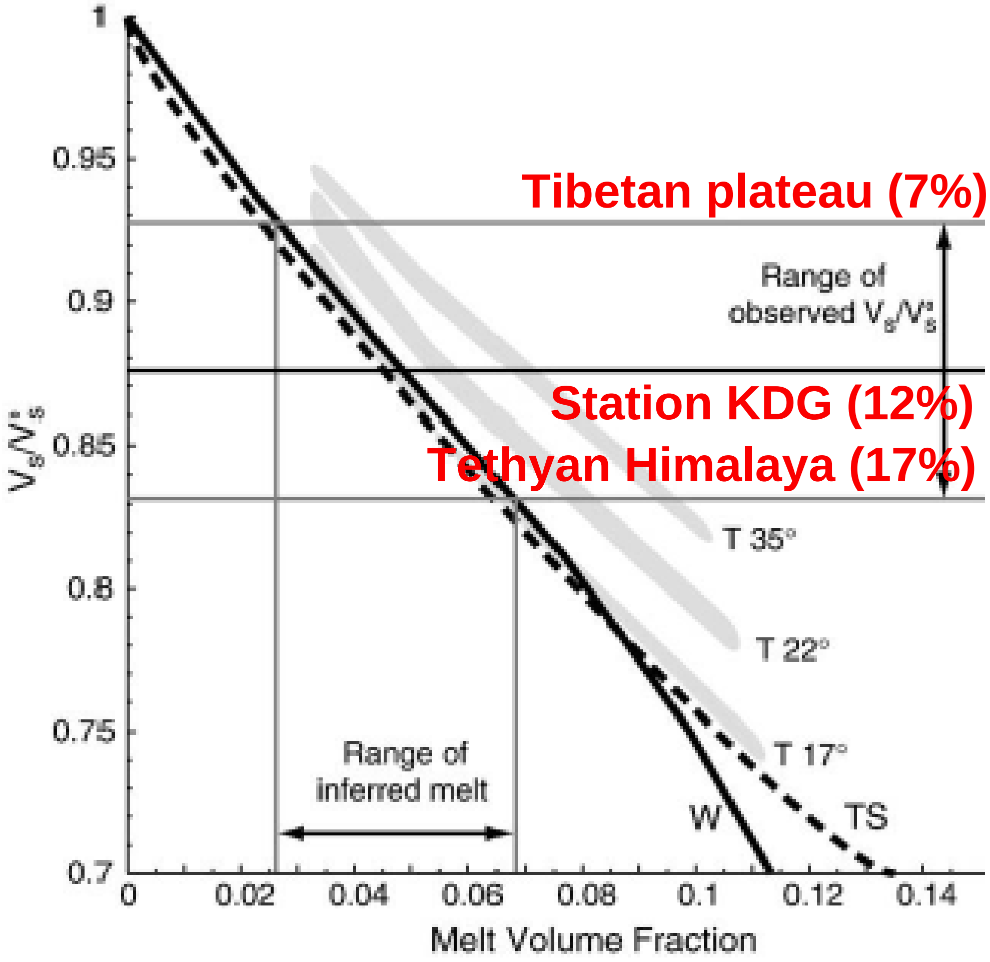
Discussion



GHS
Tethyan Himalaya
ITSZ
Ladakh Arc Complex
DCH
TM
HNL
RTS
MTH
HMS
LEH
KDG
TGR
TKS
Vs [km/s]
3
3.2
3.4
3.6
MHT
Indian Moho
Depth [km]
0
20
40
60
80
100
0
50
100km
Resistivity [ohm-m]
1
10
100
1000

Discussion

- Black line (Watanabe, 1993) presents randomly-oriented triangular melt tubes
- Gray relationships (Takei, 2000) are the analogue results for 3 different wetting angles, 17, 22 and 35°
- Dashed line (Taylor and Singh, 2002) for the slow propagation direction in a medium containing perfectly aligned oblate spheroids of aspect ratio 10



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Conclusions

- The Indian Moho deepen from the Himalaya foredeep (~40 km depth) to the Karakorum Fault in Ladakh (~75 km depth) and the Indian plate may penetrate as far as the Bangong Suture even the Altyn Tagh.
- 3-7% partial melt at present day beneath and north of the South Tibetan Detachment in the mid-crust of the Himalaya and Tibetan plateau of NW India.
- The observations in this study confirm earlier speculations based only on MT data about a low-viscosity layer beneath the NW Himalaya, and are consistent with a southward-shallowing, mid-crustal ductile channel that may be active at the present day

Thank you!