Northeast Tibetan Crustal Structure from INDEPTH IV controlled-source seismic data

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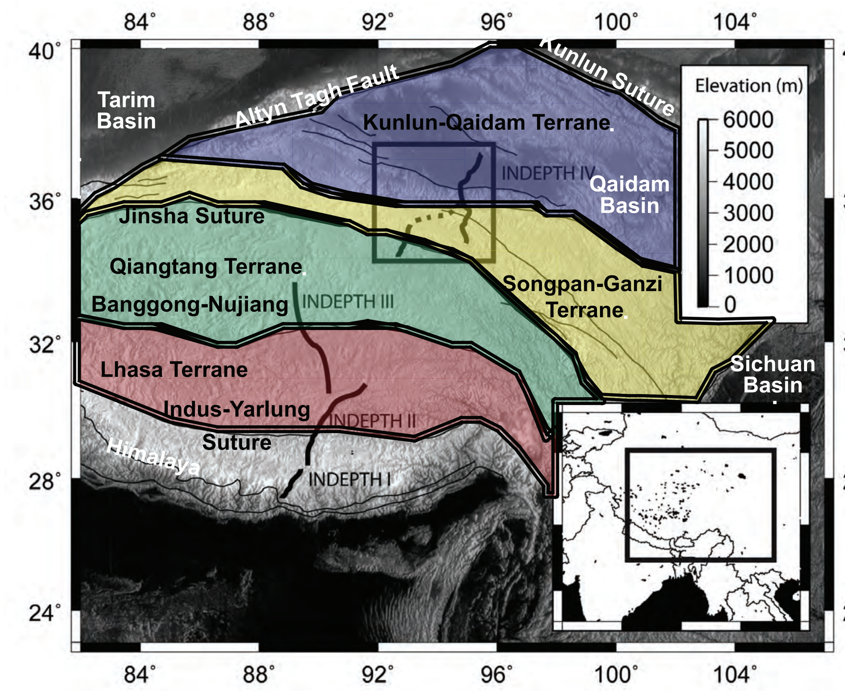
Project INDEPTH

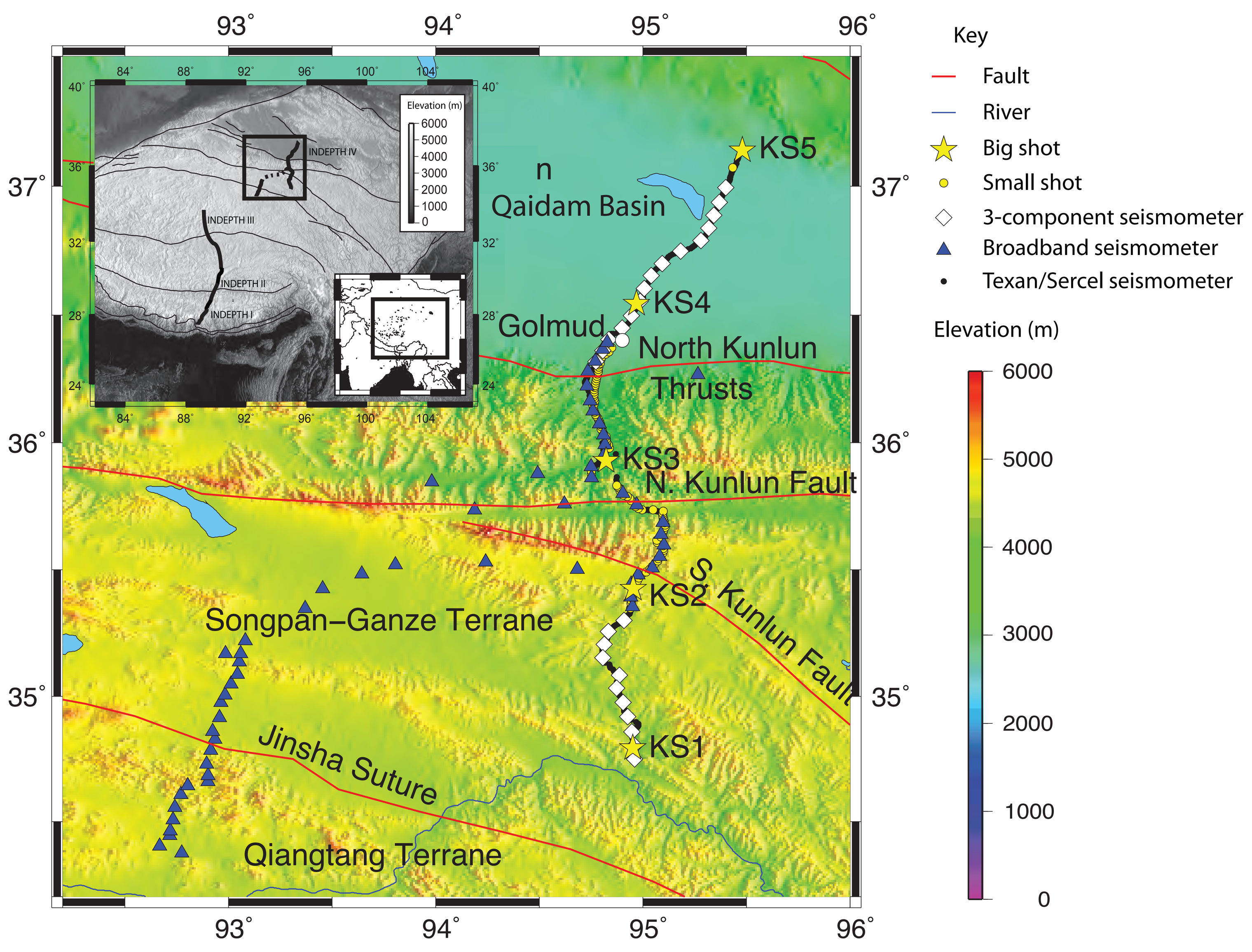


Project INDEPTH (International Deep Profiling of Tibet and the Himalaya) IV geoscientists are investigating geologic and geodynamic questions in northeast Tibet, completing a roughly North-South seismic, magnetotelluric, and geologic transect (initiated by INDEPTH I in 1992) of the Himalaya and Tibet.

Key scientific targets include:

- Tectonic response of northeast Tibet to the India-Asia collision.
- Relative roles of escape tectonics, intracontinental subduction, and ductile flow near the Kunlun and Jinsha sutures.
- Regional crustal, velocity, and reflectivity structure.
- Fault geometries of strike-slip and thrust systems beneath NE Tibet.

INDEPTH IV



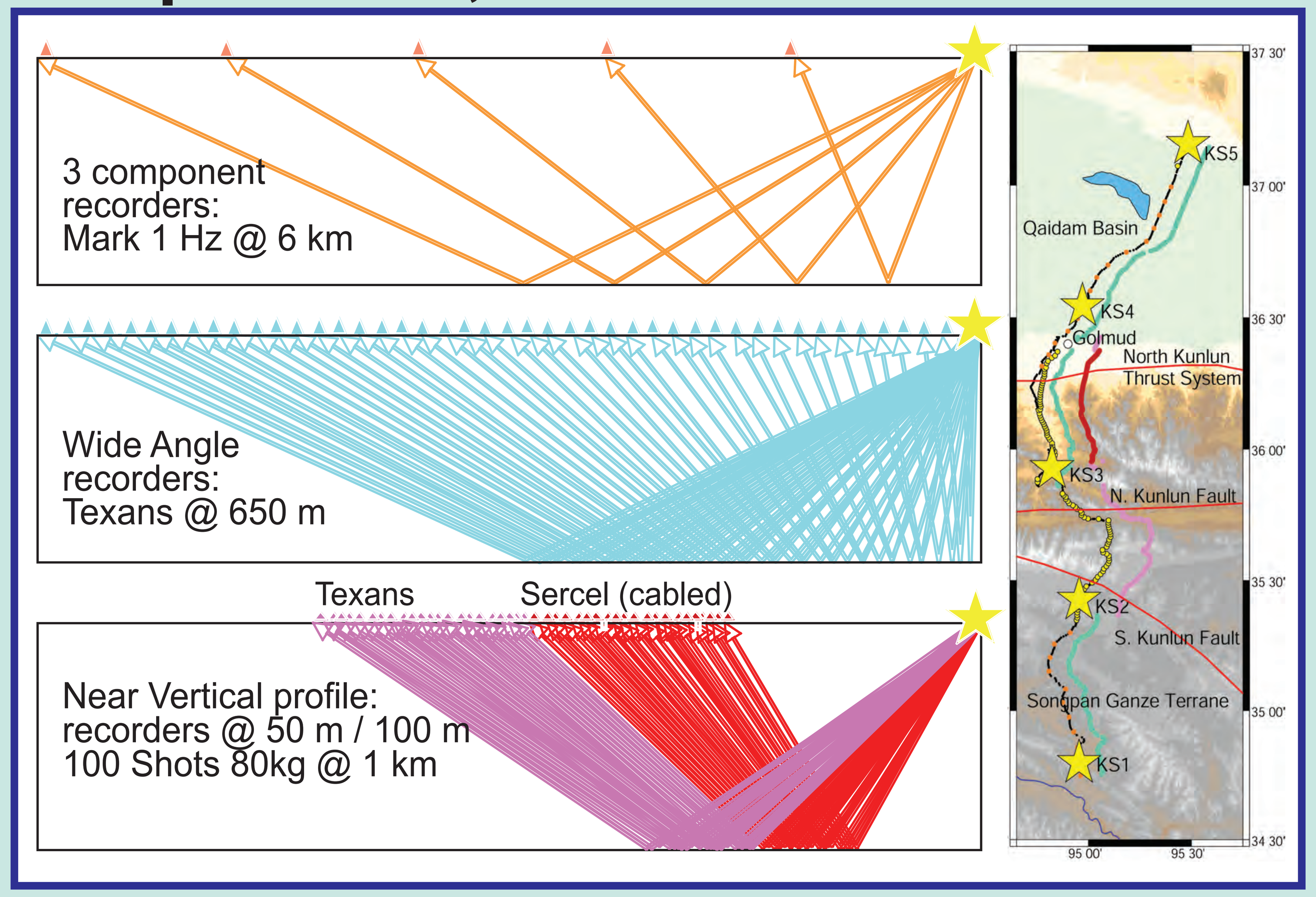
Topographic map of Northeast Tibet showing the locations of INDEPTH IV Texan and Sercel, 3C short-period, broadband instruments, small shots, and large shots. Nested black and white insets show progressively larger regions including locations of INDEPTH I-IV profiles spanning Tibetan plateau from South to North.

Controlled-Source Experiment, 2007

We recorded a 270 km profile extending from the Qaidam Basin, across the North Kunlun Thrusts (NKT), the Kunlun Mountains, the North and South Kunlun Faults (NKF, SKF) onto the Tibetan Plateau (from 'KS5' to just South of 'KS1'). The recording spread consists of three elements as shown to right:

1) Three component (3C) array (48 Geophysical Instrument Pool Potsdam and SEIS-UK short-period and broadband instruments at 5-6 km spacing);
2) Wide-angle (WA) deployment of 295 IRIS PASSCAL Reftek seismometers at 650 m spacing;
3) Near-vertical (NV) deployment of 655 Refteks at 100 m spacing and 1000-channel Sercel cabled spread with 50 m geophone spacing.

Sources included five large shots (KS5 to KS1) roughly evenly spaced along the profile containing 1000-2000 kg of seismic explosives, augmented by ~110 small shots (each ~60-80 kg) at a nominal 1 km spacing in the middle ~120 km of the profile.



INDEPTH is more than controlled-source seismology:

Though not discussed here, INDEPTH-IV includes passive broadband seismology, both linear arrays (see INDEPTH IV map) and areal arrays (operating as ASCENT with PKU in China); magnetotelluric profiling (with CUGB); gravity measurements along the controlled-source profile (CAGS); and geological mapping, thermochronologic and stratigraphic studies (CAGS), with various western partners.

Acknowledgments

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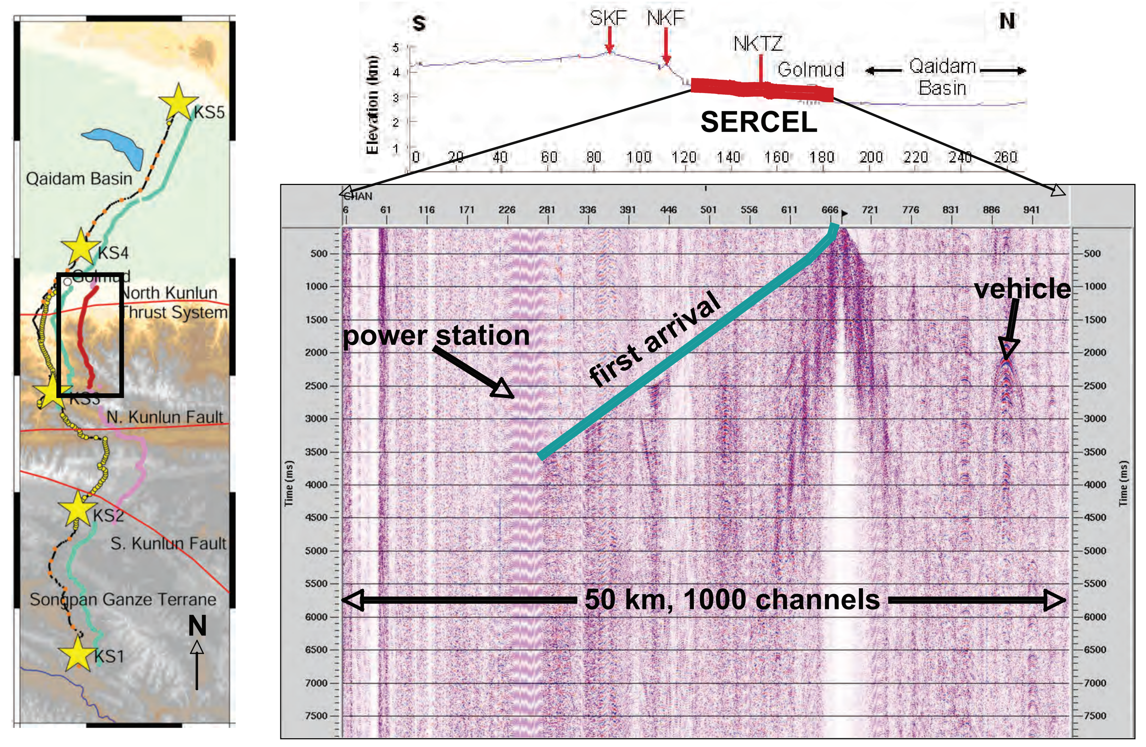
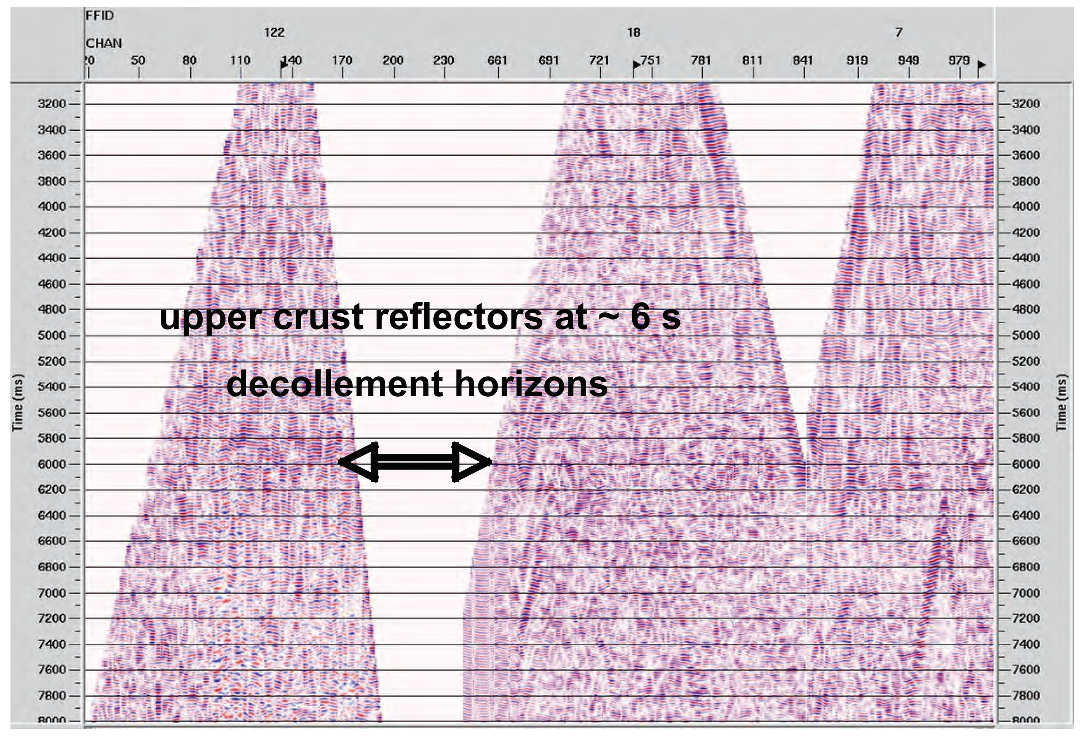
Data and Initial Analyses

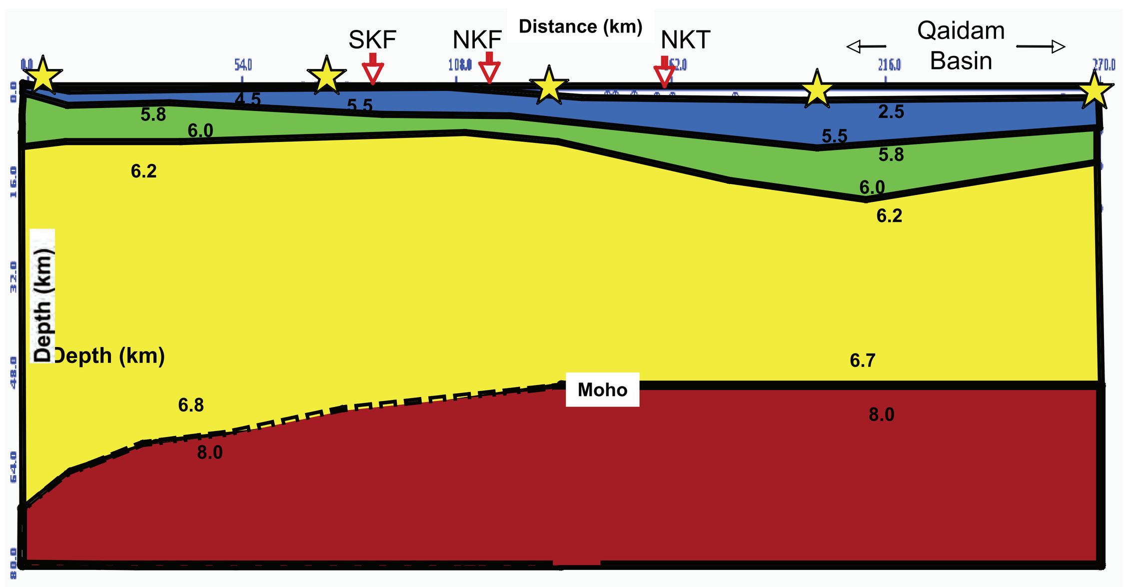
Near Vertical Sercel Recordings



example shot gather (top) & single-fold section (bottom): processing is underway at Cornell



Preliminary P-wave velocity model

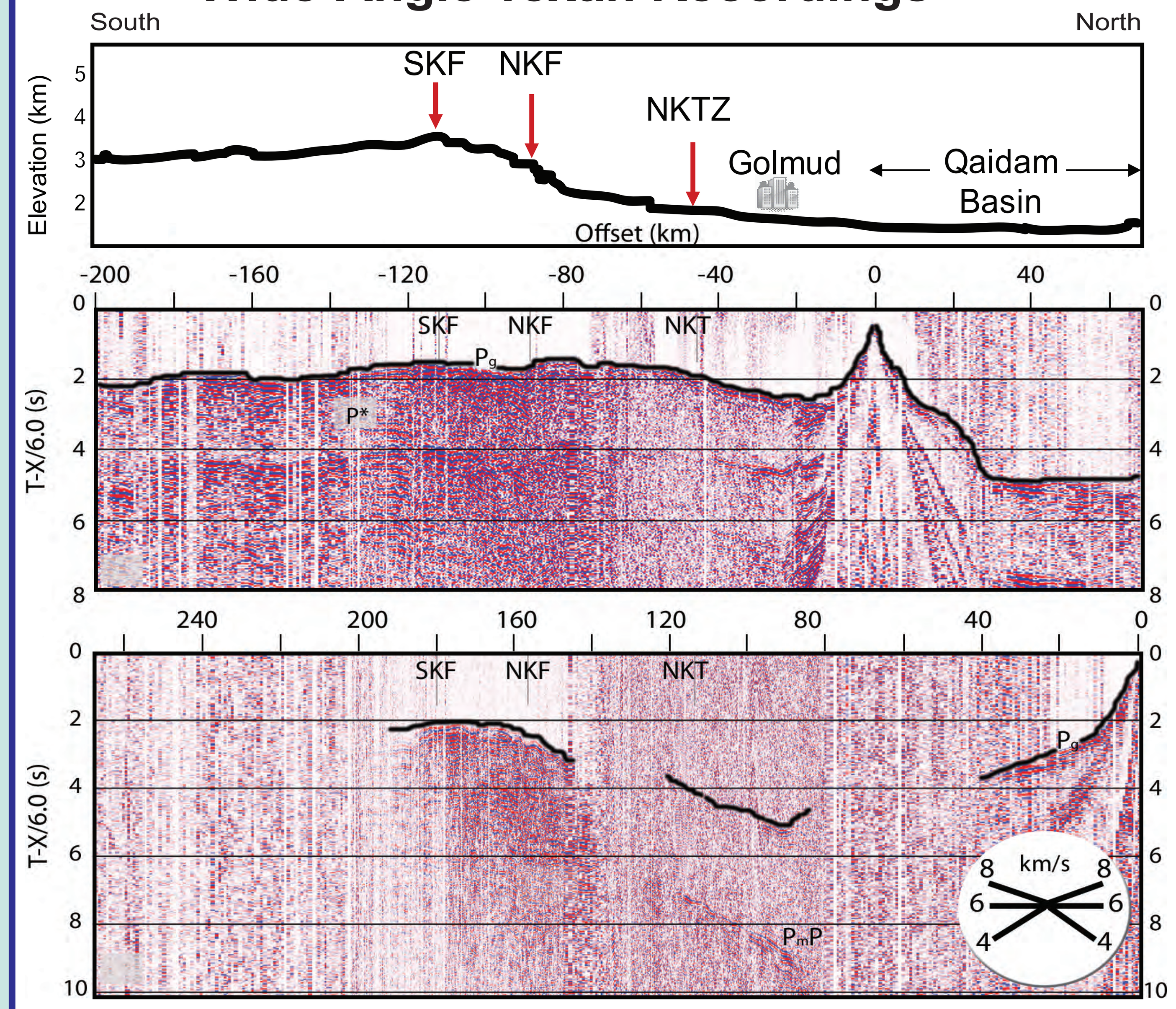


We employ two-dimensional ray-tracing using Colin Zelt's RAYINVR code (Zelt & Smith, 1992) to determine the crustal velocity structure by modeling basin and basement refractions as well as lower-crustal and Moho reflections.

The preliminary model incorporates a southward-thinning, low-velocity sedimentary Qaidam basin, crustal velocities of 6 km/s, lower-crustal reflectors beneath the Tibetan Plateau, and Moho depths of 50-55 km beneath the Qaidam Basin. These results are consistent with previous reflection lines farther east in the Qaidam Basin (e.g., Galvé et al., 2002).

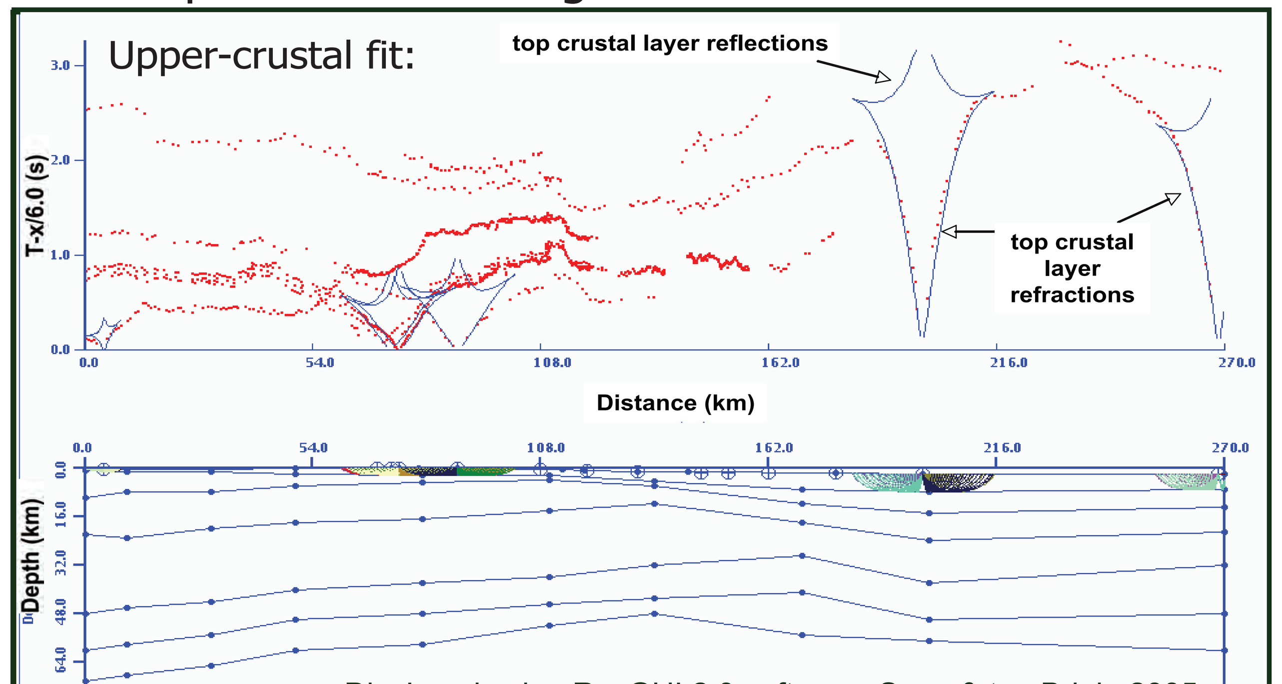
Near-vertical data from the small shots contains strong s-wave arrivals as well as reflectors at ~6 seconds beneath the Kunlun front range that we interpret as North Kunlun Thrust décollement horizons.

Wide-Angle Texan Recordings



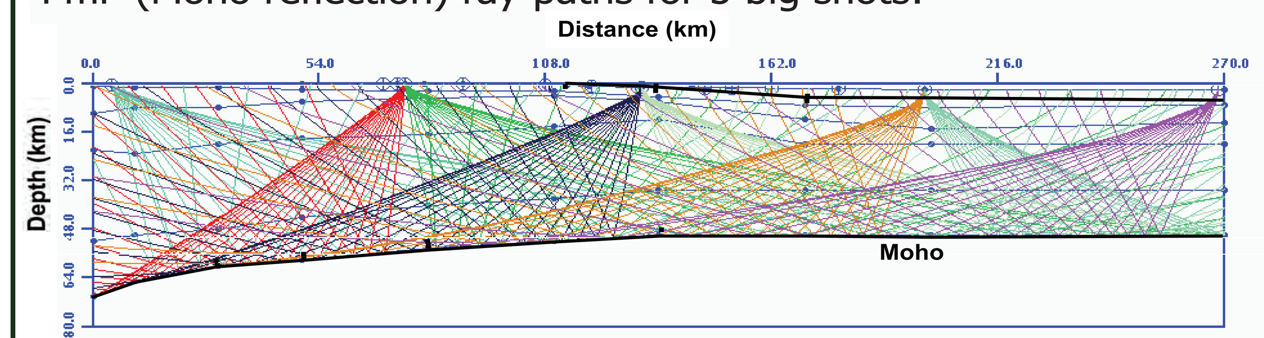
Example seismic record sections from (top) 1500 kg shot KS4 and (bottom) 2000 kg shot KS5. Sections are reduced at 6 km/s and bandpass filtered. Pg – crustal diving wave; PmP – Moho reflected phase; P* – lower crust reflection.

Velocity modelling at Stanford: over 3500 travel-times picked from 6 large and 18 small shots



Displayed using RayGUI 2.0 software; Song & ten Brink, 2005

PmP (Moho reflection) ray-paths for 5 big shots:



KS5 & 9119 travel time curves: top 2 layers reflections/refractions & Moho reflection: