Crustal Structures underneath the Longmen Shan mountain range from passive seismological data

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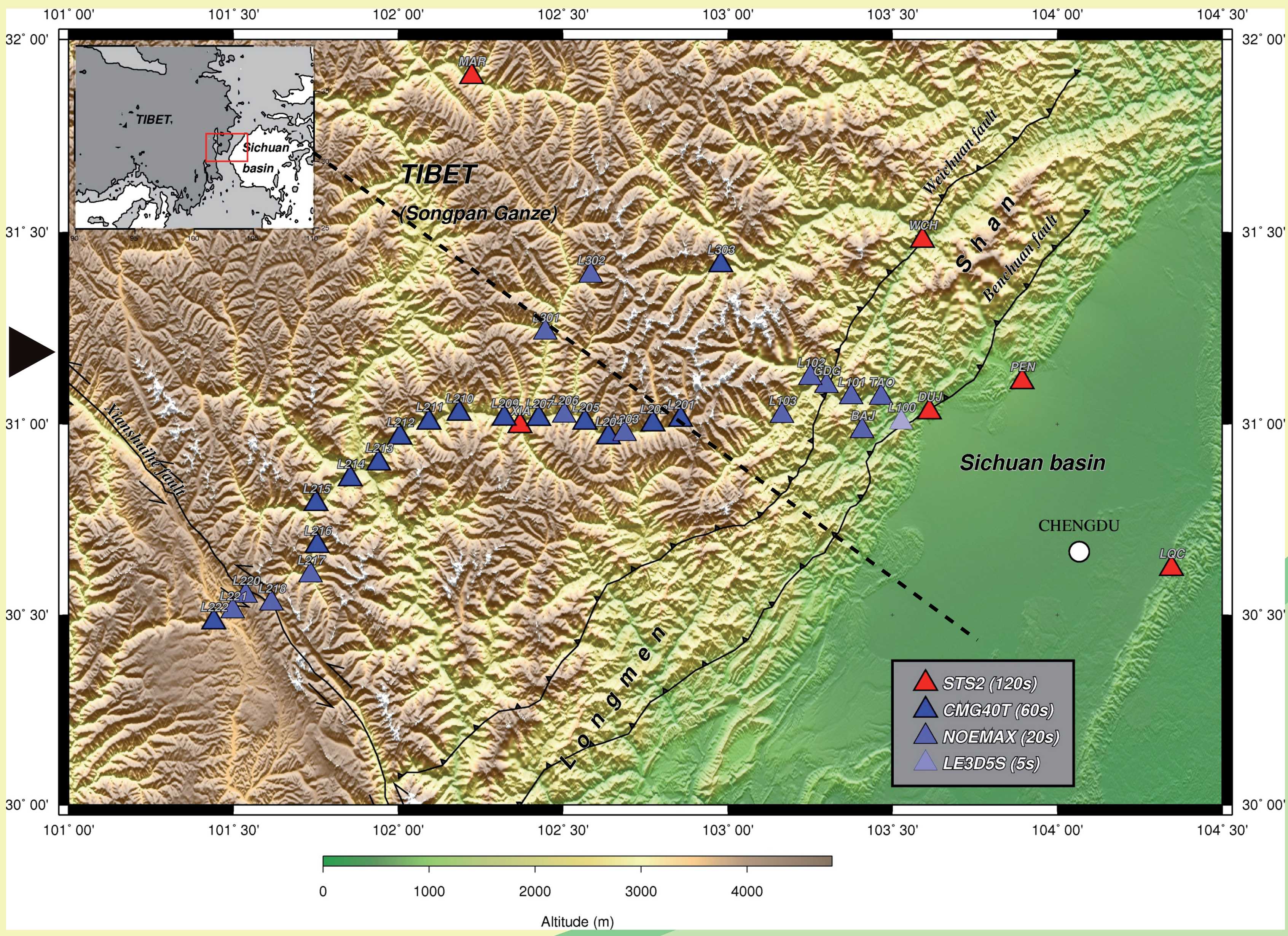
The seismological experiment

Our knowledge about the formation, the evolution and the dynamic of the Tibetan plateau is deeply linked to the results obtained through numerous seismological campaigns since more than 20 years. These experiments yield major informations about the structure and the composition of the crust and upper mantle in central Tibet, as well as along its southern, western and northeastern borders. However, very few is known about the lithospheric structure of the eastern border of the plateau, constituted by the Longmen Shan belt that separates the plateau from the Yang Tse craton. It is however a key zone to understand the strain regime linked to the India-Asia collision on the plateau's borders.

In the framework of a collaboration between several French institutes and the Chengdu University of Technology, a temporary network of 36 seismological stations has been deployed in the central part of the Longmen Shan belt from November 2005 to April 2007. The network is mostly constituted by a dense line of stations, with a mean inter-station of about 10 km, running from the front range to the Xianshuhe fault.

The mains objectives of this experiment were 1) to determine variations in crustal thickness across the belt, 2) to precise the crustal structure and composition, especially to test the existence of a mid-crustal low viscosity channel 3) to better constrain the mechanism of the extrusion of the tibetan upper-mantle toward the east.

Figure 1 : Topographic map of the central part of the Longmen Shan with the position of the seismological stations deployed during this experiment. The color of the symbol indicates the type of sensor installed at each site. The label on top of each symbol is the station name used during field work.
The configuration of the network has been chosen to mostly apply receiver-function and tomographic techniques to the data. Some lateral sites have been installed to better locate the seismicity in the high range around the four sisters mountains.



Technical Facts

Sensors : 3 components Streikeinsen STS2, Guralp CMC40T, Agecodagis NOEMAX and Lennartz LE3D5S
Digitizers : Reftek 72A (x4) + Titan 6T (x6) + Minititan 3XT (26)
Acquisition mode : continuous
Sampling rate : 20 sps or 31.25 sps
Location : Broadband STS2 in buildings of the Sichuan Seismological Bureau on concrete pills. Others in open area
Mean inter-station distance : 8km (from L201 to L222)

Phase 1 : November 2005 - November 2006

6 STS2 (▲) : LQC, PEN, DUJ, WCH, MAR, XIA +
4 NOEMAX (▲) : BAJ, TAO, GDG, L302

Phase 2 : July 2006 - April 2007

16 CMG40T (▲) + 6 NOEMAX (▲)
+ 4 LE3D5S (▲)

Preliminary Results from Receiver Functions Analysis

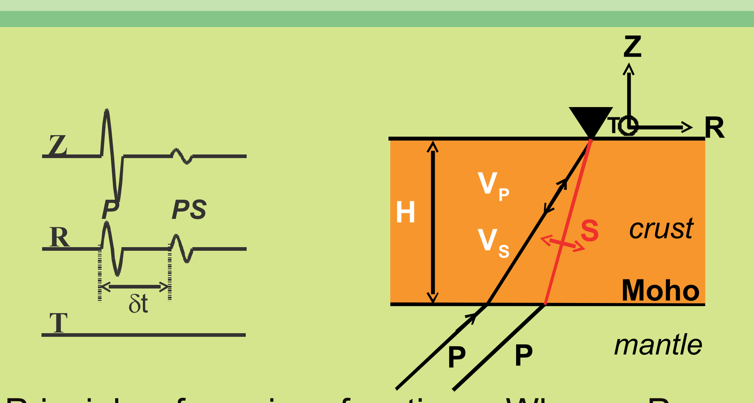


Figure 3 : Principle of receiver functions. When a P wave impings on a simple one layer crust (right), a PS converted wave is created at the Moho and is mostly observed on the radial component (R) on a 3 components seismogram, a few second after the P wave (left).

Main Objectives

☞ Geometry of the Moho across the range : Is the crust fully compensated ? ☑

☞ Rheology of the crust : **Is there a mid-crustal low viscosity channel** in the tibetan crust ? ☑ ☑ ☑

☞ Upper crustal structure : Do the Weichuan and Benchaun faults merge at depth ? ☑ ☑

☞ Mantle deformation : What role plays the Yang-Tsé craton in the extrusion of the tibetan lithosphere ? ☑ ☑

☞ Xianshuhe fault : Is it a lithospheric boundary ? ☑ ☑ ☑

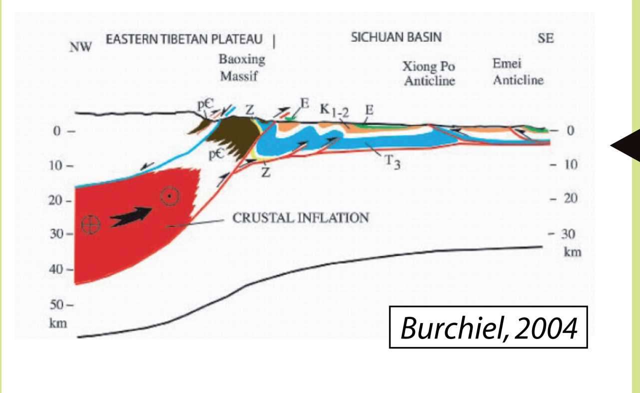


Figure 2 : Presence of a mid-crustal low viscosity channel in the tibetan crust is a very popular model to explain both the high topography of the Longmen Shan and the lack of present day horizontal shortening. However, there is still no direct proof for the existance of it. One of our objectives is to try to detect a low velocity zone within the crust associated to the horizontal flow of hot, and probably partially molten, material.

Seismolocicals Tools

Receiver functions

Tomography (Local, teleseismic, from ambient noise correlation)

Earthquake location (Depth)

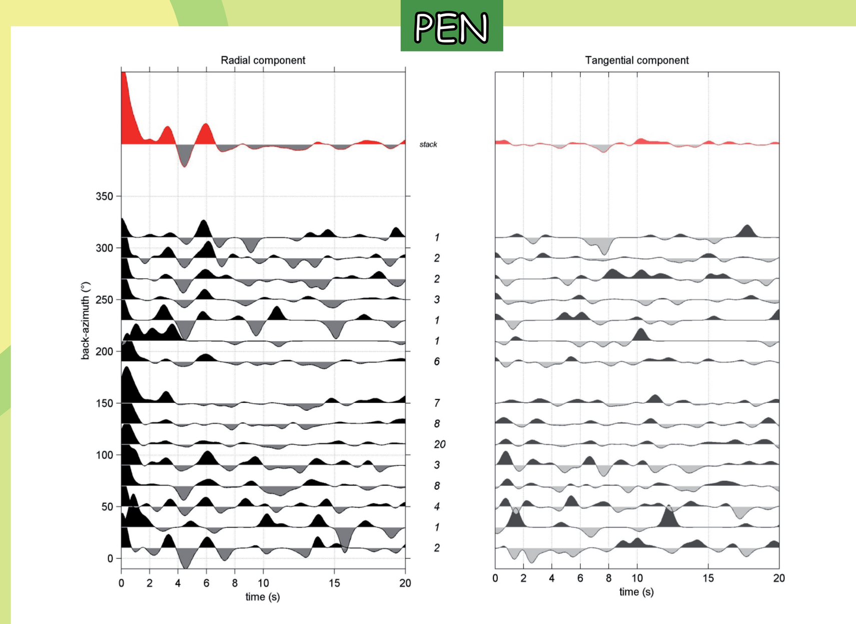
SKS splitting

Principle :

- Incident P waves from teleseinsmic earthquakes produces a PS converted phase at each interface corresponding to a velocity contrast.
- The time delay between the PS and the P phases (t) depends on the depth of the interface and the sign and amplitude of the velocity contrast.
- Deconvolution of the radial seismogram by the vertical one produces a " receiver function " on which all the peaks are PS phases, exécpt the first one at 0s corresponding to the P-wave.
- The times series receiver functions can be migrated, assuming a velocity model, to retrieve the depth of the interfaces.

Preliminary Results :

Figure 4:
Stack of receiver functions at station PEN within 20° of width back-azimuth bins. The red trace at the top correponds to the stack of all receiver functions for each station.
Radial receiver functions (on the left) should contain all the P -> S conversions if the medium consists in a stack of horizontal isotropic layers.
Transverse receiver functions (on the right) indicate how the structure deviate from this postula.
The positive peak at ~6 seconds corresponds to the PS conversion at the Moho.



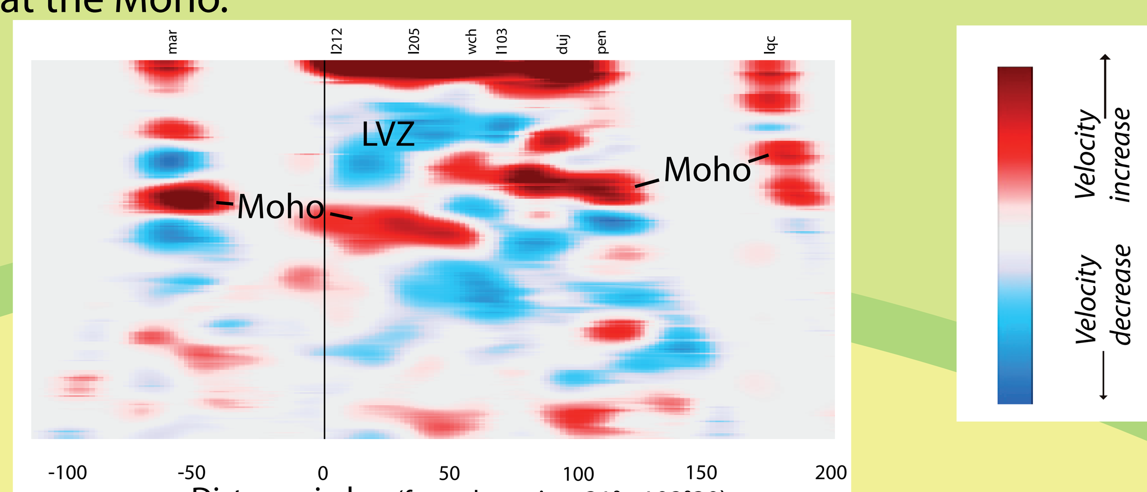


Figure 5 : Migrated cross-section (along the dotted line on figure 1) of receiver functions colors (resp. blue) depicts interfaces (resp. decrease) of velocity with depth. The step of the Moho toward the plateau is well seen. Along the profile, MAR station (at the west) is localised northern than the others stations, and the Moho is shallower which imply an apparent East deeping of the Moho.