A new seismological experiment to constrain the lithospheric structure across the Longmen Shan

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ABSTRACT

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.

Collaboration

- Chengdu University of Technology, PRC
- Ecole Normale Supérieure, Paris, FR
- Institut de Physique du Globe, Strasbourg, FR
- Institut de Physique du Globe, Paris, FR
- Hong-Kong University, SAR, PRC

Technical facts

Sensors : 3 components Streikeinsen STS2, Guralp CMG40T, Agecodagis NOEMAX and Lennartz LE3D5S

Digitizers : Reftek 72A (x4) + Titan 6T (x6) + Minititan 3XT (26)

Acquisition mode : continous

Sampling rate : 20 sps or 31.25 sps

Location : broadband STS2 in buidings of the Sichuan Seismological Bureau on concrete pills. Others in open area.

Mean inter-station : 8 km (from L201 to L222)

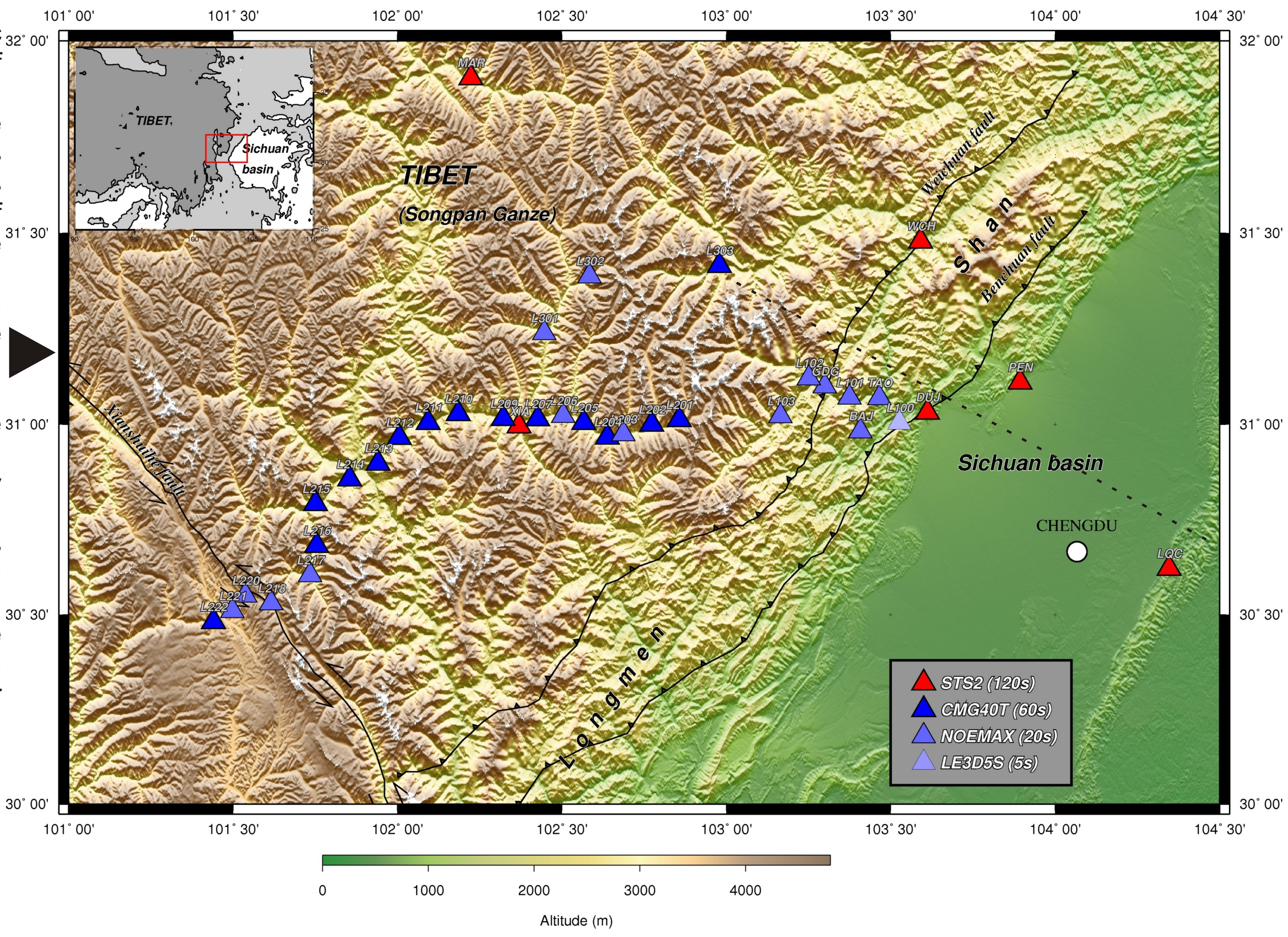
Phase 1 : November 2005 - November 2006

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 (▲)

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.



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 ? ☑ ☑ ☑

Seismological "Tools"

Receiver functions

Tomography (Local, teleseismic, from ambient noise correlation)

Earthquake location (Esp. depth)

SKS splitting

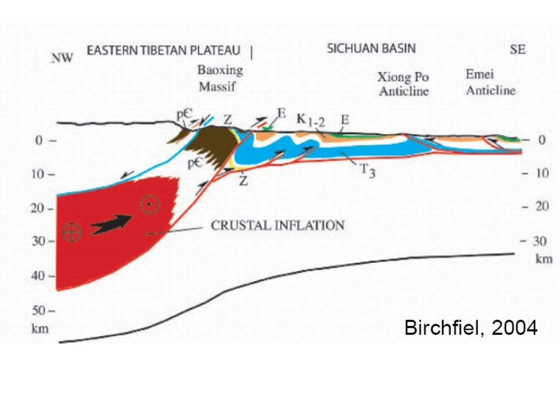


Figure 2 : Presence of a mid-crustal low viscosity channel in the tibetan crust is a very popular model to explain both the high topography of the Longmen Shan and the lack of present day horizontal shortening. However, there is still no direct proof for the existance of it. One of our objectives is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

Preliminary results from receiver functions

Principle

- Incident P waves from teleseismic earthquakes produce a PS converted phase at each interface corresponding to a velocity contrast.
- The time delay between the PS and the P phases (δt) depends on the depth of the interface. The sign and the amplitude of the PS phase depend on the sign and amplitude of the velocity contrast.
- Deconvolution of the radial seismogram by the vertical one produces a so called "receiver function" on which all the peaks are PS phases, except the fisrt 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.

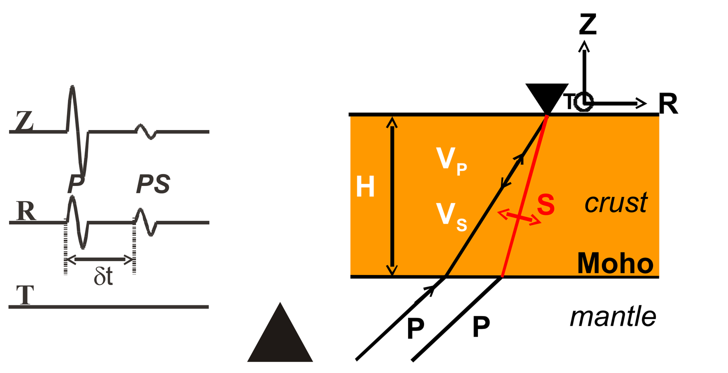


Figure 3 : Principle of receiver functions. When a P wave impings on a simple one layer crust (right), a PS converted wave is created at the Moho and is mostly observed on the radial component (R) on a 3 components seismogram, a few second after the P wave (left).

Figure 4 : Stack of receiver functions at stations LQC, PEN and DUJ within 20° width back-azimuth bins. The red traces at the top correspond to the stack of all receiver functions for each station.
Radial receiver function (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. LQC and PEN do not show strong energy on the transverse component whereas DUJ does (perhaps due to a mis-orientation of the sensor). Note the positive-negative-positive peaks sequence visible at the 3 stations. The positive peak at ~4.5/6s corresponds to the PS conversion at the Moho.

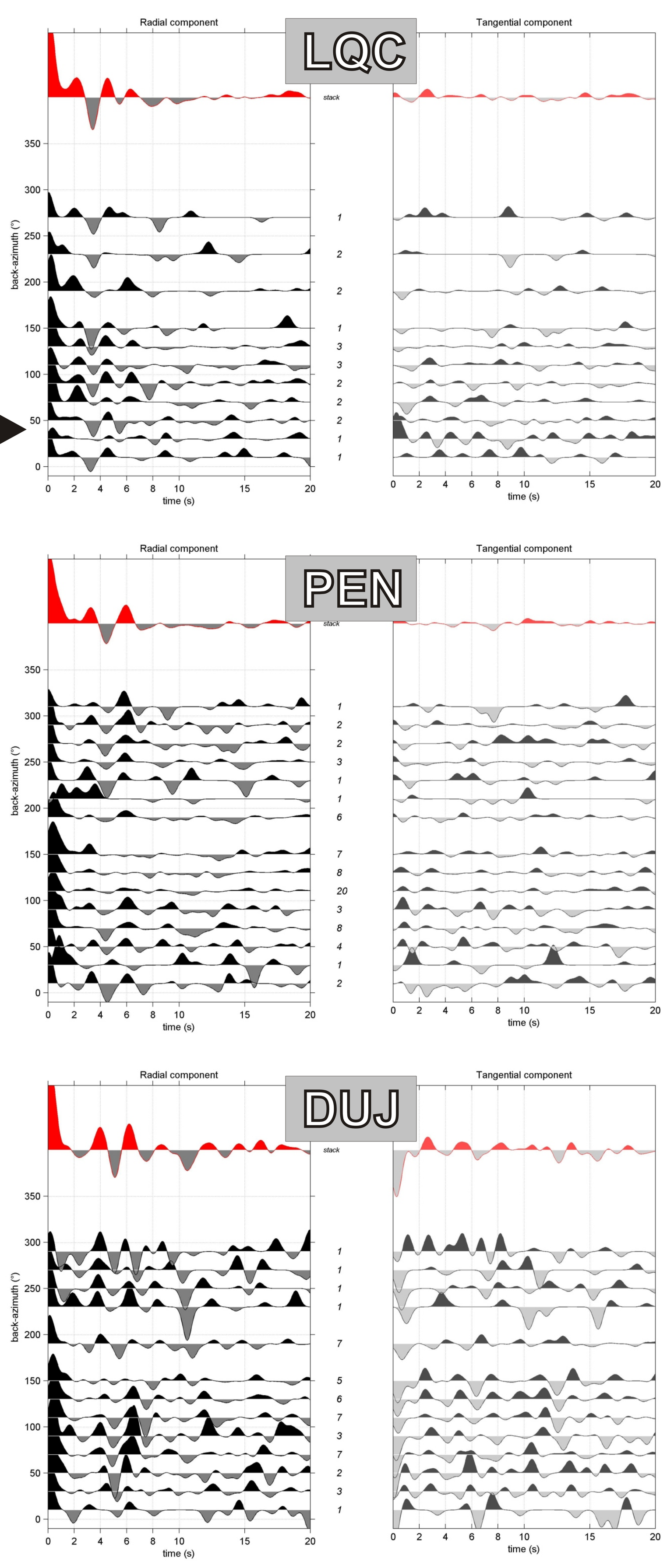


Figure 5 : Migrated cross-section (along the dotted line on figure 1) of individual receiver functions computed at stations LQC, PEN and DUJ. Red colors (resp. blue) depicts interfaces with an increase (resp. decrease) of velocity with depth.
The deepening of the Moho toward the plateau is well seen. Just beneath the Moho a low velocity zone is observed both below the front range and below the Sichuan basin.