

A 3-component reflection seismic survey at 38°S: Illuminating the Chilean subduction zone with Project TIPTEQ

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Nearly all earthquakes with high magnitudes ($M_w > 8$) are generated along convergent margins. A quarter of the worldwide seismic energy in the last century was released in the Chilean part of the Andes, and thereof, most energy by the largest historically recorded earthquake in 1960 ($M_w = 9.5$).

It is important to understand the triggering mechanisms and processes that shape those mega-thrust earthquakes. Therefore we have to understand the structural and petrophysical properties of the seismogenic coupling zone, where those earthquakes are suggested to initiate. That is one of the main aims of project TIPTEQ* (from The Incoming Plate to mega-Thrust Earthquake processes).

Project TIPTEQ is made up of 13 subprojects. Here we will present the reflection seismic sub-project: seismic and structural image of the plate interface. Together with marine data from 2001 project SPOC [1], the newly acquired high-resolution 3-component reflection seismic land data will yield a reflection seismic section that will cover the entire seismogenic coupling zone from its up-dip to its down-dip end.

A near vertical reflection (NVR) seismic profile, an expanding spread profile (ESP) and a SH-shot configuration (horizontally polarized shear waves) will illuminate the present state of the ruptured plate interface at the southern Central Chilean margin.

In the following we will shortly describe the three main parts of the experiment.

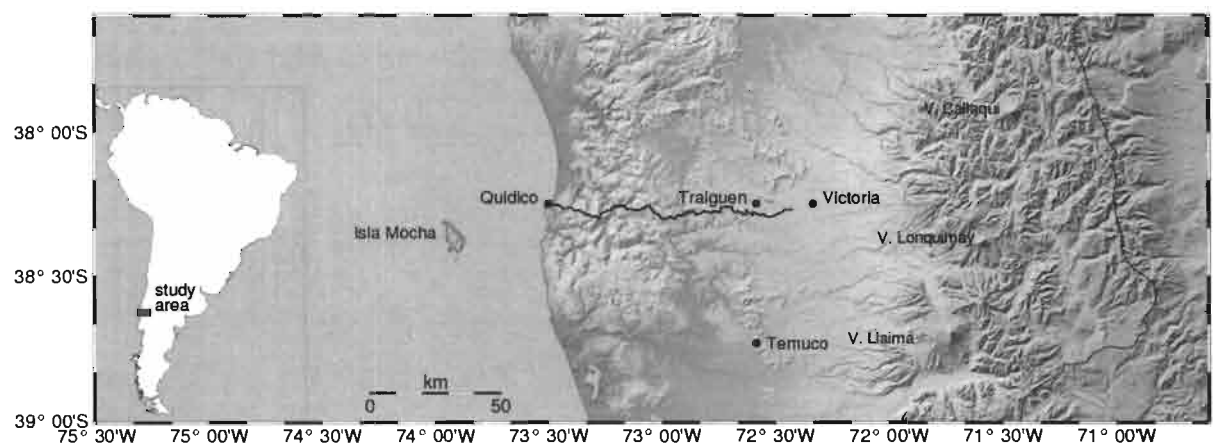


Fig. 1: Location map showing the profile line

A 90 km long near vertical reflection (NVR) seismic profile was shot in South Chile at approx. 38°S in January 2005. The profile runs from the Central Valley (Victoria) to the Pacific Ocean (Quidico) along an east-west trending line, thus crossing the relocated hypocenter of the historic 1960 Valdivia earthquake (see [1]). This event, starting at c. 38°S at a hypocentral depth between 30-40 km below the continental forearc, ruptured the margin progressively towards the south for approximately 1000 km, and had a coseismic slip of up to 40 m.

An 18 km long spread made up of 180 evenly spaced three-component geophones was moved 4.5 km in a daily roll-along. Four NVR-shots along the active spread each day (see Fig. 1, Fig. 2) yielding an up to 8-fold CDP coverage should deliver a high-resolution image of the seismogenic coupling zone between the subducting Nazca Plate and the South American continent.

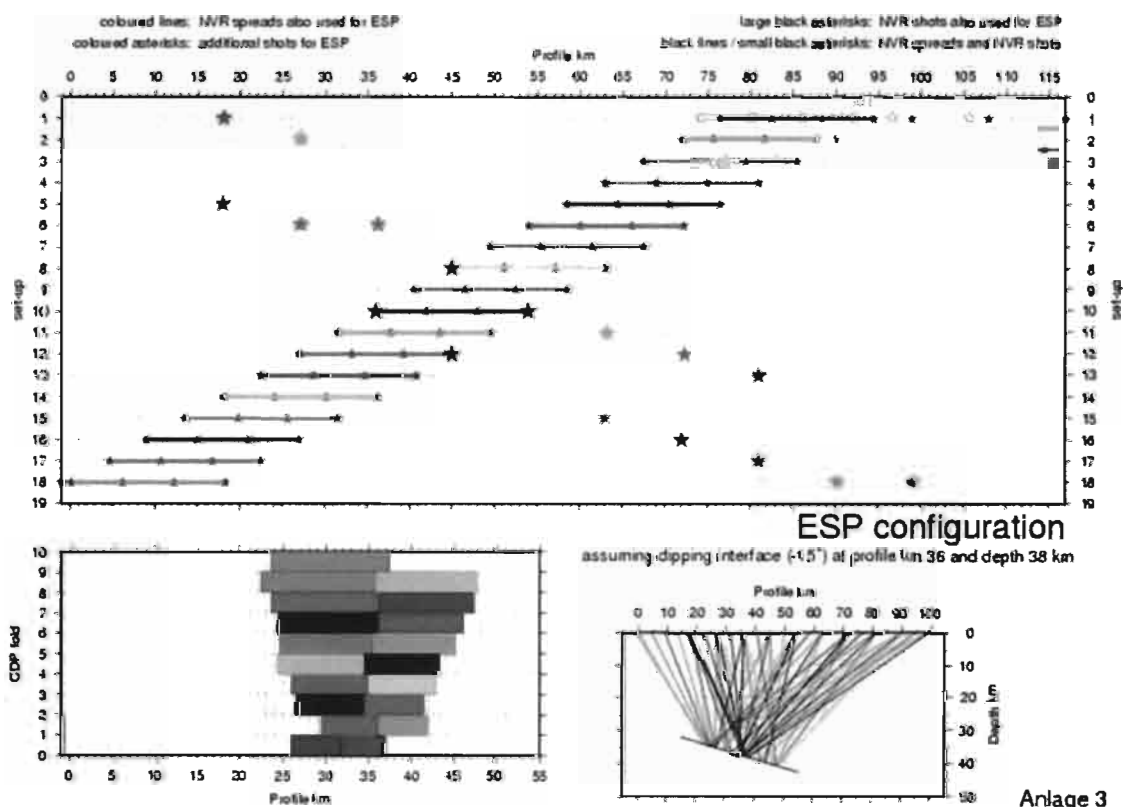


Fig. 2: ESP-, NVR-shot configuration and CDP coverage for ESP

The expanding spread experiment component focuses on the down-dip limit (30-50 km depth) of the seismogenic coupling zone, where mega-thrust earthquakes are suggested to initiate. The configuration with an approximately 10-fold CDP coverage, made up of approx. 20 shots with offsets up to 90 km (see Fig. 2), was designed to give a detailed image of this region harbouring the hypocenter of the 1960 earthquake.

The SH-shot configuration with single-fold CDP coverage along the whole profile was carried out as a pilot study to test SH-wave generation by three-hole (Camouflet) shooting in a crustal regime (see Fig. 3). Using 3-

component recordings, S-wave images should be obtained to yield an improved picture of the petrophysical contrasts within the subduction zone system.

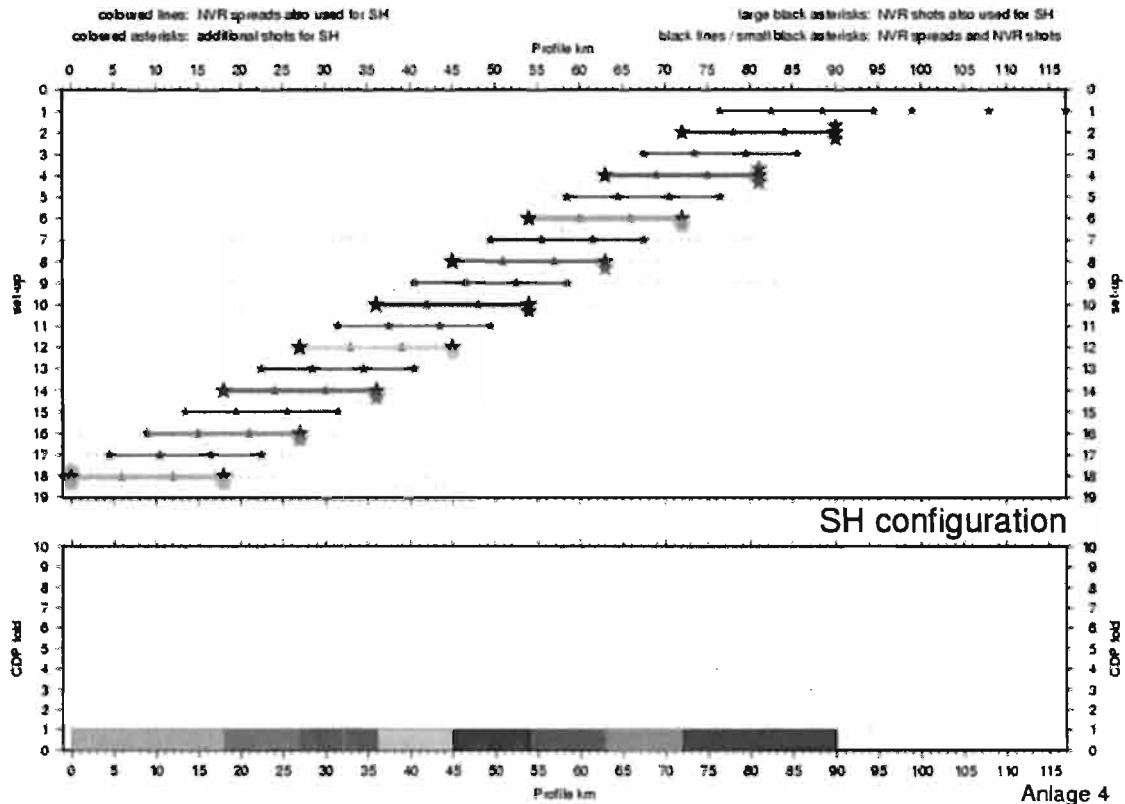


Fig. 3: SH-shot configuration and CDP coverage

All parts of the seismic survey are complemented by numerical modelling. Numerical simulations of NVR-, ESP- and SH-shots were performed in advance of the seismic survey. Subsurface wavefields were calculated with a FD programme on a Linux-Beowulf-Cluster, based on the velocity model obtained by S. Lüth from an evaluation of the 2001 SPOC data (see Fig. 4) [1].

A prestack depth migration (P-P, P-S, S-P and S-S) will give a detailed structural image of the subduction zone that will serve as a basis for the geodynamic interpretation. The ESP-component of the project allows for traveltimes and amplitude analysis, such as AVO and amplitude ratios. This analysis will give additional information on porosity, fluids and heterogeneity in the system and may be used to update the existing velocity model. Finally the SH-data will be used to analyze lateral and vertical variation of medium parameters. For all parts FD modelling will provide synthetic data for comparison and constrains.

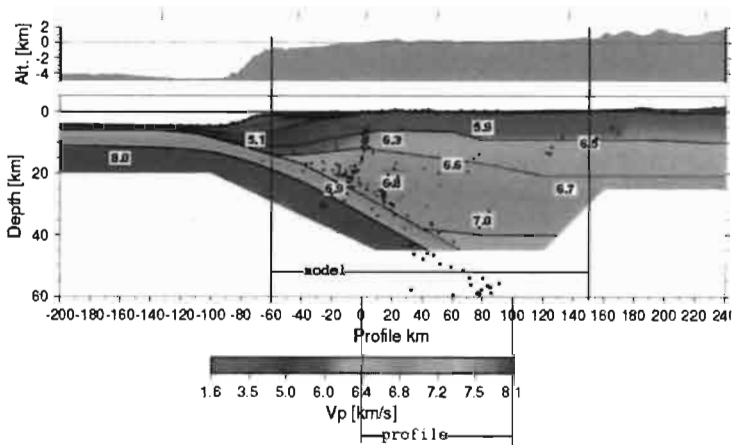
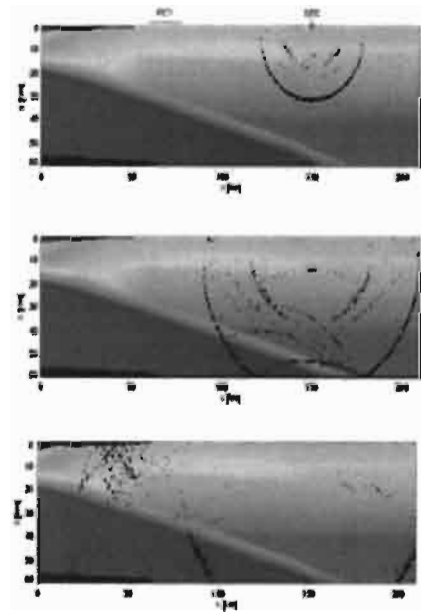


Fig. 4: SPOC Velocity model and snapshots of the wavefield from a FD calculation for an ESP-shot at 90 km along the profile



Here, we will present results of the numerical modelling and compare them with preliminary results obtained by the evaluation of TIPTEQ field data as well as the partly coincident two-fold seismic pilot line acquired in 2001 (SPOC onshore survey) at the same latitude. The focus of the presentation will be on ESP- and SH-shot data. A more general overview will be given in a talk by P. Wigger (see Wigger et al. this volume).

Reference

- [1] Krawczyk, C. and the SPOC Team, 2003. Amphibious seismic survey images plate interface at 1960 Chile earthquake. EOS Trans. Am. Geophys. Union, 84: 301, 304-305.

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