VERY HIGH RESOLUTION SEISMIC DATA FOR GEOTECHNICAL APPLICATION TO TUNNEL DESIGN AND HYDROGEOLOGY

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Civil engineering and hydrogeologic works share an increasing need of knowledge of deep layers (formations with thick overburden, control of deep aquifers, etc.). These problems cannot be resolved by seismic refraction, neither electric nor potential methods, due to complexity of layers. Then we were forced to use the reflection method. This method allows us to obtain signal from positive or negative impedance changes and an important control of fractures. This procedure has obtained previously a great development as the main procedure in oil search. Our idea is to adapt this very expensive technology to the problems and conditions of civil engineering without loss of quality and accuracy of the results.

DATA ACQUISITION

In the works described below have been used a 12 channel digital seismograph with 0-96 dB dynamical range, filters 25-1000 Hz and 25 to 1024 ms sampling rate.

As sequential source an 8-kg sledgehammer was used. From 4 to 8 impacts were stacked.

As high resolution was necessary a spread allowing a 1200% stack with 1,25 m offset C.D.P. 100 Hz geophones were used.

PRE-PROCESSING

A careful edition of data is necessary which allows the suppressing of useless traces, and a through study of near surface layers for accurate static computing. Though during the processing residual fittings are applied, any error greater than half wavelength would damage the quality of the sum.

PROCESSING

It consists in the classic amplitude recovery, static application, prefiltering, filtering for improve the S/N ratio, FK filtering if necessary, prestack deconvolution (predictive or in FK domain), application of residual static before and after the velocity analysis (this step is very important). The velocity analysis is carried out in most cases by means of "velocity scan". In such analysis the information from boreholes, outcrops, etc. is introduced. Then the mutes computed in pre-processing are applied and the stack is carried out.

The post stack processing can consists in a deconvolution and/or another application of an

improving routine for the ratio S/N.

A stacked section is so originated, and after this, migration is effected, by finite differences or in FK domain. The set of these two sections, stack and migrated, is important for the data interpretation.

INTERPRETATION

The interpretation is based mainly on:

a) an exhaustive analysis of geological data, surface and boreholes,

b) the study of sections, non migrated and migrated for definition of faults and fractures pattern,

c) definition of the same sections of reflections corresponding to prominent impedance changes,

d) the intervals between reflectors and faults to define the seismofacies (set of amplitudes, frequencies, velocities, character, etc.) which allow correlation with blocks of equal or different geological characteristics and to establish a correct geological model.

In the following we show two cases. They are very different in their purposes and their geology.

As high resolution was necessary a spread allowing a 1200% stack with 1,25 m offset C.D.P. 100 Hz geophones were used.

A) PARACUELLOS TUNNEL

The problem is the analysis of subsurface around the trace of a tunnel in an area where outcrop a Precambrian unit (Paracuellos shales), and Cambrian units: Bámbola quartzites, Embid siltstones and quartzites, and Jalon Formation.

From the geological map appearance, it looks a uniform area, without tectonic complexity. The detailed study of the ground surface seems to confirm this idea, but some boreholes show possible discrepancies.

The analysis of seismic sections shows an impressive set of faults, which leads to a division in compartments of the beds. Moreover there are prominent reflections that do not correspond to the area dips. This leads to think that these are due to subhorizontal faults (gravity tectonics of lateral compressions??). The definition of different compartments seismofacies originate a very complex interpretation where a Palaeozoic unit would overthrust another unit of the same age. Both units would suffer a recent tectonization. Also intercalations between both units. Due to the length of the section, we show only both ends of it.

Now the tunnel is being excavated and the reports of the working company confirm our interpretation in a 90%.

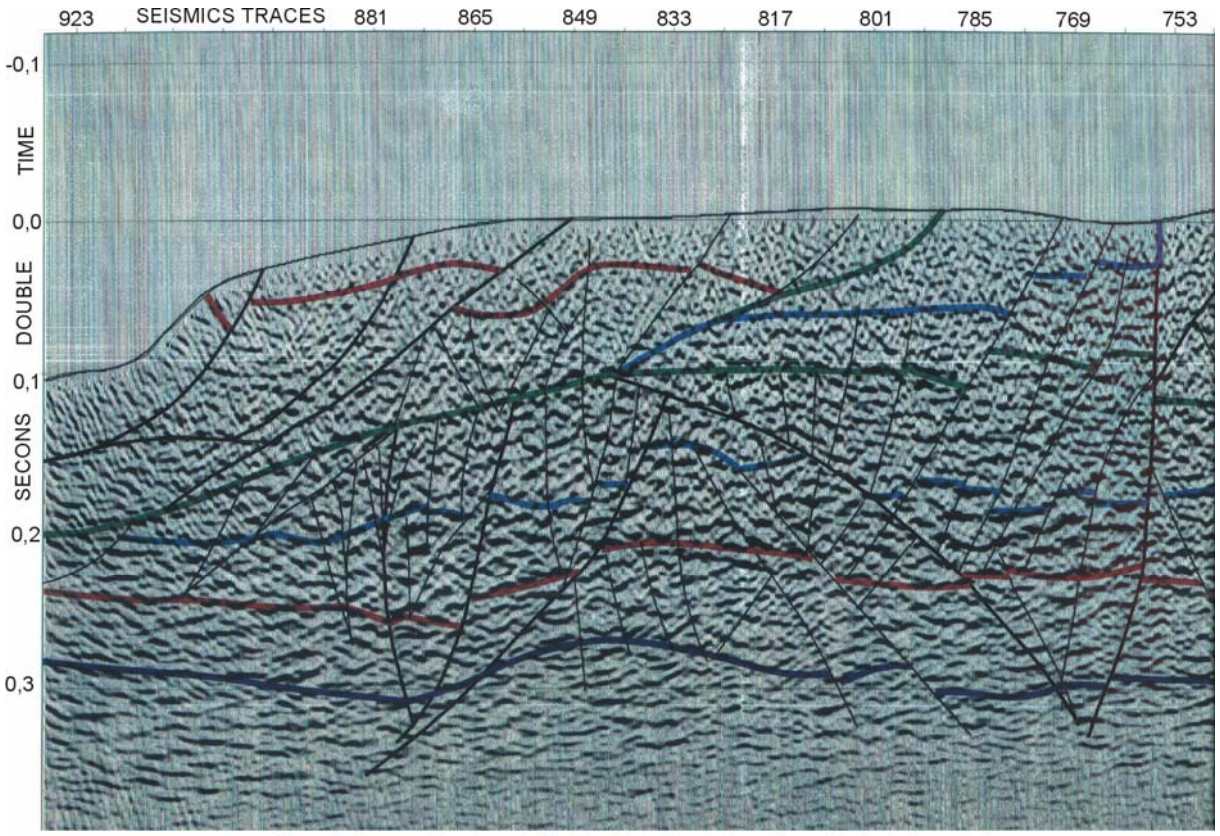

Figure1: Paracuellos tunnel. Final part of migrated section with the interpretation

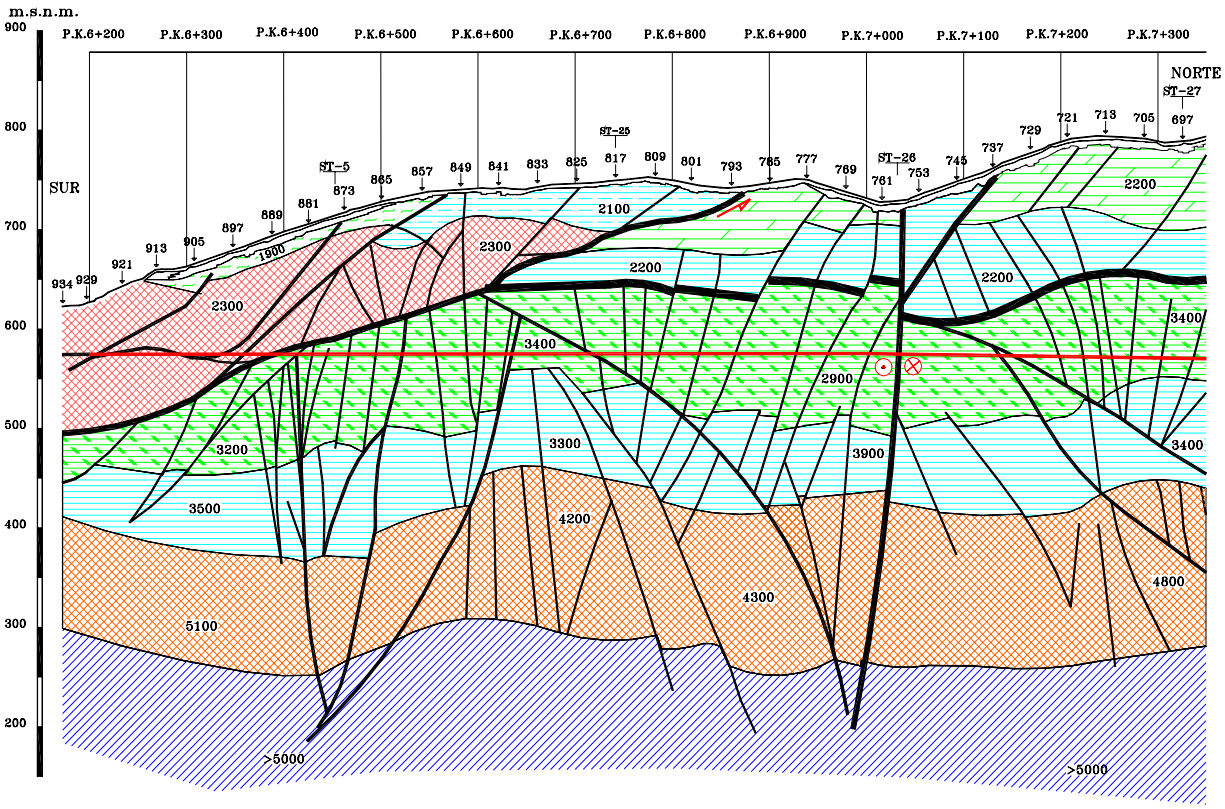

Figure 2. Paracuellos tunnel. Interpretation. Cross section of the final part.

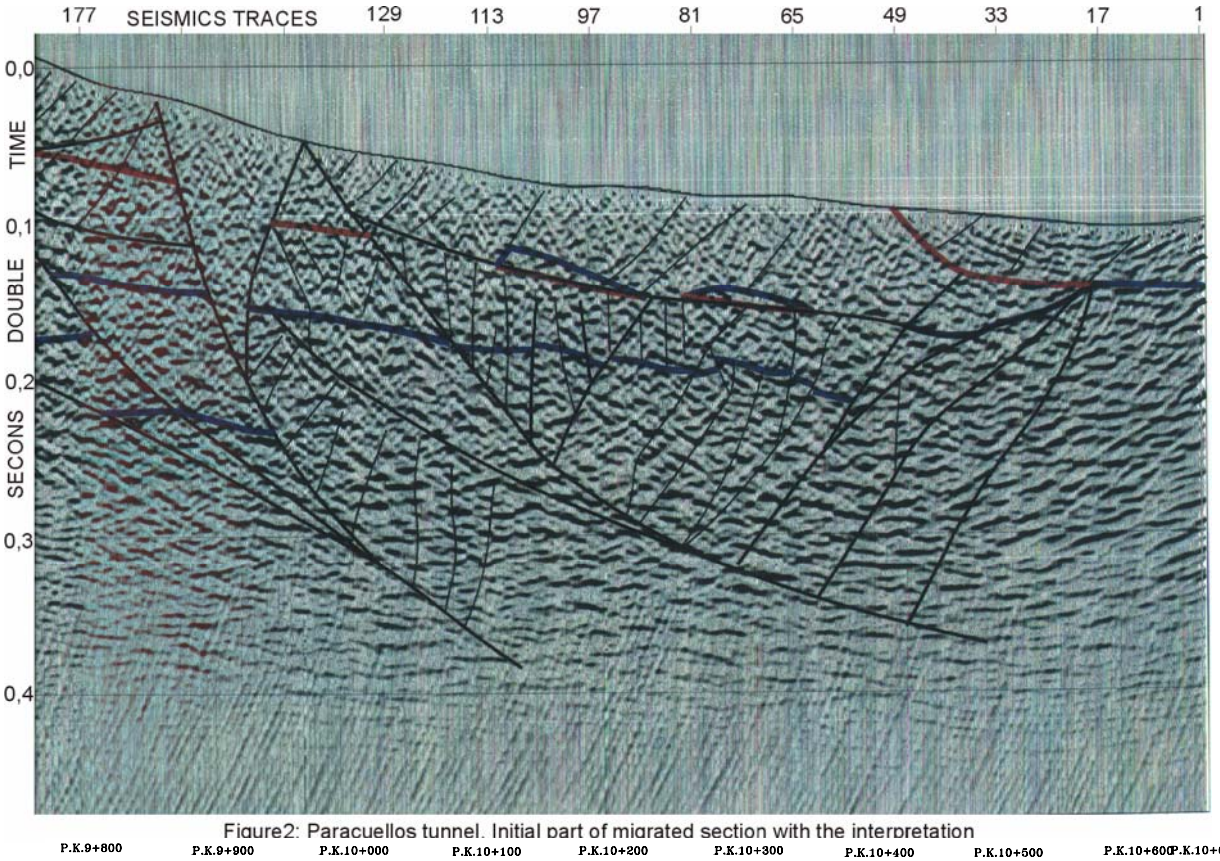

Figure2: Paracuellos tunnel. Initial part of migrated section with the interpretation

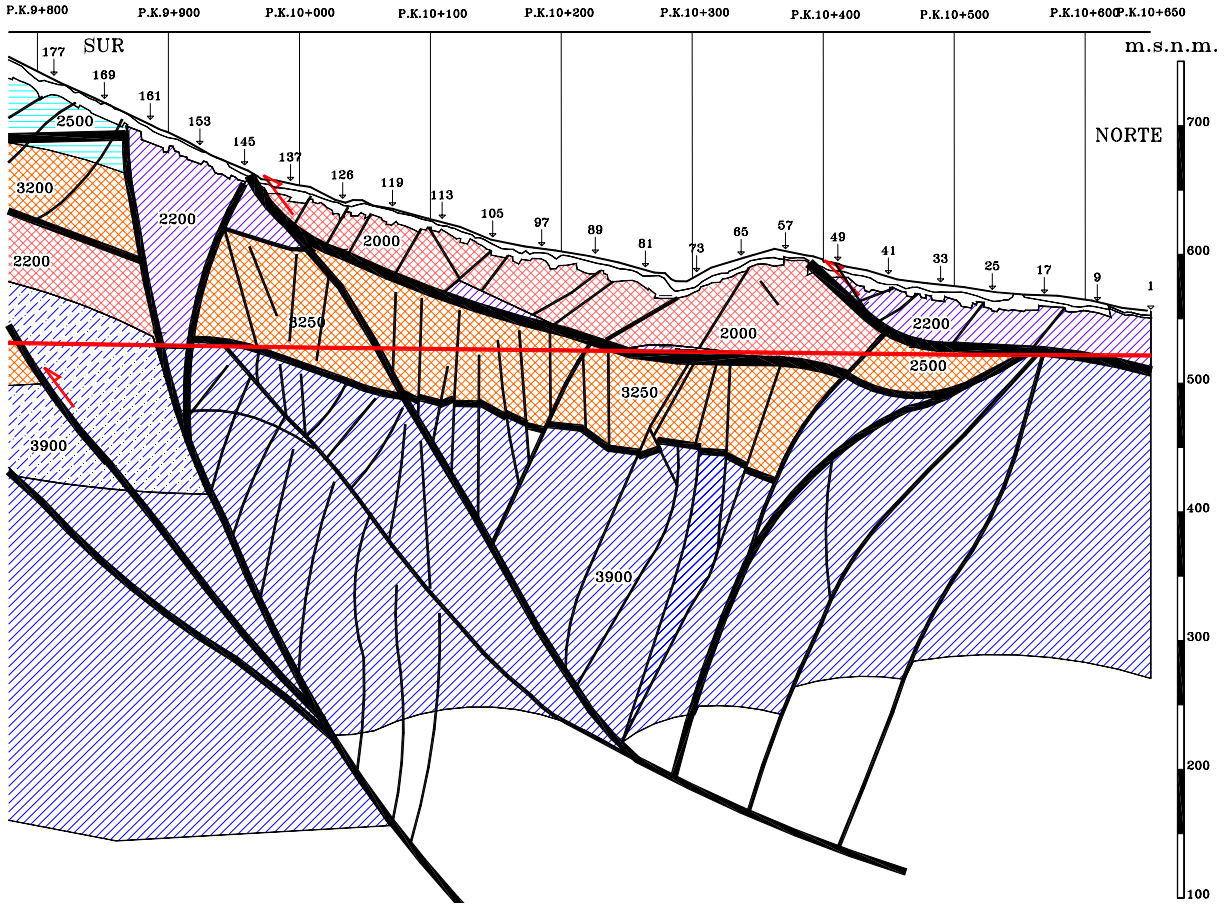

Figure 4. Paracuellos tunnel. Interpretation. Cross section of the initial part.

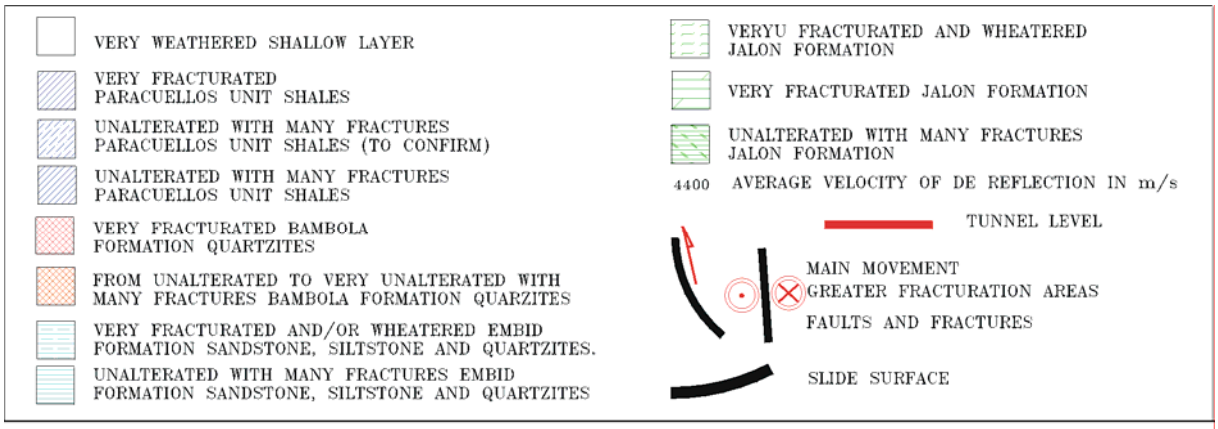

Figure 5: Key figures 2 y 4. Possible geologic atribution. ....

B) LA CABOTA SYNCLINE

In this case, the problem is the study from a hydraulic point of view of the position and geometry of a muschelkalk carbonate layer, which is an important aquifer. It is a syncline covered by quaternary sediments. There is a borehole, which has been very useful for it confirms the velocity analysis and allows a good correlation. There is a very good definition of premiocenic discordance and there is a tectonic of distortion and tearing which does not affect the modern sequences.

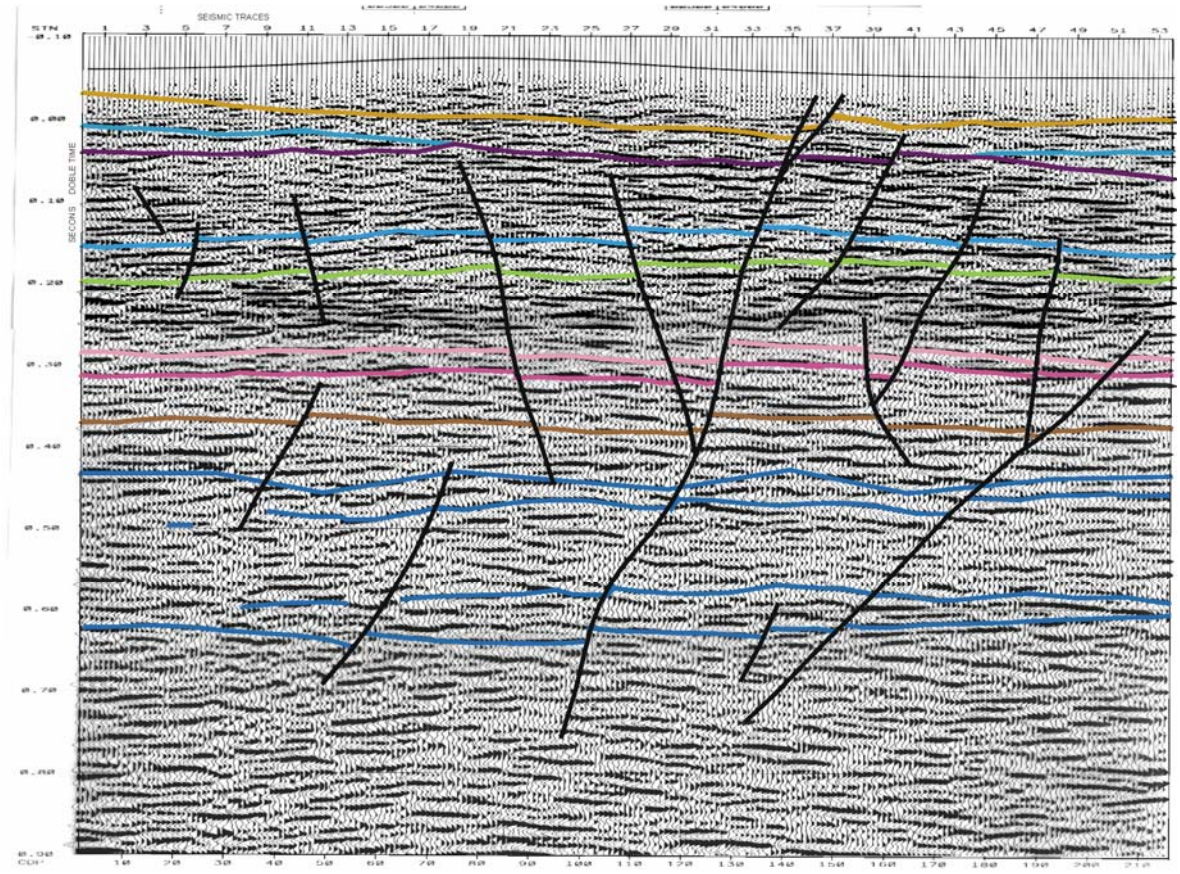

Figure 6: Cabota Syncline. Migrated section with the interpretation

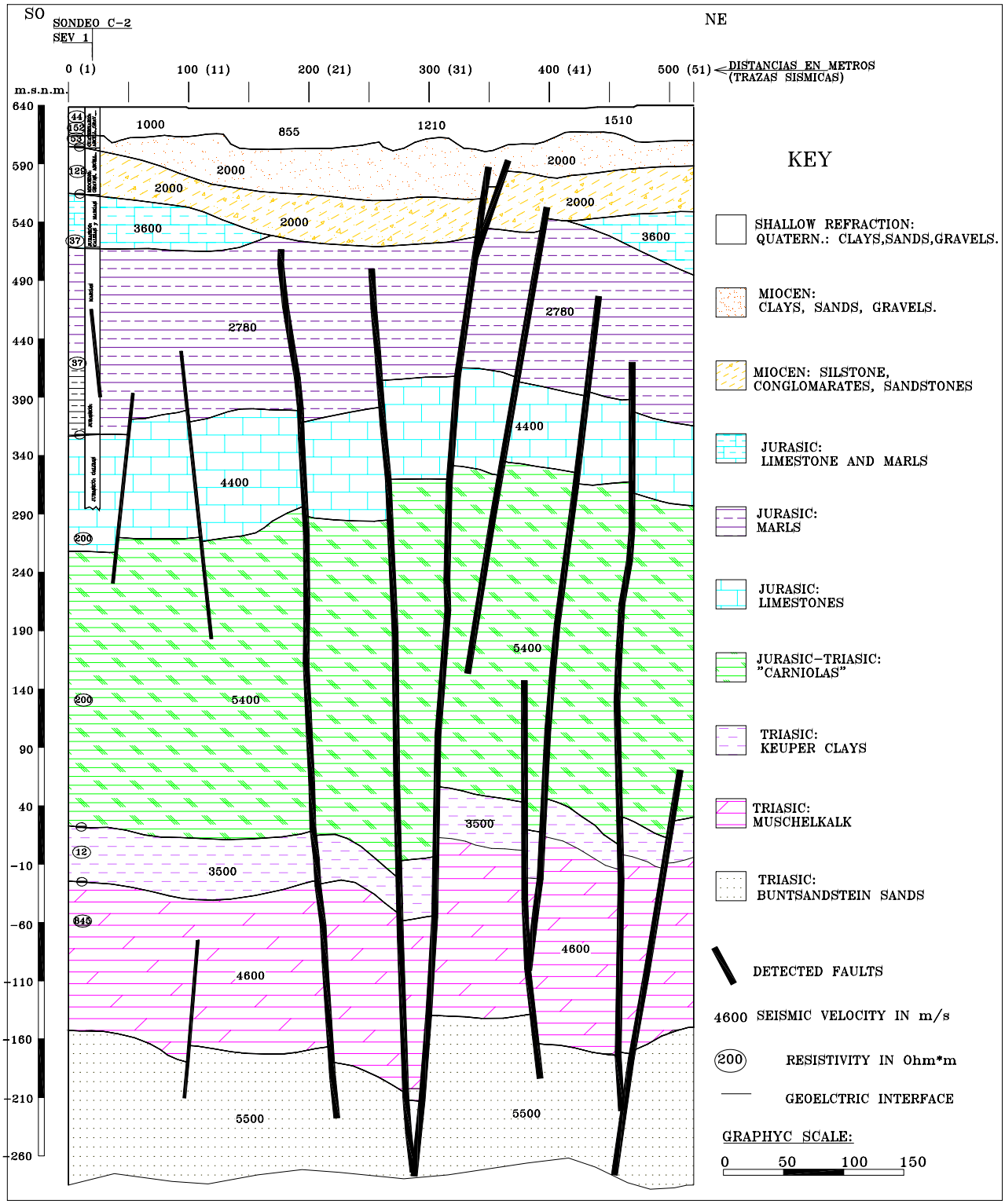

Figure 7: Cabota sinclyne. Interpretation. Cross section.