The topography of the seismic Lithosphere-Asthenosphere Boundary in Iberia and adjacent regions

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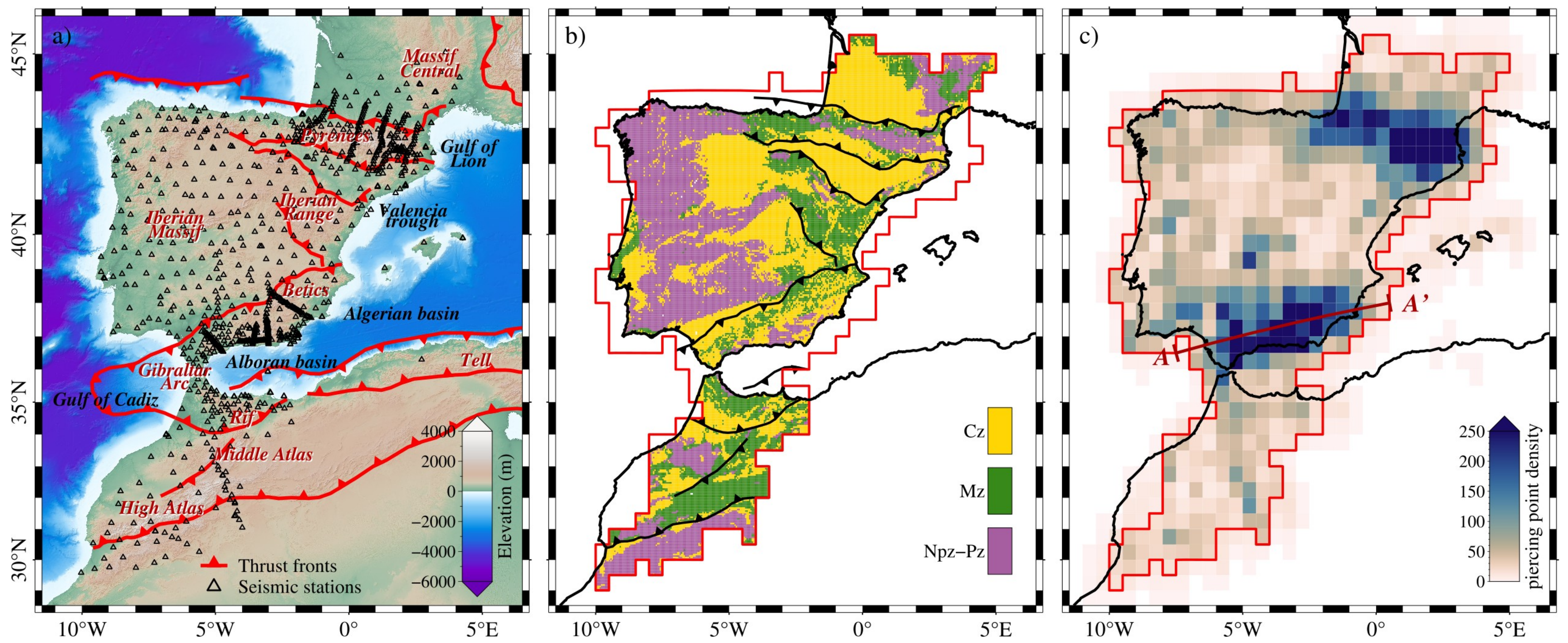

Fig. 1: a) tectonic setting and location of the seismic stations; b) age of the surface geology in the study area (Cz: Cenozoic, Mz: Mesozoic, Npz-Pz: Neoproterozoic-Paleozoic); c) piercing point density at 100 km depth.

DATA AND METHODS

With 998 available broadband seismic stations in the area, we use receiver function analysis to map the lithosphere-asthenosphere boundary (LAB) in the Ibero-Maghrebian region. Receiver functions are time series of P-to-S (PRF) or S-to-P (SRF) wave conversions that occur at seismic discontinuities and that can be obtained from teleseismic events recorded with three-component seismometers.

The study area limit (in red) is defined by a minimum piercing point density (15 points per 0.5º cell). Each piercing point corresponds to a single teleseismic event and receiver function.

Mapping the LAB

Why use S-wave receiver functions, or SRF?

- No contamination of multiples
- Much larger lateral sampling

SRF were depth migrated using common-conversion point (CCP) stacking. We constructed a grid of SRF CCP profiles with constant 0.25º spacing covering the study area. The LAB converter was automatically picked in each CCP profile using a set of conditions to prevent the picking of other phases (e.g. polarity, maximum and minimum depth, pulse prominence). A LAB depth map was obtained by interpolating the LAB picks with inverse distance weighting. Uncertainty is estimated at ±10 km. We also updated the regional Moho map with the PRF from the latest desployments in the Betic Range.

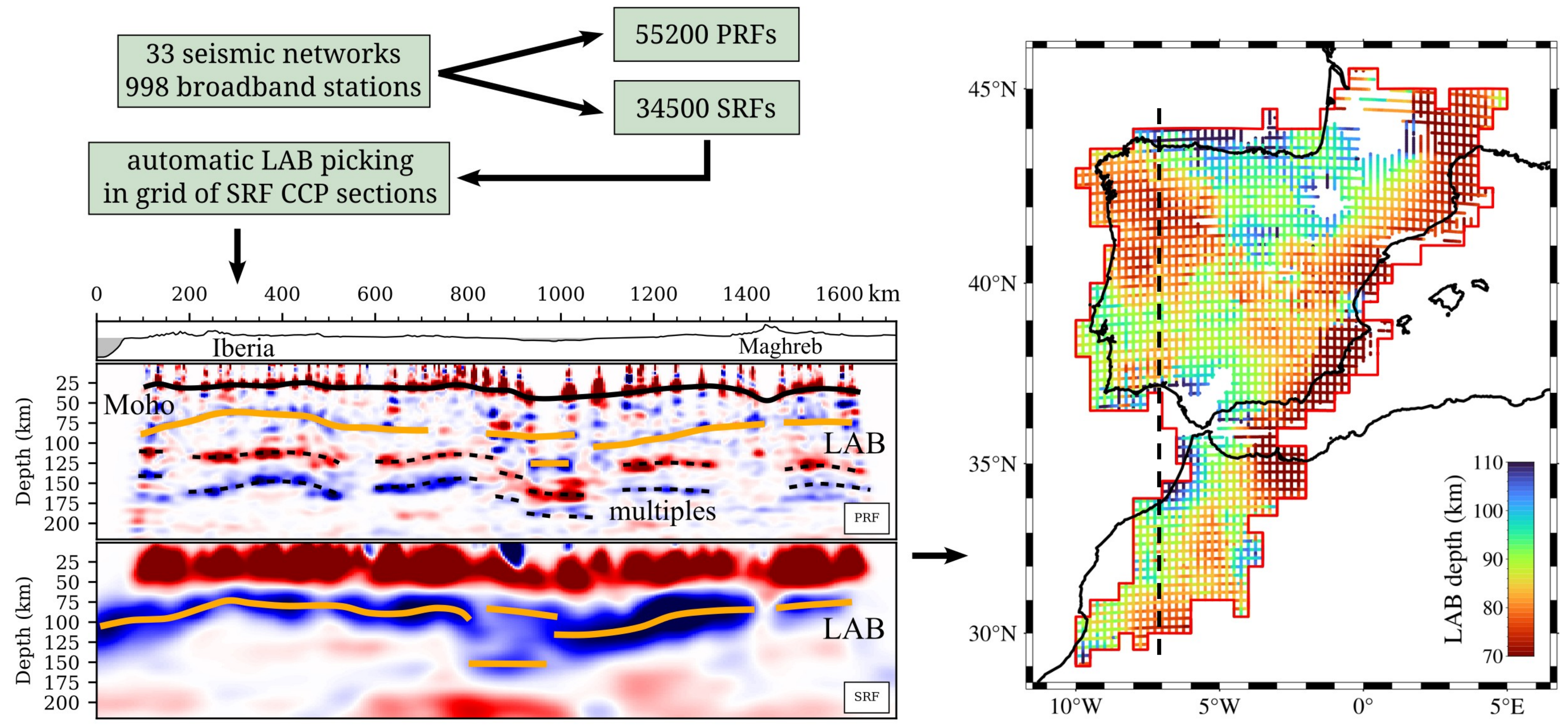

Fig. 2: workflow for obtaining the LAB depth map (right). Contour lines are shown every 10 km.

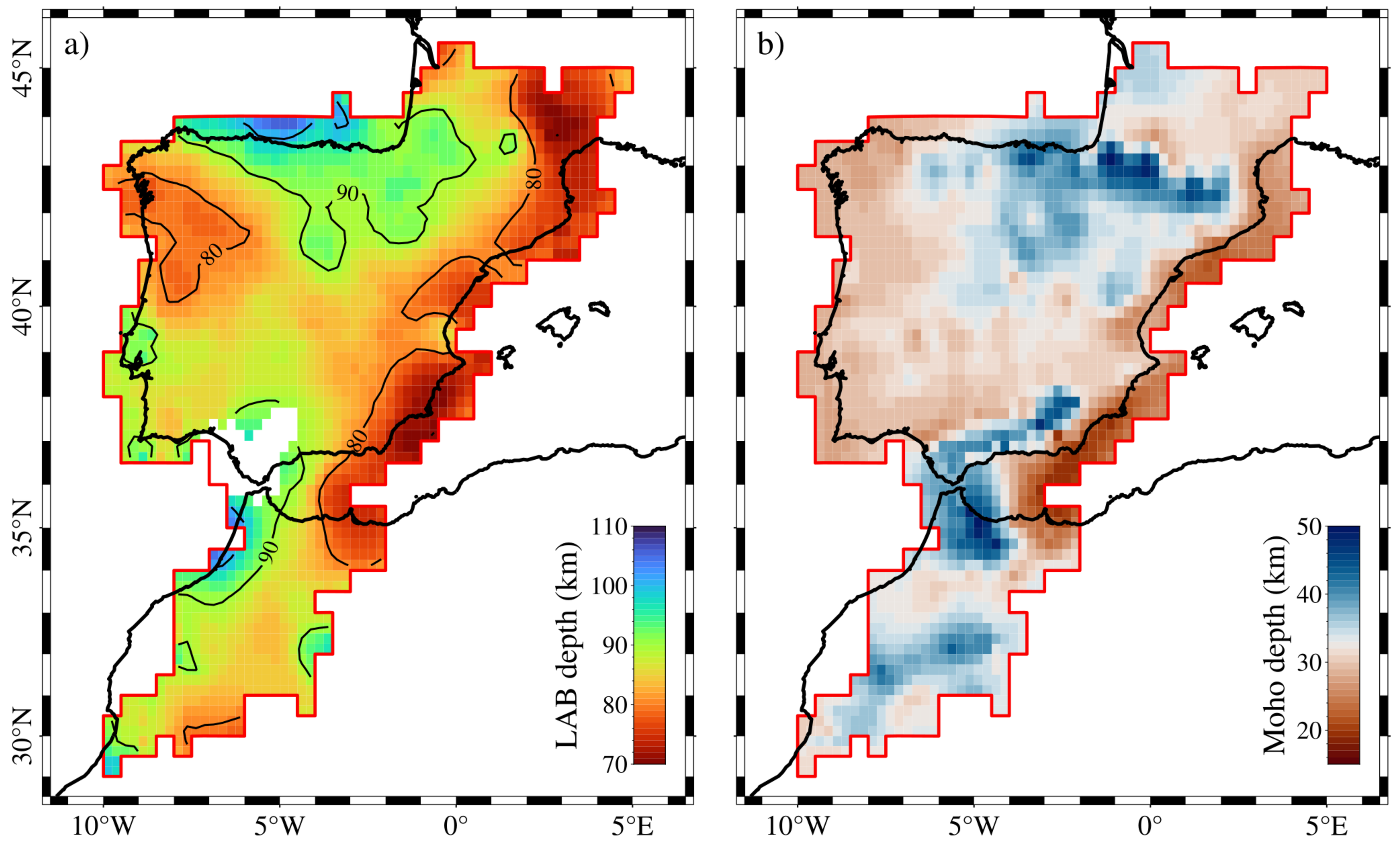

Fig. 3: a) LAB depth, with contour lines are shown every 10 km; b) Moho depth.

LAB FEATURES AND COMPARISON WITH THE MOHO

Most of the Ibero-Maghrebian region is characterized by a relatively shallow LAB, being shallowest along a corridor of <80 km depth stretching from the Massif Central to the Rif along the Mediterranean coast, achieving a minimum depth of 70 km. The LAB is also <80 km in northwest Iberia, but deepens in most central Iberia and the Atlas range (80 to 90 km). Only in the Gulf of Cádiz and in north-central Iberia a depth of >90 km is reached.

The LAB and the Moho are expected to be positively correlated, so that lithospheric thickness should increase with crustal thickness. This is the case in 1) northern Iberia, with thickened crust (>35 km) and deeper LAB (>90 km), 2) eastern Iberia and the Alboran basin, with thinned crust (<30 km) and shallow LAB (<80 km), and 3) the Hercynian crust of the Iberian Massif, with both a shallow Moho (~30 km) and LAB (<80 km) given the old age of the crust. However, the LAB and Moho depths are not correlated in parts of the Gibraltar Arc and in the Atlas mountains, suggesting that in some areas the high topography is not isostatically compensated.

LAB SLOPE AND SUBLITHOSPHERIC NEGATIVE VELOCITY GRADIENTS (NVG)

Major tectonic structures in the region, such as the STEP fault in the Betic Range and the eastern limit of the pyrenean underthrusting in NE Iberia, are responsible for sharp LAB depth transitions. The sharpest LAB lateral change occurs along the western margin of the Massif Central, and is probably linked to the Sillon Houiller transform and the Toulouse fault. Increased LAB slope is also found immediately east of the Jurassic oceanic lithosphere (JOL) of the Gibraltar-Alboran slab, coinciding also with the location of intermediate depth seismicity.

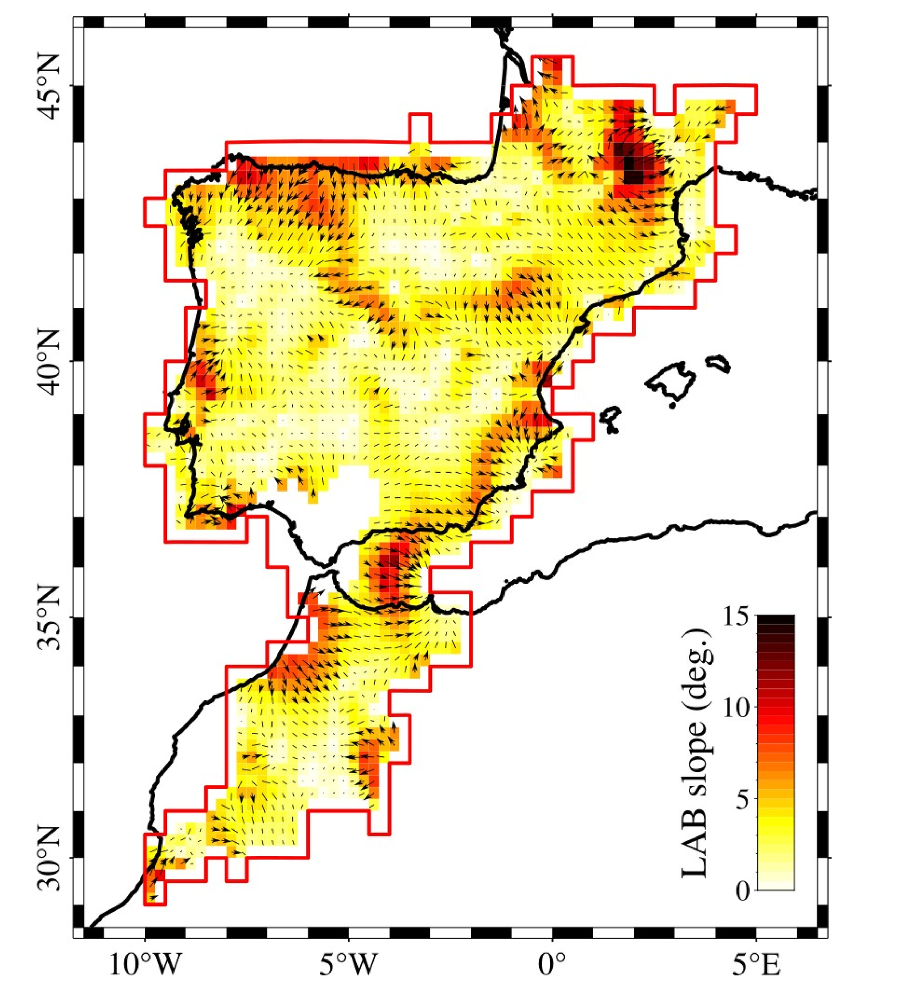

Fig. 4: LAB gradient (as slope in degrees), with vector field indicating the upslope gradient direction.

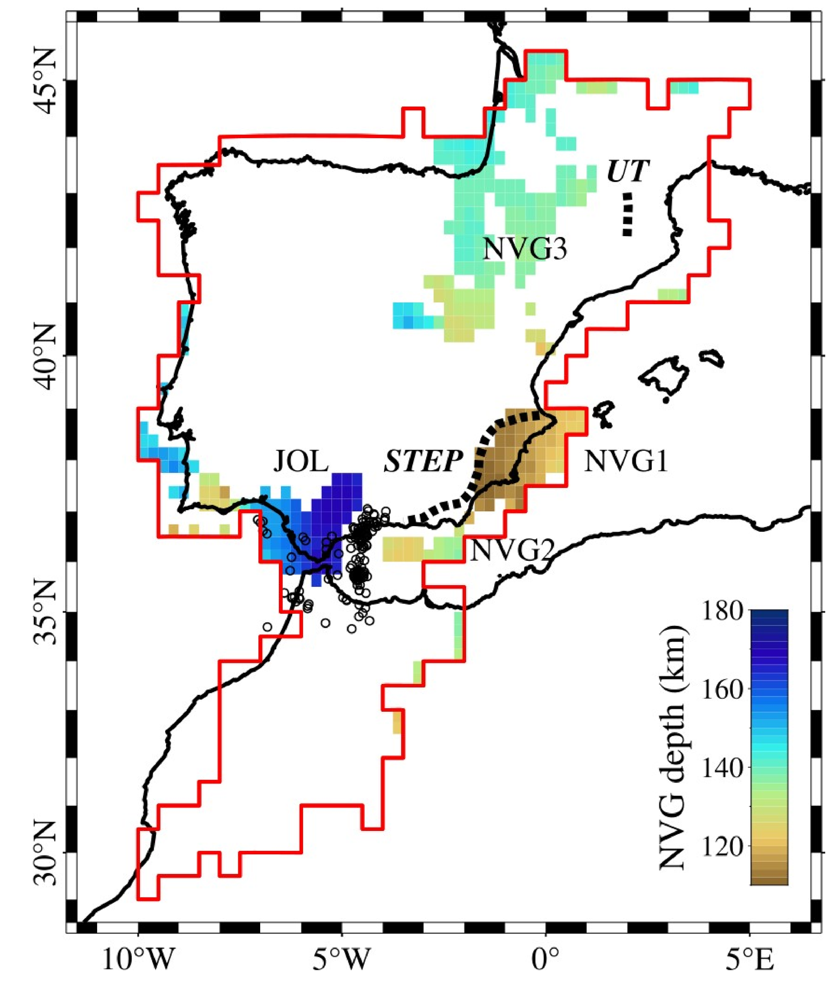

Fig. 5: location of the JOL, NVG layers, the STEP fault, the Pyrenean undesthrusting (UT) and the epicenters of intermediate seismicity in the Gibraltar Arc.

Three sublithospheric negative velocity gradients (NVG) were found at varying depths. In the Gibraltar Arc we associate two of such NVG to slab-related processes (either flow of hotter mantle materials through slab windows or areas of partial melting). The third NVG (under the Western Pyrenees and Iberian Range) remains open to speculation, but could be a case of two-layered melt structure which has been found to occur in several regions around the globe in different tectonic settings.

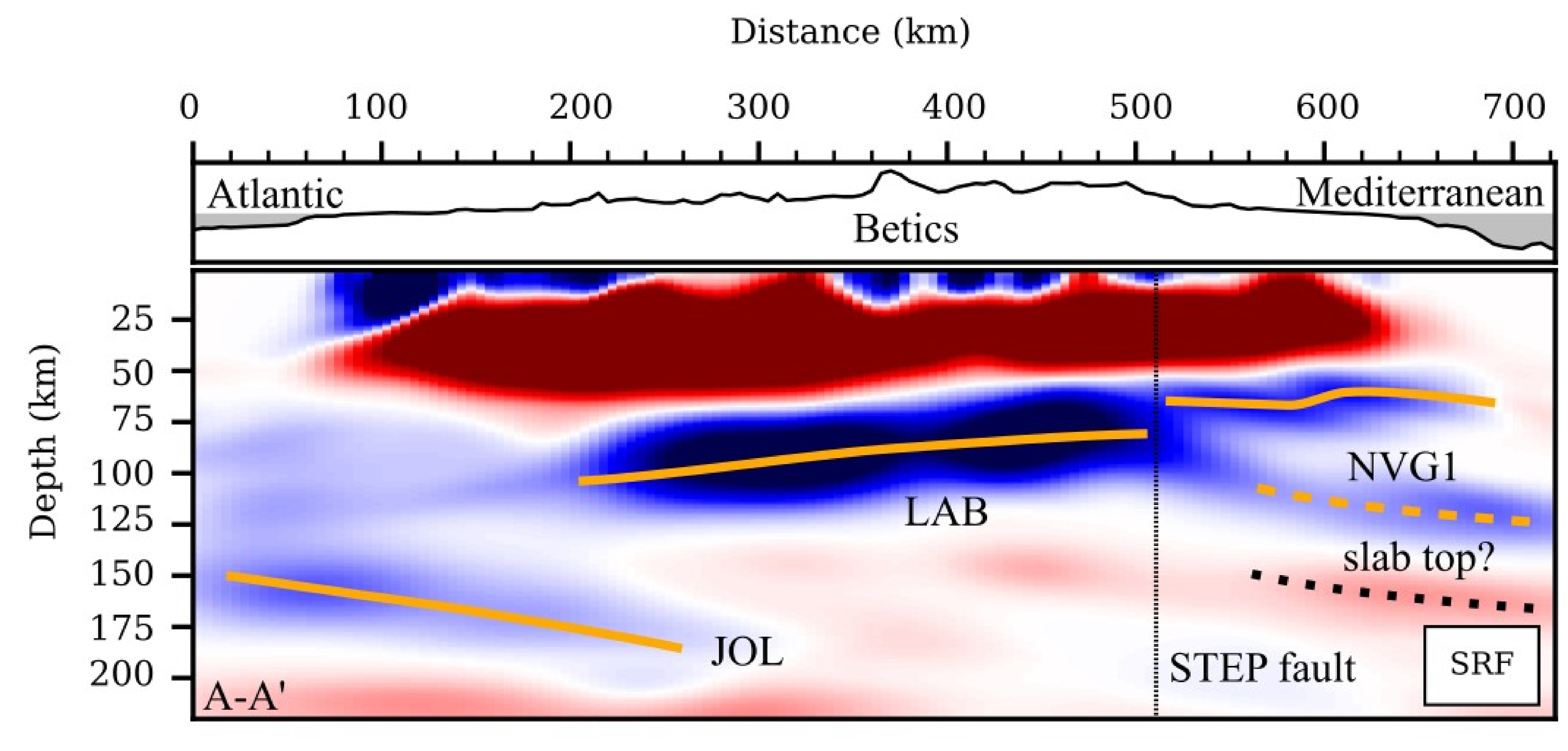

Fig. 6: Interpreted SRF CCP profile A-A' in the Gibraltar Arc (ESE-WNW). Location in Figure 1c.

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