EGU2019-16953

EGU General Assembly 2019

Coda Attenuation Analysis in Western Iberia and its SW offshore area

D. Vales [(1)], J. Havskov [(2)], L. Matias [(3)], S. Silva [(3)]

(1) Instituto Português do Mar e da Atmosfera, Portugal, (2) University of Bergen, Norway, (3) Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lisboa, Portugal

dina.vales@ipma.pt

1. Summary

In this study, we determine the seismic attenuation of both onshore zones in the west and south of Iberia and of the offshore zone southwest. We apply the Coda Wave Decay (CWD) method for each hypocenter station pair. Then we compute average values on a geographical grid using regionalization and tomography. We use seismic data recorded by the permanent seismic network and multiple datasets from 4 temporary networks of ocean-bottom seismometers (OBS) deployed offshore SW Iberia. These OBS networks that covered the Gulf of Cadiz, the eastern Horseshoe Abyssal Plain and at the Gorringe Bank, provide a unique opportunity to map the coda Q values of the offshore of SW Iberia. We analyze seismograms of 999 selected earthquakes occurred between January 1999 and October 2018, which were recorded by stations within 100 km epicentral distance and the focal depths were less than 50 km.

We find that coda Q can clearly distinguish areas with different Q in Western Iberia and its offshore areas, moreover our observations of coda Q values are spatially well correlated with geology and tectonics. Interestingly, we observe very low Q values in the extreme offshore SW area, the Gorringe Bank and surrounding where the sediments overlay directly exhumed mantle. The high Q values are observed in Western Iberia, the stable Iberian Massif and the intermediate Q values are found in the sedimentary basins, the Lusitanian and the Lower Tagus basins. Additionally, we find that the area with similar lower Q value is in the SE Iberia (Betics range) which is also the area that has been associated with low Q in the other previous studies. Comparing with coda Q for other regions, where coda Q has been determined with the CWD method and the same parameters, the largest Q in the Iberian Massif is higher than the Q in Norway, and the lowest Q is comparable to the low Q area of the Azores.
We conclude that coda Q is a useful tool to study detailed regional differences in attenuation when small epicentral distances are used.

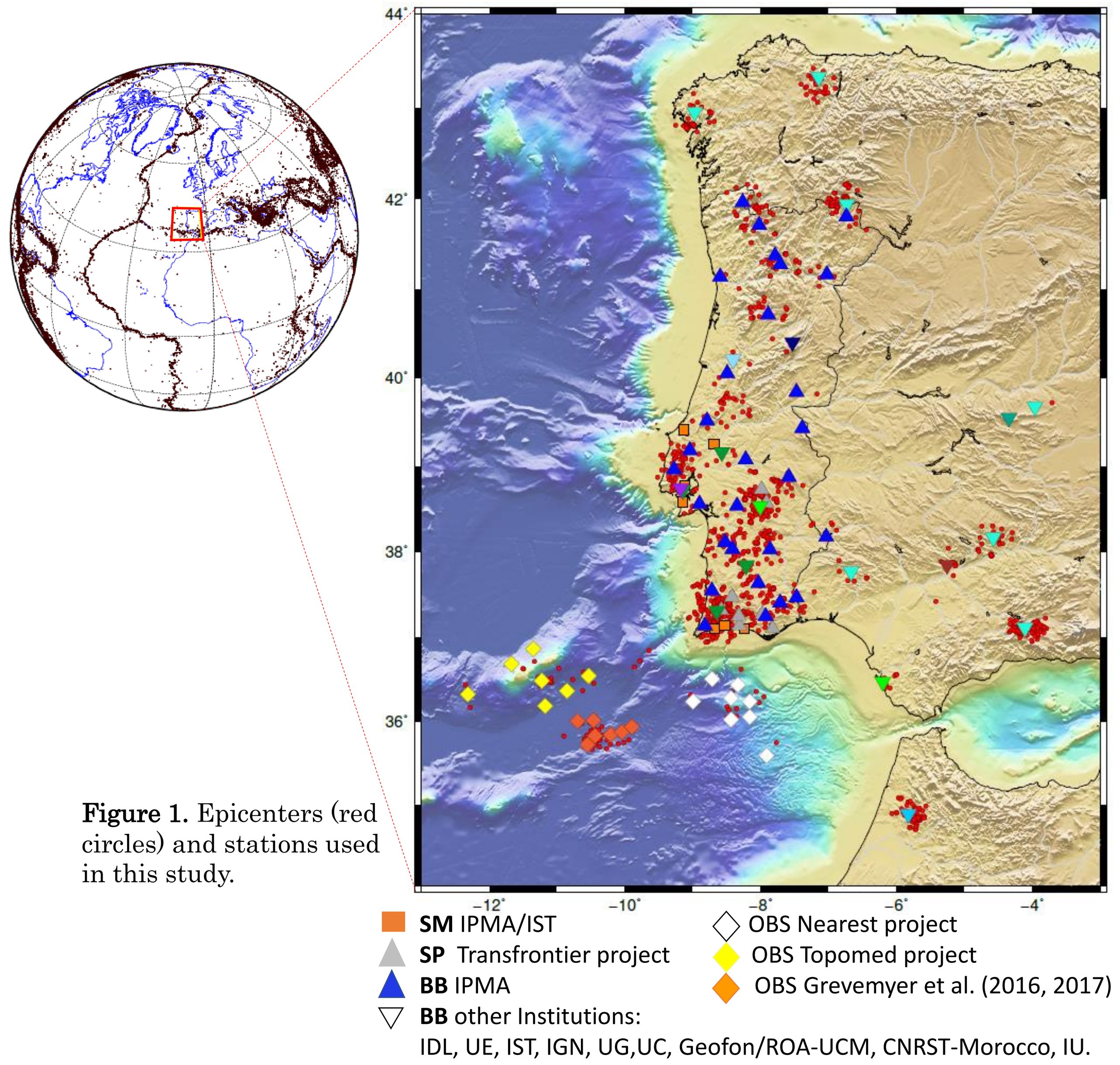

Figure 1. Epicenters (red circles) and stations used in this study.

3. Coda Wave

The processing parameters are:
Start time of processing window from origin time, called lapse time: 30s; The lapse time must be at least 2 times the S-travel time; Time window analyzed: 30s; Spreading parameter: 0.5; Minimum signal to noise ratio at end of coda window: 3.0; Minimum, absolute correlation coefficient: 0.6; and Frequencies and filter used: center frequency 1,2,4,8,16Hz with 2 octave bandwidth, and 8 poles.

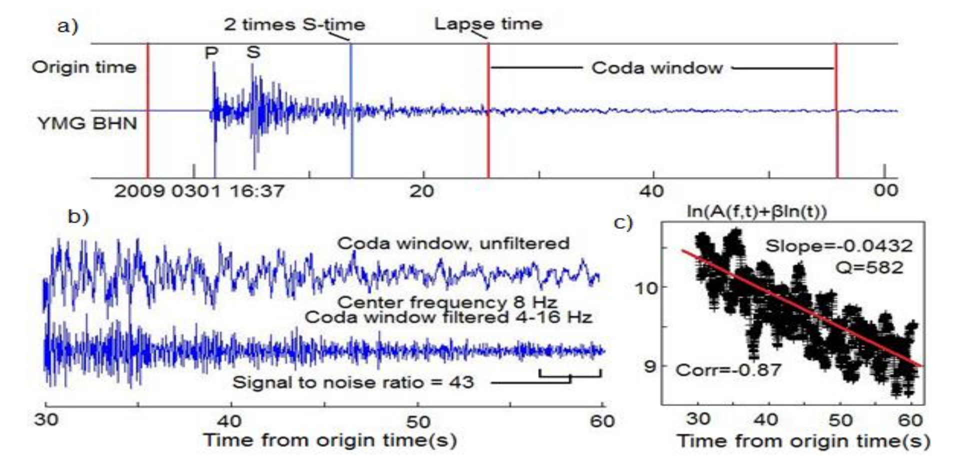

Figure 3 Coda wave processing. **(a)** The trace shows the original unfiltered trace with the coda window position selected. It is seen that the lapse time (time from origin to start of coda window) is larger than twice the S-travel time. **(b)** The filtered and unfiltered coda decay window. It has a good signal-to-noise ratio (SNR) of 43 measured as indicted for the last 3 s of the filtered window. **(c)** The corrected coda envelope as a function of time. The correlation coefficient of the fit is 0.87 and the slope is 0.0432 giving a coda Q of 582 (adapted from Havskov et al. 2016).

6. Results

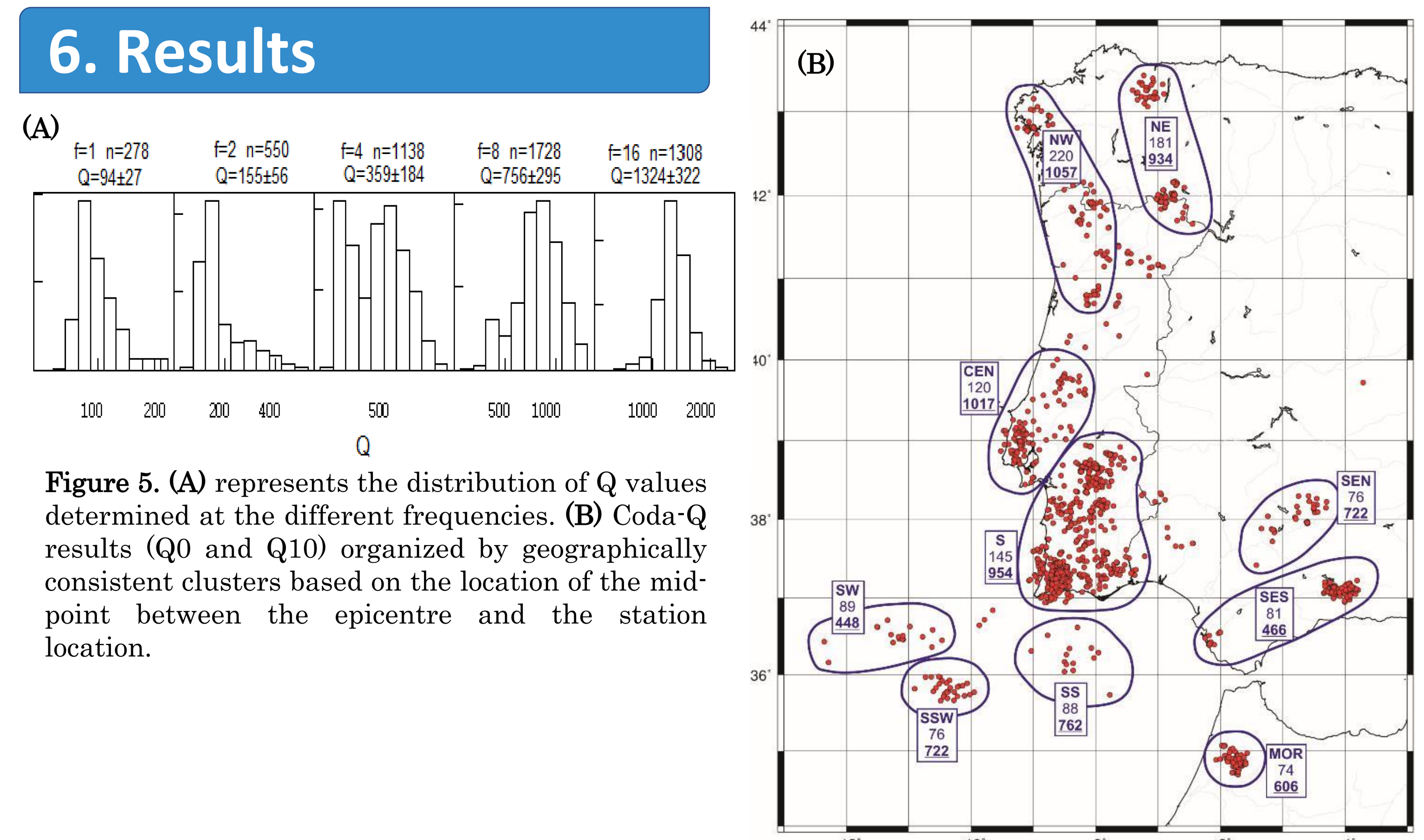

Figure 5. (A) represents the distribution of Q values determined at the different frequencies. **(B)** Coda-Q results (Q0 and Q10) organized by geographically consistent clusters based on the location of the mid-point between the epicentre and the station location.

The regionalization and inversion of coda Q data is done for each of the frequencies computed (1 Hz, 2Hz, 4Hz, 8Hz, 16Hz) and for each grid cell. In each area the coda values were fitted to $Q=Q_0*f^{\alpha}$ and we use that equation to calculate Q0 and Q10.

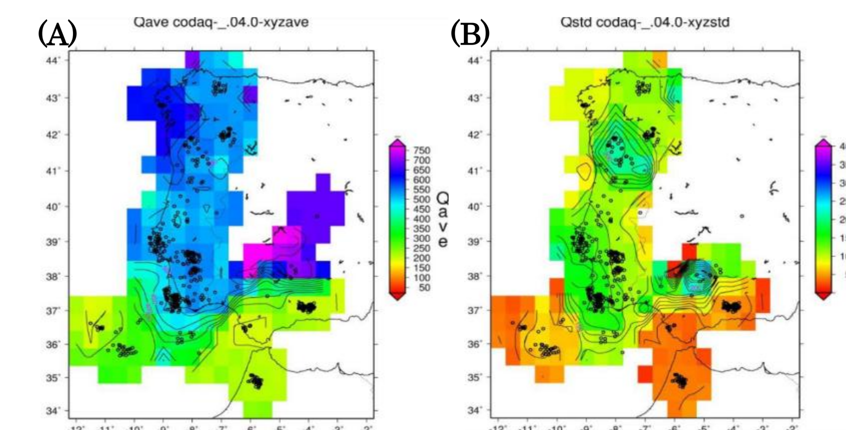

Figure 6. (A) Average coda Q value and **(B)** Standard deviation of coda-Q values for each grid cell and frequency of 4 HZ.

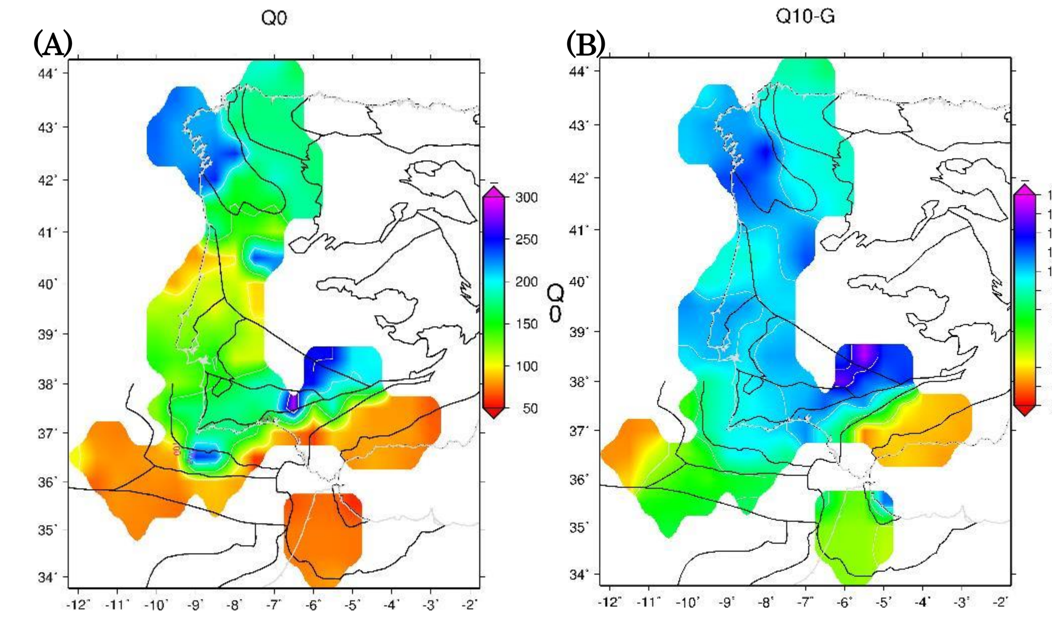

Figure 7. Q_0, and Q_{10} obtained from the regionalized coda-Q grids together with the geologic domains considered in this study

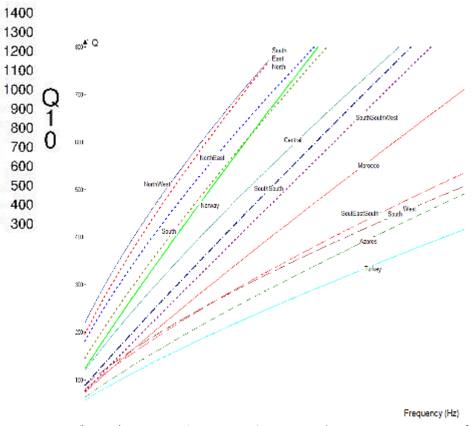

Figure 8. Coda Q as a function of frequency in different areas.

2. Geotectonic Setting

The core of the Peninsula is the Iberian Massif, inherited from Variscan orogeny, covering the western and central Iberia with a rather uniform crust of ~31–33 km thicknesses. Here, the northwesternmost-westernmost of Iberia presents the exception as the crust thins to values of 26-28 km (Mancilla et al., 2015). In the Mesozoic, the extensional episodes expressed on the basins Lusitanian and Algarve are tied to the opening of the North Atlantic and the westernmost limit of the Tethys oceans, respectively. The Cenozoic Lower Tagus Basin resulted from the Neogene tectonic inversion.

The IM is considered the stable continental zone of Iberia (e.g. Johnston, 1989), whereas both northern and southern Iberia suffered an intense crustal deformation. This deformation, the Alpine orogeny, was the result of the compression between African–Iberian plates leading to the generation of the Pyrenean and the Betics belts.

The Betic Range is the northern segment of an arc-shaped mountain belt being across the Gibraltar Strait and continuing south up to the Rif Chain in northern Africa. Crustal thicknesses under the Betic-Rif orogenic system are approximately 25 - 35 km. At the External Zones of the Betic Range, maximum crustal thickness up to ~ 46 km (e.g. Mancilha and Diaz, 2015). To the north of External Betics, the foreland Guadalquivir basin stands on the southern boundary of the Iberian Massif. The crust in this area thins to ~27 km. Northwestern Morocco, beneath the Rif Mountains, the crust is very thick exceeding ~50 km.

Off-shore SW Iberia, the Mesozoic is also marked by the Central Atlantic, Tethyan and the North Atlantic rifting episodes. While, in the Cenozoic is related to the propagation of the subduction zones from the western Mediterranean, through slab roll back and the origin of the Gibraltar Arc. The region is subdivided into different geologic domains according to the lithospheric affinity (e.g Martínez-Loriente et al., 2014) and the thickness of the sediments layer. These two criteria are fundamental to the interpretation of our study.

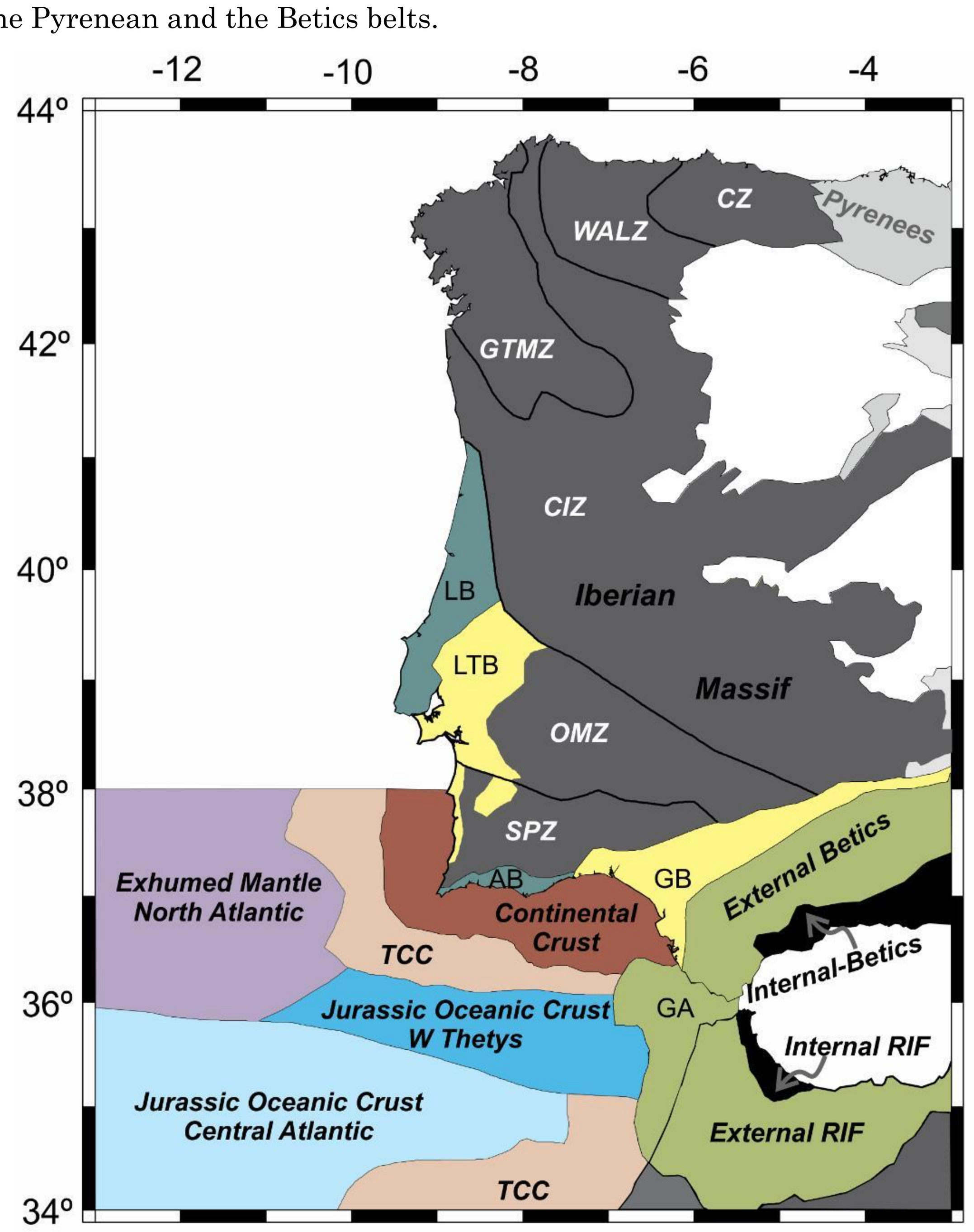

Figure 2. Geotectonic map of the study area.
CZ- Cantabrian Zone, WALZ-West Asturian Leonese, Zone GTMZ- Galicia Trás-os-Montes Zone, CIZ- Central Iberian Zone, OMZ- Ossa-Morena Zone, SPZ- South Portuguese Zone, LB- Lusitanian Basin, LTB- Lower Tagus Basin, AB-Algarve Basin, GB-Guadalquivir Basin, GA-Gibraltar Arc, TCC-Thinned Continental Crust.

4. Regionalization

We consider that the coda observations are the result of the interaction of the S waves with scatterers and wave paths that surround the hypocentre and the seismic station. This allow us to obtain a geographical and continuous distribution of coda-Q parameters. Given the density of data and the area covered by our study we decided to use a regional grid with 0.5°x0.5° cell size.

Let's consider that the index (i) identifies the cell in the studied area and $Q_{j,AV}$ identifies the coda-Q measurement (j), N in total. The purpose of regionalization is to fill the geographical grid with coda-Q values (Q_i) using the observation constrains. If A_{ji} is the area that cell (i) is estimated to influence observation (j), then we may compute the regionalized value of coda-Q for cell (i) as the weighted average

$$\frac{1}{Q_i} = \frac{\sum_{j=1}^{N} \frac{1}{Q_{j,AV}} \frac{A_{ji}}{A_{j,TOT}}}{\sum_{j=1}^{N} \frac{A_{ji}}{A_{j,TOT}}}$$

We consider that coda-q is the result of multi-scattering involving an eliptical area surronding the epicenter and the station. The eliptical area limits are computed assuming 3.45 km/s for the S-wave velocity and a total propagation time of 45 s.

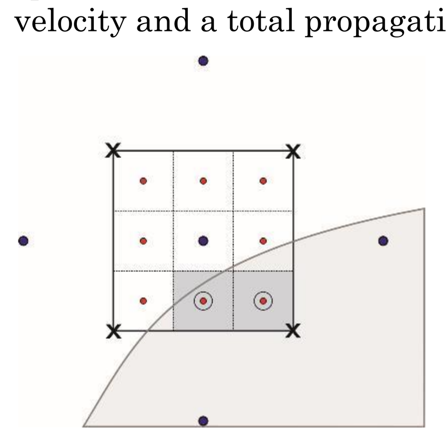

Figure 4. Blue dots are the main grid cell centres. The corners of one cell are identified by crosses. Each cell is divided into 9 sub-cells with centres identified by red-dots. The large light blue area represents the scatterers influence domain as computed under the 2D model and simplifying assumptions described above. The influence area for this geometry is computed by summing the areas of the 2 sub-cells with centres inside the scatterers influence domain, here identified by the open circles (2/9 of the main grid cell area in this example).

5. Inversion

Q calculation can be linearized by the following system of equations

$$a_{j1}x_1 + \cdots + a_{ji}x_i + \cdots a_{jn}x_n = b_j \qquad j = 1, \cdots, N$$

Where: $x_i = \frac{1}{Q_i}$ $\quad a_{ji} = \frac{A_{ji}}{A_{jTOT}}$ $\quad b_j = \frac{1}{Q_{j,AV}}$

The system of linear equations can be expressed in the matrix form as

$$AX = b$$

The system is over-determined and sparse, meaning that most of the equations will have only a few non-zero coefficients. To solve this set of linear equations we used the MATLAB package AIR Tools II by Hansen and Jørgensen (2018).

7. Conclusions

- The data using OBS observations near the mainland show similar offshore results as the adjoining continent. Low Q was obtained to the west, where the crust is very thin or absent.
- The distribution of high and low Q areas is similar to earlier studies, however, with more details than the earlier coda Q studies.
- Tectonics more than Moho depth seems to be the main factor in variation in Q.
- Using regionalization and inversion techniques, a resolution 0.5°x0.5° was possible, which is similar to the Lg tomography study. Coda Q studies can therefore be used as a simple tool to study detailed regional differences in attenuation.

References

Grevemeyer et al. 2016. Mantle earthquakes beneath the South Iberia continental margin and Gulf of Cadiz – constraints from an onshore-offshore seismological network. J. Geodynamics, 99, 39-50
Grevemeyer et al. 2017. Seismotectonics of the Horseshoe Abyssal Plain and Gorringe Bank, eastern Atlantic Ocean: Constraints from ocean bottom seismometer data. JGR, 122, 63–78
Hansen & Jørgensen 2018. AIR Tools II: algebraic iterative reconstruction methods, improved implementation. Numerical Algorithms, 79(1), 107-137.
Havskov et al. 2016. Coda Q in different tectonic areas, influence of processing parameters. , 106(3), 956-970
Mancilla & Diaz 2015. High resolution Moho topography map beneath Iberia and Northern Morocco from receiver function analysis: Tectonophysics, 663, 203–211.
Martínez-Loriente et al. 2014. Seismic and gravity constraints on the nature of the basement in the Africa-Eurasia plate boundary: New insights for the geodynamic evolution of the SW Iberian margin. JGR, 119, 127–149.