Establishing a relationship between S-wave velocity, geothermal gradient and thermal conductivity for the Iberian Peninsula and surrounding areas

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1 Introduction

Thermal conductivity (k) determine the rate of heat transport by conduction from the lithosphere to the surface. Heat flow (HF) in the surface is related to the thermal gradient (grdT) and thermal conductivity in steady-state by the Fourier Law,

$$q = -k * grdT$$

where, q represents the surface heat flow, k is the thermal conductivity and grdT is the thermal gradient.

When modelling thermal data, k is usually given as a fixed value in the range of (2.5 to 5 W m^{-1} K^{-1}), where 2.5 W m^{-1} K^{-1} and 3.2 W m^{-1} K^{-1} are the typical values assigned to the crust and mantle respectively. Measurements of k are restricted to shallow layers of the crust, are discrete, and often do not illustrate correctly its depth and lateral distribution.

Can we estimate the thermal conductivity of the Iberian Peninsula?

2 Data

Data used in this study is calculated in acordance to the depth of the Curie isotherm (CDP) (Andrés et al., 2017). Thus, the data is refered to a layer of heterogeneous thickness. For onshore areas the CDP is allways above the Moho. For offshore areas, it is almost allways below the Moho, so upper mantle is included.

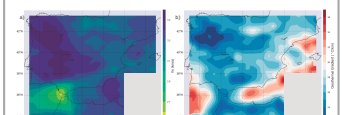
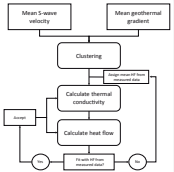


Figure 1. a) mean S-wave velocity from Palomeras et al. (2017); b) mean geothermal gradient from Andrés et al. (2017).

3 Methodology

The proposed methodology (Fig 1) is based on determining a k map from the correlation between V_s map and grdT map determined by calculating the depth of the Curie isotherm for the Iberian Peninsula.



- The data is cross-ploted (Fig. 3), and a statistical classification method based on a non-supervised algorithm, the expectation-maximization (EM) algorithm is used to classify populations within the cross-plot (Fraley et al. 2002) (Fig. 3). The liniear regressions of each population is the relationship between thermal gradient and thermal conductivity.
- Calculate k assigning a known mean HF value for each area
- Calculate the HF from the calculated k and grdT
- Calculate differences between calculated HF and observed HF and iterate until the minimum misfit is obtained.

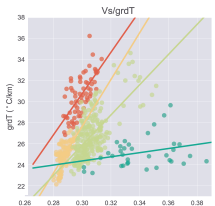


Figure 3. Cross-plot of Vs and grdT with colored populations and linear regressions overlapped.

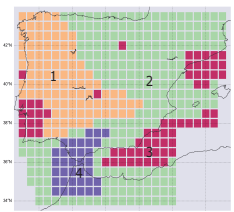


Figure 4. Map of distribution of clusters. Geographically, the populations correspond with different tectonic domains in Iberia. 1. Variscan domain, 2. Alpine domain, 3. Mediterranean, 4. Gibraltar Arc.

4 Results

- Differentiation between the Variscan domain, values above 2.8 W/mK with maximums up to 3.2 W/mK, and the Alpine domain, mean value of 2.6 W/mK (Fig. 5).
- Offshore areas have values up to 3.6 W/mK with mean value of 3 W/mK.
- Gibraltar Arc region presents very low values between 1.4 W/mK and 2.4 W/mK, with and average thermal conductivity of 2 W/mK.

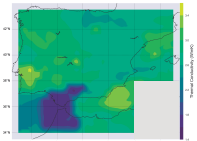


Figure 5. Mean thermal conductivity calculated.

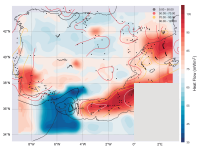


Figure 6. Calculated HF with overlapped observed HF.

- Good fit between calculated and observed HF offshore and onshore despite the poor coverage inland (Fig. 6).
- Gibraltar Arc abrupt change is captured
- Mean misfit of ~5 mWm^{-2} and standard desviation of 18,90.
- Small wavelenght anomalies cannot be captured, thus the results.

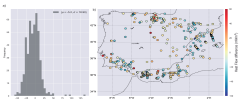


Figure 7. Differences between observed and calculated HF. a) Histogram of the differences, b) plot

5 Conclusions and future work

- Differentiation between different tectonic domains.
- Methodology sensitive to inclusion of upper mantle.
- Good aproximation for lateral distribution of thermal conductivity at a regional scale.
- Prior knowledge of HF is needed as input. Bad response to small wavelenght signals.
- In future work we aim to include seismic attenuation in the methodology to better constrain lateral variations.

Anknowledgements

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