Rayleigh Wave Dispersion and Anisotropy in the Tyrrhenian Sea

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Abstract

This study aims to extend our knowledge of the velocity structure and seismic anisotropy for Italy and the Tyrrhenian Sea by measuring interstation Rayleigh wave dispersion using seismic data from stations surrounding the region of interest (green triangles, Fig.1). Results allow us to infer a depth dependence for the anisotropy (Fig.2), and thus complement the interpretation of splitting measurements (Fig.4). Additionally, the 3D shear-wave velocity structure images a strong low velocity layer confined to a depth of around 80 km (Fig.3). The areas of low velocity are in good agreement with recent volcanism (Fig.5).

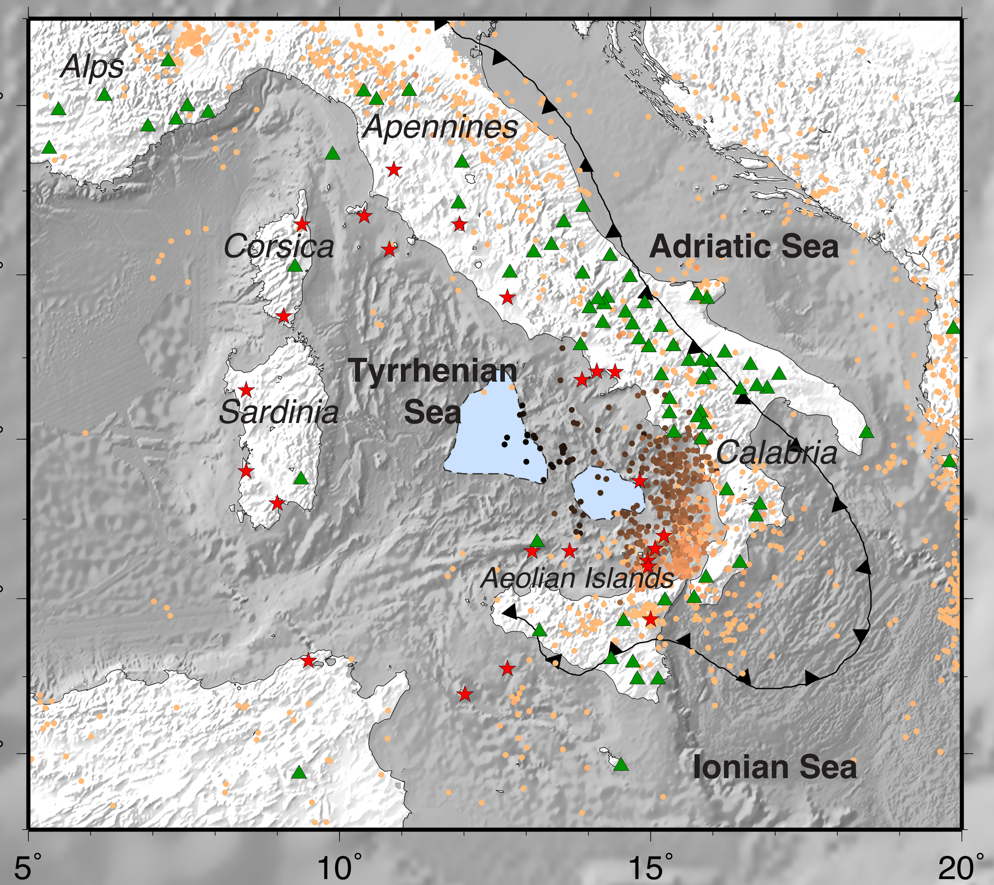

Figure 1

Subduction in the Mediterranean has a long and complex history of eastwards migration across the western Mediterranean Sea. At present, the Ionian slab subducts actively under southern Tyrrhenian Sea, as indicated by a deep, narrow Benioff zone (seismicity indicated as brown dots) and volcanism of the Aeolian Islands (red stars). Further north, the Calabrian slab is possibly stagnant, but still subject to active volcanism. In contrast, non-orogenic volcanism is observed on Sardinia. The two basins in the Tyrrhenian Sea are indicators of backarc extension.

Anisotropic Phase Velocity Maps

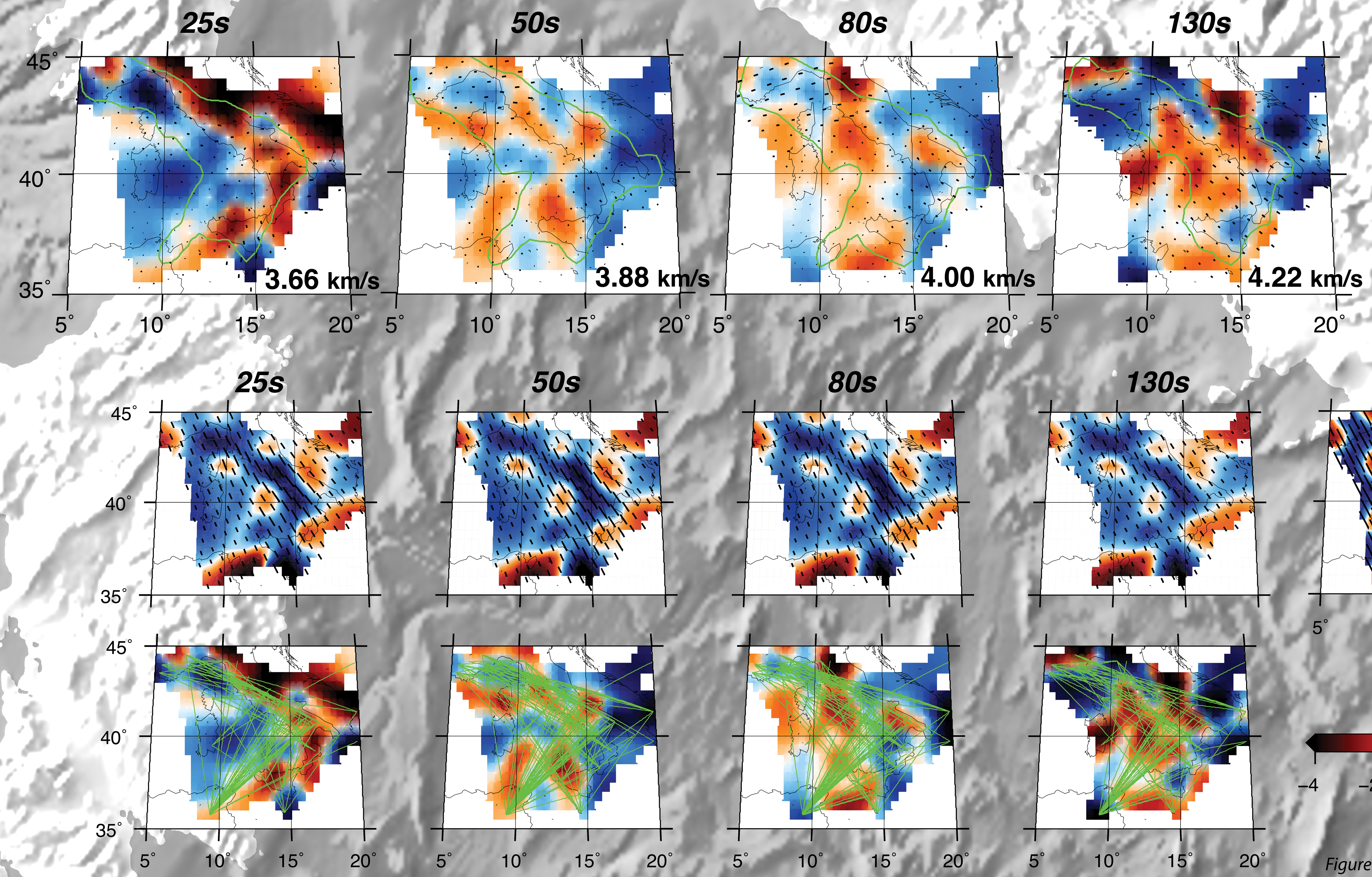

Figure 2

Phase velocity maps (Fig.2) are obtained from the inversion of up to 127 high quality, averaged interstation phase velocity curves from 77 stations. We applied sufficient smoothing and damping in order not to over-interpret non-stable results (1. row). Resoltion tests (2. row) show the areas of good recovery. They coincide with the aeras of good ray path coverage (3. row). The isotropic pattern (colours) reflect the heterogeneous structures used as input for the shearwave velocity inversion (Fig.3). Anisotropy is small for shallow regions (25s, 50s), but becomes more aparent around 80s with E-W fast orientations in the northwestern part. Even deeper (130s) NW-SE fast orientations define the rest of the resolved study area.

3D Shear-wave Velocity Structure

The inversion for isotropic shear-wave velocity images the 3D distribution of heterogeneities relative to AK135 (Fig.3). The most striking observation is a strong low velocity layer at about 80 km depth. It covers the backarc region of the Calabrian and Ionian arc, the islands of Sardinia and Corsica and the onshore parts of Italy.

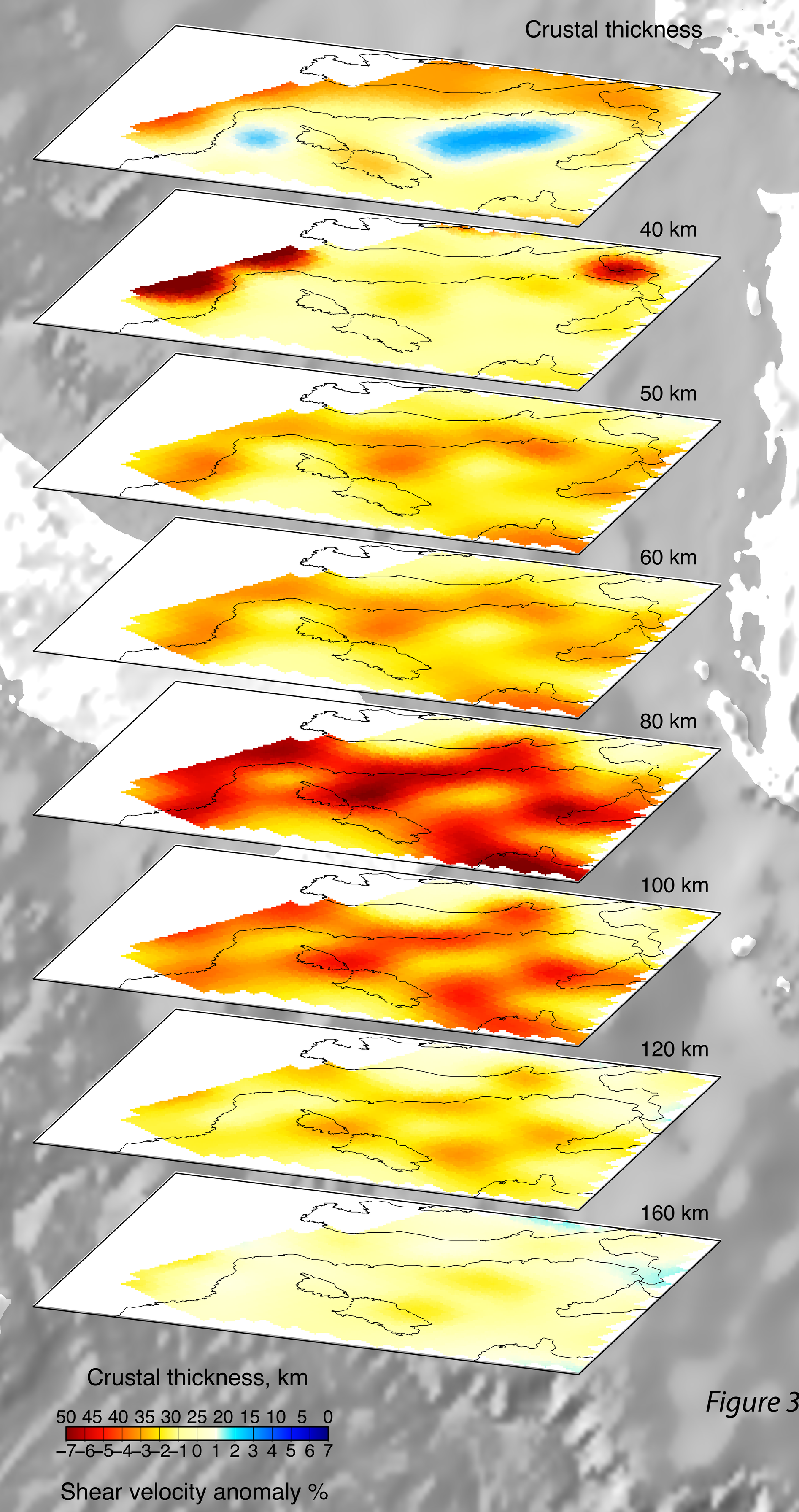

Figure 3

Mantle Anisotropy

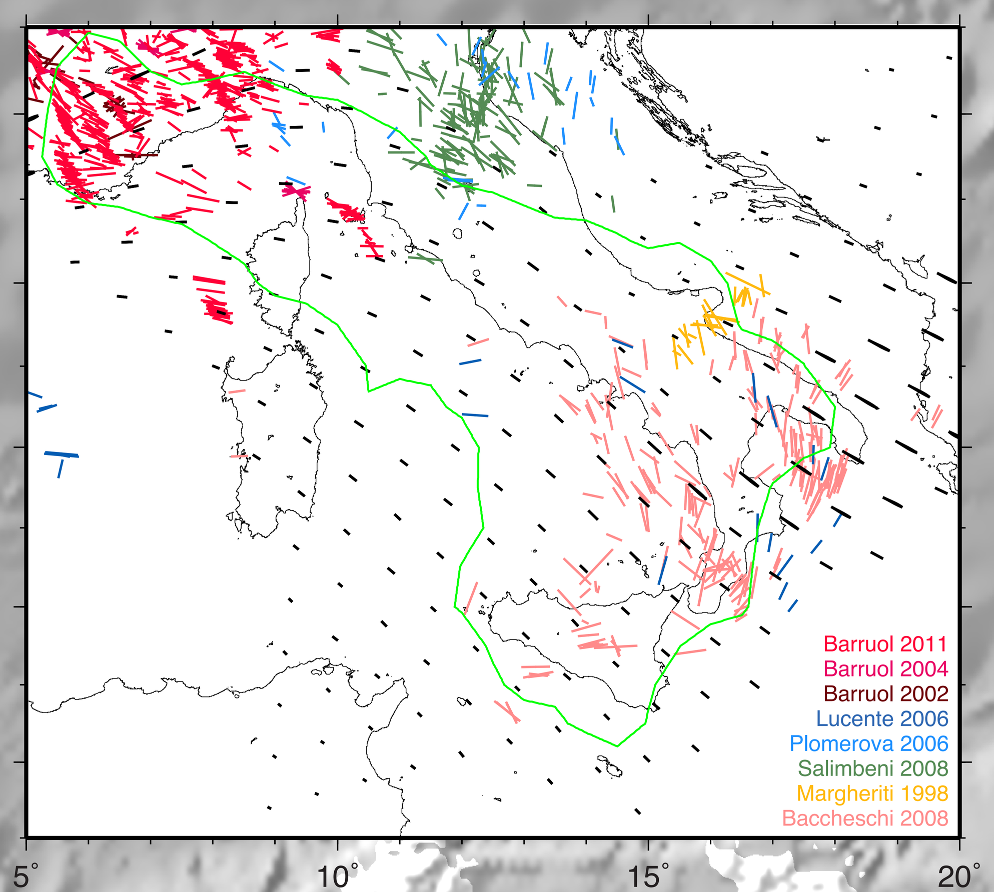

Figure 4

A large amount of teleseismic SKS splitting measurements from various studies and deployments are available for mainland Italy (Fig.4, color bars). Comparison with fast orientations from 130s surface waves (black bars) shows a good first order agreement and suggests that the main source of anisotropy lies below the lithosphere. We can distinguish two main anisotropic areas:
1.) Southern Italy and Sardinia with NW-SE fast orientations and 2.) Northern Apennines and the area north of Sardinia with more East-Westerly fast orientations.

Interpretation

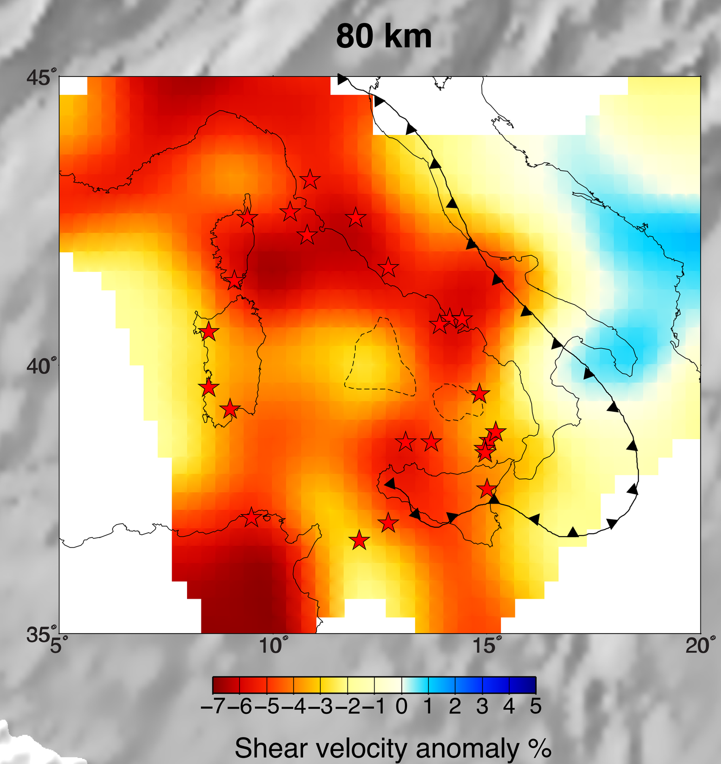

Figure 5

The areas with strong low velocity anomalies coincide with areas of recent orogenic and non-orogenic volcanism (Fig.5). In backarc regions melting reactions take place in depth down to 100 km. Below the islands of Sardinia/Corsica, non-orogenic volcanism is linked to decompression melting of the slab lying on the 660 km discontinuity (Raddick 2002, Beccaluva 2011). The concentration of the velocity anomaly around 80 km can be caused by the thicker lithosphere in these regions. Moreover, the uplift associated with the upward flux is reflected in residual topography, which shows a good correlation with the low velocity regions.

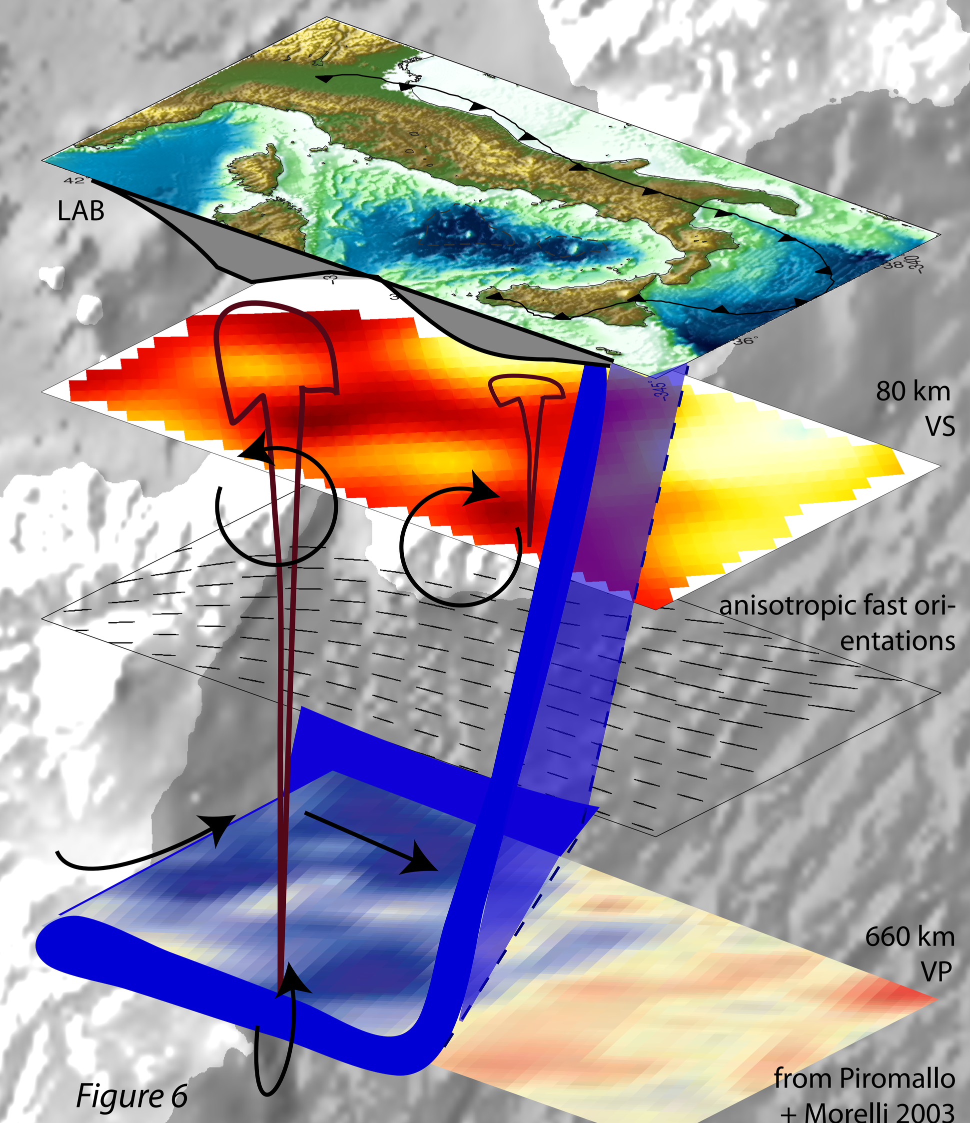

Figure 6

Summary

- The strong low shear-velocity anomaly confined to about 80 km depth is ascribed to arc volcanism mainland Italy and offshore southern Italy and to decompressional melting initiated by mantle upwelling around the edge of the ponding slab below Corsica
- Anisotropy is mainly located below the lithosphere with E-W orientations in the North related to toroidal flow around the western Alpine slab and NW-SE orientations in the South due to flow normal to the retreating Ionian slab
- Shallower parts show low anisotropy attributed to mantle upwelling/uplift and small scale convection

Acknowledgements

We use publicly available data from the following networks: Geofon, Midsea, Retreat, Mednet. Thanks to Bill Fry, Laslo Evers and Gert-Jan van der Hazel for help with retrieving data. Processing is largely based on codes developed by Sergei Lebedev and Thomas Meier. The research leading to these results has received funding from Crystal2Plate, an FP7-funded Marie Curie Action under grant agreement number PITN-GA-2008-215353