Geophysical Research Abstracts
Vol. 14, EGU2012-8968, 2012
EGU General Assembly 2012

Anisotropy of the upper mantle beneath the Northern Apennines based on data from the passive seismic experiment RETREAT (Italy)

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Active orogeny in the Northern Apennines relates to the collision of the Tyrrhenian plate and the westward-subducting Adriatic plate, accompanied by an eastward retreat of the trench. To explore the upper mantle structure, we evaluate body-wave anisotropy from data recorded during the passive seismic experiment RETREAT (2003-2006). We measured arrival times of teleseismic P waves and analyzed lateral variations of directional dependences of P-wave travel-time deviations, i.e. pattern of P spheres, showing directional terms of relative travel-time residuals. To create self-consistent anisotropic models of the upper mantle, we also take into consideration variations of polarization azimuths of the fast split SKS waves (Salimbeni et al., Tectonophysics 2008).

According to signatures of P-wave anisotropy, the upper mantle beneath the Northern Apennines can be divided into several domains. A consistent bipolar P-sphere pattern was found in the Tyrrhenian region. In the Adriatic region, we delimited two domains with slightly different P-sphere patterns, but both reversed relative to the pattern in the Tyrrhenian province. Between the Adriatic and Tyrrhenian regions, approximately one half of the stations form a transitional zone characterized by no or a weak P pattern.

Detected splitting of core-mantle refracted shear waves proved anisotropic structure of the upper mantle beneath the Northern Apennines. We observe both geographical and azimuthal variations of the fast shear-wave polarizations, which differ in individual provinces. In the Tyrrhenian region, the NW-SE polarization azimuths prevail independently of back-azimuths, while in the transition and in the Adriatic region, the polarization azimuths show a large variability with event back-azimuths. Moreover, at least two different dominant polarization azimuths exist for the waves propagating from the East to the Adriatic domains, which can be associated with anisotropy both in the lithosphere and in the sub-lithospheric mantle. In the whole region, the polarizations probably related to the mantle flow rotate clock-wise from the western coast through the transition zone to the eastern coast.

We associate the laterally varying anisotropic signal in the Adriatic region predominantly with changes of fabric of the continental Adriatic lithosphere (Plomerova et al., EPSL 2006). Smoothly varying fast shear-wave polarizations beneath the Tyrrhenian plate, which is thinner than the Adriatic one, could be associated with preferred orientation of olivine due to a flow in the sub-lithospheric mantle. Nevertheless, the nearly trench parallel fast-shear polarizations suggest a slab-parallel flow instead of a slab-perpendicular flow, which is expected in the extensional zone. Mantle lithosphere fabric in the Tyrrhenian plate seems to be detected only in the anisotropic parameters of P waves indicating easterly dipping high velocities there.

To evaluate effects of well-known trade-off between anisotropy and heterogeneity, represented here by the high-velocity subducting Adriatic slab, we calculated synthetic P spheres for the most recent tomographic model of isotropic velocity perturbations in the upper mantle beneath the Northern Apennines (Benoit et al., G3 2011). It is evident that the P patterns evaluated from the RETREAT data cannot be explained by heterogeneities and have to be associated with anisotropic wave-propagation.