Topographic Imaging of European Mantle Plumes
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Summary

Recent numerical experiments based on tectonically realistic formulation for the lithosphere and representative mantle rheology, have shown that plume-induced undulations exhibit temporal successions of uplift and subsidence at various wavelengths. From spectral (Fourier) analyses of undulations, it appears that there are two groups of wavelengths (200-400 km and 60-100 km) present. Interestingly, a spectral analysis of Europe's topography also reveals two dominant groups.

To discriminate between tectonically-induced undulations (uni-directional deformations) and plume-induced undulations (omni-directional deformations), we use a spectral analysis with a wavelet formulation. The European lithosphere is well suited for this approach since it has been suggested that two mantle plumes (the Massif Central and the Eifel area) underlie Western Europe, where Alpine compression has folded the lithosphere over several hundreds of kilometers.

The laboratory analysis of Europe's surface topography confirms that energy distribution of the topographic undulations outside the main volcanic areas is homogeneous, thus contrasting with the large-scale and medium-scale high-energy features that are obtained for the Massif Central and Eifel areas. Similar signatures are also found beneath the northern Sudetes area.

The shape of these mantle plumes is characterized by high-energy coefficients at medium-scales. Computed topographic undulations, and their wavelet transforms, using the Mexican hat and the Morlet wavelets, are identified at medium-scales (white ellipses). The topography obtained in numerical results resembles the Mexican hat curve. The wavelet analyses with the Morlet wavelet yield too many high-energy coefficients. Wavelet analysis with the Mexican hat wavelet yields fewer high-energy coefficients and an apparent regional trend attributed to anomalous mantle plumes.

Numerical investigation of plume-lithosphere interaction, as initially performed by Guillou-Frottier & Jaupart (1995) following Burov & Guillou-Frottier (2005), is considered here. Two « plume Rayleigh numbers » are used to study the influence of the plume's temperature contrast and the heat flux through the lithosphere on the topographic evolution. Results are displayed in the form of cross sections along 39 profiles on the map. Large and small wavelengths topographic profiles are used to compare undulations in mantle plumes in Europe. Profiles are also compared with similar profiles in other geographic areas.

TOPOGRAPHIC PROFILES IN WESTERN EUROPE
Analysis of dominant wavelengths (Fourier transforms)

LABORATORY EXPERIMENT (Guillou & Jaupart, 1995)

NUMERICAL EXPERIMENT (Burov & Guillou-Frottier, 2005)

Massif Central Area, France

Eifel Area, Germany

Numerical simulation of plume-lithosphere interaction, with the upper surface, and a tectonically realistic formulation for the lithosphere...

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References