

**Elastic and Viscous Anisotropy in Earth's mantle –
Observations and Implications**

by

Einat Lev

Submitted to the Department of Earth, Atmospheric and Planetary Science
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Abstract

In this thesis I address the topic of anisotropy – the directional dependence of physical properties of rocks – from two complementary angles: I use seismic anisotropy to detect deformation in the mantle, and I demonstrate the importance of accounting for rheological anisotropy in mantle flow models.

The observations of seismic anisotropy in the Earth's interior allow geophysicists to probe the direction and mechanism of deformation, through the detection of lattice- and shape-preferred orientation and the derived elastic anisotropy. I capitalized upon this property when I investigated the deformation of the mantle underneath Eastern Tibet and compared it to the surface and crustal deformation. This work revealed an intriguing regional variation, hinting a change from north to south in the processes controlling the deformation of this complex region.

Preferred orientations in rocks can change the rheology and lead to anisotropy of viscosity, a property often ignored in geodynamical modeling. I included anisotropic viscosity in a number of test flow models, including a model of shear in the upper mantle due to plate motion, a model of buoyancy-driven instabilities, and a model of flow in the mantle wedge of subduction zones. My models revealed that anisotropic viscosity leads to substantial changes in all the flows I examined. In the upper mantle beneath a moving plate, anisotropic viscosity can lead to localization of the strain and the extend of power-law creep in the upper mantle. In the presence of anisotropic viscosity, the wavelength of density instabilities varies by the orientation of the anisotropy. The thermal structure and melt production of the subduction zone mantle wedge changes when anisotropic viscosity is accounted for. It is thus crucial that geodynamical flow models are self consistent and account for anisotropic viscosity.

Thesis Supervisor: Bradford H. Hager

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