

Project Summary. Long-period surface wave studies have reached a level of fidelity and spatial resolution that has allowed them to contribute in striking new ways to understanding the geodynamics of the lithosphere and asthenosphere. Yet in some cases, the results of surface wave studies are hard to reconcile with other types of geophysical studies and especially with results from shorter-period body waves. Some areas of particularly important disagreement include the velocity gradient in the lithosphere, the depth and intensity of the Low Velocity Zone and the magnitude, direction and depth-dependence of anisotropy. The working hypothesis of this proposal is that many of these differences result from the different ways these two different types of seismic waves, which have period ranges differing by one-to-two orders of magnitude, average small-scale heterogeneity in the earth. This hypothesis is based on results from effective medium theory, which indicates that the “average” properties of the heterogeneous earth should be strongly frequency-dependent. The proposed approach to this problem is through modeling the effect of small-scale heterogeneity on both surface and body wave propagation using a synthetic seismogram method (due to Chesnokov) that explicitly represents the earth in terms of a large-scale deterministic part and a small-scale statistical (or “stochastic”) part (described by correlation functions). A key question is whether models can be found that are “realistic” in the sense of being compatible with what little is known about small-scale mantle heterogeneity, and which reconcile the disagreements alluded to above. The degree to which these models predict anisotropy of attenuation – in our opinion an underutilized seismic observable - will also be examined, and existing databases (e.g. by Dalton & Ekstrom) will be examined for evidence of anisotropy of attenuation in surface wave data.

Intellectual Merit. This proposal is focuses on understanding the structure of the lithosphere and asthenosphere, parts of the earth that central to many geodynamic processes (e.g. convection, melt production). One goal is to reconcile two different communities’ – surface wave and body wave - view of the structure of this region; another is to derive models of small-scale structure that relate to those geodynamic processes. The results are thus likely to be integrative, that is, to bring together what are currently disparate interpretations of earth structure.

Broader Impacts. The effective medium methodology that we are proposing to apply to lithosphere/asthenosphere problems is now quite widely used in exploration geophysics to understand the how small scale heterogeneity affects seismic wave propagation at the scale of a single sedimentary basin or petroleum reservoir. The collaboration that we are proposing here brings together a group with extensive knowledge of that methodology with a group with a long tradition of studying global seismological problems. The synergy will allow us to approach global problems in a new way.