Probing Earth’s Depths

Deep below our feet, the Earth is alive. Beneath the crust, the section of the earth known as the mantle is slowly moving. Heat differences in the mantle cause the hotter rock to rise and the cooler rock to sink, much like the convection of boiling soup. The fact that the mantle is still solid rock means that it takes millions of years for it to move large distances. Yet, this flow is important to understand, because it is the major driving force for plate tectonics. A better understanding of mantle flow will produce a better understanding of plate motion and interaction within the plates.

Since the mantle is far out of reach from most direct measurements, scientists must turn to other methods to get a picture of what goes on below. One method, which is being pursued by Rutgers Professor Vadim Levin and undergraduate researcher Brandon Schow, is seismic anisotropy. Some waves from distant earthquakes will travel down through the core and then follow a near-vertical path up through the rock in the mantle, and be picked up by seismometers. The idea behind seismic anisotropy is that seismic waves will travel different speeds depending on how the wave is aligned with the crystal grains of the rock it is passing through. If the crystals are randomly aligned, the effects of this is negligible. However, if the crystals are aligned, which can happen due to mantle flow, it will cause the seismic wave to split into two different waves, one traveling faster than another. This can be analyzed on the seismograph, and the direction of splitting can be obtained.

One of Schow’s jobs is to try to better understand if mantle flow determines the fast splitting direction for signals received in Quebec, or if there is a contribution from the crust. This crustal contribution would be due to old mantle which has been aligned in a direction different from current mantle flow, then “frozen” on to the bottom of the crust. In order to investigate this, Schow has made splitting measurements on stations in Quebec, as well as collecting data from numerous pre-existing measurements in the area.

Schow is planning on comparing this data and making observations based on comparisons with whole-earth mantle flow models developed by Professor Alessandro Forte, from the University of Quebec at Montreal. The parameters of this model can be used to predict seismic anisotropy. Once this prediction is made, the door is open to many more questions. For example, do the mantle flow models correctly predict the seismic anisotropy? If not, is it due to crustal contribution or error in the models? On top of this, the models predict different splitting directions at different depths. Because of this, Schow will also attempt to investigate the actual presence of multiple layers of anisotropy.
Illustration 1: Four splits in Eastern Canada and figure showing the locations of earthquakes which provided data