A joint geophysical investigation of the Cascadia subduction system using data from dense arrays of passive seismic and magnetotelluric stations

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Abstract:

Joint analyses that combine multiple geophysical methods can yield improved characterization of the subsurface over that acheived by single methods. Here, we investigate the Cascadia subduction zone using dense seismic and magnetotelluric (MT) data sets collected along three profiles, each roughly perpendicular to the strike of the dipping slab at that location. (figure 1)

We present images generated by 2-D Generalized Radon Transform (GRT) inversion of scattered teleseismic data, along with results from 2-D Non-Linear Conjugate Gradient (NLCG) inversion of roughly collocated MT data. The seismic and MT images in A-A’ and the seismic image in C-C’ have been previously published, but the MT image in C-C’ and both images in B-B’ represent new work in various stages of completion.

The migrated seismic image for B-B’ (figure 2a) clearly shows the subducted oceanic crust as a dipping low velocity layer that persists to ~40-50 km depth. It also depicts the region within which eclogitization is taking place, along with a disrupted continental Moho that may be weakened by serpentinization and weakened fluid phases within the underlying mantle wedge. The collocated MT image (figure 2b) shows highly resistive features corresponding to sections of the subducted slab. There are also conductive features associated with the release of fluids during eclogitization as well as fluids/partial melt within the mantle wedge that appear to be linked with the volcanic arc.
The real strength of this approach comes into play when we not only use both the seismic and MT methods to constrain one another, but also look at how the interpretation varies along strike. All three profiles show conductive regions associated with both eclogitization and fluid/melt phases in the mantle coincident with disruption in the Moho. There are also some potentially important differences between the profiles, such as a strong resistive feature present between these two conductors in A-A’ and B-B’, but not in C-C’. This resistor could be indicative of a decoupling of the tip of the mantle wedge, a cooling, serpentine saturated region that affects fluid pore pressures upstream and fluid release downstream. It may be a glimpse into the reason why C-C’ is the only line of the three along which earthquakes are very rare. This sort of combination of techniques and use of multiple along strike images promises much insight into the nature of subduction settings, and speaks to the value of large-scale data collection projects such as Earthscope.

Figure 1: Map of the Cascadia region showing the three primary transects, plate boundaries, the volcanic arc, and earthquake activity

Figure 2: GRT migration (top) and NLCG MT inversion (bottom) for the B-B’ transect across central Washington

References: