Subduction potential at the eastern margin of North America

Suzan van der Lee, Klaus Regenauer-Lieb, Dave Yuen, S. Mark Wang

Inferring the processes in and dynamics and evolution of Earth’s interior is crucial for predicting how earthquake and volcanic activity will change in time and space. Three-dimensional models of S-velocity beneath North America combined with numerical modeling shows that large-scale lithospheric faulting associated with subduction zones, can develop when the lithosphere is wet. Dry lithosphere such as that of the Atlantic Ocean thus needs to be hydrated to allow a new subduction zone to form on the US East coast. However, numerical modeling shows that a supra-lithospheric ocean cannot sufficiently hydrate the lithosphere and hence the source of hydration must come from below. The hydrous dike-shaped upwelling discussed above is the perfect candidate for such hydration and subsequent initiation of subduction. Under the sediment load off the US east coast the hydrated lithosphere will yield and can form a shear zone that cuts across the entire thickness of lithosphere. A new subduction zone is so initiated, up to half a billion years after a former subduction process provided the necessary ingredient, H2O.

In the context of this abstract and many others, we are excited about the enormous amounts of new data that will be forthcoming in the next dozen years from the USArray. This data will both revolutionize the resolution with which we can image upper mantle structure at the eastern continental margin, and allow for potentially associated seismic activity to be monitored more closely. Arriving at the east coast, USArray might show us the driving mechanism for the Wilson Cycle.

S-velocity models for the North American upper mantle show a giant dike of S-velocities about 0.1 km/s slower than the average upper mantle. Of temperature or relative content of iron, silicon, carbon dioxide, and water, we deem the latter the most likely explanation for the unusual S-velocity anomaly. Resolution tests, based on a recent set of over a thousand wave trains of continent-wide S and surface waves, show that the shape of the anomaly is resolved. However, S-velocities in the transition zone are underestimated. The low-velocity dike connects to a weak low-velocity zone at the top of the upper mantle in Grand’s model (2001). The giant dike is east of and parallel to the Appalachians and to the strike of the Farallon slab in the top of the lower mantle (Grand, 2000). The dike most likely represents an upwelling. Past dehydration of subducted Iapetus lithosphere or more recent dehydration of the subducted Farallon plate are potential sources for the inferred wet rock in the low-velocity dike.

Figure: Anomalous S-velocity in the North American upper mantle from seismic-tomographic imaging (upper mantle from Van der Lee, 2002, and lower mantle from Grand, 2001) using S, multiple S, and surface waves. The upper-mantle column of low-velocity anomalies beneath the eastern continental margin presents a side view of the giant low-velocity dike.