Mantle dynamics, lithospheric structure, and topographic evolution of the southeastern US continental margin

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The surface geology of the eastern United States is extraordinary in its complexity. This complexity reflects a wide range of tectonic processes that have operated in the region over the past billion years, including episodes of subduction and rifting associated with two complete cycles of supercontinent assembly and breakup. A record of these processes is preserved in the geological units and topography we see at the surface today. It is unknown, however, how the crust and mantle lithosphere have responded to these tectonic forces over time, and whether and how the geological units preserved at the surface relate to deeper structures. The persistence of Appalachian topography through time remains a major outstanding problem in the study of landscape evolution. There is an ongoing interplay among erosion, topography, rock type, and mantle flow at depth that controls the structures we see at the surface today. However, understanding the complex role played by each of these factors requires better constraints on the history of topographic change and its relationship to the deep structure and dynamics of the mantle.

Recent results from pilot projects in the southeastern US have motivated the upcoming Mid-Atlantic Geophysical Integrative Collaboration (MAGIC) project. MAGIC aims to address fundamental questions about the geophysical evolution of the eastern United States by studying surface processes, crustal and lithospheric structure, and deep mantle flow across Virginia, West Virginia, and Ohio. We plan a two-year deployment of 28 broadband seismometers in a dense linear transect from the Atlantic coast to the continental interior. In combination with EarthScope USArray Transportable Array (TA) stations our experiment geometry will provide an opportunity to image isotropic and anisotropic crust and mantle structure from the coast to the continental interior in unprecedented detail. Our geodynamical modeling effort will focus on quantitatively testing several different hypotheses for the pattern of mantle flow by using 3-D, time-dependent, numerical models to make testable predictions about mantle anisotropy and surface topographic change, which will be tested against results from the seismology and geomorphology components of the project. The geomorphology work will use quantitative stream profile data and cosmogenic isotopes to understand the history of erosion rates and topographic change throughout the Appalachian region. Insight from all three efforts will be combined to obtain a vertically integrated picture of tectonic processes from the surface through the crust and mantle lithosphere to the asthenosphere and deeper mantle.