Evolution of continental crust through two Wilson cycles in ENAM
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The continental crust of eastern North America, the birthplace of the concept of the Wilson cycle (Wilson, 1966), has undergone two cycles of supercontinent assembly and breakup since the Mesoproterozoic. EarthScope research presents opportunities to improve understanding of tectonic inheritance from the Grenville orogen (assembly of Rodinia), though Neoproterozoic supercontinent breakup and opening of Iapetus, to Paleozoic Appalachian orogenesis and assembly of Pangaea, and subsequent Mesozoic breakup of Pangaea and opening of the Atlantic. The results of these large-scale events are and have for >2 centuries been the focus of studies of outcrop and shallow subsurface geology; now EarthScope can investigate fabrics and heterogeneities of these events in the deeper crust and mantle lithosphere. Although the problems to be addressed are regional in scope, focused studies, using Transportable Array (TA), Flexible Array (FA), and GeoPRISMS research in selected transects and areas, are needed to illuminate the geometry and spatial distribution of lateral and vertical variations in thickness and strength of continental crust and lithosphere, and overprints of successive events.

Discovery of the lithospheric geometry of the successive major constituents of eastern North America will form the basis for understanding fundamental processes. This margin offers opportunities to test two fundamental hypotheses: (1) during continental rifting, brittle faulting of the upper crust is linked to ductile extension of the continental lower crust and mantle lithosphere; (2) transform motion is expressed in brittle faults in the upper crust and by linked ductile transform-parallel fabrics in the mantle lithosphere. First characterizing the lithospheric structure of the Iapetan rift margin, the Appalachian orogenic belt, and the Mesozoic rift margin will support testing of other hypotheses: for examples, (1) rift-stage structures significantly influence subsequent orogenic structures and foreland-basin evolution; and (2) continental fabrics of earlier events of extension and contraction exert controls on Mesozoic rift structures.

Reconstructing the geometry of the Neoproterozoic Iapetan rifted margin of Laurentia is fundamental to understanding the role of tectonic inheritance in Appalachian contraction and Mesozoic extension. Basement-rooted Appalachian structures shortened and translated various components of the older rifted margin. Balanced restorable cross sections have supported palinspastic restoration of the geometry of the Iapetan rifted margin (Fig. 1) from the Marathon embayment to the Virginia promontory (Thomas, 1991, 1993, 2011), and from the Quebec embayment through the Newfoundland embayment (Allen et al., 2009, 2010). In the region between—around the Pennsylvania embayment and New York promontory, basement massifs reflect complex Appalachian deformation (Fig. 1); however, the present (displaced) distribution of Neoproterozoic synrift and Cambrian-Ordovician passive-margin rocks document rift initiation and evolution along the Neoproterozoic rifted continental margin. Structural complexity and uncertain magnitude of translation frustrate efforts to use conventional techniques of structural geology in building an accurate palinspastic reconstruction of the margin, indicating the need for nonconventional approaches. The lithospheric expressions of rift segments and transform faults can be characterized where the rifted margin has been palinspastically restored, and then that expression can be used as guide to the location of the rift where it cannot be restored by conventional methods. Along-strike variations in rift expression between lower-plate and upper-plate configurations of basement faults are partitioned by transform faults, some of which offset the trace of the rift. Facies and thickness of synrift and passive-margin stratigraphy vary along strike in patterns that indicate differences in lithospheric subsidence history between upper-plate and lower-plate rifts and along transform faults (summary in Thomas, 2006).

The tectonic load placed on the Iapetan continental margin by Appalachian deformation is reflected in foreland-basin subsidence. Magnitudes of tectonic thickening of the crust and foreland subsidence require lithospheric adjustments, and resolution of lithospheric structures is essential to understanding evolution of continental crust during contractional events that lead to supercontinent assembly. Variations in subsidence along the orogenic foreland correspond to large-scale transform faults of the Iapetan rift margin (Thomas, 2006), suggesting a focus for investigation of along-strike variations in lithospheric thickness and strength. Appalachian foreland structures and crustal subsidence change dramatically along strike between the Pennsylvania embayment and New York promontory (contrasts between the central and northern Appalachians).

Inboard from the Iapetan rift (and from the contractional effects of Appalachian orogenesis), basement fault systems have rift-parallel and transform-parallel orientations (Fig. 1), and are temporally and kinematically linked to Iapetan rifting (Thomas, 2006, 2010, 2011). Distal to Appalachian synorogenic foreland basins, high-amplitude, long-wavelength cratonic domes/arches and basins characterize the North American craton. Expressions of these structures in the lower crust and mantle and linkages to Iapetan rifting and/or Appalachian contraction are yet to be determined; however, they have important implications for understanding the structure and stability or instability of continental cratons, as well as intraplate seismicity and seismic hazards. In this context, crust-lithosphere studies along the eastern margin can be linked to EarthScope projects in the Midcontinent.

Mesozoic continental breakup and opening of the Atlantic Ocean overprinted the extensional phase of another Wilson cycle upon the Iapetan extensional and Appalachian-Pangaean contractional crustal structures (Thomas, 2006). The fill of Triassic grabens and seaward thickening Jurassic and younger deposits of the Atlantic Coastal Plain record rift initiation and evolution to passive-margin subsidence. Some components of Atlantic opening directly overprint older Iapetan extensional structures and/or Appalachian-Pangaean contractional structures, whereas some elements of the Atlantic rift margin cut across the older structures (Thomas, 2006). One challenge here will be to differentiate the effects of Iapetan and Atlantic extension at the scale of crust and lithosphere.

The TA and densification with the FA will be necessary to resolve the shallow crustal structures. New seismic data must be integrated with the outcrop geology to give the best possible resolution of the Appalachian contractional structures. Available relatively high-resolution geologic mapping will guide locating of FA transects, some of which should incorporate active-source reflection surveys, as well as passive-source experiments. Studies of lithospheric structure along the eastern Laurentian margin will enable unique interpretations of (1) the growth and modification of continental lithosphere and sedimentary cover through two Wilson cycles of continental accretion and rift initiation and evolution, (2) along-margin variations in structure and evolution of the lithosphere, and (3) tectonic inheritance through two Wilson cycles.

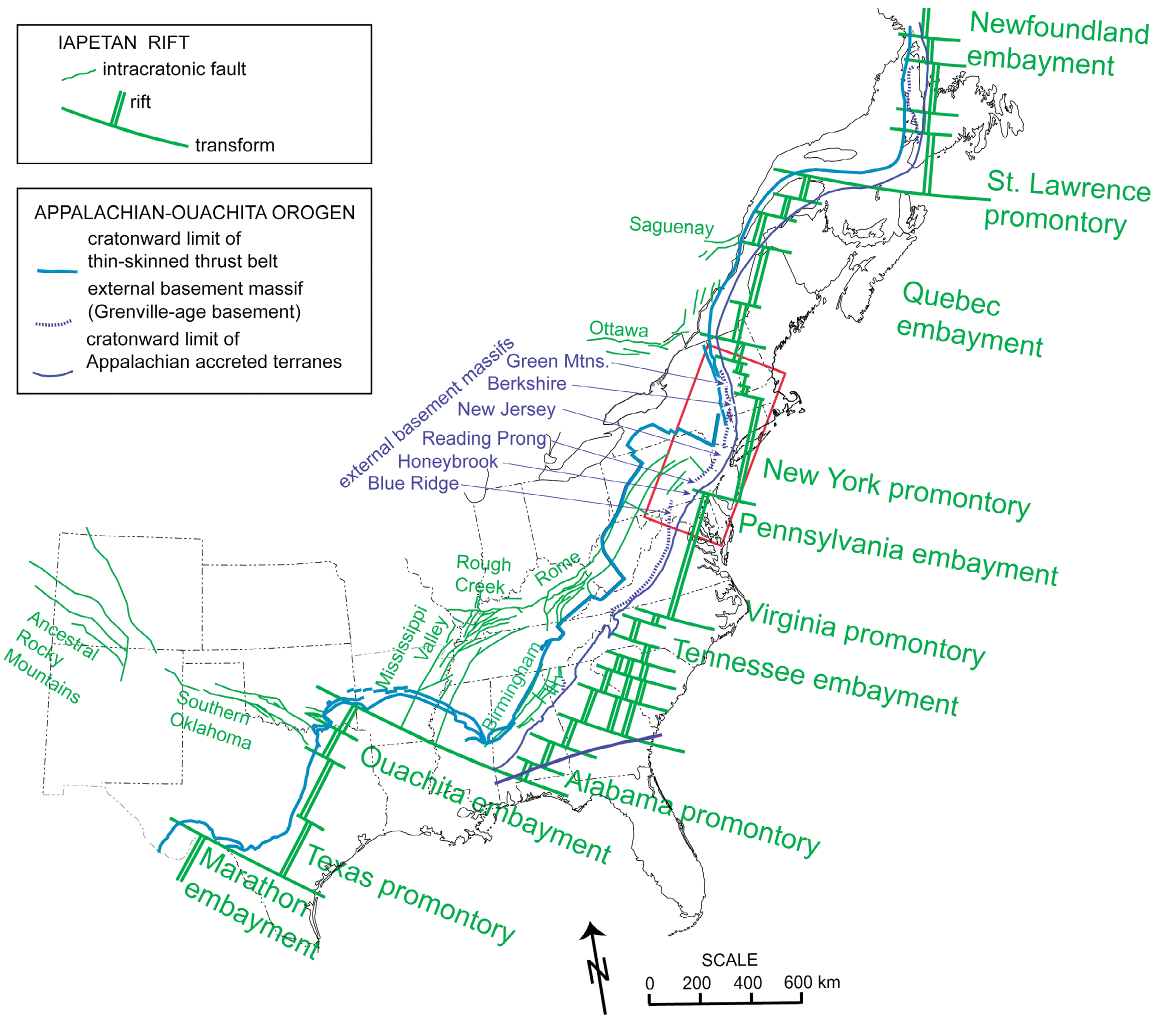

Figure 1. Map of Iapetan rifted margin of eastern Laurentia (green lines) and Appalachian-Ouachita orogenic belt (blue lines). Red rectangle shows focus area.

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