Geodynamic models of convergent margin tectonics: Implications for the development and structure of the Appalachians

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The Appalachian orogen, along with virtually all Phanerozoic and Proterozoic orogens, is now recognized as a "collage" of so-called suspect or exotic terranes. Those terranes which collided with the ancient eastern margin of North America were in many cases overthrust onto the flank of the continental craton (e.g. the Taconic allochton). This process of partial subduction of continental lithosphere, sometimes called A-subduction, appears to be the norm during continental collision. Therefore, a geodynamic model designed to investigate the geologic consequences of A-subduction is applicable to any orogen in general.

Our quantitative geodynamic model for continental margin evolution follows geologic development from rifting, through the cooling passive margin phase, to eventual overthrusting of an exotic or suspect terrane and the creation of a foreland basin. The models are two-dimensional and use finite-differences and finite-element techniques to compute thermal evolution and lithospheric flexural response, respectively.

Geological and geophysical studies have identified to inferred a number of large-scale features common to most orogens. These include: (1) the foreland basin adjacent to the thrust belt, (2) a strong negative-positive couple in the observed Bouguer gravity anomaly, (3) a crustal scale structural ramp spatially coinciding with the gravity couple, and (4) very thick crystalline overthrusts (20 km thick) with relatively little associated topography lying outboard of the crustal ramp. The last two features have been inferred from seismic reflection studies.

Our geodynamic model either reproduces or offers explanations for all of these features. (1) Foreland basins are now well known to be the flexural consequence of thrust loads upon the lithosphere; the model correctly accounts for flexure of a lithosphere whose strength is thermally control-

led. (2) The location of the Moho throughout margin development is predicted because the model explicitly accounts for the initial rifting history of the margin. Computed gravity anomalies across the model demonstrate that the commonly observed negative-positive couple is probably caused by the shift in Moho position across the ancient rifted margin. The position and wavelength of gravity anomalies in the southern Appalachians suggest that the ancient stretched margin was approximately 200 km across and presently underlies the Blue Ridge. (3) the "hinge line", which marks the boundary between unstretched and stretched continental lithosphere, is shown to spatially coincide with the position of the crustal scale ramp inferred in the COCORP northern Appalachian line as well as in the Swiss Geotraverse of the Alps. (4) Very thick overthrusts without high topography are reproduced in our model because they are emplaced in a pre-existing ocean basin or passive continental margin with significant water depths. Thus the thick crystalline overthrusts in the Appalachians inferred by COCORP reflection seismology are not incompatible with the present low topographic expression.