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Towards a kinematic model for Iapetus Ocean closure

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Summary

Since the earliest days of plate tectonics, the evolution of the northern Appalachians and the Caledonides of the British Isles has served as a type example of the 'Wilson cycle' of ocean closing and opening. Orogen development has been illustrated using cross-section time-slices. This approach is valuable, but it leads to several implicit assumptions: (i) subduction was initiated at previously 'passive' continental margins; (ii) convergence was mainly orthogonal; and (iii) terranes and zones had ribbon-like geometry extending parallel to continental margins.

The post-Pangea tectonic evolution of the Earth provides little support for these assumptions. In 180 Myr of ocean opening no subduction zone has been initiated by inversion of a passive margin; collisional tectonics has involved a variety of terrane geometries and orientations, and convergence has ranged from approximately orthogonal (as in the Himalaya) to extremely oblique (as in the southern margin of the Caribbean Plate).

We use the software GPlates to display alternative kinematic models, that operate on the surface of a sphere, for the Northern Appalachians and the Caledonides of Britain and Ireland. We first restore the effects of Mesozoic extension and late Paleozoic strike-slip using previous estimates. We then attempt to reconstruct possible Ordovician to Silurian terrane paths that honor: paleomagnetic data; evidence of terrane linkage from detrital zircon provenance; and suggested positions of peri-Gondwanan terranes along the margin of Amazonia – West Africa. The results suggest that terranes attributed to Ganderia and associated peri-Gondwanan arcs crossed the Iapetus in several separate pieces, arriving at the Laurentian margin at different times in the Ordovician and Silurian. Portions of "Ganderian" and "Avalonian" continental crust may have travelled together after being juxtaposed during Monian/Penobscottian interaction on the margin of Gondwana, that involved along-margin strike-slip, transpression, and/or transtension. These methods lead to more actualistic explanations of Appalachian / Caledonide tectonics, and of the operation of the 'Wilson cycle" in Earth evolution.