Paleozoic orogenesis and Pangea amalgamation controlled by mantle circulation changes?

J. BRENDAN MURPHY[1,2], JOHN W.F. WALDRON[3], CHRISTOPHER J. SPENCER[2], ZHENG-XIANG LI [2], WILLIAM J. COLLINS[2], ROSS N. MITCHELL[2], AND R. DAMIAN NANCE[4]

1. Department of Earth Sciences, St. Francis Xavier University, Antigonish, Nova Scotia B2G 2W5, Canada <bmurphy@stfx.ca>

2. Earth Dynamics Research Group, The Institute for Geoscience Research, Department of Applied Geology, Curtin University, Perth, Australia

3. Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2E3, Canada

4. Department of Geological Sciences, Ohio University, Athens, Ohio 45701, USA

A plethora of studies have documented the evolution of the Appalachian-Caledonide belt from an accretionary orogen during consumption of the Iapetus Ocean in the Cambrian– Ordovician to a collisional orogen as the Rheic Ocean was consumed in the Devonian–Carboniferous. Collectively, these events culminated in the collision of Laurentia, Baltica and Gondwana and the amalgamation of Pangea. To a first order, we know where and when these events occurred, but much less about the driving mechanisms responsible.

Recent advances in the understanding of how mantle convection as supercontinents amalgamate and disperse allow the evolution of this orogenic belt, the subsidence history of major sedimentary basins in the interior of Laurentia, and the amalgamation of Pangea to be understood in a geodynamic as well as a kinematic framework. Numerical modeling indicates that mantle convection patterns have evolved between degree-1 and degree-2 convection patterns during the supercontinent cycle has been suggested. A focused zone of downwelling that facilitated Gondwana amalgamation would have evolved to become a second zone of upwelling and a transition to degree-2 mantle circulation is predicted within 50 m.y. of Gondwana's amalgamation. Its amalgamation near the south magnetic pole around 550 Ma is predicted to have led to the development of a new upwelling zone at about 500 Ma. A concomitant girdle of downwelling would have been developed close to the paleoequator, where Laurentia was situated, and where the Williston and other prominent intracratonic basins were initiated during this time interval.

The establishment of the downwelling zone and subduction girdle by the end of the Cambrian explains the onset of subduction along the Laurentian margin within the Iapetus Ocean (despite its relative youth) and why subduction continued along that margin after arc-continent collision and ophiolite obduction associated with the Taconic-Grampian orogeny. The associated geoid low would explain (i) the migration of subduction zones and peri-Gondwanan terranes from Gondwana, thereby opening the Rheic Ocean leading to the eventual closure of Iapetus Ocean by the collision of those terranes and Baltica with the Laurentian margin, (ii) the development of cratonic basins on Laurentia in the early Paleozoic, and (iii) the subsequent re-establishment of

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subduction within the Rheic Ocean along the Laurussian margin which continued until terminal collision and the amalgamation of Pangea.

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