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Extension preceding continental rupture and generation of the Laurentian ocean-continent transition zone – Neoproterozoic basement-cover relationships in the Grampian Caledonides of Scotland.

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The evolution of many ancient rift and passive margin basins can commonly only be studied in outcrop after tectonically driven uplift following orogenesis. Such basins are thus deformed, metamorphosed and partially eroded as a consequence of closure of the oceanic system in which the passive margin was originally established. The mid-Neoproterozoic to Cambrian age Dalradian Supergroup of Scotland and Ireland accumulated during the rifting and break-up of Neoproterozoic Rodinia, and was subsequently deformed and metamorphosed by mid-Ordovician arc-accretion (c. 460 Ma) in the Caledonian Orogeny. As a consequence, there are significant challenges in restoration and interpretation of the original basin geometries and lithostratigraphical relationships in such a setting.

A particular challenge concerns the structural and stratigraphic relationships at the boundary between the Dalradian Supergroup, and the underlying early-Neoproterozoic metamorphic basement. The depositional age of the Dalradian succession is not well constrained but the oldest strata (Grampian Group) are post (Grenville) 1.0 Ga and likely to pre-date 800 Ma. If such really is the case, then the thick marine siliciclastic deposits characteristic of the lower Dalradian Grampian Group succession accumulated in an interval before 800 Ma, at the same time as the underlying basement was experiencing an early stretching phase (distributed high angle faulting) and crustal thinning (low-angle shearing). A regional-scale ductile shear zone (Grampian Shear Zone) in the upper levels of the underlying basement is arranged sub-parallel to the present structural base of the Dalradian. The high-temperature, medium pressure regional metamorphism in the basement is c. 830 Ma old while the low-angle ductile shear zone is c. 800 Ma old. Parallelism of the ductile shear zone with the strata above and below, suggests that this shear zone may have behaved as a mid-crustal extensional detachment that developed coeval with marine deposition at the top of the crust. This metamorphic basement can thus potentially be regarded as a metamorphic core complex generated during the early stages of continental rifting and extension in Laurentia, concomitant with marine deposition on its upper plate/hanging wall.

Rupture and break-up of Neoproterozoic Rodinia preceded opening of the Iapetus Ocean. The youngest Dalradian rocks comprise pericontinental sedimentation, parts of which apparently accumulated directly upon exhumed serpentinitic crust in a deep marine setting. Continental fragments separated from the passive margin during rift-drift transition. The Neoproterozoic extensional architecture exerted significant control on the subsequent Caledonian collisional kinematics and focussed ductile deformation structures. Despite these challenges, the Scottish sector of the Laurentian ocean-continent transition zone can be compared with modern hyper-extended magma-poor rifted margins.