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Neoproterozoic fragmentation of the Scottish Sector of Laurentia – an ancient analogue for the Iberian and UK/Irish ocean-continent transition zones

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The Neoproterozoic Dalradian Supergroup of Scotland and Ireland is intensively deformed and metamorphosed by mid-Ordovician arc-accretion (c. 460 Ma) during the Caledonian Orogeny. Emplacement of an extensive suite of Siluro-Devonian Caledonian granitoids further complicates reading the sedimentary record.

Nevertheless we can determine a history of stretching and break-up affecting the Neoproterozoic supercontinent of Rodinia and leading to creation of the Iapetus Ocean. Three key intervals of late-Neoproterozoic sediment accumulation are recognised - new geological mapping, isotopic datasets (Sr, O and C, U/Pb zircon, Sm/Nd WR), and sequence stratigraphical approaches are refining constraints on the lithostratigraphical architecture and basin evolution of the Dalradian Supergroup. Thick siliciclastic deposits accumulated (pre-800 Ma?) during an early stretching phase (distributed high angle faulting) that led to crustal thinning (low angle shearing). Three major limestone – pelite – quartzite depositional cycles succeeded these earlier siliciclastic deposits, recording episodic subsidence in an intracratonic but largely marine environment; the second cycle overlaps the late Precambrian (Cryogenian) glaciation and concludes with the distinctive Marinoan tillite succession (c. 635Ma). The last of the three cycles is terminated, in some parts of the Dalradian, by deposition of serpentinitic muds and conglomerates and volcaniclastic sediments; pods and lenses of both massive and serpentinised ultramafic rock also interrupt the sedimentary record at this level (thus possibly indicating mantle exhumation). In other areas, a major part of the 'type' Dalradian succession is absent and we now recognise a major overstep unconformity at this level. From this level onwards across the Dalradian, rapid foundering of the margin, and the transition from rift- to drift-dominated processes, resulted in an overstepping accumulation of laterally and vertically variable, increasingly immature clastic sediments and volcanic rocks. Within 30-40 Ma of the end of Marinoan glaciation, an Iapetan oceanic rift was generating MORB rocks in a localised 600 my old (proto-) rift in the SW part of the Grampian Terrane. Rapid foundering thus pre-dated the first appearance of MORB basalts. Turbidite deposition then persisted after this first emergence of oceanic rocks until the early-Ordovician when convergence began to record arc-accretion and collision.

During rift-drift transition, continental fragments apparently separated from the passive margin; the architecture of the Scotland-Greenland sector of Laurentia possibly resembled the present-day configuration of troughs and highs on the UK/Irish sector of the Atlantic continental shelf. Marginal plateaux analogous to the Rockall platform would have been separated from the intact continental margin by sub-basins analogous to the Rockall Trough. Such features would have channelled sediment outboard of, and along, the new passive margin in submarine fan systems. The extensional geometries of the various components of this architecture exerted control on the collisional geometry and acted as nuclei for deformation structures during Grampian orogenesis. Compound collisions in the mid-Ordovician stacked much of the original continental fragments into the complex pattern observed today. The challenge is thus to see through that later deformation and read the record of continental separation. There is much in the depositional architecture of the Dalradian Supergroup that suggests that a magma-poor passive margin is a viable model for this sector of the Laurentian margin.