Convergence of Avalonia and Laurentia, Devonian, Northern England

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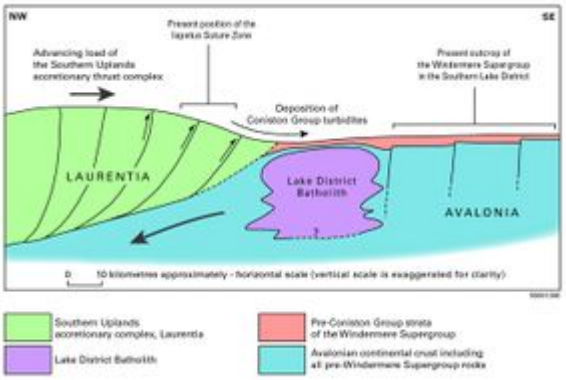
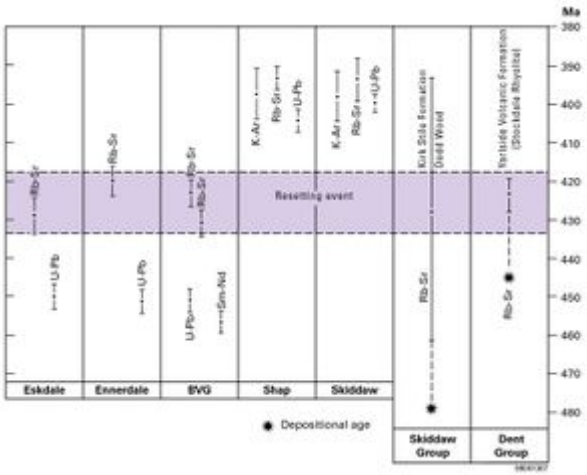
Introduction



Migration of the Southern Uplands accretionary thrust complex onto the Avalonian continental margin: the tectonic setting for deposition of the Coniston Group in the early Ludlow. P916058.



Summary of radiometric dates from the Lake District inlier showing the resetting effect at about 420–430 Ma. P916059.

In northern England the last traces of definitively local, subduction-related volcanism are seen in the Ashgill Dent Group. The bentonite layers that occur sporadically through the Silurian groups of the Windermere Supergroup, though demonstrating intermittent ash fall, could have been derived from a distant volcanic source and do not confirm continued southwards subduction of Iapetus Ocean crust beneath Avalonia. This is believed to have ceased by the end of the Ordovician. Instead, continued subduction at the northern, Laurentian margin of the Iapetus Ocean effected continental convergence by the late Llandovery or Wenlock. The initial stages of collision do not seem to have been a dramatic, mountain-building affair, and the first indication of continental proximity was the establishment of a relatively tranquil depositional setting right across the suture zone; the laminated hemipelagites of the Brathay Formation and its coeval equivalents in Scotland and the Isle of Man, in the Riccarton and Dalby groups respectively, were the result. The collision process has been widely described as ‘soft’.

Notwithstanding the ‘softness’ of the initial collision, the accretionary complex that had developed at the leading edge of Laurentia (the Southern Uplands terrane) initially overrode and depressed the north-western margin of Avalonia, resulting in the dramatic increase in subsidence and sedimentation rates recorded in the Ludlow part of the Windermere Supergroup by the Coniston Group and Bannisdale Formation (P916058). Flexure of the Avalonian footwall in response to loading may have been instrumental in the widespread resetting of the Rb-Sr isotopic systems in all Ordovician igneous rocks to a broadly Ludlow age range — about 420–430 Ma, (P916059); the U-Pb and Sm-Nd systems were unaffected. Under these circumstances the resetting would have accompanied a hydration of the rocks that arose from increased permeability through fracturing.

The foreland basin phase of the Windermere Supergroup did not progress; instead the basin filled during the late Ludlow and Pridoli, from about 420 Ma, culminating in deposition of the shallow water lithofacies seen in the Kirkby Moor Formation. The convergence of Laurentia and Avalonia had probably ceased by then and, from the late Silurian onwards, their relative movement became dominated by sinistral strike-slip, which had been intermittently affecting development of the Southern Uplands accretionary complex since late Llandovery time. By about 410 Ma, the Early Devonian, the regional tectonic regime had become sinistrally transtensional, allowing emplacement of a swarm of lamprophyre dykes (detailed below) right across the sutured tracts; dyke intrusion was probably focused above a deep-seated crustal shear zone. Transtensional sedimentary basins also formed during this phase and within them accumulated thick successions of fluvial, Old Red Sandstone lithofacies. Traces of these cover rocks are preserved in the Southern Uplands, and the underlying Lower Palaeozoic strata were probably the source of the Old Red Sandstone sedimentary sheets that spread southwards across the Iapetus Suture into northern England. Few physical traces now remain of this sedimentary cover. The Peel Sandstone of the Isle of Man (described below) may be a remnant, but its former widespread presence provided the necessary cover beneath which Acadian deformation and metamorphism occurred. For example, across the southern Lake District, an original cover at least 3.5 km thick is required above the highest preserved, Pridoli beds of the Windermere Supergroup to achieve the grade of Acadian metamorphism seen therein.

The Acadian Orogeny caused the first regionally significant, penetrative deformation of the Lower Palaeozoic rocks on the Avalonian margin, affecting the Pridoli strata of the Windermere Supergroup as intensely as the Tremadoc strata of the Skiddaw Group. This deformation phase was therefore not related to closure of the Iapetus Ocean, but was instead driven by a subsequent convergence regime that followed the period of Early Devonian transtension. As discussed in Chapter 1, this was most probably linked to the closure of the mid European Rheic Ocean further to the south.

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