

Lower Palaeozoic oceans and Wilson cycles

ANDERTON¹ has recently suggested that Iapetus (the ocean separating north-west and south-east Britain in the Lower Palaeozoic) may have opened as late as the beginning of the Cambrian. There seems to be a general consensus now that these two parts of Britain were brought together in late Silurian-early Devonian times and that an ocean between them—Iapetus—was thereby destroyed. It has been almost tacitly assumed since the early models of Wilson² and Dewey³ that this ocean must have opened some time before this. Most models (including my own⁴) have assumed that an ocean existed between north-west and south-east Britain for a considerable period. But, from palaeomagnetic reconstructions of the late Precambrian and early Palaeozoic^{5,6}, Iapetus was probably not a two-sided ocean comparable with the Atlantic and there therefore seems little justification for trying to narrow down the timing of opening of a non-existent ocean.

There are few reliable constraints on the relative latitudinal positions of the two sides of the Caledonides in late Precambrian times. One interesting palaeomagnetic result suggests that the Baltic Shield may have lain to the south-east of Scotland in late Grenville times⁷. This position would make the similarities between the Scottish Dalradian and the northern Norway late Precambrian more easily understandable and the 'opening' suggested by Anderton¹ may be allied to the separation of the Baltic and Laurentian shields. This would be regarded as the 'opening of Iapetus' by Scandinavian geologists but is a different concept from that generally envisaged in Britain and it must be remembered that the original designation of Iapetus⁸ was for the Svalbard-Scandinavia-Greenland segment of the Caledonides. Faunal differences between south-east Britain and Scotland thus become irrelevant to the opening of that ocean.

The position of south-east Britain in early late Precambrian and early Palaeozoic times is essentially unknown, but the combination of a distinctly different Precambrian structural history between the two sides and the widely different Lower Cambrian faunas suggests that north-west and south-east Britain were not in juxtaposition at any time before the final closure of Iapetus. Palaeogeographical models^{5,6} have all put south-east Britain at the edge of completely different continental masses from Scotland—and not on the 'other' side of a linear ocean. It is only by rotations and large scale lateral translations (along major transforms of the ocean floor⁹) that the two sides eventually came together at the end of the Silurian. The

Iapetus Ocean thus only existed as a two-sided closing ocean for probably the last part of Ordovician and Silurian times, at least in the Britain-Appalachia segment of the Caledonides.

Many reconstructions suggest completely different patterns of movement for the various sections of the south-east margin of the Caledonian orogeny. Morocco, Avalon (Newfoundland)/New England, Iberia/Brittany, England/Wales, central Europe and Scandinavia may all have moved independently from widely separated positions on the globe to their final resting place against the more or less uniform north-west margin of Greenland-Scotland-northwest Newfoundland-Appalachia. This is fairly unlikely in that one might not expect several microcontinental fragments to collide at even approximately the same time to form the Caledonide orogeny (even allowing for the now well recognized differences in time of collision between Scandinavia and north-west England⁹). There is no evidence that these microcontinental fragments show any evidence of collision with each other before the final closure of Iapetus. The fact that Morocco, Avalon/New England, south-east Britain and Brittany/Iberia also show evidence of a similar late Precambrian history at the margin of a continent suggests that these fragments may have lain along one continental margin¹⁰ which gave rise to the Cadomian cordilleran-type continental margin orogeny.

The sediments of the central European area of this age are marine, probably not shelf sediments, and include a considerable proportion of submarine volcanics, but again the geotectonic nature of the volcanicity and its significance are uncertain. However, it still seems likely that a late Precambrian-early Palaeozoic ocean margin lay along the line of the central European Palaeozoic massifs.

Thus the closure of Iapetus at the end of the Lower Palaeozoic seems a good example of the end of a Wilson cycle. But the late Precambrian and Cambrian history of the two sides of the closing ocean suggests that the opening phase of the Wilson cycle—the splitting apart of the continental mass—probably only affected Scandinavia and Laurentia. In this respect the suggestion¹¹ that the 560-Myr alkaline volcanic¹² and rift system of the North Atlantic may be an indication of the initial splitting may be correct. These volcanics and graben structures occur in Canada, South Greenland and near Oslo on the Baltic Shield, while the Carn Chuienne granite of the Scottish Moine area, which is also an alkaline pluton¹³ of this age¹⁴, may well be a Scottish equivalent of this suite. However, the suggestion that the Charnwood Forest volcanics also belong to this event, and even that it lies in a rift structure⁹, are not based on any real evidence. In fact all the volcanics on the south-east side which

have been suggested as remnants of the initial splitting probably belong to a volcanic arc system resultant from subduction under this continental margin⁹.

The whole concept of a Wilson cycle—of continental splitting, ocean widening and continental closure—thus takes on a new light. Study of the closing oceans of many areas through geological time, now made possible by the palaeomagnetic and palaeogeographical compilations of Smith *et al.*⁵ and Zeigler *et al.*⁵, reveals that many collisions are not between continental fragments that had previously been even approximately adjacent, although neither goes far enough back into the Precambrian to describe the early portions of the two sides of Iapetus.

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ANDERTON REPLIES—I agree with Wright about the need to reconsider the Wilson cycle and most of his points about the plate tectonic evolution of the British Isles. As I have discussed the opening of Iapetus in some detail elsewhere¹, I shall just summarize my present views.

I agree that during the Precambrian, north-west and south-east Britain evolved in isolation from each other and that the late Silurian/early Devonian continental collision brought them together for the first time. However, the similarities between Laurentia and Baltica suggest that these areas were part of the same plate during the late Precambrian (although not necessarily in their post-Caledonian relative positions), that this plate split at the end of the Precambrian or in early Cambrian times to form the Iapetus Ocean and that the ocean subsequently closed. Thus, although it does not make sense to talk about the opening of Iapetus in the restricted