Caledonian structures in Britain south of the Midland Valley

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Acccess to the countryside

This volume is not intended for use as a field guide. The description or mention of any site should not be taken as an indication that access to a site is open or that a right of way exists. Most sites described are in private ownership, and their inclusion herein is solely for the purpose of justifying their conservation. Their description or appearance on a map in this work should in no way be construed as an invitation to visit. Prior consent for visits should always be obtained from the landowner and/or occupier.

Information on conservation matters, including site ownership, relating to Sites of Special Scientific Interest (SSSIs) or National Nature Reserves (NNRs), in particular counties or districts, may be obtained from the relevant country conservation agency headquarters listed below:

Scottish Natural Heritage, 12 Hope Terrace, Edinburgh EH9 2AS.

Countryside Council for Wales, Plas Penrhos, Ffordd Penrhos, Bangor, Gwynedd LL57 2LQ.

English Nature, Northminster House, Peterborough PE1 1UA.

Preface

This volume deals with those sites selected as part of the Geological Conservation Review (GCR) within the southern British part of the Caledonides, that is, the paratectonic Caledonides — a Caledonian terrane without strong and pervasive deformation and metamorphism, such as occurred further north. This orogenic belt formed by long and complex processes of earth movements between 500 and 380 million years before the present (?late Cambrian to mid-Devonian times), and has been classic ground for geologists for two hundred years. It is perhaps no accident that James Hutton in 1795 chose to illustrate his geostrophic cycle (and unconformity) with three visually explicit examples of the deformation wrought on Lower Palaeozoic rocks by Caledonian events.

The former Caledonian mountain chain, which can be seen today in fragmented pieces in Scandinavia, Britain and Ireland, and North America, was ultimately the result of the collision of two continental plates and the closure of a former ocean, Iapetus. Some of these fragments, including those in Scandinavia, southern Britain, and the Republic of Ireland and the Maritime Provinces of Canada, are thought to have lain on the south side of the ocean before collision: the rest of North America, northern Ireland, and Scotland are thought to have lain north of the former Iapetus. The width of the late Precambrian to Early Palaeozoic ocean, at various stages before its closure, has been greatly debated (McKerrow and Cocks, 1976; Phillips *et al.,* 1976). Much concerning its formation, its narrowing and destruction, and the tectonic (and plate tectonic) consequences of these events has yet to be elucidated, but it is clear that the mountain chain that formed by mid-Devonian times was once continuous across what has become the Atlantic area, and that deformation phases which affected the rocks on the western side of the Atlantic are comparable with those of the Taconic and Acadian orogenies in the Appalachians (Bailey, 1929). Before the opening of the north Atlantic, around 60 million years before the present, the eroded Caledonides with their characteristic NE–SW tectonic grain, stretched for some 5000 kilometres, from the Arctic to the southern United States.

The orthotectonic Caledonides of Britain, that is those areas affected by metamorphism and tectonism north of the Highland Boundary Fault, will be dealt with in subsequent volumes of the GCR series. This volume describes key sites demonstrating Caledonian tectonism in Wales, the Lake District, and in Scotland, south of the Midland Valley. The first two areas lay, in pre-collision times, on the south side of Iapetus, Wales being the site of the deposition of a great thickness of Early Palaeozoic sediments and volcanics in a marginal basin. Of course, the Welsh Basin is even more famous for containing the type areas and type localities for the Early Palaeozoic Cambrian, Ordovician and Silurian systems. The Caledonian structures in these rocks show particularly the influence of structures in the (Precambrian) basement. The Lake District has been interpreted as being the setting of an Early Palaeozoic island arc, in some interpretations lying south of a subduction zone in which the south-eastwards-moving oceanic floor of Iapetus was being destroyed.

In Early Palaeozoic times, Scotland, including the areas and sites in this volume in southern Scotland, lay on the opposite side of Iapetus to those in Wales and the Lake District above the complementary subduction zone. Rocks in the Southern Uplands have been interpreted as the product of an accretionary prism, that is as wedges of ocean floor pushed, thrust, and welded (accreted) by plate tectonic movements on to the north-western continental margin of Iapetus. These rocks include deep-sea sediments mixed with slivers of ocean crust on which they had been deposited during the Ordovician and possibly the Silurian Period, all carried on to the continental margin, lying to the north of the putative subduction zone, as they were 'scraped off' the back of the subducting ocean plate.

The Southern Uplands have been a proving ground for tectonic models and for testing the constraints imposed by the vitally important graptolite biostratigraphy. One model, for instance, suggests that subduction and deformation may have ceased on its northern margin by the early Silurian Period. In this view, the early Devonian culmination of the Caledonian deformation is really confined to the folds and cleavage of the Lake District and Wales, although the subsequent sinistral fault movements throughout the British area provide final, unifying evidence of Iapetus' closure.

The present site descriptions were initiated in 1983, building to some extent on the small coverage of existing SSSIs. The Southern Uplands sites were mostly visited and described in 1983/4, with some updating in 1986, whereas the Lake

District and Welsh site descriptions were not completed until 1988. Contributors were asked to employ the standard Geological Conservation Review criteria, that is to identify sites of national importance, to describe their features, and detail the scientific justification for GCR selection and ultimately SSSI notification. However, a slightly different approach was required in assessing structural sites than would be required when, for instance, selecting more conventional stratigraphical or palaeontological sites; the guidelines followed were that localities should be selected for structural features which best illustrated Caledonian deformation, but in three distinct subareas. In effect, this meant scrutiny of the literature and canvassing of expert opinion in identifying all sites which were known to exhibit important structural features to advantage and, to some extent, the seeking out of sites which might display a particular structural characteristic. From this preliminary list it was necessary to select those localities which best illustrated the typical features of the various phases of deformation, as well as the principal variations and exceptions. Many potential sites had to be excluded because they duplicated features seen elsewhere; and it has not been possible to illustrate some aspects of deformation as no appropriate site was known.

This last point raises the matter of the great burst of geological research activity there has been in the areas described, since the site descriptions were written. All three areas have not only undergone considerable scrutiny by academic researchers in the last three years, but have also been locally subject to very detailed attention from the British Geological Survey. This has revealed many new potential sites which illustrate known features of Caledonian deformation or features that have acquired a new significance as research has progressed. In this latter category are sites which might better illustrate the timing of Caledonian events (for example, as a result of the dating of igneous bodies, cleavage), details of internal processes (for example, fracture systems, cleavage development, shear criteria, strain variations) and evidence of external processes (for example, plate movement, major fault displacements). It will be noted that sites from the Midland Valley have been excluded from this volume. At the time of its preparation there was very little information available concerning Caledonian structure, but it was clear that this was to become an area of significance in the 'jigsaw' of Caledonian evolution. Being so intimately involved in the stratigraphy, sedimentology, and igneous history, the structure of the area will be covered in later relevant GCR volumes.

W.A. Wimbledon

References