British Silurian stratigraphy

Title page and preliminaries

R.J. Aldridge Department of Geology, University of Leicester, UK

David J. Siveter Department of Geology University of Leicester, UK

Derek J. Siveter Oxford University Museum of Natural History, Oxford, UK

P.D. Lane School of Earth Sciences, University of Keele, UK

D. Palmer Cambridge, UK

and

N.H. Woodcock Department of Earth Sciences, University of Cambridge, UK

GCR Editor: L.P. Thomas

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Contents

Gasworks Lane

Marloes

Scrâch Track

Cilgwyn–Ydw Valley

Trefawr Track

Cwm-Coed-Aeron

Fron Road (Cefn-cerig Road)

Coed Glyn-môch Track

Cwm Clyd Quarry (Garth Bank Quarry)

Caban Côch

Banwy River

Aberarth–Morfa

Craigyfulfran

Rheidol Gorge

Yewdale Beck

Skelghyll Beck

Brow Gill Beck

Spengill (Backside Beck)

Dob's Linn

Grieston Quarry

Thornylee Quarry

Old Cambus Quarry

Woodland Point

Roughneck Quarry

Penwhapple Burn

Blair Farm

Gutterford Burn

Birk Knowes D. Palmer

4 The Wenlock Series Derek J. Siveter

Introduction

Occurrence

Palaeoenvironmental setting

Biostratigraphy

Site selection

Hay Head Quarries

Daw End Railway Cutting

Wren's Nest

Scutterdine Quarry

Little Hill

Linton Quarry

Hobbs Quarry

Cwm-Ton Area R.J. Aldridge

Cilwrgi Quarry R.J. Aldridge

Brinkmarsh Quarry

Buckover Road Cutting

Moons Hill Quarry

Penylan Quarry

Rumney Quarry

Rumney River

Marloes

Freshwater East (South)

Hughley Brook

Buildwas River Section

Whitwell Coppice Eaton Track

Farley Road Cutting

Easthope–Harley Hill

Longville–Stanway Road Section

Lincoln Hill

Burrington

Dolyhir Quarries

Trecoed–Castle Crab

Pen-cerig

Coed-mawr

Dulas Brook

River Irfon

Sawdde Gorge

Wernbongam

Buttington Brickworks

Trewern Brook

Banwy River

Penstrowed Quarry

Ty Mawr

Arcow Quarry N.H. Woodcock

River Rawthey N.H. Woodcock

Torver–Ashgill N.H. Woodcock

Brathay Quarries N.H. Woodcock

Balmae Coast P.D. Lane

Meikle Ross (Borgue Coast) P.D. Lane

Knockgardner D. Palmer

Ree Burn–Glenbuck Loch David J. Siveter

Lyne Water and Lynslie Burn David J. Siveter

5 The Ludlow Series David J. Siveter

Introduction

Occurrence

Palaeoenvironmental setting

Biostratigraphy

Site selection

Pitch Coppice

Wigmore Road

Goggin Road

Sunnyhill, Mary Knoll Valley

Deer Park Road

The Whitcliffe

Deepwood

Bow Bridge

Burrington Farm Stream Section

Elton Lane

Mary Knoll Valley

Church Hill Quarry

Mocktree Quarries

Aymestrey Quarries

View Edge

Upper Millichope

Turner's Hill

Woodbury Quarry

Gurney's Quarry Linton Quarry

Longhope Hill

Wood Green

Perton Road and Quarry

Tites Point

Brook House

Meeting House Quarry

Mithil Brook and Cwm Blithus

Beacon Hill

Sawdde Gorge

Dinas Brân

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Access 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. 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 not 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 (NNIts) in particular counties or districts may be obtained from the relevant country conservation agency headquarters listed below:

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

English Nature, Northminster House, Peterborough PEI IUA.

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

Preface

Britain has often been described as the 'cradle' of modern geology. Certainly, the extraordinarily diverse geology of the British Isles provides a remarkably good sample of rocks that record Earth history. The rocks of Britain formed the basis for pioneering studies by geologists in the 18th and 19th centuries. Their observations, and the ideas they developed to explain what they saw, laid the foundations of the science as we now know it. Consequently, many revolutionary theories about geological processes, the formation of rock, and landscape development were devised here, and many names for rocks, minerals, fossils and intervals of geological time originated in Britain.

The Silurian rocks of Britain were named by R.I. Murchison after the 'Silures', an ancient Romano-Celtic tribe. Murchison published 'The Silurian System' in 1839, making this geological system one of the earliest to be defined formally. The British placenames Llandovery, Wenlock and Ludlow provided the internationally used series-names within the Silurian System. As a result of this pioneering work, the Silurian rocks of Britain gained an international importance that continues today. Of particular importance is their historic role in the foundation of one of the major subdivisions of geological time — the Silurian, which is now recognized internationally.

Rocks of Silurian age are exposed in scattered outcrops across Britain from the Midland Valley of Scotland southwards to the Severn estuary and westwards to Pembrokeshire. Silurian rocks form the geological foundation to some of the most attractive and valued of Britain's scenery. Silurian rocks typically form upland hills and vales whilst the more dramatic mountainous landscapes are made of yet older and harder rocks and the lowlands are largely underlain by Mesozoic and Cenozoic rocks.

Early in the 19th century, little was known scientifically about any of the ancient upland rocks, but they rapidly became the focus of intense interest and debate as geologists strove to map them, make sense of their structures and describe their fossil remains.

Scientific investigation has revealed the extraordinary history of the Silurian Period and the building of the British Isles from widely separated crustal blocks. The Silurian rocks of Britain record the terminal phases of one of the major plate tectonic events of Early Palaeozoic times. The rocks are formed mainly of ancient marine sediments, deposited between 440 and 410 million years ago. They accumulated on the seafloor of an ancient ocean, and on the margins of its bordering continents. During Silurian time this ocean floor disappeared as two continental masses collided. The Silurian deposits were caught up in processes of folding and faulting that produced a vast elongate mountain belt. It stretched

from today's northern Scandinavia, through Britain, Ireland and Newfoundland into New England. As the mountains were uplifted so they were subject to erosion and weathering. The sediments produced by these processes were distributed by rivers over the surrounding landscapes. These largely non-marine deposits accumulated in basins flanking the mountains to form the youngest Silurian strata.

The prolonged process of burial and tectonism transformed the original soft sediments of Silurian times into relatively hard and compact, folded and faulted sedimentary rocks. They now form one component of the vast piles of Lower Palaeozoic strata that record this event. The geological character of the rocks has played an influential role in the recent glacial history of these islands and in the post-glacial complex history of human settlement and conflict.

Early Tertiary uplift of northern Britain caused extensive erosion and removal of the Mesozoic cover rocks and uncovered the old Lower Palaeozoic rocks in the north and west. Whilst their elevation enhanced the development of ice sheets over the last million and more years, their relative hardness protected them from wholesale glacial erosion and promoted the sculpting of landscapes in the Southern Uplands of Scotland, the Lake District and Wales. The resulting topography, weather and soils associated with the upland terrain have provided both refuge and barrier to human occupation and economic development.

Valuing Silurian rocks and landscapes

'...gentle airs,

Birds, running streams, and hills so beautiful

On golden evenings,...'

Wordsworth remembers the Silurian landscape around Lake Coniston in 'The Prelude'.

Silurian landscapes, such as those of the Scottish Southern Uplands, the Lake District and Welsh Borderland have been celebrated in prose, verse, music and paint. For over three hundred years, artists from Walter Scott, Burns, Keats, Wordsworth and Turner to Ruskin, Elgar, Vaughan-Williams and Housman have been stimulated by their topography. The aesthetic and more practical recreational value of some of these landscapes has been formally recognized since the 1950s with the establishment of the National Parks and Areas of Outstanding Natural Beauty.

Economically, the role of most Silurian rocks has not been very significant compared with those of Ordovician age. However, there has been important mineralization of Silurian strata in the Southern Uplands and Central Wales. The mineralization postdates the Iapetus closure and collision. Late Devonian to early Carboniferous age Zn–Pb hydrothermal vein deposits in the Leadhills–Wanlochhead orefields are hosted by Lower Palaeozoic greywackes. Scotland's lead requirements were met by these mines until the 1930s. Uraniferous veins in Silurian shales near Dalbeattie originate from a Devonian age granodiorite. Similar and contemporaneous Cu–Pb–Zn sulphides, of hydrothermal origin and hosted in Llandovery strata, have been mined since Tudor times in Central Wales.

Some of the Wenlock limestones of the West Midlands have had an interesting historical role within the context of the Industrial Revolution. Around Dudley and the greater Birmingham area, these Wenlock limestones were quarried in the 14th century for building Dudley Castle keep. Being in part pure calcium carbonate, they were subsequently burned in kilns to produce lime for agricultural use in the 17th century. Their proximity to Britain's thickest coal seam, the Mid-Carboniferous age South Staffordshire Thick Coal (9–12.8 m) led to their 18th century use in the earliest days of the Industrial Revolution as a flux in the smelting of iron.

Dudley lies in the midst of the so-called 'Black Country' and quarrying was so extensive that it had to be continued underground. In doing so, the largest manmade limestone caverns in Britain were formed and connected in 1785 to the national canal system by the earliest narrowboat canal tunnel in the world. Coincidently, the working of these Wenlock limestones provided a wealth of palaeontological information about Silurian times but subsequent urban development has threatened to 'overrun' the outcrop, until it was protected as the first National Nature Reserve for geology in 1956.

Historically, there has been quite extensive but localized economic use of Silurian rocks for domestic vernacular building, stone walling, road construction and the manufacture of lime and bricks. This has resulted in the excavation of numerous small quarries over the centuries. These quarries have in turn provided important exposures of rocks whose outcrop is typically obscured by soil and vegetation. However, with more recent change of building practice, few of these are still actively excavated and many have become degraded and overgrown, whilst others are being infilled with waste.

Most Silurian rocks with potential for stone construction are unsuitable for modern masonry use, being of insufficient hardness or too irregularly cleaved. Generally, Silurian rocks have a relatively high mud and silt content and have not been metamorphosed beyond a low level (chlorite grade). Exceptions are the coarser grained turbiditic sandstones of parts of the Lake District and Central Wales outcrop. These (e.g. Arcow Quarry, Ribblesdale, see Wenlock Chapter) are amongst the few Silurian rocks with potential strength for modern use as aggregates for roads or concrete. Consequently, there are few large modern working quarries in the outcrop.

Conservation

The sites that allowed the pioneers of geology to hone their observational and interpretative skills and build up a geological history are as important today as they ever were. Many problems remain for the elucidation of Britain's geological history, and the development of our knowledge would be nothing without recourse to sites where the geology can be demonstrated, researched and theories put to the test. This is amply illustrated by the fact that whilst this book documents present knowledge of the sites described, these sites continue to provide the basis for fresh insights into Silurian geology. The important works of Zalasiewicz and Williams (1999) on the Wenlock of the Builth area, and that of Ratcliffe and Thomas (1999) on the nature of the mid-Silurian carbonate platform of the Welsh Borderland, are just two examples, both being published too late to be fully incorporated into the present volume.

Active conservation measures are needed to protect the most important geological sites. The Geological Conservation Review is a major contribution to that effort, in systematically identifying and documenting the most important sites that are protected as 'Sites of Special Scientific Interest' (SSSIs; see Ellis *et al.,* 1996 for a review of the ongoing geological conservation process in Britain). No other country in the world has attempted such a comprehensive review of their geological heritage.

The GCR publications series must serve many purposes. The books provide the scientific justification for the conservation of the sites described. They also need to give an authoritative account of the geology and geological context of each site. Consequently, the site reports need to include enough detailed and technical information to bring out their scientific importance. But many people other than scientists will be touched by the GCR, such as those concerned with the physical conservation of the sites and the management of the land upon which they lie. These people will need to know the significance of the site in their custodianship — perhaps not the full technical details as provided by the reports, but the context of their site and the main reasons why it is conserved. Also, there is a general need to provide contextual information in simpler terms in the published GCR books. It is for this reason that the general introduction (the first chapter) and summary highlights for each site (given in the 'conclusions' sections), coupled with the glossary, are aimed at a less specialized audience.

Well over a hundred sites are conserved for their contribution to Britain's Silurian stratigraphy and this has inevitably made this a lengthy compilation. But geologists will be able to build upon the comprehensive review provided by this volume and continue to study the sites whose long-term conservation is now assured.

Douglas Palmer December 1999

References