The Dalradian rocks of Scotland

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(Front cover) Medium-scale folds with fanned spaced cleavages, related to the major early (F1) Kilmory Bay Syncline and developed in the basal part of the Crinan Grit Formation at the Kilmory Bay GCR site, Knapdale. The folding is controlled by a single competent bed of fine-grained quartzite within incompetent metamudstones that exhibit chlorite-grade, greenschist-facies regional metamorphism. Most of the GCR sites in this volume are important as representatives of key parts of the Dalradian succession, for their characteristic lithologies and for the regional metamorphism and spectacular structures imposed upon them during the Caledonian Orogeny. Some have historical value, and it was here that graded bedding was first used, in 1911, to demonstrate the way-up of deformed strata in the Scottish Highlands. (Photo: P.W.G. Tanner.)

2024 note:

This GeoGuide version of *The Dalradian Rocks of Scotland* is adapted from the "Accepted manuscript" that was later published in 2013 as a special issue of the *Proceedings of the Geologists' Association,* comprising the following papers:

The Dalradian rocks of Scotland: an introduction, Proceedings of the Geologists' Association, Volume 124, Issues 1–2, 2013, Pages 3-82, ISSN 0016-7878, https://doi.org/10.1016/j.pgeola.2012.06.002.

The Dalradian rocks of the south-west Grampian Highlands of Scotland, Proceedings of the Geologists' Association, Volume 124, Issues 1–2, 2013, Pages 83-147, ISSN 0016-7878, https://doi.org/10.1016/j.pgeola.2012.07.008.

The Dalradian rocks of the central Grampian Highlands of Scotland, Proceedings of the Geologists' Association, Volume 124, Issues 1–2, 2013, Pages 148-214, ISSN 0016-7878, https://doi.org/10.1016/j.pgeola.2012.07.009.

The Dalradian rocks of the Highland Border region of Scotland, Proceedings of the Geologists' Association, Volume 124, Issues 1–2, 2013, Pages 215-262, ISSN 0016-7878, https://doi.org/10.1016/j.pgeola.2012.07.013.

The Dalradian rocks of the northern Grampian Highlands of Scotland, Proceedings of the Geologists' Association, Volume 124, Issues 1–2, 2013, Pages 263-317, ISSN 0016-7878, https://doi.org/10.1016/j.pgeola.2012.07.010.

The Dalradian rocks of the north-east Grampian Highlands of Scotland, Proceedings of the Geologists' Association, Volume 124, Issues 1–2, 2013, Pages 318-392, ISSN 0016-7878, https://doi.org/10.1016/j.pgeola.2012.07.011.

The Dalradian rocks of the Shetland Islands, Scotland, Proceedings of the Geologists' Association, Volume 124, Issues 1–2, 2013, Pages 393-409, ISSN 0016-7878, https://doi.org/10.1016/j.pgeola.2012.07.007.

Pre-publication PDF versions are also available on the NORA, the NERC Open Research Archive

This GeoGuide version is presented in the same format as the other GCR volumes on this site.

Preface

The Geological Conservation Review Series

The comparatively small land area of Great Britain contains an unrivalled sequence of rocks, mineral and fossil deposits, and a variety of landforms that provide a geological record of a large part of the Earth's long history. Well-documented ancient volcanic episodes, famous fossil sites, and sedimentary rock sections used internationally as comparative standards, have given these islands an importance out of all proportion to their size. The long sequences of strata and their organic and inorganic contents have been studied by generations of leading geologists, thus giving Britain a unique status in the development of the science. Many of the divisions of geological time used throughout the world are named after British sites or areas; for instance, the Cambrian, Ordovician and Devonian systems, the Ludlow Series and the Kimmeridgian and Portlandian stages.

The Geological Conservation Review (GCR) was initiated by the Nature Conservancy Council in 1977 to assess and document the most important parts of this rich heritage. The GCR records the current state of knowledge of the key Earth science sites in Great Britain and provides a firm basis upon which site conservation can be founded in years to come. Each GCR title in the series of over 45 volumes describes networks of sites of national or international importance in the context of a portion of the geological column, or a geological, palaeontological or mineralogical topic.

Within each volume, the GCR sites are described in detail in self-contained accounts, consisting of an introduction (with a concise history of previous work), a description, an interpretation (providing geological analysis of the features of interest and assessing the fundamentals of the site's scientific interest and importance), and a conclusion (written in simpler terms for the non-specialist). Each site report is a justification of the particular scientific interest in a locality, of its importance in a British or international setting, and ultimately of its worthiness for conservation.

The aim of the Geological Conservation Review Series is to provide a public record of the features of interest in sites that have been notified or are being considered for notification as Sites of Special Scientific Interest (SSSIs). The volumes are written to the highest scientific standards but in such a way that the assessment and conservation value of the site is clear. It is a public statement of the value placed on our geological and geomorphological heritage by the Earth science community and it will be used by the Joint Nature Conservation Committee, the Countryside Council for Wales, Natural England and Scottish Natural Heritage in carrying out their conservation functions. The three country agencies are also active in helping to establish sites of local and regional importance. Regionally Important Geological/Geomorphological Sites (RIGS) augment the SSSI coverage, with local groups identifying and conserving sites that have educational, historical, research or aesthetic value, enhancing the wider Earth heritage conservation perspective.

All the sites in this special issue have been proposed for notification as SSSIs; the final decision to notify sites lies with the governing councils of the appropriate country conservation agency.

The Dalradian rocks of Scotland

There is such a diversity of rocks, minerals, fossils and landforms packed into the piece of the Earth's crust we call 'Britain' that it is difficult to be unimpressed by the long, complex history of geological change to which they are testimony. But if we are to improve our understanding of the nature of the geological forces that have shaped our islands, further unravel their history in 'deep time' and learn more of the history of life on Earth, we must ensure that the most scientifically important Earth science sites are conserved for future generations to study, research and enjoy. Moreover, as an educational field resource and as training grounds for new generations of geologists on which to hone their skills, it is essential that such sites continue to remain available for study. The first step in achieving this goal is to identify the key sites, which is a primary aim of the Geological Conservation Review.

The GCR, formally launched in 1977, is a world-first in the systematic selection and documentation of a country's best Earth science sites. No other country has attempted such a comprehensive and systematic review of its Earth science sites on anything near the same scale. After three decades of site evaluation, consultation with the scientific community, and site documentation, we now have an inventory of over 3000 GCR sites, selected for 100 categories covering the entire range of the geological and geomorphological features of Britain.

The minimum criterion for GCR site selection is that sites should offer the finest and/or the most representative feature for illustrating a particular aspect of geology or geomorphology. The resulting GCR sites are thus, at the very least, of national scientific importance and many of these include features regarded as either 'classic' (i.e. a 'textbook example'), internationally important, or simply 'unique'. Some are, in addition, visually spectacular.

The present Special Issue of the Proceedings of the Geologists' Association is the 39th to be published in the GCR series which, when complete, will stretch to more than 40 volumes and provide a vast geoconservation information resource. This special issue summarizes the considerable research that has been undertaken on the localities described and will be invaluable as an essential reference source for those engaged in their study and aims to provide a stimulus for further investigation. It will also be helpful to teachers and lecturers and for those people who, in one way or another, have a vested interest in the GCR sites: owners, occupiers, planners and those concerned with the practicalities of site conservation. The conservation value of the sites is mostly based on a specialist understanding of the Earth science features present and is, therefore, of a technical nature. The account of each site ends, however, with a brief summary of the geological interest, framed in less technical language, in order to help the non-specialist.

This special issue deals with the state of knowledge of the sites available at the time of writing, and it must be seen in this context. There is still much to learn about the GCR sites documented here, in increasing our knowledge and understanding of geological history and processes. Geological studies, like any other science, are ever-developing, with new discoveries being made, and existing models being subject to continual testing and modification as new data comes to light. While the existing sites continue to enable us to add to our geological knowledge, increased or hitherto unrecognized significance may be seen in new sites. Indeed, during the writing of this special issue, a number of additional localities were considered for inclusion and, after a period of assessment, were ultimately deemed to be worthy of GCR status and were included in this account. That fact is almost inevitable when one considers that some of the original networks of sites were drawn up over two decades ago.

Therefore, it is possible that further important sites will be identified in future years for the GCR as research continues. However, it must be stressed that the GCR is intended to be a minimalist scheme, with the selection of only the best, most representative, example of a geological feature, rather than the selection of a series of sites showing closely analogous features.

This account clearly demonstrates the value of the GCR sites to the study of Dalradian rocks in Scotland and their importance within the wider context of Britain's outstanding scientific and natural heritage, and I am grateful to the authors for their perseverance and forebearance in the preparation of this book and their valuable contribution in assisting JNCC in its conservation goals.

N.V. Ellis, GCR Publications Manager January 2011

A catalogue record for this book is available from the British Library.

Recommended citation

Stephenson, D., Leslie, A.G., Mendum, J.R., Tanner, P.W.G., and Treagus, J.E. (2012) *The Dalradian Rocks of Scotland,* Proceedings of the Geologist's Association, **123**, xxx-xxx.

Access to the Countryside

This special issue 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 (NNRs) in Scotland may be obtained from:

Scottish Natural Heritage, Great Glen House, Leachkin Road Inverness IV3 8NW.

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Acknowledgements

This special issue is the combined work of 24 authors, many of whom, in addition to their own site descriptions, have made valuable comments on other aspects of the work. Sadly, John Roberts and Steve Robertson both died during the early stages of preparation and their contributions have been completed by P.W.G. Tanner and M. Smith respectively. Peter Thomas, Derek Flinn and Robert Scott died whilst the special issue was being prepared for publication. All made major contributions to their own areas of the Dalradian outcrop and to our overall understanding of Grampian Highland and Shetland geology.

The regional papers containing the site reports have been compiled by their first-named authors and have been edited by D. Stephenson. This introductory paper has been edited by P.W.G. Tanner and J.E. Treagus, and S.H. Treagus is thanked for additional comments. Overall compilation and editing was by D. Stephenson. The GCR editor was P.H. Banham and the referee was M.R.W. Johnson, who also provided valuable editorial suggestions. The project was cofunded by the Joint Nature Conservation Committee (JNCC) and the British Geological Survey (BGS) and has been managed by N.V. Ellis for JNCC and D.J. Fettes and M. Smith for BGS.

The initial site selection and site documentation for the Dalradian block of the Geological Conservation Review was by S.J. Moorhouse. Since then, much new mapping and refined interpretation has taken place, and the site list has been revised, firstly by J.E. Treagus and subsequently through a panel consisting of R. Anderton, A.L. Harris, J.R. Mendum, J.L. Roberts, P.W.G. Tanner, R. Threadgould and J.E. Treagus. Additional sites to represent the Dalradian of Shetland were suggested by D. Flinn and F. May. The necessary amendments to the GCR documentation were greatly facilitated

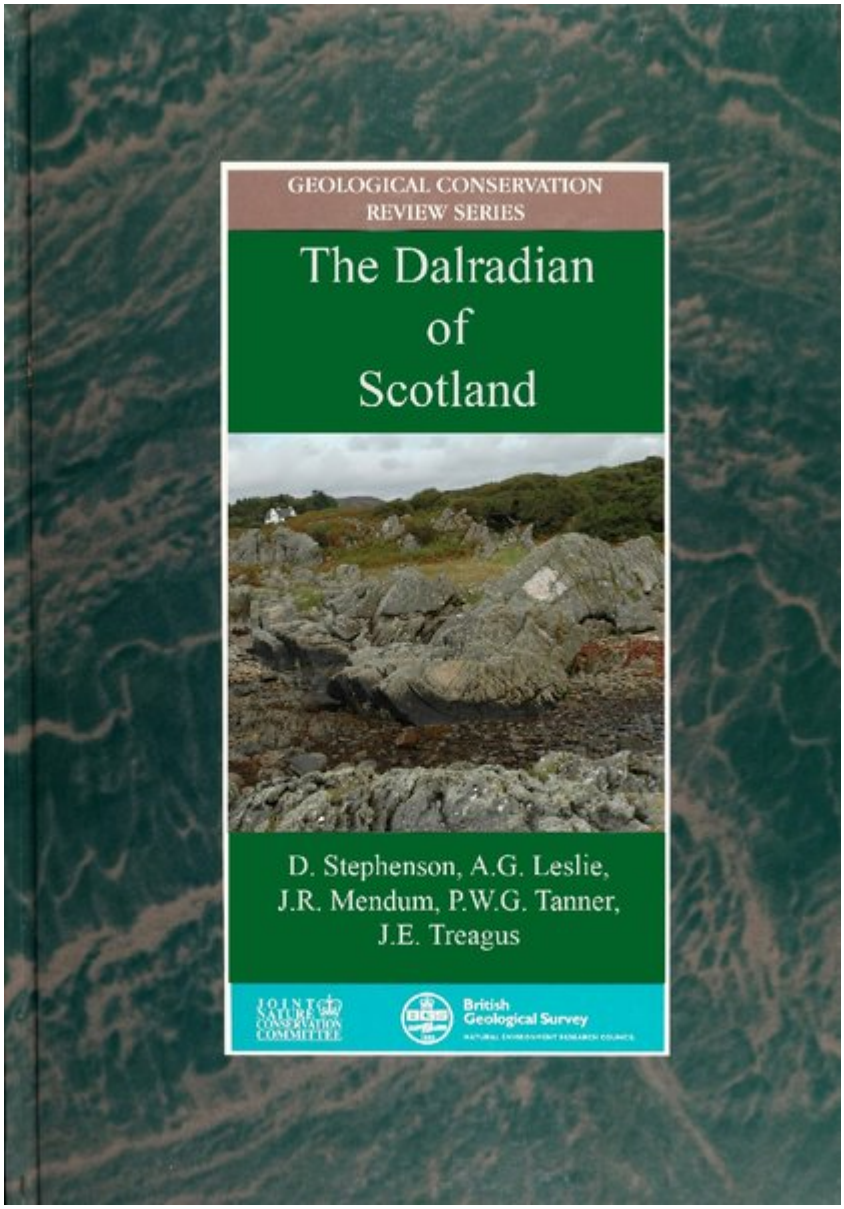
by R. Wignall (for Scottish Natural Heritage).

K.M. Goodenough and S.W. Horsburgh assisted with preliminary drafts of key maps and all diagrams were drafted for publication by S.C. White (JS Publications, Newmarket) and K.J. Henderson (BGS, Edinburgh). Photographs were scanned and prepared by B.M. McIntyre (BGS, Edinburgh). Photographs from the BGS collection are reproduced by kind permission of the Director, BGS © Natural Environment Research Council; all rights reserved (PR/23–27).

Several of the principal authors of the Dalradian GCR have been involved in the writing of other reviews of the Dalradian of Scotland and, inevitably, sections of introductory text have been adapted and updated from their contributions to those earlier works. In particular, large sections have been adapted from *British Regional Geology: the Grampian Highlands* (Stephenson and Gould, 1995) and some smaller sections have been adapted from a chapter in *The Geology of Scotland* (Strachan *et al*., 2002) and from a recent review of the evolution of the north-east margin of Laurentia (Leslie *et al*., 2008). The original sources of many key diagrams taken from these and other works are acknowledged in their captions.

The first complete draft of this volume was submitted to the JNCC in June 2009. In 2010, the JNCC terminated its involvement in Earth Science conservation and abandoned its contractual agreements to publish the remaining GCR volumes. So, the authors are greatly indebted to Diarmad Campbell, Chief Geologist Scotland for the BGS, for funding the drafting of remaining figures and to the Geologists' Association, for ensuring that this volume is published as a Special Publication of their proceedings. We are particularly grateful to Neil Ellis of the JNCC for his efforts to secure a new publisher and to Professor James Rose, Editor in Chief of the Geologists' Association, for making it all happen.

Finally, on behalf of all of the site authors, we would like to record our thanks to the owners and managers of land and quarries who have allowed access to the sites, either during previous work or specifically for the GCR exercise.



(Front cover) The Dalradian of Scotland. Description as Frontispiece.