**Book Reviews**

**Geology of the Airdrie district. I. H Forsyth, I. H. S. Hall and A. A. McMillan.** Memoir of the British Geological Survey for 1:50000 Geological Sheet 31W (Scotland), HMSO London. 1996, 94 pp, 26 figs., 12 plates, £37.50 ISBN 0-11-884508-X.

While to those unfamiliar with the area the geology of the Airdrie district, in the Midland Valley of Scotland, might appear undistinguished, the geology has in fact a remarkably wide range of economic interest, being part of the richest mineral district in Scotland and a major factor in the Scottish industrial revolution with its coal, ironstone, limestone, fireclay, brickclay, building sandstone, moulding sand, hard rock dolerite, alum shale, sand, gravel and abundant surface, and more limited underground, water resources. Although the solid rocks are mainly Carboniferous, such a range of fossils, sedimentary and basic igneous rocks occurs, that there is an abundance of interest for the amateur and professional geologist.

The new memoir covers the western half of the old one inch sheet 31 and extends from eastern Glasgow northwest nearly to Fintry, across the Campsie Fells north-eastwards almost to Stirling and south nearly to Motherwell. It includes Lennoxtown, Kirkintilloch, Lenzie, Kilsyth, Castelecary, Cumbernauld, Glenboig, Coatbridge and Bellshill, i.e. it covers one of the most densely populated parts of Scotland. Surprisingly, the only previous memoir of the area was published 118 years ago in 1879, and comprised 87 pages, unrelieved by a single illustration (figure or plate), which dealt with the geology of the whole Sheet 31. However, part of the western edge of the present area was included in the special memoir on the Glasgow district (last edition, 1925) and the coal-bearing strata were referred to in parts of the memoirs on the Economic Geology of the Central Coalfield of Scotland, published between 1917 and 1937. Nevertheless, all these publications are 60 or more years old now.

The authors have done a splendid job in producing a new memoir which is an immense improvement, in every aspect, on the previous version – readability; illustration; synthesis; understanding of the geology; detailed correlation of the stratigraphy and palaeontology; late or post-Carboniferous intrusive igneous rocks; structure; Quaternary; economic geology; geophysical investigations. Four appendices list cited BGS boreholes, 1: 10 000 solid maps; 1: 10 000 drift maps and Geological Survey photographs, but no reference is made as the where the numerous old borehole and mining records might be consulted (in BGS?)

A detailed account of the Carboniferous sedimentary history with its varied fluvial, deltaic, terrigenous and marine conditions of deposition includes in the lower part the Clyde Plateau Volcanic Formation, up to 400 m thick, which was preceded by magmatic updoming. Olivine basalts, basalts and hawaiites with subordinate trachy-basalts and mugearites, were erupted from two ENE-trending linear vent systems on the north and south margins of the lava block of the Campsie Fells–Kilsyth Hills–Denny Muir area.

Over 100 centres, often with tephra cones of tuffs, agglomerates and breccias and with highly vesicular lava tongues, were the outlets from which the general lava stack was erupted and about a third of these lie within the present district. Many different magma chambers were involved as shown by the variety of phenocrysts in different lavas such as plagioclase; olivine plus augite or plagioclase, olivine and augite. There is a strong alkali basalt trend characteristic of many continental rift volcanic systems. The huge 1500 m neck of the multiple Waterhead Central Volcanic Complex overlies an 8 × 6 km NW–SE solidified magma chamber thought to be filled with gabro. In the more distal facies, the lava sheets are separated by weathered zones which usually have a thin tuff laid on top of the lava and then weathered rather than being solely bole-like weathered lava.

The Quaternary is described in stratigraphical order (not an easy task) in 15 pages with six figures including generalized sections along and across the River Kelvin and across the River Clyde. The importance for civil engineering of a detailed knowledge of the Quaternary lithologies is illustrated by a section across the Baillieston motorway interchange. With the economic use of the Carboniferous rocks being greatly diminished from a 100 years ago, the importance of the Quaternary, which is up to 90 m thick, has been relatively enhanced. Although brief reference is made to the extensive areas of man-made surface, or near surface, deposits (‘Fill or Disturbed ground’) the extent of this problem for civil engineering projects is best brought out in Browne and McMillan’s 1989 account of Geology for land use planning: Drift deposits of the Clyde Valley, with the accompanying thematic maps, which is modestly only sparingly referred to.

This is a sound, professional and very readable account of a complexly faulted area of Carboniferous sediments and volcanic rocks, complicated by the existence of a mass...
of detailed information from old mines and quarries, which the authors have successfully synthesized. It is strongly recommended.

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Geology of the Fortrose and Eastern Inverness district. T. P. Fletcher, C. A. Auton, A. J. Highton, J. W. Merritt, S. Robertson and K. E. Rollin. Memoir of the British Geological Survey for 1:50 000 Geological Sheet 84W (Scotland), HMSO London, 1996. xi + 137pp, £50, ISBN 0-11-884511-X.

This Memoir deals with my geological backyard, so I approached it with more than just academic interest. What I hoped for was a publication that brought together data heterogeneous in respect of geological time, discipline and approach, that provided new insights, extended my local knowledge, provided a background for continuing research, and communicated complex investigations in a lucid way. I was not disappointed.

Over 70 years have passed since Horne’s 1923 Memoir and map of the area were published. But the value of his observations – a significant number no longer in exposed sections – is as notable as the wealth of new information in this revised version. Horne was a Late Victorian/Edwardian polymath of an Earth scientist with a sympathetic quality which allowed him to admit bafflement at times. One of his 6 inch maps of the Findhorn valley (just outside this District) notes a ‘curious depression’. The new Memoir, in defence to the times, eschews such language (and no doubt such unformed thoughts), but happily, logs a number of modern unsolved curiosities – of which more shortly.

The district covered by the resurveyed map (unfortunately still only available in June 1997 in expensive electronic format) straddles a section of the Great Glen Fault at the head of the Inner Moray Firth and includes the SW limits of the Orcadian Basin. It incorporates part of the Black Isle peninsula immediately to the North of Inverness as well as ground to the south and east of the town. Basement rocks, deformed and metamorphosed during the Caledonian Orogeny are present as is a complex suite of major and minor intrusions, both of which are of only partially understood age and affinity. In addition, as the authors rightly enthuse, ‘Few parts of the British Isles can rival this area in the range, quality and accessibility of glacially related features and Quaternary sediments ... there are several sites of international importance. This importance is reflected in the fact that about 40% of the text deals with Quaternary geology – a marked change from the original Memoir. Seventy years ago, the Devonian fish of the area attracted much of the attention. Today the hot topic is climate and sea-level change for which evidence dating back over 430 000 years has been found.

The Introduction has an attractive emphasis on a sense of place: this may be formal science, but its field setting is valued. In addition to the Quaternary, chapters are allocated to Metamorphic rocks, Igneous rocks, Devonian rocks, Mesozoic rocks (absent of course!), Devonian and later structures, Geophysics and Economic Geology. Useful appendices contain new geochemical analyses of both igneous and metamorphic rocks. There is a revised stratigraphy of the Old Red Sandstone in Hugh Miller’s early stamping ground; a re-examination of the nature of the Rosemarkie Metamorphic complex and a local expression of the Central Highland Migmatite Complex; geophysical modelling and a new analysis of thermal metamorphism, which together provide a significantly more coherent picture than was previously available of both the exposed and as yet partially unroofed igneous complex straddling the Nairn and Findhorn valleys; and a new synthesis of recent research on Quaternary features and processes. Till lovers using the Memoir will have a field day (or two) – though the ‘accessibility’ mentioned by the authors and the perceived interests of Highland estates are not necessarily compatible.

Horne-type ‘curious depressions’ in current knowledge include the affinities and age of the Rosemarkie Metamorphic inlier on the Black Isle which is anomalous in terms of the Moine Series but also aberrant in terms of style of Lewisian outcrop, as well as good distance East of known Lewisian outcrops. However, I recently saw another ‘aberrant’ type of Lewisian outcrop near Loch Maree. As yet, both geochemical information and reliable dates on the Rosemarkie inlier are lacking. Another persistently unresolved question is attribution of the metasediments SE of the Great Glen Fault to the Moine Series or the Grampian Division of the Dalradian. ‘Central Highland Migmatite Complex’ is one of that useful class of descriptive terms which duck the genesis question and allow further inquiry unhindered by loyalty to one theory or another. I wonder whether other sciences have equivalents of this useful cop-out. A modern nomenclature and clarifying stratigraphy for the Devonian sediments of the area was long overdue and is most welcome. I hope it gains currency more rapidly than the comparable stratigraphy of the Jurassic of the Inner Hebrides which is too frequently ignored. It is not clear, however, why a couple of sandstone Members remain ‘unnamed’ and correlation of sediments across the Great Glen Fault remains, in part, unresolved.

The importance of access to field localities, of conservation of important outcrop, and of the maintenance of an archive of samples of past work, emerges in several different chapters where unique sites and samples provide the only information about critical field relations. One of Horne’s original samples was from an outcrop which could not be re-located. This sample provides the only available information about the aspects of the metasedimentary origins of the psammites in the Moy area. In some localities, field relations are inherently difficult to establish because of poor outcrop, and the situation is worsened by blanket forestry – a fact BSc Forestry and Conservation students in the international class at Inverness College are well aware of. The importance of individual outcrops is further emphasised in the Middle Findhorn valley, SE of Inverness. A single known outcrop demonstrates fining up
in the original sediments: so way up interpretation of sequences of alternating psammite and migmatitic semipelites elsewhere is dependent on its conservation.

There are a few minor gremlins in the text (incorrect references to page numbers, at least one incorrect map reference), an occasionally irritating use of unnecessary jargon, and locality maps with some important sites not included. To balance this, the chapter on metamorphic rocks, for one, is exemplary in its detail and clarity of description of complex features. I was left a little puzzled, however, at an editorial policy which allowed for definitions of basic terms such as ‘til’ in the Quaternary section, but left unexplained terms such as 2.5D modelling in the geophysics chapter. The illustrations are numerous and effective, but as always, there are never enough.

One of the reasons that my copy of this Memoir is already becoming well-thumbed, is its very reliable and frequent eight-digit referencing of sites, invaluable for planning field trips. It is also an updated synthesis of current knowledge of the area across a range of geological disciplines with a bibliography which will usefully support education and research (hopefully in the developing University of the Highlands and Islands).

In short, this Memoir has a place on the shelf of anyone researching or teaching about many aspects of the geology of the Highlands and beyond. However, at £50 for Memoir and £45 for the digitized map it’s more like a small investment than a book purchase. And shouldn’t the BGS produce CDROM as well as text versions of Memoirs? I do hope future editors will extend the uses of computer technologies beyond investigation and analysis to presenting information in ways more vivid, updatable and controllable by users than linear text. Surely we won’t have to wait another seventy years for this? After all, virtual fieldwork is already a reality and Horne would surely have delighted in modelling his ‘curious depression’.

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**Geology in South-West Scotland: an excursion guide.**
(Edited by P. Stone). British Geological Survey, Keyworth, Nottingham. 1996, 214pp, £10.00, ISBN 0-85272-261-3.

Southwest Scotland is a region that until recently, has been largely neglected by the tourist hordes (including those of a geological persuasion) intent on attaining the better known attractions that lie further to the north. And yet this area offers a range of landscapes and geological phenomena equal to (and in some respects surpassing) any to be seen elsewhere in Britain – and with the added advantage of many magnificent, readily accessible coastal exposures.

As one who cut his research teeth, so to speak, on these rocks this reviewer views the appearance of this fact-packed and fascinating volume with mixed feelings – of admiration for the authors and editor and of guilt-tinged regret that the geological treasures of the Southwest have now been revealed to all, with the attendant risk of inundation by those previously passing hordes!

The timing of this volume is also apposite, enabling the 24 contributors, largely drawn from the British Geological Survey, to convey the results of the re-mapping and radical re-appraisal of this region that has been undertaken over the past few decades, and which follows in the illustrious footsteps of Lapworth, Peach and Horne, nearly a century earlier.

The Guide starts with a brief but helpful introduction that summarises the main geological highlights of the region. This describes, in commendably simple language, many of the features, terms and concepts encountered in the 18 itineraries that form the main body of the Guide. Between them these excursions span the 500 million years from the Ordovician to the Pleistocene and range geographically from the Rhins of Galloway to Langholm, and from Sanquhar to Whithorn.

Each itinerary follows a similar well-tested plan, initially listing the main points of geological interest to be seen, then providing logistic and safety advice (how to get there, what to wear, potential hazards, etc.), an outline of the geological setting of the trip and then the locality-by-locality descriptions. A laudable feature is that almost every locality description is followed by an interpretation of its geological significance (sometimes more than one, at controversial sites!). This enables even inexperienced practitioners to gain insights into the methodology of geological fieldwork and to appreciate how the ‘bigger picture’ can be built up. In places the terminology used and concepts introduced in the itineraries might appear daunting to the novice (and to those of us who find it increasingly difficult to keep up with the rapidly expanding vocabulary and concepts of geological fields outwith our own specialism!). However, help is at hand, in the form of a Glossary and Mineral Table appended to the Guide. I have not ‘road-tested’ every itinerary, but those areas with which I am familiar have been described in exemplary fashion.

Of the 18 excursions described, all but the last four are intended to occupy a single day, although several of these itineraries require youthful energy, draconian time-keeping and a following wind to do justice to all the localities listed within the hours of daylight! Excursions 1 to 8 are designated as of general geological interest. Most of these trips are located around the more popular tourist centres in this region. Not only do they provide excellent introductions to the local geology but most also include interesting historical and cultural snippets to round out each trip.

The specialist or committed enthusiast is catered for in Excursions 9 to 14. each of which is devoted to a specific geological topic or related topics and is described in rather more technical terms. Nevertheless, in these trips, too, there is much of interest for the less experienced to appreciate and enjoy (not least the superb coastal scenery in which all but two of the excursions are set).

The final four excursions (15–18) are also aimed at the more advanced practitioner, prepared to spend longer
(2–3 days), travel further and expend more energy (some steep climbs and walking distances of up to 10 km) in order to gain more regional insights into specific topics, such as the sequence and structure of the Northern and Central Belts, or the relationships between phases of tectonic deformation and the emplacement of minor and major igneous intrusions in central Galloway. Again, many of the localities described in these itineraries are equally appropriate for study on their own, displaying some spectacular geological features that are clear even to the less-trained eye.

Two short Appendices complete the Guide: a synopsis (with locality table) of the occurrence and genesis of the metalliferous ores found in this region that once contributed substantially to the Scottish economy and a summary map and annotated table of the 49 geological Sites of Special Scientific Interest designated in southwest Scotland. The SSSIs are usefully cross-referenced to the earlier itineraries and it seems a pity that this was not also done, where appropriate, for the ore minerals locations. One might also cavill at the lack of photographs in the Guide (even the front cover picture caption is tucked away in a rather obscure corner).

Nevertheless, at £10 this book is still a bargain and a worthy tribute both to the late Byron Lintern, to whom it is dedicated, and to BGS and the Edinburgh Geological Society (who supported its publication). Used in conjunction with the ‘Scottish Borders Geology’ Guide (Scottish Academic Press 1992) the geological enthusiast now has the means to assess in the field the current interpretations of the geological evolution of the Southern Uplands and can also visit numerous localities displaying excellent examples of a great variety of geological features. Already I can see those geo-hordes breasting the slopes of Criffel and Cairnsmore!

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Geology of the Rhins of Galloway district. P. Stone, A.W.A. Rushton, J.W. Gaskarth, R.J. Merriman, B. Roberts, G.S. Kimbell and J.A. Evans. HMSO, London, 1955, 102 pp, 39 text figures, 12 photographic plates and 2 tables. £32.50, ISBN 0-11-884513-6.

This new Survey memoir from the Southern Uplands is no ordinary update: in describing the area covered by the recently issued Special 1:50 000 Rhins of Galloway Solid Geology Sheet (Sheets 1, 3, parts of 4W and 7 of the Geological Survey of Scotland) it is a culminating work in an intensive 20-year programme of British Geological Survey mapping and research. Over the last forty years a revolution in the interpretation of the Lower Palaeozoic rocks of southern Scotland has stimulated widespread international interest in a terrane of apparently monotonous shales and greywackes. The memoir confirms the subtle attractions of these rocks and, in a mass of new observations and data, provides fuel to advance and energize the debate on their interpretation.

In their classic and monumental memoir of 1899 Peach and Horne described the stratigraphy and structure of the Lower Palaeozoic rocks of the Southern Uplands in such intimidating and comprehensive detail that none dared to challenge or revise for almost 60 years. Their structural model was of a large compound anticlinorium and synclinorium in which isoclinal folds, real or imagined, were the panacea for all problems and faulting played no significant part. In 1959 Craig and Walton provided the first important criticism of the Peach and Horne interpretation, probing its inconsistencies and preferring a series of large compound monoclines descending to the north and accompanied by large strike-parallel faults, which, by repeatedly throwing down to the south, introduced progressively younger rocks in that direction. The Craig and Walton revision and particularly the presence of faults slicing the terrane into strike-parallel tracts of generally north younging turbidites was immediately confirmed in a number of PhD studies. Their initially enigmatic and unusual structural model found its explanation, notably by way of publications by Dewey, McKerrow, Leggett and Eales, as a fore-arc accretionary prism on the northern margin of the closing Iapetus Ocean. Thus the Southern Uplands were catapulted from relative obscurity and geological disinterest to become a critical element in the Caledonian plate tectonic modelling of the seventies. BGS committed an enthusiastic team to the mapping of the whole Southern Uplands region. Early in their work the Survey geologists found some evidence which was difficult to reconcile with the prism model and in 1987 advanced their own alternative interpretation of the terrane as sheets of back-arc basin sediments stacked by southerly directed thrusting when the volcanic arc on its outboard margin was crushed against Laurentia in late Llandovery times. The still unresolved controversy between proponents of the accretionary prism interpretation and the Survey alternative has achieved the status of a geological cause célèbre. The new Rhins memoir, although slim relative to the Peach and Horne work it now in part supersedes, describes a key battleground, consisting of the longest (almost 50 km) and best exposed coastal section across the northern and central belts of the Southern Uplands terrane. It contains a wealth of detailed evidence extracted by the conscientious application of an extraordinary variety of methods and so provides compulsive material against which all Southern Uplands protagonists will wish to test the mettle of their hypotheses and prejudices.

Phil Stone, leader of Survey’s Southern Uplands group, presents the facts with quite commendable clarity, aided by six specialists accorded the status of contributors and some ten other geologists whose assistance is recorded in the acknowledgements. Indeed two of these assistants, McCurry, credited in whole or in part for the mapping nine out of the 30 1:10 000 sheets on which the 1:50 000 map and memoir are based, and Davies (4 sheets) appear to threaten contributor status. There is splendid use of a second colour in many of the beautifully drafted diagrams – diagrams that successfully and economically summarize huge bodies of sedimentological, petrographic, tectonic and geophysical data. A dozen photographs of superb quality are not only well chosen for their scientific interest
but splendidly evoke the ambience of summer days of field work in an empty and beautiful part of Scotland. (Indeed the reader might, on the evidence of these photographs decide that the only human inhabitants of the area are the leader of the BGS team and his photographer!) Errors of fact, of typography or illustration, if they exist at all, have, with one tiny exception, eluded me.

The memoir is organized into 13 chapters, a bibliography and appendices. Chapter 1 provides an excellent introduction to the geology of the area, generally and particularly to the evolution of the modern geotectonic interpretations. The two currently competing models in the ‘Southern Uplands controversy’ – fore-arc accretionary prism and back-arc thrust stack – are clearly presented in the text and in diagrams of admirable clarity and simplicity. The overwhelming interest in the interpretation of the Lower Palaeozoic rocks is emphasized by the lack of any reference to the Carboniferous and Permian rocks of the Stranraer basin in the introductory chapter.

Chapter 2 describes the Lower Palaeozoic (Upper Ordovician and Silurian) successions. The plural is necessary since each of the 12 strike-parallel, fault-defined tracts has its own distinct stratigraphic variation on a basic theme. Careful BGS collecting has produced much new biastratigraphic evidence, usefully summarized in the now obligatory Southern Uplands ‘leggogram’ (fig. 6). (This diagram includes the only typographical error I have been able to find – ‘clingari’ for clingani in the list of Caradoc graptolite zones.) Figures of representative Ordovician and Silurian graptolites are usefully included.

Chapters 2 to 6 provide the detailed stratigraphy of the Moffat Shales, Leadhills, Gala and Hawick Groups. Three of these four Groups are mainly of unfossiliferous greywacke, where painstaking petrographic analyses by Jim Floyd have now allowed differentiation and correlation of a number of formations over much of the Southern Uplands terrane. The field evidence that some of the Ordovician turbidites carry volcanic-arc detritus derived from the south, so critical to the back-arc hypothesis, is clearly presented in Chapter 4. The illustrations in these four chapters, including photographs, triangular diagrams summarizing formational petrographic/compositional characteristics and palaeocurrent diagrams, are particularly effective.

Chapter 7 deals with the Caledonian structure of the Rhins. At terrane scale the structure of the Southern Uplands has a simple and coherent pattern, however interpreted, but at outcrop level there is remarkably complicated variation. Perhaps for this reason the text of this chapter is less easily understood, to my reading less convincing, than that of its predecessors but again the diagrams, including some 15 neat and effective stereograms summarizing a wealth of structural data, are entirely commendable. Throughout Chapter 7 the structure is presented in the context of the back-arc thrust-stack hypothesis: observation and hypothesis seem closely interwoven in a manner which is not scientifically ideal. For example there are several tracts in the Central Belt outcrop at the southern end of the Rhins in which the greywackes young predominantly to the south and the first folds verge northward. These interestingly anomalous tracts were first recognised and mapped by McCurry, who interpreted their geometry, an approximate mirror image of that in the surrounding ‘normal’ tracts, as a consequence of a temporary switch from subduction to obduction. McCurry’s interpretation seems in accord with the much more recent metamorphic map of white mica crystallinity (fig. 31) but is surprisingly ‘contradicted’ (p.53) by the authors of the memoir in favour of a much more complicated back-thrusting and pop-up model.

Chapter 8 provides descriptions of the petrography and geochemistry of the two small Caledonian igneous complexes at Portencrockie and Cairngarroch, of the numerous Caledonian lamprophyre dykes and of the much rarer Tertiary dolerites. The work includes new chemical analyses and some excellent colour photomicrographs of the Caledonian rocks.

Chapter 9 records and discusses the results of a detailed study of the low-grade metamorphism of the Lower Palaeozoic rocks using white mica crystallinity (Kubler) indices. The exciting possibilities arising from the application of this new technique by Dick Merriman and Bryn Roberts are immediately evident from a study of the contoured map (fig. 31). This must be a model approach to be fruitfully copied in many other areas of similar metamorphic grades. Merriman and Roberts reach important conclusions about the age of thrust faulting and accretion and hence about the evolution of the structure of the terrane, concluding that the ‘regional pattern is in fact one of inverted burial metamorphism, with grade increasing into sequentially younger tracts of strata’ (i.e. southwards) (p. 70). This pattern ‘is compatible with the accretionary prism model of Leggett et al. (1979) . . . but would require earlier closure in the back-arc model of Stone et al. (1987)’. In these conclusions Chapter 9 contrasts, quite delightfully for those who would hate to see a good argument finally resolved, with the line taken in the rest of the memoir. Curiously, the important implications of the illite crystallinity work do not appear to have much influenced the interpretations and modelling of the earlier chapters.

Chapters 10 to 13 deal with the Carboniferous and Permian strata of the Stranraer Basin, regional geophysics, Quaternary deposits and economic geology, briefly but effectively, with excellent diagrams encapsulating much information.

Summarizing, the Geology of the Rhins of Galloway district is recognized as a major milestone in the understanding of the Lower Palaeozoic rocks of the Southern Uplands. It invites the many geologists now interested in the Southern Uplands controversy to test their ideas against a huge body of beautifully presented observations. It also deserves to be read and quarried by the authors of text-books and lecture notes for its excellent examples of how some apparently monotonous rocks can be made interesting and exciting through the careful collation, integration and interpretation of observations from fieldwork and laboratory. It is an elegant case history of the successful application of modern techniques to old, once intractable, problems.

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