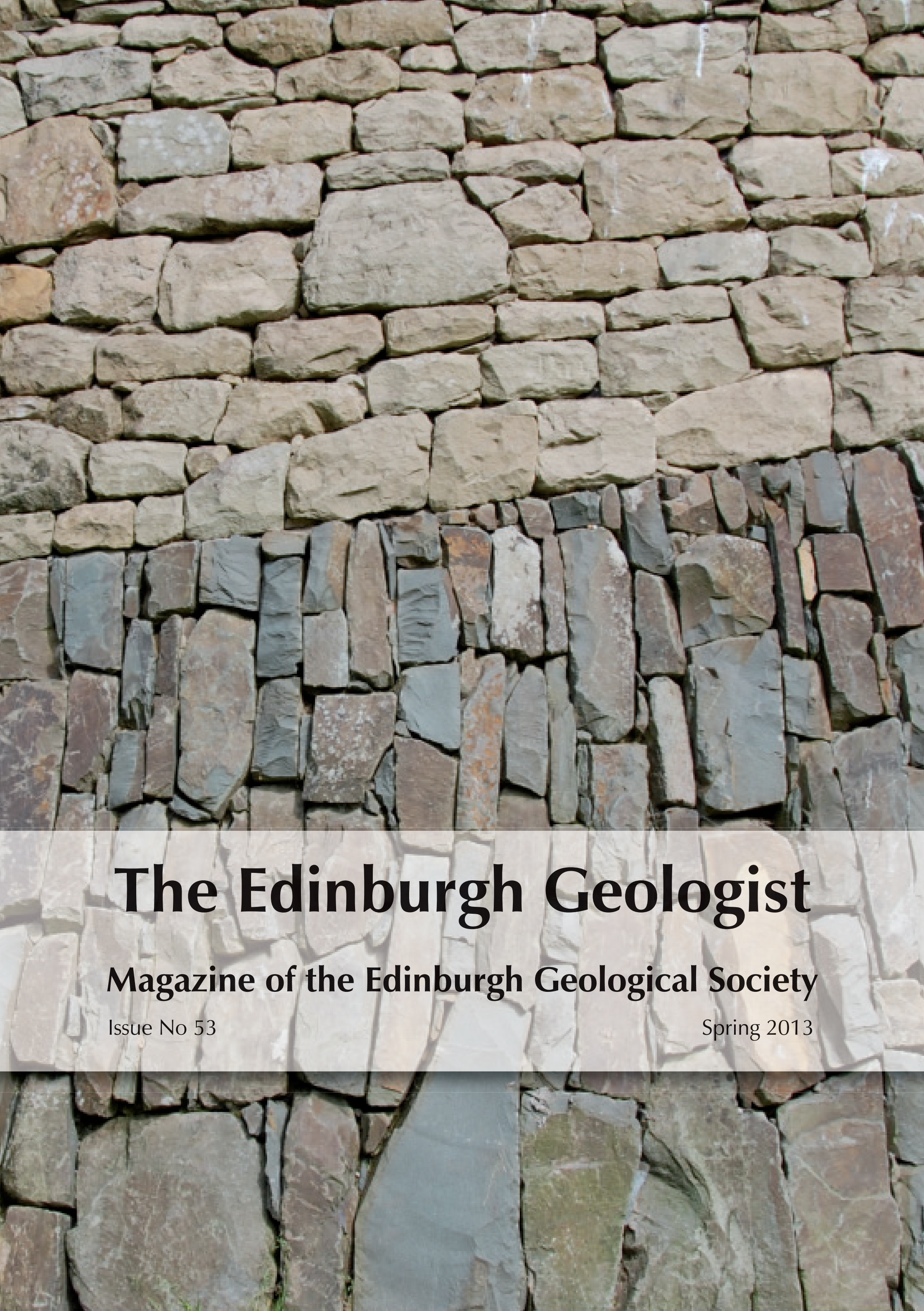

The Edinburgh Geologist

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Cover Illustration

Another construction inspired by Hutton's Unconformities in the Jed Water and at Siccar Point. This detail is from a dry-stone sculpture by Max Nowell that stands in Lothian Park, Jedburgh. Lower Carboniferous, Ballagan Formation sandstone from Swinton Quarry, near Duns, 'overlies' Silurian, Hawick or Ettrick Group greywacke from the Bowhill Estate near Selkirk.
Photograph by Bob McIntosh.

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Mixed fortune for Siccar Point and some extraterrestrial curiosities

An editorial ramble by Phil Stone

The focus on Hutton's Unconformity at Siccar Point on the front cover and in the editorial ramble of our last issue proved timely—but for an unwelcome reason. As *Edinburgh Geologist* for Autumn 2012 went to press, the news emerged that a planning application had been lodged with Scottish Borders Council that sought approval for a pipeline to be built from the vegetable processing plant just inland from Siccar Point to the shoreline just to the east of the Point, so that waste (mostly soil and vegetable matter) could be discharged into the sea. As you might expect, the application proved controversial. Scottish Borders Council received 441 objections, including a large international component, many of which feared that the development would visually impact and periodically foul the world-renowned site of Hutton's Unconformity. Practical issues were also raised concerning the area of unstable, landslipped cliff that the pipeline would have to cross, as shown by the illustration on page 2. Nevertheless, the application for the effluent discharge pipe and associated works has been approved in principle by Scottish Borders Council, subject to archaeological, ecological, geological and visual conditions and subject to the applicant entering into a Legal Agreement with the Planning Authority to comply with the constraints. The Geological Society of London, amongst others, has responded by seeking assurance that a qualified engineering geologist be retained to assess the slope instability issues. We can but cross our collective fingers and hope for the best.

But at least Hutton's unconformities are celebrated somewhere in the Borders, in the form of a dry-stone sculpture by Max Nowell that graces Lothian Park in Jedburgh as part of the 'Hutton Trail'. A detail from one of Bob McIntosh's photographs of the work is featured on the front cover of this issue of *EG*; another one, reproduced on page 3, shows the full extent of the sculpture and 'unconformity'. Elsewhere in the Borders, research work is beginning on the remarkable Early Carboniferous fossil tetrapod fauna found by the late Stan Woods. I'm delighted to include in this issue of *EG* an article by Nick Fraser describing the importance of the fossils and

Siccar Point and the area to its east, from the air, showing Hutton's Unconformity (red H), the approximate position of the proposed buried pipeline (green dashed line) and the approximate extent of landslide deposits, from BGS DiGMapGB-50 digital data, outlined in red. (BGS image number P064426).

celebrating Stan's role in their discovery.

Surprisingly, the story surrounding the original discovery of the unconformity at Siccar Point by Hutton, Hall and Playfair, seemingly well-documented, is perhaps a little more complicated that we had imagined. For the **Letters** section in this issue of *The Edinburgh Geologist*, Bill Gilmour has written to point out that Hutton was involved with three different gentlemen called Hall, with credit perhaps being allocated to the wrong one. It seems that there were also two different Clerks, father and son, with the elder being Hutton's artistic collaborator Clerk of Eldin, but the younger accompanying Hutton when the Arran unconformity was discovered. The recent exhibition of Clerk Seniors's work at the Edinburgh City Art Centre, anticipated in the

Lothian Park, Jedburgh: Max Nowell's dry-stone sculpture inspired by Hutton's unconformities at Siccar Point and Allar's Mill (Jed Water).

last *EG* was interesting but a bit disappointing from a geological perspective. The works on display were almost exclusively landscape or architectural drawings, with only one of the geological etchings represented — the cross-section of Arthur's Seat and Salisbury Crags from the Lost Drawings — together with a displayed notebook page showing sketches of 'whin dykes at Fairley', presumably Fairlie on the Ayrshire coast. For other geological interest one had to pick out the columnar jointing to be seen in the etchings of Dumbarton Rock and Castle, and in the island (perhaps Long Craig) forming the foreground to a view of North Queensferry.

But we do have some splendid, early geological images in the article by Bob McIntosh reviewing the collections of historical geological photographs held by the British Geological Survey. Then, to complete this issue of *EG*, Doug

Fettes provides some further insights into the Dalradian, and we end with a couple of book reviews.

Extraterrestrial curiosities

Another letter, from Kenneth Aitken, picks up on a previous extraterrestrial editorial theme with an account of spectacular features near his home in Germany. And in the same vein we can celebrate the successful arrival on Mars, back in August 2012, of the Curiosity rover, and its first examination of the local rocks. Much has been made of the Scottish connections of *Curiosity's* first target area—Glenelg—even if the association is far from direct. For *Curiosity's* mission NASA divided the Martian landscape into quadrants and gave each one a name derived from Canada's North West Territories, in the case of Glenelg one derived from a place near Yellowknife. Of course, like the other three (at least) Canadian Glenelgs—Nova Scotia (where else?), New Brunswick and Ontario—the name may well have commemorated Scottish roots, though an Australian Glenelg was named in honour of Lord Glenelg, Colonial Secretary from 1835 to 1839. Whatever the etymology, the geological importance of the Martian Glenelg is the apparent coming together of three distinct types of terrain and in that respect the palindromic form of Glenelg is a neat coincidence since you will get the same result whichever way you look at it—though maybe the choice of a palindrome wasn't actually coincidental. What most certainly was coincidental was the identity of the first rock analysed by *Curiosity's* on-board X-ray spectrometer, and which proved to be very similar to a terrestrial mugearite. This type of alklaline basalt was first defined (in 1904 by Alfred Harker) from Mugeary, a locality on Skye just 25 miles west of Glenelg. Curiouser and curiouser, as was said about another Wonderland.

Curiosity spent the last few weeks of 2012 sniffing around Glenelg and then set off towards a large depression known as Yellowknife Bay with the intention of drilling into what appears to be layered, sedimentary rock. Remarkable close-up images showed thin beds of rounded pebbles and well-developed cross-lamination cut across by thin veins thought to contain gypsum. As *EG* goes to press, *Curiosity* had tested its drilling equipment, scrubbed off any potential terrestrial contamination and had acquired its first haul of powdered rock for onboard analysis: a spectacular achievement. Next it's off to Mount Sharp (*aka* Aeolis Mons). The journey is only about 10 km but with a top speed of about 100 m/day, and the likelihood of distractions along the way, it might take *Curiosity* quite a while to get there.

Letters

Bill Gilmour writes on Hutton's unconformities:

May I comment on your Editorial, regarding James Hutton?

It is sometimes assumed that Sir James Hall led Hutton and Playfair to Siccar Point. Hutton was close to three members of the Hall family: Sir John Hall, his son Sir James and the brother and uncle of the baronets, Mr William Hall. Sir John was about sixteen years older than Hutton; they had exchanged letters since Hutton's student days. Sir James, who inherited when he was just fifteen, was to migrate from Hutton's sceptical student, to be in Sir Archibald Geikie's view, "the founder of Experimental Geology". William Hall planned and built post roads and farmed at Whitehall by Chirnside and so lived only five miles from Hutton at Slighhouses.

Hutton found the unconformity at Loch Ranza in 1787, when he was on Arran looking at granite with John Clerk of Eldin's son John Junior. In *The Theory of the Earth*, he says he had "long looked for" such a junction but had only found "confused masses of vertical and horizontal bodies". Slighhouses is surrounded by an unconformity, there is another between there and his hill farm at Nether Monynut, while every time he travelled from Edinburgh to the Borders, he crossed from red to black soil. Understandably, he seems to have been pleasantly surprised at Loch Ranza. The discovery inspired a two year campaign to find other examples.

Again, in *The Theory* Hutton wrote, "I inquired of Mr Hall of Whitehall . . . I particularly entreated him to examine the bed of the Whittater (*sic*), which he executed to my satisfaction . . . Mr Hall having had occasion to examine the Pease and Tour burns, in planning and superintending the great improvement of the post road upon Sir James Hall's estate while Sir James was abroad, he informed me that the junction of the schistus and sand-stone strata was to be found in the Tour burn." So, it was William Hall's finger, which first touched the unconformity at the Tour Burn. That of course led to Siccar Point being found in June 1788, by Hutton, Playfair and Sir James Hall.

Some pages later, Hutton describes a later survey of the Eye, when "Mr Hall was to meet us". He does not give a date but it was after June and was raining. Nor does he define "us"; he appears to exclude Sir James, who was "shooting muir game", which might take us to August. Likely, he and Playfair met William Hall. They descended the Eye, where they found that a "whin-stone mass seems to be here interposed between the pudding-stone and schistus". They then "pursued the coast southwards until we found the junction of the schistus and sand-stone strata about two miles from Eyemouth".

William Hall was one of a small group of people who are known to have joined Hutton in the field: Sir George Clerk-Maxwell on their tour of the Highlands, James Watt from Edinburgh to Birmingham, Clerk-Maxwell's brother, John Clerk of Eldin to Glen Tilt, the Clyde Coast and Galloway, his son John Junior to Arran, John Playfair to Berwickshire and the Lake District and Sir James Hall as above.

Kenneth Aitken writes on the Nördlinger Ries impact crater

Though I am still a member of the Edinburgh Geological Society I now live in Freiburg and work in Aalen, both in southwest Germany. Hardly surprisingly, the geology that I now get a chance to participate in is exclusively German. Aalen is not that far from Nördlingen, the centre of the Nördlinger Ries, one of the biggest meteoritic impact craters in Europe. One of the streets in Nördlingen is named after Eugene Shoemaker who, together with Edward Chao, proved in 1961 that the Nördlinger Ries resulted from a meteoritic impact. In fact, two massive meteorites fell within twenty kilometers of one another, at what are now Nördlingen and Steinheim, probably almost simultaneously about 15 million years ago, although that is still in dispute. The resulting explosions were so devastating that traces have been found up to 450 km away. From the famous 'Daniel' tower of the church in Nördlingen, which is built almost exclusively of suevite[1], one can see the rim of the outer Ries crater about 10 km away. Incidentally, in a recent Edinburgh Geologist was mentioned moon rock that had been stolen. Well, in the Nördlinger Ries Crater Museum, there is a large piece of moon rock, which was gifted by the astronauts of Apollo 14 who trained in several quarries of the Nördlinger Ries in the seventies. Perhaps any EGS members who are visiting Germany would like to visit Nördlingen and Steinheim to get a feel of two ancient geological events.

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[1] suevite … a greyish or yellowish breccia that contains both shock-metamorphosed rock fragments and glassy inclusions that occur typically as aerodynamically shaped 'bombs'. The term was originally coined to describe the rock type associated with the Nördlinger Ries impact crater. (Ed.)

Evolution's missing chapter

By Nick Fraser

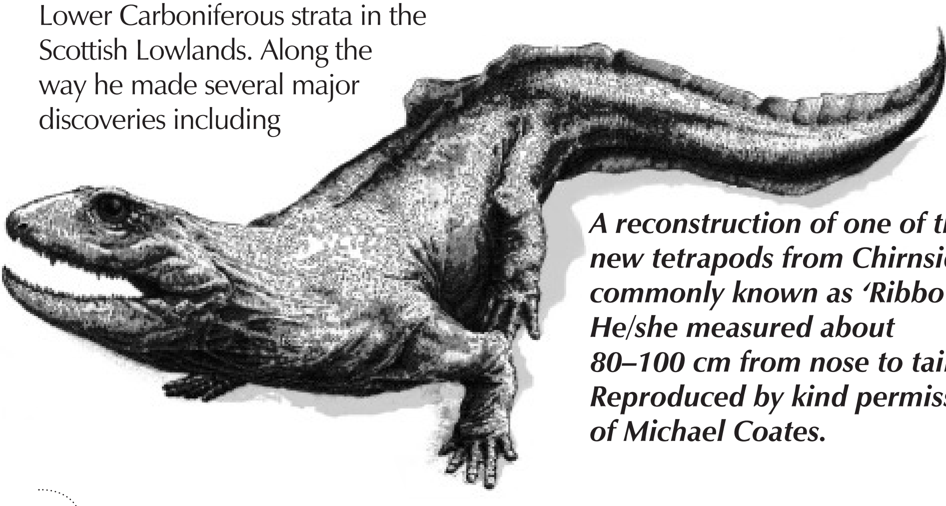
Tetrapods, or back-boned animals with four legs, were the first vertebrate animals to walk on the land. We, together with all other mammals, are tetrapods as well as all birds, reptiles and amphibians. The earliest tetrapods evolved from a particular group of fish that possessed fleshy lobed fins. In certain members of these lobed-finned fishes the fins developed to become weight supporting, walking limbs. The first of these tetrapods were rather bizarre animals with seven or even eight digits on each limb and included forms such as *Acanthostega* and *Ichthyostega* from the latest Devonian. They certainly bear no resemblance to any life forms living today. These early tetrapods in all probability used their limbs to 'scramble' over the beds of lakes and river systems, but they would have lacked any capacity to move across dry land. However in time, and with fully-developed lungs, we believe that new forms evolved that lived and looked much more like amphibians do today, and which subsequently led on to fully-terrestrial reptile-like animals. This process began about 360 million years ago. But under what circumstances did it take place and what was the Earth like at this time? Until now we have had very little information to help us answer these questions. The early Carboniferous period (from 360 to 340 million years ago) is historically known not only for its extreme scarcity of tetrapod fossils, but also the rarity of terrestrial invertebrates. The period is often referred to as Romer's Gap after the great American vertebrate palaeontologist Alfred Sherwood Romer who first recognized that this represented one of the most

The late Stan Woods collecting fossils in the Borders.

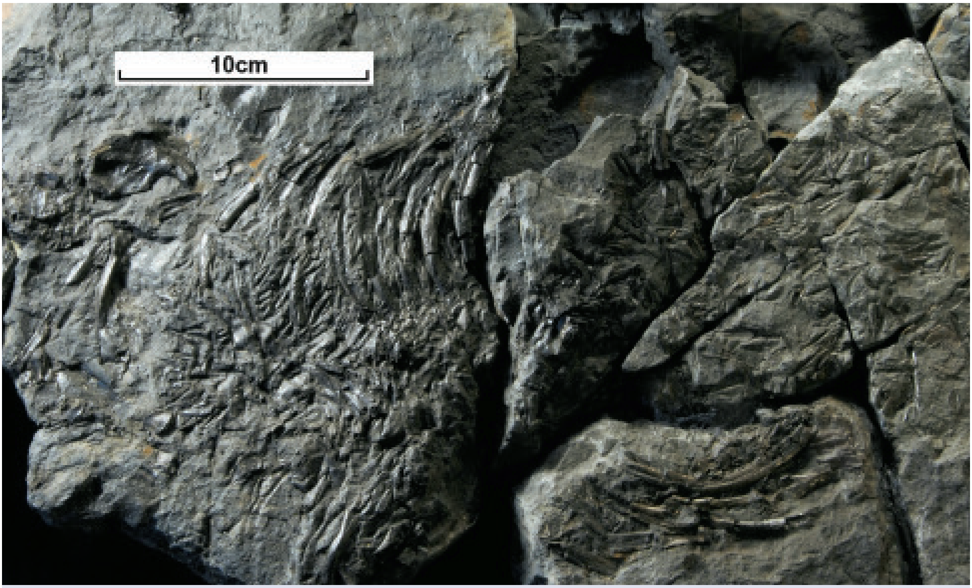
significant gaps in our understanding of the evolution of life on earth. Just what went on in this interval has remained a mystery to palaeontologists, yet it was a pivotal step for the evolution of life on land and without this step the world would have been a very different place today. Now, for the first time, new fossils from Scotland, and in particular the Borders, promise to reveal a much clearer picture of terrestrial life at this time.

These fossils were discovered by the renowned field palaeontologist, Stan Wood, who sadly died earlier this year but left an amazing legacy. Stan worked tirelessly in the Borders for over twenty years in his quest to better understand life at this cross roads in the evolution of terrestrial life. He was convinced that southern Scotland held the key and doggedly pursued his goal, searching all accessible (as well as some practically inaccessible) outcrops of Lower Carboniferous strata in the Scottish Lowlands. Along the way he made several major discoveries including *Westlothiana* – affectionately known as 'Lizzie'—but his biggest triumph was a cache of vertebrates and invertebrates, fossils he came across near Chirnside in 2008.The fossils are all from the Ballagan Formation, a distinctive rock unit that outcrops widely across the Midland Valley of Scotland, East Lothian and the Borders through into Northumberland. They include plants, scorpions, myriapods, fishes and of course several of the elusive tetrapods. They will take several years to study in detail but the find has been hailed by Sir David Attenborough as very exciting. He wrote, "The fact that they shed light on a part of geological history that hitherto has been almost blank makes Stan Wood's discoveries of world-wide importance".

The majority of these incredibly important fossils will be housed in Edinburgh at National Museums Scotland.



A reconstruction of one of the new tetrapods from Chirnside, commonly known as 'Ribbo'. He/she measured about 80–100 cm from nose to tail. Reproduced by kind permission of Michael Coates.



Amongst the fossil bones on this slab can be seen the prominent and very robust ribs that gave rise to the nickname 'Ribbo' for this new tetrapod. © National Museums Scotland.

The TWeed Project
The scientific significance of the finds cannot be overestimated and an expert group of scientists has been assembled to research the fossils. Operating under the acronym TWeed—**T**etrapod **W**orld: **e**arly **e**volution and **d**iversification—the project involves twelve scientists from across the UK, and is funded by the Natural Environment Research Council. The consortium is led by Prof. Jenny Clack (University Museum of Zoology, Cambridge) and involves the Universities of Leicester, Cambridge and Southampton, the British Geological Survey and National Museums Scotland.
During the next 4 years the TWeed team will be the first to have the opportunity to study the fossils and to search for others. Team members will investigate the environmental, depositional and climatic context in which this momentous episode took place.

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Dalradian structure and metamorphism

By Doug Fettes

In *Edinburgh Geologist* number 50 we looked at the evolution and age of the Dalradian sedimentary basin. Here the story is continued with an assessment of the structural architecture of the Dalradian succession and the associated metamorphic patterns, for which increasing isotopic and petrological data are doing much to clarify the nature and timescale of the tectonothermal processes involved.

The Dalradian basin lay on the edge of Laurentia as it broke away from the supercontinent of Rodinia and the Iapetus Ocean opened up. The ocean probably reached its maximum width in the Early Ordovician and then began to close. At around 474 Ma a volcanic arc system collided with the Laurentian margin, the results of which can now be traced from the Taconic terranes of eastern North America through Ireland and Scotland at least as far as Shetland (Fig. 1). In Scotland this collision gave rise to the Grampian tectonothermal event. Around 430 Ma years, the microcontinent of Avalonia docked against Laurentia and shortly afterwards, around 425 Ma the continental mass of Baltica collided with Laurentia initiating the Scandian event (Fig. 1); these collisions did not greatly affect the Grampian terrane.

Grampian Event

As the volcanic arc closed with the continental edge, oceanic crust was obducted onto the youngest Dalradian sediments along what is now the Highland Border. These ophiolitic rocks now form a series of serpentinised bodies with associated cherts and black shales (Garron Point Group) that rest on the highest beds of the Trossachs Group of the Dalradian succession, giving a maximum age for initiation of the Grampian Event of ca 474 Ma. As collision progressed the volcanic arc probably became buried under the leading edge of the continent, compressing and deforming the Dalradian succession; the crust thickened and the deeper rocks became progressively metamorphosed.

The deformation is generally considered in four discrete phases (D1-D4). The folds related to all four phases have gently plunging and broadly parallel axes. The first two phases effectively produced major, broadly flat lying, recumbent folds.

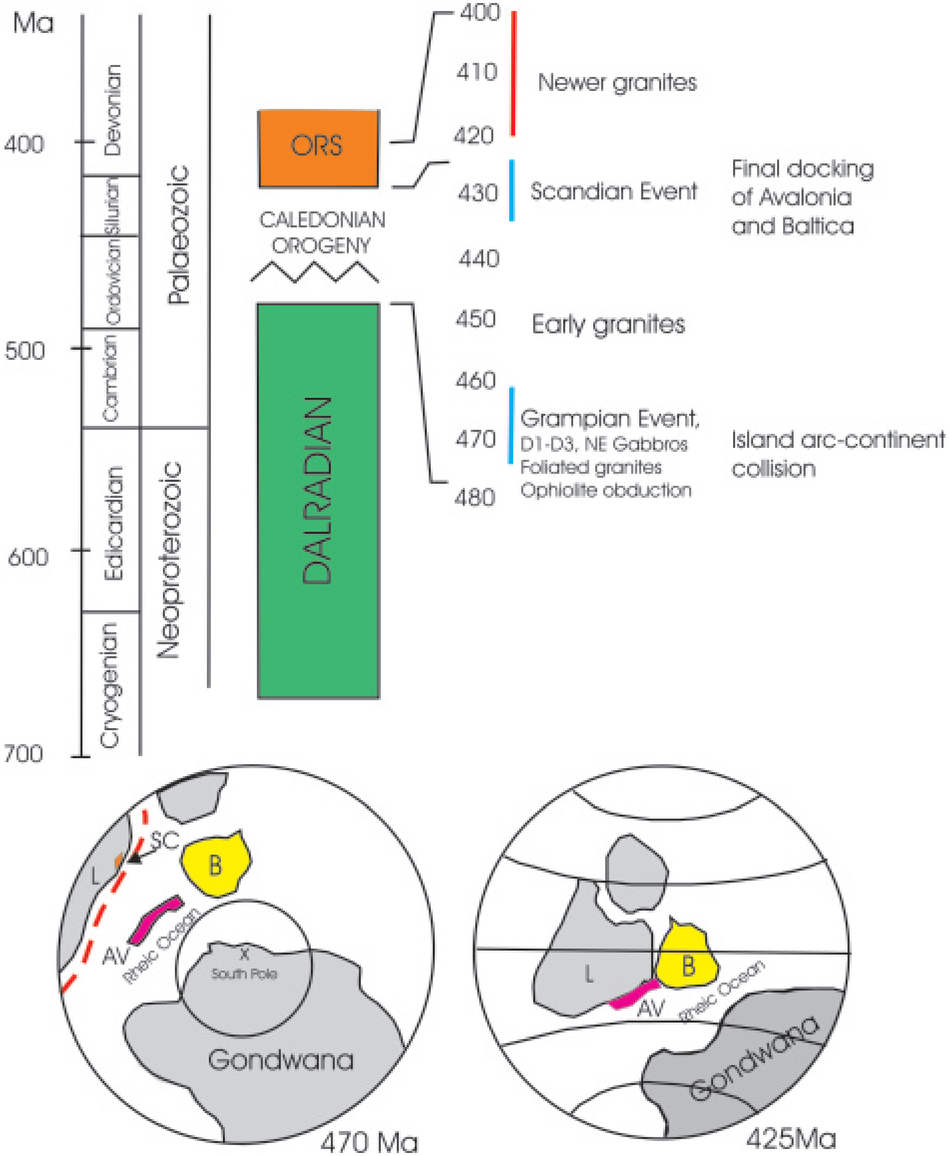


Figure 1 Stratigraphical column showing the elements of the Caledonian Orogeny. Global reconstructions show stages in the convergence of continents: L, Laurentia; B, Baltica; AV, Avalonia; SC, Scotland; red dashes = volcanic arc system.

The second two phases generally produced more upright structures. The early structures are dominated in the Southern Highlands by the Tay Nappe, a major regional scale fold that causes large-scale inversion of the beds. To the NE the nappe dies out and is absent in the Buchan area, such that the beds there are largely right-way-up. Effectively, the pile of deformed Dalradian rocks was thickest in the SW and Perthshire and relatively thin in the NE. The main growth of metamorphic porphyroblasts occurred from syn-D2 to syn-D3. A minimum age for the Grampian tectonometamorphism is given by the earliest of the post-tectonic granite intrusions at ca 455 Ma.The Grampian Event was therefore relatively short lived, lasting around 10 Ma and peaking at 470–465 Ma.

Buchan Block

In general terms the age and nature of the arc-collision events is similar along the Laurentian margin but an exception is the Buchan Block of NE Scotland. This is bounded to the west by the Portsoy-Duchray Hill Lineament, a long-lived shear zone, and to the south by the Deeside Lineament, a somewhat enigmatic structure, now marked by a series of major granite plutons (Fig. 2). Both these lineaments are thought to reflect major lines of weakness in the underlying basement. The Buchan Block was originally considered as a distinct entity, structurally, stratigraphically and metamorphically different from the rest of the Dalradian succession. However, it is now accepted that the lithostratigraphical divisions of the Buchan Block can be correlated with those of Perthshire and areas farther SW. The deformation sequences are also comparable, although D2 and D4 are poorly developed in Buchan. The region however differs in a number of characteristics.

1. As noted above, the Dalradian succession in Buchan does not have the major nappe development and crustal thickening seen in Perthshire and the SW. This is reflected in regional geophysical patterns where the Buchan Block exhibits much higher gravity values than the rest of the Dalradian region; a characteristic interpreted as reflecting a relatively shallow basement under only a moderately thickened Dalradian succession.

2. The orientation of the major fold axes (primarily D1 and D3) is approximately N-S in the Buchan region as opposed to a NE-SW orientation over the rest of the Dalradian (Fig. 2). The latter orientation is parallel to the Highland Boundary Fault and the

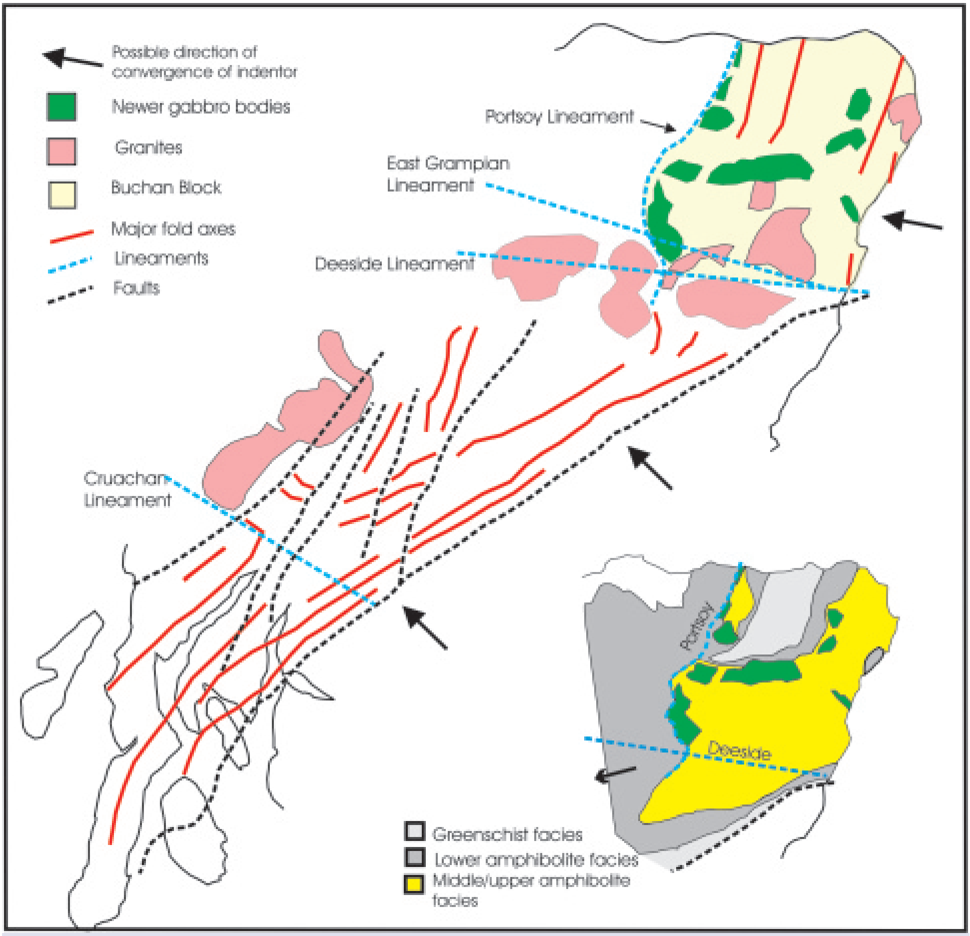


Figure 2 Major structural elements of the Dalradian Belt. Inset map shows the metamorphic facies of the Eastern Highlands and the position of the high grade rocks.

presumed zone of continent-arc collision.

3. The Buchan Block was an area of very high heat flow as evidenced by the style of metamorphism and associated 'Older Granite' masses and the suite of 'Newer Gabbros'.

Metamorphism

The early workers identified two styles of metamorphism in the Dalradian belt. Firstly, the Barrovian, indicative of intermediate pressure metamorphism (with intermediate heat flow) and characterised by garnet and kyanite. It was first defined in the Angus glens by Barrow, and is now considered to typify the bulk of the Dalradian crop. Secondly, the Buchan, indicative of low pressure metamorphism (high heat flow) and characterised by cordierite and andalusite. It was first defined in the Buchan region by Read. Although initially considered to be separate events it is now accepted that the growth of the porphyroblasts in the two regions is broadly synchronous and that there are wide transitional zones between the two types. It is important to note that the highest grade rocks (i.e. middle and upper amphibolite facies) within the Dalradian belt occur in the Eastern Highlands (Fig. 2). Consequently it is convenient to consider the Barrovian area in two parts, the classical area in the SE Highlands (Barrovian s.s.) and that comprising Perthshire and the SW (Barrovian s.l.).

The background cause of Dalradian metamorphism was thermal relaxation of the overthickened crust. However, this does not explain the intense metamorphism seen in the Eastern Highlands nor the speed with which peak temperatures were reached (see below). These factors require significant additional heat input. Thus fluids, magmas or both must have introduced considerable quantities of additional heat. In Buchan the Newer Gabbro suite is an integral part of this input; the highest grade rocks (sillimanite + K-feldspar) of the region occurring in the aureoles. The Older Granites may also be seen as agencies of the enhanced heat input.The highest heat flow occurred in Buchan, reducing to the west and south, and with the adjacent areas having increased temperatures due to heat transfer from the Buchan 'hotspot'. Thus the classical Barrovian areas reflect thermal regimes enhanced relative to those of Perthshire and the SW.

Timing

In the Barrovian (s.s.) area the metamorphism was syn-D2- to post-D3. It lasted about 10 Ma (ca 472–462 Ma) with a short but intense period of heat input, possibly as a series of short pulses, syn-D3, around 465Ma, which was responsible for the higher grades of metamorphism (middle and upper amphibolite facies).

In Buchan the peak of metamorphism was probably syn- to post-D2. There is a close association between the intrusion of the Newer Gabbros and the Older Granites, both dated at ca 470 Ma and the peak of metamorphism at ca 471–469 Ma. This would imply that the highest temperatures were reached in the Buchan area possibly 3–4 Ma before that in the Barrovian (s.s.) region. This accords with the timing of peak conditions relative to the deformation sequence: syn-D2 in Buchan and syn-D3 in the Barrovian (s.s.) region. These timings support the suggestion that the heat input was focused in Buchan and moved out into adjacent areas.

Models

Why is the Buchan Block different? Perhaps the simplest possibility is that the volcanic arc that collided with the Dalradian margin did so obliquely, with the major indentation in the SW and that the induced stress along the continental edge was relieved by slippage on a line of weakness in the basement, now recognised as the Deeside Lineament. The Buchan Block would not therefore have suffered the compression and crustal thickening experienced by the main Dalradian areas. The relief of stress may also have allowed some rebound and extension of the Buchan Block leading to decompression melting and to the enhanced heat flow. Subsequent compression led to thrusting on the Portsoy line and the major D3 folding. Another possibility would involve a fragmented arc, one element colliding with southern regions and a second fragment colliding with Buchan less forcibly and at a slightly different angle than was the case to the south.

A slightly longer and fully referenced version of this article is available as an online supplement to this issue of The Edinburgh Geologist at www.edinburghgeolsoc.org.

Key references

AGUE, J J & BAXTER, E F, 2007. Brief thermal pulses during mountain building recorded by Sr diffusion in apatite and multicomponent diffusion in garnet. *Earth and Planetary Science Letters*, Vol. 261, 500–516.

CARTY, J P, CONNELLY, J N, HUDSON, N F C & GALE, J F W, 2012. Constraints on the timing of deformation, magmatism and metamorphism in the Dalradian of NE Scotland. *Scottish Journal of Geology*, Vol. 48, 103–117.

HARTE, B & HUDSON, N F C, 1979. Pelite facies series and the temperatures and pressures of Dalradian metamorphism in E. Scotland. In, Harris, A L, Holland, C H & Leake, B E (eds) *The Caledonides of the British Isles—reviewed*. The Geological Society of London.

VORHIES, S & AGUE, J, 2011. Pressure-temperature evolution and thermal regimes in the Barrovian zones, Scotland. *Journal of the Geological Society*, London, Vol. 168, 1147–166.

Historical geological photograph collections at the British Geological Survey

By R P McIntosh

Within a short time frame in the 1890's the British Association for the Advancement of Science (BAAS), the Geologists' Association (GA) and the Geological Survey of Great Britain and Ireland (GSGBI) all started, for different reasons, major collections of geological photographs. All were firmly focussed on geological field photographs of Great Britain and Ireland, all the collections were long-lived or are still active today. They have now been brought together by the British Geological Survey, the last being the GA Carreck Archive collection which was placed in BGS on permanent deposit in 2012. The first two collections have been available for some time on the BGS image resource GeoScenic and work has started on the GA collection to digitize the photographs and capture the metadata which is to be released in 2013.

Geology and photography have a long association. As early as 1840, L L B Ibbotson exhibited daguerreotypes at a British Association meeting. In the late 1850s photography was already being used to record geological features in the field, most notably Robert Mallet's photographic record of the effects of the 1857 Neopolitan earthquake. Later, photographers such as O W Jeffs and W J Harrison were not only taking pictures but were using them in publications and writing about the value of photography to geology.

The BAAS Collection

In 1888, Jeffs proposed to the BAAS that they should address the need for systematic photographic coverage of the geology of the United Kingdom. His proposal was accepted and the BAAS set up a committee under the chairmanship of James Geikie, for the 'collection, preservation and systematic registration of photographs of geological interest in the United Kingdom'. The collection soon expanded and was housed in London, first in the Geological Survey and Museum Library at Jermyn Street and later at the new premises in Exhibition Road, where it complemented the Survey's own collection of photographs. The BAAS committee arranged the sale of prints and lantern slides, and every year lists of photographs were published in the BAAS Transactions.

Salisbury Craigs, Edinburgh. Junction of intrusive dolerite and Old Red Sandstone. By S H Reynolds. BAAS, 1906. P246811. The sedimentary rock is now regarded as Lower Carboniferous sandstone of the Inverclyde Group.

The collection itself is organized on a county-volume basis though some counties are better represented than others. The Committee was very active up to the Second World War, but afterwards activity declined and by 1956/57 there was no longer any mention of the Geological Photographs Committee.

During WW2, the collection had suffered disaster. The negatives, indexes and several albums were transferred to the offices of Prof. S H Reynolds (Secretary of the Photographic Committee) in Bristol, where they were totally lost in an air raid. The print collection moved to Imperial College, then to Southampton University Department of Geology, where contact was lost. Research by the BGS Library Service in the 1980s finally relocated the collection and agreement was reached

Sgurr nan Gillean, Skye, Pinnacle route. Craggy form of Tertiary gabbros. By W W Watts. BAAS, 1896. P235469.

for its permanent deposit with BGS where the photographs were conserved and later scanned and a new catalogue made.

The collection at BGS consists of over 7000 photographs from an original total of over 9000. Most photographs covering Ireland are held at the Ulster Museum and a few albums, Dorset, Hampshire, and Lancaster, remain unaccounted for.

Geological Survey of Great Britain (now BGS) Collection

The Geological Survey of Great Britain and Ireland started systematic field photography in 1891 under Director Archibald Geikie. Mr A Macconochie, Assistant Curator of the Survey collections, along with Mr Robert Lunn, General Assistant in the Edinburgh Office, under the direction of the geologist Jethro Justinian Harris Teall, were sent to

Hailes Quarry, Slateford. Edinburgh. Quarry in Hailes Sandstone overlain by shales (Calciferous Sandstone Series). By R Lunn. BGS, 1913. P000183. The Carboniferous Hailes Sandstone is now placed within the Strathclyde Group (Visean).

the North West Highlands to take a series of photographs in order to 'help explain points of geological structure'. Lunn continued to undertake field photography in the Highlands lugging the heavy wooden half-plate camera and tripod and the fragile glass plate negatives with him, and so started the official Survey collection of photographs. In England, field photography began slightly later in 1904. There, surpassing Lunn in achievement, Jack Rhodes joined the Survey in 1910 and during a career spanning forty-six years he added almost 9000 photographs to the Survey's English A series collection, travelling by donkey or horse and cart, later by motor cycle combination and finally by motor car from 1945.

The collection is organized into lettered series and reference albums of print. Good authoritative descriptions were written by the BGS geologists.

A = England and Wales
B = Scotland—Half plate
C = Scotland—Quarter plate
D = Scotland more recent formats

Near entrance to No. 1 Mine in Raasay Ironstone Mines, 1.9 km. east of Raasay House. Inverness-shire. Building of 'steam navvy' or dragline, for removal of superficial deposits, by prisoners of war under armed guard. By R Lunn. BGS, 1917. P000048.

The first printed catalogue was published in 1910. Classified catalogues were published, arranged by subject, of the best photographs in 1948, 1956 and 1965. There are many other 'special collections' for non-field photographs. The captions and descriptions have now been digitally captured and the photographs scanned and made available on GeoScenic.

From the 1990s, with the advent of digital databases, a single unified sequence was created and these collections have now been combined.

The Geologists' Association Carreck Archive

The third major UK collection of field photographs is that of the Geologists' Association. The GA was founded in 1858 with the purpose of bringing together enthusiasts from all levels and ages, a tradition it still carries out today with its encouragement for 'Geology for All'. The GA Carreck Archive,

At Newlands Corner. Motor excursion in Surrey. GA, June 6th 1914. P804705.

named after Marjorie Carreck, who was the coordinator and custodian of the collection for fifty years, has recently been professionally conserved for the GA. The collection was formally deposited with BGS in June 2012 and is held in proper archival conditions along with the other two collections.

The Carreck Archive is essentially a record of the GA activities from the 1890s to the mid-1990s, mostly albums of black and white photographic prints from a range of GA field meetings, with named locations, sections, and pictures of GA members on those excursions. Other material includes albums of negatives, bundles of photographic prints and other ephemera relating to the GA, e.g. menus from the annual dinners, postcards, letters etc. All very interesting material for historians of geology.

The future

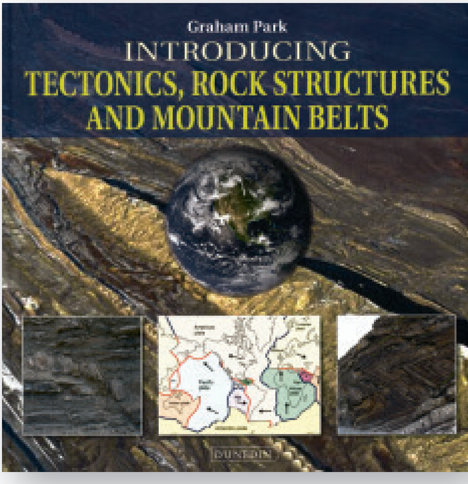
The BGS and BAAS collections have been available for some time on GeoScenic: the National Archive

Descending a Denehole at Hangman's Wood, West Thurrock, Kent. GA, 1907–09. P805290. "In the course of ploughing this field the horse's feet broke through the surface. We procured a rope and the pole of a waggon and investigated the interior. The shaft descended through about 12 feet of Thanet Sand and entered into a beehive-shaped chamber about 20 ft. high. These deneholes were formed in getting the chalk in past ages for marling the land."

of Geological Photographs (http://geoscenic.bgs.ac.uk). This excludes the BAAS material held at the Ulster Museum, and the missing albums. The GA photographs are now being digitally captured and in the best traditions of the GA 'Geology for All' the captions are being transcribed by a team of volunteers. The intention is to release the GA collection alongside the BAAS and BGS collections in 2013. Together, they will form a fascinating and comprehensive historical collection of UK geological photography.

Book reviews

Introducing Tectonics, Rock Structures and Mountain Belts by Graham Park. Dunedin Academic Press, Edinburgh. 2012. Paperback, 132 pp. Price £14.99.
ISBN 978-1-906716-26-4



The latest contribution to geological literature from Dunedin Press aims to *"share the excitement of discovering how the all-embracing theory of plate tectonics can help to explain the multitude of complexities revealed in the study of rocks"*. Its author, Graham Park, initiated the series in 2006 with Introducing Geology (2nd edition 2010). This latest and larger format book delves deeper into small and large scale tectonic structures and features, and is aimed at *"students and others interested in geology"*. It first spells out the global framework linked to plate tectonics, then moves on to summarize traditional structural geology concepts, before describing the structure of igneous intrusions and gravitationally induced features. The last three chapters look at the tectonic interpretation of orogenic belts with examples taken from both 'modern' (Jurassic and later) and ancient (Lower Palaeozoic and earlier) orogens. An appendix containing classification tables for the basic terminology is followed by a fairly comprehensive glossary (with good text links), and some brief recommendations for further study. The text is generally well-written, the layout good, and the illustrations suitably numerous and relevant, though unsurprisingly several diagrams and some photographs are repeated from the earlier introductory book. Most of the diagrams are commendably simple, suitably colourful, and easy to understand, though some have minor errors; the standard of the photographs is generally disappointing. More importantly, there are numerous errors and inconsistencies in the text and diagram captions, notably in the cross-referencing between diagrams.

A problem with venturing into geologically deeper waters is that one needs to be a stronger all-round swimmer. Ideally, the author should have presented the latest concepts and interpretations supported by recent references, and his book should reflect current best-practice with regard to classifications and terminology. It is in these areas that the book falls down somewhat. The reader could easily be misled into thinking that this is an up-to-date view of the subject, when in truth some descriptions, interpretations and definitions have long been superseded.

Perhaps the most glaring example is Figure 8.4 that portrays a model for cauldron subsidence and granite pluton emplacement in the Etive-Glencoe area. The interpretation was taken from a sketch in a 1966 publication by Johnstone (not Johnson as stated), which in turn followed the much earlier (1909) work of Clough and colleagues. Although this was ground-breaking over a century ago, more recent detailed fieldwork, radiometric dating and geochemical analyses have thrown significant new light on the volcanic and intrusive history of this area. For example, the main basaltic andesite lava outpourings in Lorn occurred at c. 425 Ma, the Glencoe Caldera formed at around 420Ma, and the constituent intrusions of the Etive Pluton and related dyke swarm were emplaced in stages between about 418 and 408 Ma. The timing and relationships suggest intrusion of separate magma pulses over a 17–20 Ma period rather than a single event lasting only a few million years as implied by Park.

One of the examples chosen by Park to illustrate ancient orogenic belts is the British Caledonides. The treatment is typical in that whilst the summary is moderately satisfactory, there are inconsistencies with geometry and with the timing of events. Grampian deformation is shown (Figure 12.4) affecting the Moine of the Northern Highlands, but in the text the impression is given that Scandian folding and metamorphism is dominant here. The Great Glen Fault is portrayed as moderately dipping, but is in fact subvertical. The Lake District and Welsh deformation events are Mid-Devonian (Acadian) but are correlated here with Southern Uplands events that occurred in the late Silurian to early Devonian. Also, the oft-quoted statement that the Dalradian Supergroup totals 20 km is repeated here. The combined sequence thickness may reach this figure, but certainly not in any one place—continental rupturing would have occurred in such circumstances. The description of Barrovian and Buchan metamorphism is rather meaningless without metamorphic facies information—what constitutes lower pressure, higher temperature?

Throughout the book, some of the terminology used is subjective and rather dated. For example, should mio-geosynclines and granitisation be discussed here? Further, the classifications given in the Appendix for igneous, sedimentary and metamorphic rocks fail to follow, or even mention, the IUGS schemes, although they do reflect some erroneous popular usage. So, for example, the metamorphic scheme presented here perpetuates parochial terminology only really used in the Scottish Highlands (psammite, pelite, etc) and throws in some textural terms (slate, schist, gneiss); semi-psammite will be unknown to many geologists, and marble is now regarded as misleading and obsolete. In this context, a notable omission from the Appendix is a metamorphic P-T diagram to briefly explain the framework of metamorphic facies. As with Barrovian and Buchan metamorphism, how can the reader understand the meaning of 'Eclogite Facies' (p. 84) without some indication of the requisite pressure and temperature conditions?

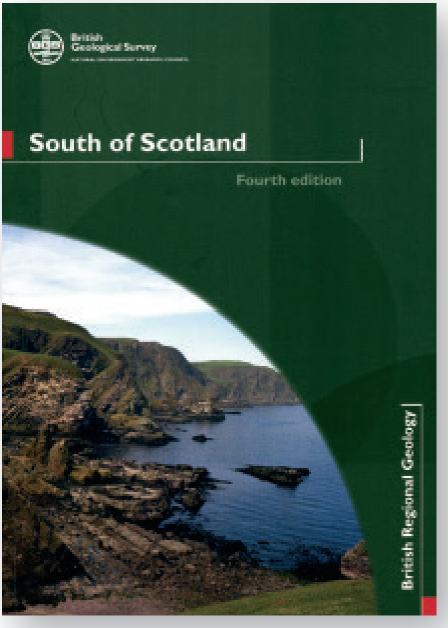
The terminology used is not only erratic, but in parts also inconsistent. For example, on pages 98–99 the many references to the Moine Thrust (+Belt/Zone) are given variable names and capitalization. Equally annoying are the incorrect variations on 'Lewisian' and 'Torridonian', whilst the main component *events* of the Caledonian Orogeny are themselves termed Grampian orogeny and Scandian orogeny (nested orogenies?). Such bad habits may seem trifling to world-weary geologists but should not be passed on to the next generation.

In summary I cannot recommend this book, either for the student or interested amateur, or for the more informed reader. Its ambitious remit and good layout and illustrations cannot overcome the deficiencies introduced by the use of dated references and interpretations, failings compounded in places by the subjective usage of geological terminology.

By John Mendum

This is an edited version of a detailed and comprehensive review provided by John Mendum, which is available in full as a supplement to the online version of this issue of The Edinburgh Geologist at www.edinburghgeolsoc.org.

British Regional Geology: South of Scotland (Fourth Edition) by P Stone, A A McMillan, J D Floyd, R P Barnes and E R Phillips. British Geological Survey: Keyworth, Nottingham. 2012. Paperback, 247 pp. Price £18. ISBN 978-085272-694-5.



The great swathe of mountains in southern Scotland, extending from coast to coast and across to Northern Ireland has traditionally been hard to interpret, indeed forbidding geologically. The bulk of it is composed by Ordovician sea-floor basalts, followed by cherts, shales, and thick greywacke sandstones, the latter extending well up into the Silurian. This succession was intensely folded and faulted, especially in the late Silurian, and great granite masses were intruded in the south-west. Unconformably overlying these ancient rocks are continental Devonian and chiefly shallow marine Carboniferous sediments, along with frequent lavas and volcanic intrusions. The whole area has been extensively sculptured by ice during Pleistocene times, and subsequent isostatic rebound created dramatic river and shoreline terraces.

Until comparatively recent times the Lower Palaeozoic succession has been very difficult to interpret. Thus Charles Lapworth, founder of the Ordovician system, noted in 1870 that these same rocks, on the Geological Survey maps were "merely indicated by a common purple tint, without the slightest attempt at subdivision". Then came Lapworth's own mighty work on the Southern Uplands (1880) and Girvan (1882), using graptolites for the first time to resolve the stratigraphy, and proposing a model of isoclinal folding to account for the structure. This phase in research culminated in the magnificent, and still useful Geological Survey Memoir of 1899 by Ben Peach and John Horne. Meanwhile, vigorous work on the overlying Upper Palaeozoic strata and the assemblage of igneous rocks proceeded through the later 19th and earlier 20th centuries, until the structure and stratigraphy of all the Palaeozoic rocks of the region were ably synthesised in the first (1935) and second (1948) editions of *South of Scotland*, the latter not greatly different from the former. An excellent third edition was published in 1971, much updated, but just anticipating the plate tectonic revolution. And then the recognition of subparallel ENE-WSW strike faults as the dominant structural control (rather than isoclinal folding) in the 1960s and 70s led to a completely new understanding of the Southern Uplands as a subduction-related accretionary complex, squeezed between colliding plates. The Survey initiated a fresh new mapping programme starting in the south west, separating and defining different formations. Other research was continuing at various universities, but the bulk of the literature, including sundry controversial models, remained scattered in various papers in numerous journals. In other words the time was ripe for an authoritative synthesis. And here it is, the fourth edition; a magnificent compilation which will prove the definitive reference for years to come.

The area covered includes the Ordovician and Silurian of Girvan/Ballantrae as well as that of the Southern Uplands proper, and there are ten chapters: Introduction, Girvan/Ballantrae, Southern Uplands, Caledonian structure and magmatism, Devonian sedimentary and volcanic rocks, Carboniferous sedimentary and volcanic rocks, the Permian and Triassic succession, the Jurassic to Palaeogene history, Quaternary processes and deposits, and Geology and Man. There is a selected bibliography and index, and a very useful bedrock geology map at the scale of 1:625 000 in the back pocket (the map also includes much of the Midland Valley and Northern England). The book is beautifully produced with 68 Figures (maps, sections, block diagrams, graptolites) and 67 Plates (landscapes, rock sequences, fossils etc.), the great majority in colour. This volume is a testament to the vast conceptual leaps that have been made in geology during the last forty years, not only with the development of plate tectonics, but also with advances in technology, which have made, for example, the division of the 'interminable' greywackes into ordered and separate, fault-bounded tracts.

In the early chapters, the history of the subduction-related accretionary complex, of which the Girvan/Ballantrae district and the Southern Uplands form parts, is narrated in detail. All the separate formations are here defined and placed in their proper stratigraphical sequence. The British stratigraphical divisions are used here, perhaps the equivalent international groupings might have been referred to also, but this is a minor omission. And the basic model is defined in quite simple, but memorable words "Whilst the Ballantrae Complex was being buried by the thick Ordovician to Silurian sedimentary succession now seen around Girvan, a very different process was operating further south. As the Iapetus oceanic crust was subducted beneath the margin of Laurentia, sections of the oceanic sequence and its sedimentary cover were intermittently stripped from the subducting plate and thrust beneath the stack of similar stripped-off slices to initiate an accretionary complex". Very nicely phrased, and the nature of this same complex and Caledonian structure and magmatism are discussed in Chapter 4, with the various great plutons of the south-west and elsewhere taken in turn.

Chapter 5 covers the suite of Devonian sedimentary and volcanic rocks magnificently exposed along the eastern shore and inland, and here the current stratigraphy is precisely defined, and the environments and palaeontology discussed. In the following chapter dealing with the Carboniferous succession the same applies, an authoritative and up-to-date treatment of this great range of strata and their palaeontology, and the igneous rocks as well. Thereafter, Permo-Triassic sedimentary rocks of the Dumfries and related basins are covered in detail, and although there are no Jurassic rocks exposed, apart from those of a small outlier near Carlisle, it is quite probable that Jurassic and some Cretaceous sediments were deposited at least in parts of southern Scotland. But there was Neogene magmatism, as described here, in the form of the great dykes cutting south-east from the vast volcanic complexes further north-west, and intrusions such as Ailsa Craig.

The Quaternary chapter (9) is a fine, well illustrated compilation, with a particularly compelling digital terrain model map (fig 58) showing the effects of a fast-flowing ice-stream in the Tweed Basin. This chapter also pays due respect to climatic fluctuations over the last few million years; and I found it eminently readable. Finally we have Geology and Man (Chapter 10), which contains a fine account of how the natural resources of southern Scotland have been used through time, coal, peat, (not forgetting alternative energy sources), building stones (of which we have many), material for aggregates, minerals such a baryte, gold, arsenic and antimony, all the ores that used to be worked in the Leadhills-

Wanlockhead area. Finally there is a section on earthquakes and other geological hazards.

What an excellent book this is, and a real testament to the many geologists who have helped to unravel the complexities of the bedrock and superficial deposits of our magnificently scenic land, especially the Geological Survey geologists; and we must not forget the cartographers and illustrators who have made this such a valuable work. If Charles Lapworth or Ben Peach or John Horne had been living today, I do not doubt that they would have been vastly impressed with how their classic work had developed and with the great new syntheses that had risen, so ably summarised here. Well done, to everybody involved! If you have not already bought it, put it on your shopping list.

by Euan Clarkson

Finally … Not in front of the children

The words ‘evolution’ and ‘geological history’ are amongst 50 expressions banned by the New York Department of Education as inappropriate for student tests. As reported in the ‘i’ newspaper of 29th March 2012, these terms ‘could evoke unpleasant emotions in the students’. The list of terms was meant as a guide to how the school tests might be improved but has opened the Department to a blaze of ridicule for taking political correctness too far. The banned words or phrases were: Abuse • Alcohol, tobacco or drugs • Bodily functions • Cancer • Catastrophes/disasters • Celebrities • Children dealing with serious issues • Cigarettes • Computers in the home • Crime • Death and disease • Divorce • **Evolution** • Expensive gifts, vacations and prizes • Gambling involving money • **Geological history** • Halloween • Homelessness • Holidays • Homes with swimming pools • Hunting • In-depth discussions of sports that require prior knowledge • Junk food • Loss of employment • Movies • Nuclear weapons • Occult topics • Parapsychology • Politics • Pornography • Poverty • Rap music • Religion • Religious holidays and festivals • Rock ‘n’ roll • Running away • Sex • Slavery • Terrorism • Television and video games • Traumatic material • Vermin • Violence • War and bloodshed • Weapons • Witchcraft and sorcery.

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