The Edinburgh Geologist

Magazine of the Edinburgh Geological Society

Issue No 58

Autumn 2015

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Cover Illustration

The enduring appeal of dinosaurs to children (of all ages) can be readily confirmed by a visit to any museum gift shop. This is just a very small part of the extensive display of *dinosauria* on offer at London's Natural History Museum. For some local examples of the real thing see Steve Brusatte's article on page 18.

Published September 2015 by The Edinburgh Geological Society

(Charity registered in Scotland number SC008011)

www.edinburghgeolsoc.org

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ISSN 0265-7244

Mostly about dinosaurs

An editorial ramble by Phil Stone

Celebrations of the William Smith map bicentenary continue and we are doing our bit in this issue of *EG* with the second of Victoria Woodcock's articles, this one focussing on Smith himself and some of his achievements beyond THE MAP. Elsewhere, there's still time to catch some of the other commemorative events. The Geological Society of London's flagship conference discussing the future of geological mapping is on 5th November; exhibitions continue until 1st November at The Natural History Museum in London, until January 2016 at the Oxford University Museum of Natural History, and until 28th February at the National Museum of Wales, Cardiff.

It was at the Mearns Colliery in Somerset that Smith first began to apply his observations of lithological succession—and first used the term 'stratification'. And it was the hunt for coal, and the canal system developed to transport it, that provided him with the wherewithal to pursue his geological mission. Now the coal industry has gone full circle, and with its decline has come abandoned workings and industrial dereliction generally regarded as a problem to be solved only by reclamation and site restoration. Not necessarily it seems. In this issue of *EG*'s second article Graham Leslie and Mike Browne map out an alternative route, viewing abandoned opencast pits as valuable resources offering opportunities for geological enlightenment rather than dismissing them as the harbingers of societal blight. Is there to be an afterlife for coal? We can but hope—and the extraordinary 'Multiverse' redevelopment of the Crawick site near Sanquhar shows what can be done.

Now for the dinosaurs

Everyone loves dinosaurs, and if you had any doubts they would have been dispelled by the recent online furore over plans to move the London Natural History Museum's enormous *Diplodocus carnegii* skeleton and replace it with an (even bigger) blue whale. The 'Save Dippy' campaign went viral, despite the skeleton being a plaster replica of an original believed to be in Pittsburgh, USA. It came to the NHM in 1905, having been a gift from the industrialist Andrew Carnegie to King

Edward VII, who was probably quite relieved to pass it on. Those historical associations notwithstanding I suspect that 'Dippy' will soon be on the move, so just for the record, here he/she is (below) in his/her glory days.

Yes, everyone loves dinosaurs, especially children and especially if they are 'our' dinosaurs, so we can all relive our childhood obsession (go on, admit it) with *EG*'s third article by Steve Brusatte, representing the PalAlba team of vertebrate palaeontologists. Steve recounts some of their recent discoveries, ichthyosaurs as well as dinosaurs, from the Middle Jurassic beds of Skye, stressing the teamwork involved in the project.

With dinosaurs, things have not always been so cooperative. They got off to a bad start back in the mid 19th century when Richard Owen was busy hijacking Gideon Mantell's specimens and generally traducing the unfortunate man's reputation. Owen coined the term *Dinosauria* (terrible/fearfully great/inconceivable lizards), probably in 1842 but with the description backdated to 1841 to ensure priority. Later that century, and on the other side of the Atlantic Ocean, the celebrated 'dinosaur war' broke out between the forces of Edward Drinker Cope (University of Pennsylvania) and Othniel Charles Marsh (Yale University). The two men's excavating teams competed on the newly discovered fossil beds of Colorado with their finds of enormous reptile bones generating huge public excitement — and with their feuding splashed across the front pages of *The Herald*, even then one of New York's major newspapers. But the collections were prodigious. A widely

The skeleton of* Diplodocus carnegii *– 'Dippy' – that currently dominates the main gallery of London's Natural History Museum.

reported figure is that for ten years, Marsh's teams alone were shipping out an average of a ton of fossil bones every week. Between 1877 and the late 1890s, between them Cope and Marsh identified and named nearly 130 new dinosaur taxa including *Tyrannosaurus*, *Brachiosaurus*, *Triceratops*—and, from Cope in 1879, *Brontosaurus*, the Thunder Lizard

Of course, in the race to be first, mistakes were made, and *Brontosaurus* was one of them, or so it seemed. In 1903, another American palaeontologist, Elmer Riggs, decided that name was merely a junior synonym for *Apatosaurus*, a beast described earlier in 1877, so that should have been the end of *Brontosaurus*. Things did not work out that way: *Brontosaurus* had entered the public imagination and was not going quietly. Quite why that should be so is a bit of a mystery, one that was mulled over by that great scientific essayist Stephen Jay Gould in *Bully for Brontosaurus*, the titular piece in one of his published anthologies. Gould noted that as recently as 1989 the US Post Office issued a set of 'dinosaur' stamps featuring *Tyrannosaurus*, *Stegosaurus*, *Pteranodon* and—*Brontosaurus*. But although mocked at the time the US Post Office was in fact remarkably prescient, because *Brontosaurus* is back! What's more, it is now a genus with three distinct species (new taxonomic details published in *PeerJ* on 7 April 2015) and dinosaurophiles the world over have been rejoicing. After all, who could possibly prefer a Deceptive Lizard (*Apatosaurus*) to a Thunder Lizard.

For the popularity of the dinosaur genre more generally, the best Gould could offer was that they were big, fierce and extinct; scary and safe at the same time I suppose. Perhaps that's one of the secrets of the *Jurassic Park* franchise. In the latest outing *(Jurassic World)* cross-bred, genetically manipulated dinosaurs maraud across the screen as usual—but despite all those recent discoveries in China they remain resolutely featherless. Just for once science stays ahead of science fiction, and the grumpy claims of 'artistic continuity' ring rather hollow. Luckily that philosophy didn't apply when dear old 'Dippy' was restructured a while ago to brandish vigorously a tail that had previously been traditionally droopy.

The *Jurassic Park* films always provided plenty of gore but that attraction was taken a step further for a recent National Geographic Discovery Channel film which happily involved our dinosaur contributor Steve Brusatte. A full size *T. rex* was constructed, complete with internal organs and gallons of blood, and a group of palaeontologists carried out an 'autopsy' of the 'dead' animal. The picture of Steve, dripping with blood, hauling the stomach out of a dinosaur was irresistible. My only concern is that this event may now enter into the bizarre realm of the conspiracy theorists. It looked so realistic that it must have been real. Dinosaurs must still be out there somewhere. After all, it's only a hundred years or so, since 'dinosaurs' were regularly being spotted deep in the African jungles (inevitably, most of the supposed sightings were described as a *Brontosaurus*)—and there's always that pod of plesiosaurs in Loch Ness.

Steve Brusatte (left) helps remove the stomach of a* Tyrannosaurus rex *during the 'autopsy' staged by the Discovery Channel.
© National Geographic.

What else?

Moving on, reluctantly, from dinosaurs, our fourth article, by Richard Buxton, offers something of a Russian revolution, suggesting that one Mikhail Lomonosov was ahead of Hutton in appreciating the immensity of geological time and the uniformity of the processes operating through it—although he seems to have overlooked unconformities. The article is part biography, part book review, so leads gently into our formal review of an unusual book celebrating the life and work of the late Donald McIntyre. Donald was a recognised authority on Hutton and would have particularly enjoyed Richard's article. He was, I think, the longest-serving Fellow of the Edinburgh Geological Society. Indeed, in *EG* 40 (Spring 2003) Donald was interviewed by then-editor Alan Fyfe to mark his having been a Fellow for 60 years. The interview is available in the online *EG* archive and is well worth revisiting.

William Smith—the man behind the map

By Victoria Woodcock

The previous issue of *The Edinburgh Geologist* celebrated the 200th anniversary of the publication of William Smith's revolutionary "delineation of the strata of England and Wales with part of Scotland". But how did this son of a farming family—a man with a practical way of life, needing to make his own way in the world—come to produce a map that is still broadly accurate today, and to devise such a novel means of presenting his discoveries? What's more, both before and after the production of his seminal geological map, Smith aimed to generate a work even grander in scale and wider in scope: there was more to him than 'just' his famous map.

Youth

Born on 23rd March 1769 in Churchill, Oxfordshire, Smith was the eldest of five children. His basic education at the village school did not equip him for the career that was to come, and the difficulty he found in clearly explaining his ideas in writing became a barrier to the publication of his scientific work in his adult life. After a youth spent gathering the skills and knowledge required to become a surveyor, in addition to gathering fossils, the eighteen-year-old Smith obtained work as an assistant to Edward Webb, a surveyor who happened to be carrying out a survey and valuation of Smith's home village at the time. Over four years of working with Webb and living with his family in Stow-on-the-Wold, the eager Smith was inducted into the surveying trade, developing a familiarity with the land that would only grow deeper with time. In 1791, on Webb's recommendation, he embarked on his first role as an independent surveyor in northern Somerset, a region which was to become key in the growth of Smith's ideas.

Separating the Strata

Working from High Littleton, several miles south-west of Bath, Smith spent time surveying a local estate. The land included collieries, giving Smith the opportunity to go underground and observe the strata closely at first-hand, and perceive the patterns of the 'steeply dipping and much faulted coal measures [...] overlain unconformably by gently inclined red marls of the Trias, followed by Rhaetic marls and by the grey limestone bands of the Lower Lias' (Cox, 1948). The regularity in the succession of the coal-seams of the district was a fact familiar to the miners working among them, but Smith had the breadth of vision to connect this with formations he had seen elsewhere, and to suspect that it may be possible to trace these patterns of succession across the entire country.

Further awareness of the local strata came from Smith's next project, begun in 1793—engagement as surveyor, and later engineer, on the proposed Somersetshire Coal Canal. Mine owners in the area wished to have a canal built enabling the transportation of coal from their mines to the planned Kennet and Avon canal, which would connect them by water to markets all the way from Bristol to London. During the initial process of taking levels along the two-branched suggested canal route, Smith confirmed some of his suspicions regarding the strata; they appeared in a regular pattern above the Coal Measures, and dipped eastwards. In the summer of 1794 he made a journey on company business, accompanied by two other members of the Canal Committee, that allowed him to expand his horizons as far as the north of England. Travelling over a period of many weeks, ostensibly to examine other canals and coal mines, Smith had the chance to study exposures and formations throughout the country, discovering that rocks that were already familiar to him did indeed reappear in a roughly north-easterly direction. Back in Somerset, the following year brought the commencement of the construction of the canal, enabling Smith to actually see the layers of strata at the excavation sites and to collect fossils from them (Figure 1).

Publication Problems

Smith's steady employment with the Somersetshire Canal Company was abruptly terminated in 1799, perhaps due to the insistence of others on building a type of lock incompatible with the geology of the area, or perhaps more to do with his purchase of property adjacent to the canal (Eyles, 1969a). Either way, his subsequent lack of regular work offered him the opportunity to travel widely, while carrying out drainage and irrigation projects for various landowners and such luminaries as Thomas Coke. Some of these contacts, together with influential individuals he had met through his membership of the prestigious Bath Agricultural Society, provided him with support and encouragement in his geological endeavours. In particular, Rev. Joseph Townsend and Rev. Benjamin Richardson—both clergymen from Bath—helped to persuade him of the significance of his discoveries, and the importance of committing them to

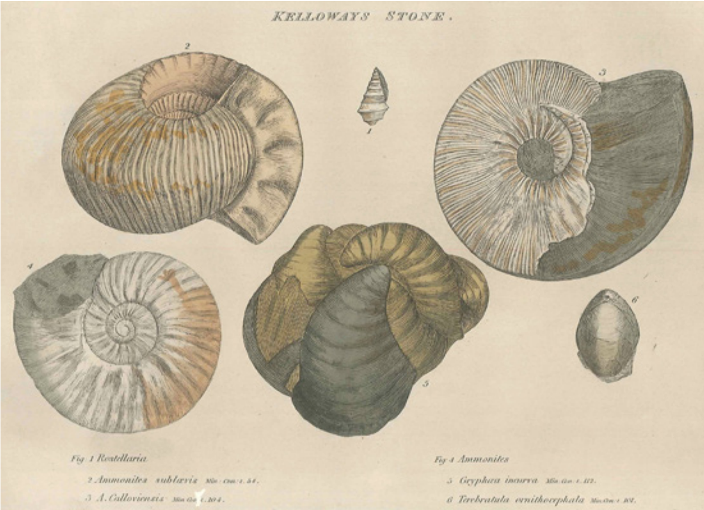

Figure 1. An illustration of fossils from the 'Kelloways Stone' stratum (Plate from Smith, William. 1816–1819. Strata Identified by Organized Fossils, Containing Prints on Coloured Paper of the Most Characteristic Specimens in Each Stratum, London: W Arding). Image reproduced by courtesy of the Geological Society of London.

paper. In 1799, Smith dictated a list of the strata and their characteristic fossils as found in the surrounding area; this was recorded and circulated by both men, and went on to be published in 1801, unacknowledged, in a book by Rev. Richard Warner entitled *History of Bath*.

At about the same time Smith also created his first surviving geological map, covering the country around Bath (Figure 2). Its style shows that he had by then hit upon the means of illustration that he would use in all later maps—that of 'colouring the basal part of each outcrop a deep tint and shading this off into a lighter tint for the overlying parts' (Cox, 1948). In addition to this first attempt, Smith geologically coloured a map showing the whole of England and Wales, and further demonstrated his intention to publish an explanatory stratigraphical work by releasing, in 1801, a *Prospectus of a work, entitled, Accurate Delineations and Descriptions of the Natural Order of the various Strata that are found in different parts of England and Wales: with practical observations thereon* (Eyles, 1969b).

However, anyone whose interest had been piqued by this announcement would have had a long wait. Smith's expertise in drainage and irrigation became so sought after that he was called upon to solve problems as significant as the failure of the Bath hot springs and the breaching of Norfolk sea defences. He had reached 'almost [...] the foremost rank of the civil engineers of the period' (Cox, 1948). Although his extensive travelling afforded him ample opportunity to gather more evidence to support his theory—and he frequently made detours for this very purpose—it left little time for formally setting down his ideas regarding strata. The intended publisher of the work advertised in 1801 went bankrupt, and with Smith's subsequent struggle to find another publisher paired with the cripplingly slow pace of his progress, it is no wonder that promising patrons such as Sir Joseph Banks eventually became frustrated with his seeming inability

Figure 2. Smith's innovative geological map of Bath and district—a modern reconstruction is shown alongside the much deteriorated original (2014 reconstruction of Smith's Map of Bath, and Geological Map of Bath by William Smith, 1799). Image reproduced by courtesy of the Geological Society of London.

to produce anything concrete. This is not to say that he made no progress at all—his travels were certainly valuable and time must have allowed his ideas to mature—but he did not publish anything relevant, nor did he make any productive connections. Ultimately, however, his luck would change and, as described in the previous article, collaboration with John Carey led to the publication of the map for which he is best known today.

Post-Map Highs and Lows

Smith's experience of life following the publication of the now celebrated map was, initially, largely negative. Despite the revenue from the map sales and the sale of his entire fossil collection to the British Museum, he still struggled financially. He did not sell as many copies of his map as anticipated—he had hoped for 750—and had several properties and an itinerant lifestyle to maintain (Cox, 1942). Over the next few years he published a number of works, including *Strata Identified by Organized Fossils* (1816), a *Geological Section from London to Snowdon* (1817), and other sections and maps, notably a series of geological maps of 21 English counties (1819–1824) (Figure 3), all while continuing to be engaged in professional work. This activity was interrupted in 1819 by a ten week spell in debtor's prison that led, prompted by the discovery that creditors had seized all the property in his London residence (Eyles, 1969a), to a long-term move to Scarborough in the north of England.

Figure 3. Berkshire from Smith's map series showing the geology of English counties (Geological map of the county of Berkshire, by William Smith, 1819). Image reproduced by courtesy of the Geological Society of London.

As he grew older (Figure 4) Smith published less, instead turning to pursuits such as lecturing and involvement in the local

Figure 4. Portrait of William Smith by Hugues Fourau (1837). Image reproduced by courtesy of the Geological Society of London.

geological scene in Scarborough. Yet he never gave up on his dream of producing a more comprehensive and far-reaching geological work; among his papers at his death was found a variety of material for a suggested publication entitled *Geological System*, as well as a range of notes relating to other projects. He died in 1839, while stopped at Northampton on his way to attend the annual British Association meeting. By this point he had finally, if belatedly, come to receive a certain level of respect from the scientific establishment of the day—most obviously demonstrated by his being the first recipient of the Geological Society's Wollaston Medal, in 1831. Besides his geological work, he left a personal legacy in the shape of John Phillips, his nephew, whom he cared for as a child and who went on to become a renowned geologist in his own right. Phillips did much to secure his uncle's scientific reputation.

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Scotland's coal — a life after extraction

By A G Leslie and M A E Browne

Coal mining in Great Britain most likely began in Roman times in the 2nd century A.D. but after they left, in A.D. 410, there seems to have been little or no active mining until the 13th century when small-scale operations began in most of the major coal fields of Scotland. This activity slowly increased up until the 18th century but then increased dramatically with the onset of the Industrial Revolution when steam engines created an almost insatiable demand for fuel. Much of Scotland's industrial growth and prosperity in the late 18th to the mid-20th century depended upon the extensive exploitation of Central Scotland's Carboniferous coal, along with fireclay, mudstone (for brick-making), ironstone, oil-shale, limestone and sandstone.

At a peak of just under 240 million tonnes of coal produced, in 1905 Great Britain was the world's biggest producer of coal. Thereafter, UK coal production and the workforce engaged in coal have declined dramatically; at the time of writing only one of three surviving deep mines is likely to operate beyond 2016 — Hatfield Colliery in South Yorkshire. Arguably a whole generation of Scots has lost touch with the coal that provided employment, income, energy and a social structure for their parents, grandparents and older generations.

Although its underground working had ceased in Scotland by 2002, coal was still quarried, and up until 2010 a third of UK opencast coal production took place in Scotland. Since then, and by April 2013, falls in world coal prices precipitated the financial collapse of the two main operators of Scottish opencast coal sites. This left seven abandoned sites, all lacking the necessary funding for restoration, that would usually have involved them being backfilled.

Turning what might be regarded as a threat into a potential asset, is this not an opportunity to retain superb geological sections that otherwise might have been lost, along with their relevant digital geological datasets? As far back as October 2007, the Spireslack canyon near Muirkirk had been proposed as a local geodiversity site (LGS) for 'The Glenbuck Geopark' by the then operators, in discussion with Strathclyde GeoConservation Group, GeoConservationUK, East Ayrshire

Council and BGS. These discussions re-surfaced when Scottish Coal went into liquidation in 2013 and the Scottish Mines Restoration Trust (SMRT) set out to discover and help implement a solution that would deal with the seven 'orphan' sites for Scottish Government.

There is a unique opportunity to deliver permanent geoconservation sites, geological education and research. **Spireslack** at Glenbuck in East Ayrshire and **Mainshill Wood** at Douglas in South Lanarkshire currently provide stunning, dramatic exposures in Scottish Carboniferous coal geology, each unique in its own right. Ideally, these potential conservation sites, perhaps along with others in the area, could be retained and re-developed during partial restoration to provide a rich visitor and/or learning experience in coal geology, the coal and hydrocarbon industry, and a former way of life of previous generations of Scots.

In the Central Belt of Scotland, bedrock is often concealed by thick unconsolidated Quaternary deposits and so accessible and informative exposures of the important Carboniferous coal-bearing sedimentary strata are rare, even in Sites of Special Scientific Interest such as the Garpel and Kennox Waters in East Ayrshire and South Lanarkshire respectively. The current generation of opencast workings provides an unrivalled opportunity to see and understand the geology of these economically and nationally important rocks; the spectacular exposures at Spireslack and Mainshill Wood can be held in trust for future generations and a rich geological story told. In fact, geology is but one aspect of this resource; both the Spireslack and Mainshill sites can also deliver a rich social and industrial history of Ayrshire and Lanarkshire for tourist, academic and student alike. Other so far un-restored opencast sites could undoubtedly add more dimensions to that story — each specific to its own geology. Opportunities to develop other complementary activities such as cycling, climbing walls, renewable energy, and forestry abound.

Spireslack 'canyon' presents a unique, semi-continuous, one kilometre long, high wall section through a thickness of over 130 m of Carboniferous strata (Plate 1). These belong to the uppermost *Lawmuir Formation*, *Lower Limestone Formation* (Hurlet and Hosie limestones), upwards through the whole of the *Limestone Coal Formation* (one of the main coal producing units in Central Scotland) and into the lower half of the overlying *Upper Limestone Formation*

Plate 1. The Spireslack 'canyon' presents a unique, semi-continuous, one kilometre long, high wall section in Carboniferous strata. The effects of faulting are clearly seen on the Hosie Limestones pavement that forms the north-west engineered back wall of the site, the fault at location X is shown in greater detail in Plate 2. At least 5 narrow basaltic dykes cut through the Carboniferous strata, one of which can clearly be seen in the high wall (at Y).

(up to the Calmy Limestone). Currently, only small portions of this extended succession are safely accessible on foot in the cut at around the levels of the Hosie Limestones (north western back wall), McDonald Coal, the Muirkirk Six Foot Coal and the Muirkirk Nine Foot Coal. Evidence of earlier 19th/20th century 'stoop and room' mining practice is still visible in the high wall face of the Spireslack excavation where an intact but somewhat crushed stoop of the Muirkirk Nine Foot Coal is juxtaposed laterally with packed mine waste in a collapsed room (or shortwall working).

Although originally deposited as flat-lying beds, the Spireslack strata experienced broadly compressional deformation in the mid- to late-Carboniferous, and now dip south-eastwards at c. 30–40 degrees across the canyon, forming one limb of a broad synclinal fold. Folding was accompanied by faulting, the effects of which are clearly seen on the Hosie Limestones pavement on the north-west back wall of the site (Plate

2). At least 5 narrow basaltic dykes cut through the Carboniferous strata. These were intruded around 60 million years ago (in the Palaeocene). At this time, the Atlantic Ocean was beginning to open and the dykes provide local evidence for that major plate tectonic event.

Mainshill Wood similarly presents a unique and continuous lateral section through a thickness of over 400 m of Carboniferous strata. These belong to the *Limestone Coal Formation* (above the McDonald Coal), the overlying *Upper Limestone Formation* and then most of the *Passage Formation*.

It is most unusual to see such a thickness of Carboniferous strata in one excavation. At Mainshill, this is brought about by the fact that a large proportion of the strata are now arranged vertically or nearly so, in itself a unique feature of the site. Unlike Spireslack, the section in the Limestone Coal Formation is so disturbed by faulting and folding that the significant and principal feature of interest for conservation at Mainshill is geological structure rather than the succession, though the latter includes at least 11 locally named coal seams. Many of these are not exposed at surface anywhere else. The Upper Limestone Formation section exposes all the main limestones, namely the Index, Huntershill (Birchlaw), Lyoncross (Tibbie Pagan's), Orchard, Calmy (Blue Tour) and Plean limestones as well as the Ellenora and Gill coals. Some of these beds could eventually be safely examined at close quarters given carefully designed partial restoration.

Plate 2. Multiple fault strands forming steps that displace the Lower Limestone Formation Upper Hosie Limestone. Note the way in which individual but linked fault strands transfer movement across a fault zone that would be recorded as a single black line on most geological maps!

The section in the Passage Formation is utterly unique and known otherwise only from the records of a few boreholes drilled to prove deep coal seams. The key features of these strata are the four thick Manson Coal seams (Plate 3), and associated marine mudstones with conspicuous shells. There are no natural exposures of the Manson strata anywhere else. Furthermore, it is usually the case that in Central Scotland as a whole, the Passage Formation only typically contains a few coal seams to about 30 cm thick. The fact that unusual thicknesses of coal-bearing strata could be accommodated in the depositional basin suggests perhaps an area of more active localised subsidence remote from the influence of river channels bringing-in sand. It is no surprise then that the stresses that could have driven that localised subsidence continued to be reflected in the subsequent deformation that gave rise to the vertical, and intensely folded and faulted strata. Near the southern back wall of the site, Limestone Coal Formation strata have been disturbed into a series of complex folds and associated faults. The junction between the complexly folded strata and the more regularly vertical strata is clearly visible and marked by a conspicuous shear zone in which the original continuity of the rock layers is almost entirely destroyed (Plate 4).

Characteristic Carboniferous rock types accessible on both sites include marine limestone with visible fossil shells (Plate 5), marine and lacustrine mudstone, burrowed siltstone and sandstone, cross-bedded sandstone, flat bedded siltstone and sandstone and rooted seat-rocks, and coal. Ironstone also occurs as thin beds

Plate 3. The thick Manson Coal seams with their associated marine mudstones and pale sandstones; there are no natural exposures of the Manson strata anywhere else in Scotland.

Plate 4. Limestone Coal Formation strata in the south-western corner of the Mainshill Wood void have been disturbed into a series of complex synformal folds and associated faults. Here, the junction between the folded and sheared strata and the more regularly vertical strata is clearly visible and marked by a conspicuous shear zone in which the original continuity of the rock layers is almost entirely destroyed.

and nodules in the mudstone and as nodules in the rooted seat-rocks. The seat-rocks represent the soil horizon that supported the vegetation growth now preserved as the coal layers that lie directly above.

The rock types can be read to show cycles of environmental change from shallow tropical seas (marine limestone and mudstone), to advancing delta and floodplains as sea-level fell across coastal areas (siltstone and sandstone), river channels (cross-bedded sandstone), tropical soils (rooted seat-rocks) and finally to tropical swamp forest (coal). Ironstone beds and nodules indicate locally anoxic oxygen-starved conditions in lakes and soils. The 'cyclicity' in the sequence of strata preserved at Spireslack and Mainshill Wood was symptomatic of sea level changes occurring on a global scale during the Carboniferous Period, some 330 to 315 million years ago.

Plate 5. Loose block of marine limestone with abundant Productid brachiopod shells, Spireslack Opencast Site.

Mainshill Wood and Spireslack provide a very strong link to the local cultural heritage of Douglas and Muirkirk. Mining communities created a strong socialist heritage in many parts and James Keir Hardie, founder of the Labour Party, lived in Cumnock for a large part of his life. Arguably Liverpool FC's most famous manager, Bill Shankly hailed from the mining community of Glenbuck, where the local Glenbuck Cherrypickers football team achieved fame as a source of some fifty professional football players. Shankly though never actually played for the first team before the club was disbanded in 1931, as the Grasshill Pit closed for the final time.

The synergy between natural, cultural and geological heritage is very strong and should be viewed as a complete package. Geology at Spireslack and Mainshill Wood delivers: unique man-made exposure(s) on a scale unparalleled in nature; rock successions with outstanding visual impact; an abundant fossil resource with opportunities for collecting; spectacular and rarely seen fault structures; a rich record of Carboniferous geological history; parallels with modern global environments; insights into previous mining methods; and an opportunity to reconstruct 3D visualisations of the sub-surface — all in all a hugely rich and diverse resource for learning and research. BGS and SMRT intend to work with others to unlock more of the secrets of these sites through video footage and digital 3D models accessible to all.

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PalAlba and the dinosaurs of Skye

By Steve Brusatte

When you think of dinosaurs, Scotland probably doesn't come to mind. Odds are, you picture a palaeontologist swashbuckling through the desert, catching the sun glint off a skeleton poking out of the sand. This is the image that we see all of the time on television documentaries, but it's not the only way to find dinosaur bones. No place proves this better than the Isle of Skye. Wind, rain, midges, rushing tides…and fossil bones, lots of them. Many of these fossils have only been discovered or studied recently, and are changing our understanding of evolution and environmental change during the Middle Jurassic, about 170 million years ago.

Much of this work is being pushed by a new collaborative group of Scottish palaeontologists, called PalAlba, which links together academics, collectors, and conservation specialists from the major institutions across the country (https://sites.google.com/site/palalbagroup/). My colleagues and I decided to pool our resources and work together to record, recover, and research vertebrate fossils from Scotland. One

Most of the PalAlba group in the collections storeroom of National Museums Scotland. From left to right: Mark Young, Nick Fraser, Neil Clark, Stig Walsh, Steve Brusatte, Tom Challands, and Colin MacFadyen. Photo by Bill Crighton.

of our primary interests is working on Skye, to collect new fossils of dinosaurs and other vertebrates (such as marine reptiles, mammals, lizards, and amphibians) and use these to better understand what was happening during the middle stanza of the Jurassic, a time when Scotland was part of an island in the growing Atlantic Ocean, washed by shallow seas and much warmer than today.

The Skye fossils turn out to be critical in this story. Of course, we are enthralled with Scottish fossils because we are Scottish palaeontologists, and wish to know more about our country's deep past. But the Skye fossils aren't merely a novelty. They are some of the only fossils of dinosaurs and other vertebrates from the Middle Jurassic, which is notorious as one of the most fossil-poor intervals of the entire 160+ million year evolutionary history of dinosaurs. It's just one of those things, a quirk of geology. Middle Jurassic rocks bearing fossils weren't deposited in many places in the world, and have been eroded in many others. Scotland, by complete chance, is an unparalleled window into this dark moment of Earth history.

And what a time the Middle Jurassic was. Although it only lasted for about 10 million years (ca. 174–164 million years ago), it was an extraordinary period of evolution and global change. The supercontinent Pangaea was just a recent memory and its fragmented pieces were just starting to drift apart. Dinosaurs had passed through the end-Triassic extinction to become dominant and spread around the world in the

The Middle Jurassic succession (intruded by several sills) seen in the cliffs of Bearreraig Bay, Skye. BGS image P000885.

Early Jurassic, and during the Middle Jurassic entirely new subgroups originated and began their march to prominence. Tyrannosaurs, stegosaurs, titanosaurian sauropods, even birds. They all got their start in the Middle Jurassic, but there are precious few fossils recording their evolutionary stories.

Our great hope is that Skye can help fill-in some of these gaps. New fossils may belong to entirely new species, perhaps some of the oldest members of some of these major new dinosaur groups beginning to diversify. They can tell us more about what these animals were like: how big they were, what they ate, how they moved. They can help us draw family trees, showing where some of these pioneering new dinosaurs came from. They can help us better understand how these various dinosaurs interacted with each other and other types of vertebrates—including some of the oldest mammals on land and entirely new groups of large predatory reptiles in the oceans—to form ecosystems during this dynamic time.

To our great thrill, Skye is beginning to yield its secrets. It's hard to believe, but the very first dinosaur fossil was discovered on Skye only a little over three decades ago, in 1982. It was the isolated footprint of a large plant-eating dinosaur, described by Julian Andrews and John Hudson from the University of Leicester. About a decade later the first bones turned up, including an upper arm (foreleg) bone from a huge long-necked sauropod that was described by Neil Clark from the Hunterian Museum in Glasgow and colleagues. Many other footprints and isolated bones were recovered over the next two decades, mainly by Neil and a remarkable local historian and fossil collector, Dugald Ross. Dugie is a Skye native with a deep love of anything historical—Iron Age artifacts, farm tools from 19th century crofters, and of course, Middle Jurassic fossils. A few decades ago he literally built a small museum by hand, the Staffin Museum, which today displays most of the dinosaur bones, teeth, and footprints found on Skye.

The PalAlba group (which includes Neil and Dugie) has been working together on Skye for a few field seasons and we are beginning to find important new specimens. During a 2013 fieldtrip, Tom Challands, Mark Wilkinson and I (all from the University of Edinburgh) discovered a handful of bones and teeth belonging to ichthyosaurs, dolphin-like reptiles that were near the top of the food chain in the oceans during much of the time when dinosaurs terrorized the land. To our great amazement, ichthyosaurs had never been described from Skye before.

Members of the PalAlba group excavating fossils in April, 2015 on the Trotternish Peninsula of northern Skye.

This led us to dig deeper, and to work with Neil and scientists at the National Museum of Scotland (Nick Fraser and Stig Walsh) to track down other possible Skye ichthyosaur specimens hiding away in museum drawers. We came across something pretty wild: an upper arm bone (humerus) and parts of the back and tail of an ichthyosaur that were found by an amateur collector, Brian Shawcross, at Skye's Bearreraig Bay in 1959. Brian could have sold the fossils, or made them into a beautiful mantel piece, but instead donated them to Glasgow University's Hunterian Museum. It took a while for scientists to recognize the importance of these bones, because when Brian found them there were few vertebrate palaeontologists working in Scotland.

But not anymore. When our PalAlba team got ahold of the fossils, Mark Young, a young Scottish expert on ancient marine reptiles, realized that they were different from all other ichthyosaurs ever found, anywhere in the world. So we had a new species on our hands, which we described in a January 2015 paper in Scottish Journal of Geology*. We christened it *Dearcmhara shawcrossi*—the genus name meaning 'marine lizard' in Gaelic (to our knowledge, the first time a fossil reptile has been given a fully Gaelic name) and the species

***Brian Shawcross holding one of the bones of* Dearcmhara.**

A reconstruction of* Dearcmhara shawcrossi *included here by kind permission of the artist, Todd Marshall.

name honouring Brian. Without Brian, nobody would have known that this uniquely Scottish marine reptile existed. Not bad for an 'amateur' without any formal training in palaeontology.

Dearcmhara was an awesome animal: about 4 metres long, it was a long-snouted, fin-backed, fish-eating reptile that prowled the waters of ancient Scotland while long-necked sauropods and plate-back stegosaurs thundered across the land. It is a relatively primitive ichthyosaur, and tells us that these smaller, more archaic species were still sticking around into the Middle Jurassic. We hope it is the first of many exciting new discoveries by the PalAlba group. We returned to Skye in April 2015 and think we found some interesting new fossils, so keep your eyes peeled…

*Brusatte, S L and 10 others. 2015. Ichthyosaurs from the Jurassic of Skye, Scotland. *Scottish Journal of Geology*, **51**, 43–55.

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Mikhail Vasil'evich Lomonosov — Russia's 'Father of Geology'

By Richard Buxton

The Vernadsky State Geological Museum

During a recent trip to Moscow, over forty years since I had visited the city as a student, I was fortunate to tour the Vernadsky State Geological Museum, which is the oldest Russian scientific, educational and cultural centre dedicated to Earth Sciences. The Museum originated from the Mineralogical Office of the Imperial Moscow University, Russia's first university founded in 1755 by the efforts of the prominent and revered scientist Mikhail Lomonosov, who is little-known in the West. The Museum contains over 300 000 minerals, rocks and fossils[1] collected by scientists and patrons during the 18th to 20th centuries, including contributions from members of Russia's royal families. In the 19th and early 20th centuries the Museum was a centre of advanced scientific ideas and a main educational and research base for generations of Russian and foreign geologists and mining specialists; these traditions are continued today.

Mikhail Vasil'evich Lomonosov (1711–1765)

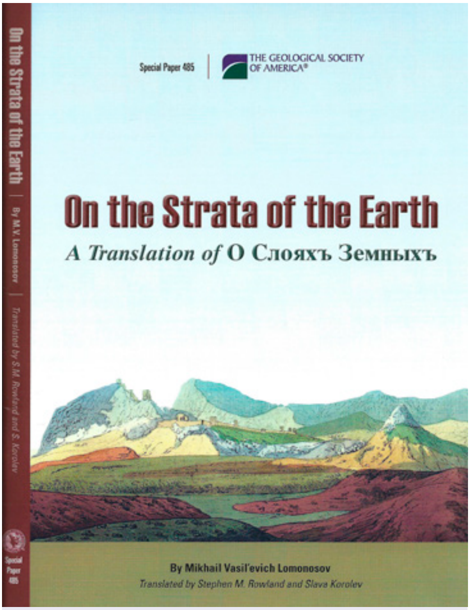
I first learnt about Mikhail Lomonosov from an Editorial in

Statue of Mikhail Lomonosov outside Moscow State University which he co-founded in 1755. Photograph by the author.

Nature Geoscience of January 2015 entitled 'Russia's Scientific Legacy'[2]. The article stressed that Russia's scientific legacy evolved largely separate from the West, isolated by political differences and made inaccessible by language. Lomonosov discovered the Venusian atmosphere from observations of the transit of Venus across the Sun in 1761[2], but he is probably best known for the eponymous Lomonosov Ridge that runs across the centre of the Arctic Ocean: discovered by Soviet expeditions in 1948 it is now at the heart of a territorial dispute between the nations bordering the Arctic. Lomonosov's own contribution to Arctic research is little known, although he was the first to explain the formation of icebergs. His contributions to geoscience are even less well-known outside Russia.

Portrait of Mikhail Lomonosov in the Vernadsky State Geological Museum. Photograph by the author.

In fact, Lomonosov is the author of an important treatise on geology which most of us who were educated in the West may never have heard of. Forming an appendix to a much longer work on mining and metallurgy, '*On the Strata of the Earth*' was published in 1763, two years before Lomonosov's death. Several of the ideas put forward are similar to, and predate, those of James Hutton, our own father of modern geology. Russian science historians have always considered the appendix to be the more original and significant work, and it is standard reading for Russian geology students. This work was finally translated into English in 2012, and so is now integrated into the internationally accessible scientific literature[3]. The publication, by the Geological Society of America, has an attractive cover with an eighteenth century sketch showing Mount Kushkaya (southeastern Crimea) with the ancient fortress of Sudagh and the Black Sea coast[4].



Lomonosov's Treatise "On the Strata of the Earth", published by the Geological Society of America as Special Paper 485, in 2012.

The task facing the two translators was formidable since they not only had to have an excellent knowledge of geology, geography and history, but they had to cope with Lomonosov's eighteenth century vocabulary and his "tangled, poetic expressions". To paraphrase one of the translators, Lomonosov's wording sounds to modern Russians as Shakespearean English sounds to us.

The end result is a very readable treatise, consisting of 186 paragraphs divided into five chapters. The first three chapters are concerned with 'Observations on the Earth's surface', 'The Strata of the Earth That Have Been Exposed by Man' and 'The Earth's Interior, and the Strata Exposed by Nature Herself'. In these sections, Lomonosov describes, with an enquiring mind, very large numbers of geological formations across the world and offers explanations for their occurrence. In the fourth chapter 'Containing Speculations about the Strata and the Interior of the Earth' he offers deeper thoughts concerning the aetiology of the geological structures described in the earlier chapters, and in the final chapter, 'The Usefulness of Speculations and Research about the Earth's Strata, Especially in our Fatherland' he devotes his writing specifically to Russia.

While there are far too many observations and ideas for me to summarise them all, I will mention a few here:

"… summits of many mountains are covered with the fragments of seashells, and other mountains are composed entirely of such shells transformed into stone". Unlike the creationists of the time he recognised that these shells would have originated on the floor of the sea and that mountain building must have occurred "… pushed up by an interior force" and that "… the force that uplifted such heavy masses can only be ascribed to the dominance of heat within the bowels of the Earth".

He believed that strata were originally fluid and laid down horizontally before turning into stone. When mountains were rising as a result of this interior force "… the rocks of which they are composed were bent, crushed and tilted…" and this explained the inclined orientation of many rocks we see today.

He recognised that advancing and submerging shorelines could be explained by the rising and falling of the Earth's surface in response to internal movement due to 'forces in the heat of the Earth', without any change in the volume of the sea.

With regard to volcanoes he refutes the mistaken view of the time that such mountains are on fire and recognises that volcanoes are "… pipes or vents through which excess subterranean fire is escaping", since the volume of material expressed is far greater than the volume of the mountains themselves.

He argues, as a result of his observations, that the Earth must be very old indeed and is critical of those who believe that the Earth is as old as the scriptures state.

Like Hutton, he believes that his observations do not contradict God's laws. Of creationists he states that "Such people not only hinder the development of science, they also harm Christianity by falsely representing it as an enemy of Nature—which is no less a product of God—and calling everything they cannot understand temptation".

Referring to mountain uplift, earthquakes and volcanic eruptions, his ideas on uniformitarianism are expressed when he states that "… such changes took place in the world not just one time, but countless times; they are happening still, and it is doubtful they will ever cease". But I was unable to find any reference to geological unconformities and their significance, which was such an important observation of Hutton.

While Lomonosov's treatise has several similarities and some differences to the work of Hutton, and inevitably will provoke comparisons between the two men, the important thing to recognise is that both individuals, working independently, made outstanding contributions to our understanding of the science of geology at the time of the Enlightenment, and often came to similar conclusions. I can recommend 'On the Strata of the Earth' as a fascinating account of Lomonosov's ideas, which have only recently been made available to the English-reading world.

Notes and References

1. For a description see the Open University Geological Society East of Scotland Branch Newsletter, July 2015, accessible via http://ougs.org.

2. Editorial. 2015. 'Russia's Scientific Legacy'. *Nature Geoscience*, **8**, p.1.

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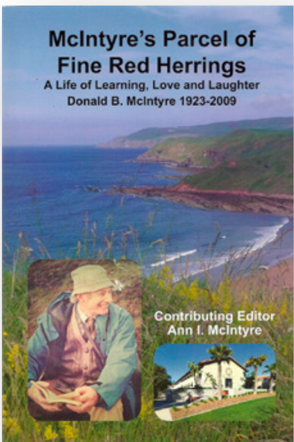
Book review

McIntyre's Parcel of Fine Red Herrings — a Life of Learning, Love and Laughter, Donald B. McIntyre 1923–2009. Contributing Editor Ann I McIntyre. Fastprint Publishing, Peterborough, England. 2014. Paperback, 405 pp. Price £12.50. ISBN: 978-178456-039-3.



Most biographies on the bookshelves are researched and written by a single author. This engaging, eminently readable volume about the geologist Donald McIntyre is different. His wife, Ann determined to gather together what she describes as a 'pot-pourri selection about his life and work'. In this endeavour she has been aided by many including Gilbert and Johanna Summers and Meg Cowie who have assisted in editing and design. The book's eleven chapters include a wide range of Donald's published and unpublished material, together with contributed reminiscences of relatives, friends and colleagues. Interspersed throughout are favourite quotations and poems. The book tracks the life of an extraordinarily talented individual whose research and teaching influenced generations of students, and concludes with a selection of Donald's addresses and talks and a number of tributes.

Donald had an infectious enthusiasm and anyone who was privileged to listen to him in full flow will recognise his character when they read this book. It begins with an interview of him conducted by Alan Fyfe for *The Edinburgh Geologist* in 2003. Tangents, it seems are there to be avoided. Yet Donald's stories always had a point to them! Reading the interview again and the subsequent chapters (1 to 3) on his formative years in Edinburgh (where he was brought up and later went up to University) and Grantown-on-Spey (where the family evacuated during the 2nd World War) it is clear that Donald was influenced by outstanding teachers and colleagues, something he always acknowledged. Wartime home in Grantown introduced him to the Cairngorm Mountains and, inadvertently though a friend's teacher, their geology; the effects of glaciation fascinated him, and the lure of mountains engaged in him a life-long interest in rock-climbing and hillwalking (as documented in Chapter 4). However, as he acknowledged, if someone really wanted to be a mountaineer geologizing was not necessarily the best career. Enrolled as a student of Chemistry in 1941 he rapidly moved into geological circles and was taught by Robert Campbell and others and latterly Professor Arthur Holmes. It is interesting to reflect that Donald's PhD thesis of 1945 on the Loch Doon Pluton was never published lest it stoke the fires of the already raging controversy about the origin of granites. An influential year in Switzerland (Chapter 5, full of anecdote) introduced him to Alpine geology and he studied Professor C E Wegmann's techniques in tectonic analysis.

After a period of teaching at Edinburgh, from 1954 Donald spent 35 years in the United States of America at Pomona College, Claremont, California where he became Chairman of the Geology Department (Chapters 6 and 7). Flowing tributes in this book from former students and colleagues demonstrate what an influential teacher he was, both in the classroom and in the field. But it was not all geology: Donald loved to play the bagpipes. His knowledge of wine benefited from his early introduction to the wines of Neuchâtel where his otherwise difficult mentor Wegmann explained the principle of fractional distillation.

After a chapter (8) documenting Donald's significant pioneering work with computers from the 1950s to 80s, the book switches to James Hutton (Chapter 9). The main picture cover of this biography is of Siccar Point, arguably the world's most famous geological locality. The significance of its angular unconformity was demonstrated by Hutton to his friends James Hall and John Playfair in 1788. Many in Edinburgh and beyond will know of Donald's significant part in the discovery of the 'Lost Drawings'* intended to illustrate James Hutton's *Theory of the Earth*. Some of Donald's finest published work is on the life and work of Hutton: Chapter 9 republishes some of his addresses and accounts of inspiring and memorable field trips, many conducted to famous Huttonian localities, following Donald's retirement with Ann and their son Ewen in 1989 to Kinfauns.

'Retirement' is documented in Chapter 10. Donald devoted time to compiling notes on Scottish building stones and a section in this chapter publishes his web Essay on the stones of Perth and Edinburgh. A more strictly edited version of his Perth material appears as a chapter in the recently published *Stirling and Perth geological excursion guide* (Edinburgh Geological Society/NMS Publishing, 2015). Chapter 11 sets out Ann's very personal account of her life with Donald and how the family brought up their son Ewen with loving care and patience: Ewen's cerebal palsy was diagnosed when he was about 9 months old. As Ann says, *Per Ardua* is the McIntyre motto.

Without knowing the significance of the main title of the book (until its amusing origin is revealed as an extract from *The Edinburgh Advertiser*, 1788), this reviewer was struck by a possible play on words of the thriller novel *The Five Red Herrings* set in Galloway by Dorothy Sayers in 1931, in which an artist is found to have been murdered. Here (so close to Loch Doon!), misleading statements designed to throw detectives off the scent are given by six suspects before the case is eventually solved. But in contrast this biography, through Ann and Donald's writings, and those of their friends and colleagues, offers trustworthy evidence of a caring life lived to the full, and of a man whose scientific output was matched by an unrivalled sense of history — a book to be thoroughly recommended!

* Craig, G Y, McIntyre, D B, and Waterston, C D. 1978. *James Hutton's Theory of the Earth: The Lost Drawings*. Scottish Academic Press, Edinburgh.

Andrew McMillan

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ISSN 0265-7244