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Cover Illustration

Kilspindie Shore Local Geodiversity Site, north of Aberlady in East Lothian. A large (1.5 m approx. diameter) dolerite erratic displaying a classic example of spheroidal (onion skin) weathering sits on beach pebbles and mid-Carboniferous sedimentary rocks.

Photograph by Angus Miller.

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The Edinburgh Geological Society was founded in 1834 with the twin aims of stimulating public interest in geology and advancing geological knowledge. We organise a programme of lectures and excursions and also publish leaflets and excursion guides. For more information about the Society and membership, please visit www.edinburghgeolsoc.org.

297 and counting

By Robert Gatliff

I'm always delighted when articles are offered and even more delighted when they build on previous articles or fit together to form a theme. In this issue Phil Stone has produced a fascinating article on graptolites which builds on our article on Dob's Linn, and Roy Thompson offered a review of a new book on the geology of the Lake District, which comes with a web-based GIS with details of all the sites mentioned in the book. This is just the kind of product the Scottish Geology Trust is aiming to put together for the whole of Scotland. Angus Miller's article explains some of the benefits of making these data more readily available, and his tale of visiting more than 30 geosites, including many of our local sites in Lothian and Borders, in 30 days.

Stuart Harker's poem about Siccar Point is also a delight, and very topical. Last year I took my sisters to Siccar Point and they came away with a new understanding of geology and time and now appreciate why I am such a geological enthusiast.

There is an article on the EGS website about James Hutton (www.edinburghgeolsoc.org/edinburghs-

[geology/geological-pioneers/james-hutton/](#)) together with a short reminder that 2026 will be the tercentenary of his birthday and a comment that EGS will be putting on events to celebrate his life and achievements. It is now only three years away and things are already happening. There are two recent biographies—a revised edition by McKirdy (2022) and a new one by Perman (2022) which will be reviewed in the next *Edinburgh Geologist*. A third book about Hutton's time in Leiden will be published in the Spring by colleagues from the Leiden Geological Society and in the summer members of their society will be in Edinburgh to go on a Hutton tour including Siccar Point, Salisbury Crags, and Arran. EGS will also hold a reception and public lecture when the author will present their findings on his time in Leiden.

EGS is represented on a group hosted by The James Hutton Institute, that is looking at a programme of things we can do to raise funds, put on events and make a real impact with the public on the truly fantastic contribution Hutton made to geology, agriculture and the Scottish Enlightenment.

There will be some competition in 2026: not only is it Hutton's tercentenary but it marks the 250th anniversary of the death of David Hume, and the 250th anniversary of the publication of Adam Smith's *Wealth of Nations*. We can expect that the Royal Society of Edinburgh will organise fitting tributes to all three events. Indeed, Hutton was a founding member of the RSE. Both Hume (Figure 1) and Smith (Figure 2) have statues on the Royal Mile.

Last year the International Union of Geological Sciences (IUGS), in conjunction with UNESCO, ran a competition to give scientific recognition to 100 key geological heritage sites. This is the start of a global programme for recognition

of geological heritage sites of high international importance. It is hoped that this will help initiatives around the world based on science, heritage, conservation, geotourism and educational activities.

Applicants had to make a case and the results were announced in October 2022 at a conference in the Basque Coast UNESCO Global Geopark. Scotland was successful in getting two sites into the top 100—Knockan Crag (the Moine Thrust) and Siccar Point (Hutton's Unconformity).



Figure 1 *David Hume statue on the Royal Mile.*



Figure 2 *Adam Smith statue on the Royal Mile.*

I'm told that the order the sites were announced and presented was not significant but the first site in the programme was Siccar Point. It was no surprise to me that it was No 1 in the historically important sites. Our thanks for putting the submission together go to Helen Fallas (BGS), Colin MacFadyen (NatureScot), and Martina Kölbl-Ebert (International Commission on the History of Geological Sciences).

In parallel with this competition, Colin MacFadyen alerted the Scottish Geological Trust that there was an opportunity to apply to the Department for Digital, Culture, Media & Sport to put Siccar Point onto the UK list of 'tentative sites' for UNESCO World Heritage status. In the Spring, we submitted a one-page outline of why Siccar Point should be considered. This was accepted and in July your editor and Colin Campbell (CEO The James Hutton Institute), with input from several others submitted a longer document which explained our case in more detail. The application included letters of support from Scottish Borders Council, Cockburnspath Community Council, the landowner, South of Scotland Enterprise, and NatureScot, together with a brief management plan. We propose to develop the ideas and seek funding to improve the footpath access, the drystone walls, the path down to the shore and information at

the site. There are no plans to increase parking facilities, but we envisage a visitor centre/small Hutton Museum in Cockburnspath which is the beginning (or end) of three long-distance paths (Berwickshire Coastal Path, John Muir Link, and Southern Upland Way). This may encourage better public transport links to and from the village—and who knows, perhaps another station on the East Coast railway.

Competition to get on the list is fierce—and submissions undergo review by a specially appointed panel. Other proposals range from marine parks in the Cayman Islands to the first garden cities in England. At least one other proposal is in Scotland—the Fort William-Mallaig railway.

Whatever the result, now expected early April 2023, the work put into the proposal means we are in good shape to start raising funds and commemorating Hutton's anniversary.

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Scotland's geosites — networks to be proud of?

By Angus Miller, Geowalks, Scottish Geology Trust and Edinburgh Geological Society

Scotland is widely acknowledged to have superb and varied geology. In my opinion it also leads the world in cataloguing and describing this geology, with a broad literature of books and websites, including excursion guides published by local geological societies, and leaflets and information boards that are often prepared by geoconservation groups and geoparks. There are more than a 1000 sites across Scotland identified as being important with a variety of designations (see adjacent box). Almost all of these sites have a modern written description, often available for free online — but this information is not always easy to find.

In response to the EGS autumn members challenge, I set out to visit a geosite every day in November 2022. This was mainly for personal enjoyment, but also an opportunity to discover some new geology and interesting dog walks, and to explore some issues related to the networks of sites and the availability of information about them. I visited 32 sites, comprising 21 Local Geodiversity Sites, 15 Geological Conservation Review sites and 12 geological Sites

Types of geosite in Scotland

Sites of Special Scientific Interest (SSSI)

are areas of land with special interest for their flora or fauna, geology or geomorphology, with statutory notification by NatureScot.

The Geological Conservation Review

(GCR) is the register of known nationally and internationally important Earth science (geological and geomorphological) sites in Great Britain. These sites were identified in comprehensive expert surveys, started in 1977. There are about 880 GCR sites in Scotland, most protected as geological SSSI.

Local Geodiversity Sites (LGS)

are sites of local interest, designated by local authorities and included in Local Development Plans.

of Special Scientific Interest. That these numbers don't add up does indicate some of the complexities and pitfalls of the current system of site designation in Scotland!

Local Geodiversity Sites (LGS) in Lothian and Borders

My site visits were often close to home, fitting in with other commitments. But I was spoilt for choice, because there is an incredible selection of 165 LGS in

the area covered by Lothian and Borders GeoConservation (LBGC): the council areas of Edinburgh, West Lothian, Midlothian, East Lothian and Scottish Borders (Figure 1). LBGC is a committee of EGS, and over the past 20 years, each of these sites have been visited, mapped and described—often by volunteers, and in other cases by surveyors through contracts with the British Geological Survey. After approval by the LBGC committee, the sites have been designated as LGS by the relevant local authority and included in Local Development Plans. A significant

milestone was reached in 2022 with the addition of 19 sites in Midlothian, surveyed by volunteers Alison and Barry Tymon. This followed a similar project in Scottish Borders, and means that for the first time, the entire area covered by LBGC has reasonably up-to-date and complete networks of local sites.

The sites are varied, reflecting the geology of the area. Sometimes a site is simply an old quarry face, such as at Auchinoon in West Lothian—but giving access to bedrock which is otherwise hidden. Other sites, such as



Figure 1 Locations of the 165 Local Geodiversity Sites in the area covered by Lothian and Borders GeoConservation: City of Edinburgh Council (30 sites – light blue), West Lothian Council (51 sites – orange), Midlothian Council (19 sites – purple), East Lothian Council (30 sites – green), and Scottish Borders Council (35 sites – dark blue). Available at www.google.com/maps/d/u/0/viewer?mid=1NzbihSekeC2OdJ36R-bBJGct2r0, map data ©2022 Google.

North Berwick Shore in East Lothian, are more extensive and allow the appreciation of a bigger story: in this case including the link between different shaped islands and their use by a variety of seabirds and marine mammals (Figure 2), and allow the appreciation of a bigger geological story: in this case including glacial erratics and sea level change (front cover). Unlike the sites of national and international importance, the designation of an LGS includes the site's suitability as an educational, historical and recreational resource. In many cases these are places that are used routinely by local people, and could easily be visited by local schools. So, how easy is it to find information about them? The new map on the

EGS website (Figure 1) shows the locations of all these sites for the first time. For some council areas, such as West Lothian and Edinburgh, the site locations link to further information and an image for each site. Otherwise, it might be a case of downloading a large pdf file and searching for the description of a site—but information for all sites is available, for free. Many of the sites are also described in the series of 32 leaflets published by LBGC. These are available as free downloads from the EGS website, as well as being distributed through local networks. However, on the ground there is rarely any indication of LGS status, so unless you stumble across information provided by LBGC or the local authority, or really get into the



Figure 2 *Volcanoes were here! The stunning plug of the Bass Rock in the background, with layered red tuff (volcanic ash) on the foreshore at Milsey Bay, North Berwick. Complex volcanic processes have resulted in a variety of islands, cliffs, headlands and beaches and a range of habitats for nature*

detail of the map associated with a Local Development Plan, it would be easy to miss the value and interest of local geology.

The Geological Conservation Review and Scotland's geological Sites of Special Scientific Interest

The Geological Conservation Review (GCR) is an astounding project, surely unmatched anywhere else in the world. Since 1977, teams of professional geologists have systematically identified and described over 3000 sites across Britain within 44 different GCR 'blocks'. The GCR was designed to identify those sites of national and international importance needed to show all the key scientific elements of the Earth heritage of Britain. These sites display sediments, rocks, fossils, and features of the landscape that make a special contribution to our understanding and appreciation of Earth science and the geological history of Britain (JNCC, 2022).

This is the best of British geology—a careful study to identify and conserve the best. Crucially, the GCR was intended to underpin the notification of Sites of Special Scientific Interest (SSSI) for geology, giving statutory protection. So all of the geological SSSI in Scotland are described in the GCR, giving modern and more extensive descriptions than is typically

contained in a SSSI citation, as well as useful overviews and references.

It won't be a surprise to readers that the Edinburgh area is replete in GCR sites. Within the city, the Arthur's Seat Volcano dominates, including Castle Rock and Calton Hill. The Firth of Forth SSSI, designated for biology as well as a range of geological features, lies just a few hundred metres from my house. This site illustrates some of the complexities and minor frustrations deriving from the clash of three different systems. The SSSI is huge, stretching around the Forth from Anstruther to Dunbar. Within a large SSSI that primarily addresses common biological elements across the area, how do you distinguish the best geology that deserves the highest level of protection (Figure 3)? This illustrates the strength and utility of the GCR, because within the whole Firth of Forth SSSI there are around 20 GCR sites including Wardie Shore, Joppa and North Berwick Coast, from 9 different GCR blocks. In contrast to the SSSI documentation, where you have to dig to find out if a site is of geological interest and why, it is easy within the GCR documentation to identify the nature of the geological interest. A downside of this compartmentalisation is that some sites are included in the GCR for two or sometimes three blocks: you could easily visit The Storr on the



Figure 3 Interpretation board at Wardie Shore, Edinburgh, prepared by EGS and Scottish Wildlife Trust to help explain the geological and biological importance of the Firth of Forth SSSI. The rocks here are included in the GCR blocks for both Fish/Amphibia and Palaeobotany.

Isle of Skye for its Tertiary Igneous interest, and miss that the site is also described in the GCR blocks for the Mineralogy of Scotland and Mass Movement! Added to this, with volumes published over a span of thirty years there is sometimes inconsistency in site names and spelling; given how fond geologists seem to be of disagreeing over details, you can imagine the pain of the Joint Nature Conservation Committee in trying to coordinate the work of committees of specialists from 44 different subject areas over more than 40 years!

Some parts of the Firth of Forth SSSI have also been designated as

LGS to capture other areas of good geology that are easily accessible. For example, the Kilspindie Shore LGS in East Lothian is within the Firth of Forth SSSI, but it is not a GCR site. Similarly, while Edinburgh Castle Rock is included in the GCR due to its igneous importance, the wider glacial landform of the Castle Rock Crag and Tail is not in the GCR, but has been designated an LGS. In general, the system of designating LGS works well across the Lothian and Borders area, to highlight areas of lesser scientific importance where good, accessible geology is on display. However there are some inconsistencies in East and West Lothian — for example,

North Berwick Shore is an LGS, a GCR and also within the Firth of Forth SSSI! It is all a bit clumsy, but perhaps the best way to understand the whole system is to appreciate that the GCR and LGS site networks generally complement each other to identify key sites at different levels of importance. The GCR underpins SSSI notification, which should mean that all GCR sites have legal protection as geological sites of national or international interest. This is not the case, but we'll come back to that!

I had an interesting and rather wet day in the outskirts of Loanhead, exploring two contrasting SSSI/GCR sites—contrasting not only in their geology but also their landscape setting and visual splendour. I started at Maiden Castle on the River Esk—not a GCR site, but part of one of the new Midlothian LGS. The river makes a spectacular meander around the Maiden Castle, exposing some Carboniferous strata, and there is an interpretation board provided by the Esk Valley Trust that explains the interesting but not very visible story of the sand and two till layers underfoot within the Hewan Bank GCR, part of the Quaternary of Scotland block. There has been a lot of vegetation growth since the landslide in 1979, but by carefully approach to the top of the landslide

at various places you can appreciate the ongoing process, and safely view the landslide toe being eroded by the River Esk from the other side of the river at Springfield Mill.

In contrast, and not just because the rain got heavier, the Bilston Glen SSSI/GCR was a disappointment. Bilston Glen is well-known as the site of one of the deep coal mines of the Midlothian basin, and a large section of the glen is buried under colliery waste. Despite this, the Carboniferous strata within the glen has been included in the GCR. What is now a heavily wooded area, with steep slopes and limited path access, does a good job at hiding this geological richness! It might be better in a dry spell, but this site does show that important geology, while being worth conserving, is not necessarily easily accessible or with a clear story that can be appreciated by a casual visitor.

I had a very different experience when I visited Lochaber, armed with maps and descriptions from the GCR volume for the Lewisian, Torridonian and Moine Rocks. I've been holidaying in this area all my life, and Druimindarroch, a few miles east of Arisaig, is a place I know well—a low, uneven rocky and boggy promontory close to the point where Bonnie Prince Charlie embarked for

France after Culloden in 1746. The site includes a raised-beach cave where the Prince allegedly sheltered! I'd been through this area on an undergraduate field trip and later with the Lochaber Geopark, so I'd some understanding of its importance in Moine geology. But I'd no idea that Druimindarroch was in the GCR, and designated as a SSSI in 1986. Following in the footsteps of John Mendum, who wrote the GCR site description, I looked at this well-kent landscape with new eyes. Although I'd spotted plenty of dykes here in the past, for they are hard to miss,

I was particularly intrigued to pick out the landscape traces of three contrasting sets of intrusions in the area (Figure 4).

I stumbled on another impressive GCR site near Carnwath in South Lanarkshire. The River Clyde Meanders GCR site illustrates the tremendous breadth of the GCR — this is not just about bedrock, or relict glacial landscapes: the GCR includes a 'Fluvial Geomorphology of Great Britain' block, where the rivers of Scotland feature prominently because they



Figure 4 *Druimindarroch near Arisaig. Good coastal exposures of the Moine metamorphic rocks are cut by Silurian microdiorite intrusions (forming the low ridge behind the houses) and two sets of dykes from the Carboniferous-Permian and Palaeogene – the latter forming the crag and island beneath the leftmost white house.*

‘afford a richer variety of process, form and pattern than other UK rivers because of the greater diversity of environments within which they have evolved’. The area where the Clyde meets its tributary, the Medwin Water, has been mapped in detail since 1848, allowing the measurement and analysis of channel change over more than 150 years. This is an excellent and easily accessible example of how rivers evolve, and I was especially delighted to find an example of an ox-bow loch (Figure 5). I’d not seen one outside of a textbook before!

Job done?

So, is all well with Scotland’s networks of geosites? Yes and no. While we can celebrate and be proud of the work of Lothian and Borders GeoConservation and the networks of 165 sites in the Lothian and Borders area, this level of activity is not consistent across Scotland. There are LGS in only 12 of Scotland’s 32 Local Authority areas and none in our National Parks (Scottish Geodiversity Forum, 2020). While it can be argued that some areas, such as Shetland and Highland, have such a plethora



Figure 5 Ox-bow loch formed by a cut-off meander on the Medwin Water, a tributary to the River Clyde near Carnwath, South Lanarkshire. The Tinto Hills GCR site is in the distance.

of GCR sites that they don't really need local sites, LGS site networks are generally useful for highlighting accessible, varied local geology that local communities can value and benefit from. The Lothians and Borders have benefited from the high concentration of geologists in this area, and the support of EGS and the local authorities. It is difficult to see how this work can be replicated elsewhere in the current climate. When Scotland's two existing National Parks were established, BGS was commissioned to undertake basic geology audits, but the recommendations to establish local networks in the National Parks were not followed through (Tisdall and Miller, 2022); twenty years after the parks were established, they are very poor at acknowledging and promoting their geodiversity.

More widely, there are significant gaps in identifying and protecting sites of national and international importance. The GCR is an impressive and valuable effort, but it has not been carried to its conclusion: 192 GCR sites in Scotland have not yet been notified as SSSI and for a further 34 sites, the GCR boundary encloses a larger area than the corresponding SSSI, but the SSSI boundary has not been updated. With no appetite in the Scottish Government or

NatureScot management for further site notification, large tracts of important geology have no statutory protection. I visited two of these sites in Lochaber: North Morar and the Fassfern to Loch Ailort Road Cuttings on the A830. These are both large sites with plenty of high-quality rock exposure. While threats to the integrity of this geology are probably limited, it is unsatisfying that a careful process started almost 50 years ago has not been seen to completion. East Lothian Council and the Loch Lomond & the Trossachs National Park are unique within planning authorities in Scotland in recognising that the unnotified GCR sites should have equal status to SSSI. That policy could be more widely adopted.

Furthermore, the GCR process should never stop. As ideas and sites change, it should be possible to add and remove GCR sites, and correct omissions. There seem to be very limited resources available to do this, although it does happen: recently a new GCR was established for the remaining intact sections of the Auchenlaich/Callander moraine in the Loch Lomond and the Trossachs National Park. However this was too late to either protect the moraine ridge from sand and gravel extraction, or to ensure it was properly surveyed before being removed (Tisdall and

Miller, 2022). And how long will it be until the Tertiary, and Lewisian, Torridonian and Moine GCR volumes are updated to reflect new terminology?

These technicalities are frustrating, but for the typical enthusiast interested in Scotland's geology, I think it really matters that the detailed information about Scotland's geosites is patchy and difficult to access. There is no up-to-date listing of GCR sites in Scotland, and map links and databases are broken with no certainty that they will be replaced. Many (but not all) of the GCR chapters are available online for free, but you need to know what you are looking for to find them. The Scottish Geology Trust is starting to work with NatureScot to try and improve access to these valuable resources, and I hope they will be easier to find and more consistent in the future. In the meantime, it is worthwhile doing the legwork to search for the volumes of high-quality information that does exist—like me, you may find rich geological stories in places you know well!

Find out more

The EGS Autumn 2022 members challenge (www.edinburghgeolsoc.org/autumn-challenge/) included maps and links to help you find geosites and further information about them.

All SSSI and GCR site boundaries are mapped on NatureScot's SiteLink map (sitelink.nature.scot/map) although it is temperamental, and the links to further information about GCR sites are broken. You can find many of the GCR site descriptions by searching at data.jncc.gov.uk.

You can find out more about the work of Lothian and Borders GeoConservation on the EGS website—volunteers welcome! www.edinburghgeolsoc.org/home/geoconservation/lothian-and-borders-geoconservation/

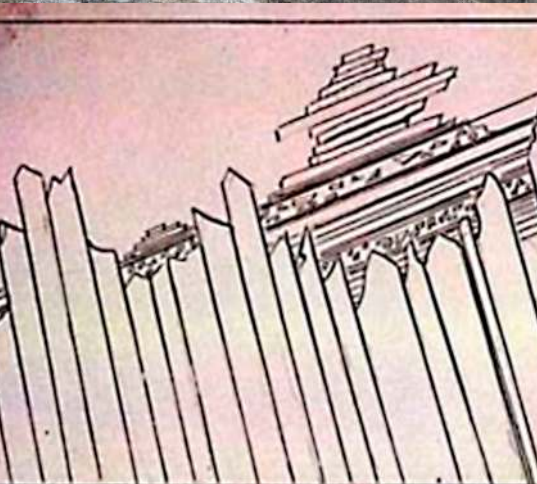
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Siccar Point



Siccar Point *Drawn by Hutton*

The world's most famous geology outcrop lies in Scotland, 40 miles east of Edinburgh on the North Sea coast.

Siccar Point's rocky wave-worn exposure forms this headland, with 3D faces of steep dips covered by flat strata topmost.

The capital city's 'Age of Enlightenment' was looming, when Auld Reekie polymath James Hutton investigated.

Curiosity of earth processes was all consuming.

Took a boat trip to review how the discordance was created.

Shipmate John Playfair skilfully recorded thoughts of the trip. How did the grey old Silurian deep sea silts get so steep?

How were they eroded, prior to burial by sands so thick?

The contact with younger Old Red Sandstone — missing time — deep

Hutton's second companion James Hall drew a field sketch, showing the outcrop rock types and geometric discordances. Those three boatmen reviewed origin options to their quetch. Sediments laid down in horizontal circumstances.

Eons must have passed for the
change in strata to occur.
Creationists would baulk at such
heretical notions.

T'was 1788, a difficult time to
challenge the Kirk.
But to Hutton the evidence was clear,
deep time promotion

Charles Lyell's principled support
came some 50 years later.
Accrued scientific acceptance for
earth process time span.

Modern techniques proved the
theory correct with rock age dater.
Twixt grey silts and red sandstone, 70
million years gap ran.

The Silurian silts are deposits of a
deep ocean.

That ocean closed by collision of
tectonic plates,
crumpling the strata forming
mountains then erosion.
The red fluvial sand shed from the
north highlands postdates.

The 'Father of Modern Geology' is
how Hutton is renown
"We find no vestige of a
beginning—no prospect of an end"
His proclamation re earth history for
Siccar Point found
and with age dating, his theory of
deep time we can amend.

Stuart Harker, July 2022.



The forgotten pioneers of graptolite palaeontology in the Southern Uplands of Scotland

By Phil Stone

In the last issue of *The Edinburgh Geologist* we celebrated Scotland's 'Golden Spike', the internationally agreed section at Dob's Linn, Moffatdale, that defines the base of the Silurian System. There, in the mudstone of the Moffat Shale Group, graptolites provide the crucial biostratigraphic control and their detailed appraisal by Charles Lapworth (1842–1920) has underpinned all subsequent interpretations of Southern Uplands geology. Lapworth's seminal paper, published in 1878, ranged well beyond Dob's Linn and covered all the important Moffat Shale exposures of the central Southern Uplands: Hartfell Spa, Craigmichan Scars, Glenkiln Burn and many others. So comprehensive was Lapworth's work that his reputation now dominates any historical assessment of biostratigraphic developments in the Southern Uplands. That is undoubtedly well-justified, but of course he did not work in a scientific vacuum, nor was he the only palaeontologist active in the field in the mid-19th century. This

article seeks to identify some of Lapworth's forgotten colleagues and predecessors and to acknowledge their contributions.

Graptolites had been noted early enough for a genus *Graptolithus* to be established as early as 1735 by the great taxonomic classifier Carolus Linnaeus (1707–1778). Not that he knew what they were; the 'writing on the rocks' might be animal, vegetable or mineral. But by the early 19th century the true nature of graptolites had been realised, with about eight taxa defined by 1840 (Rushton, 2001).

The first discovery of graptolites in Scotland was made in about 1838 by John Carrick Moore (1805–1898). He found the fossils on the west shore of Loch Ryan, Galloway, at a locality known as Slouchnagarry [NX 034 707] about 2 km north of his home at Corsewall. Moore passed the specimens to Charles Lyell (1795–1875) who announced the discovery at a meeting of the Geological Society of London on 23 January 1839.

The brief note of the presentation would appear to claim that it was Lyell himself who first noticed the fossils (Figure 1) but Moore (1840) makes clear that “Mr Moore found in a slaty rock alternating with compact beds, an abundance of fossils, determined by Mr Lyell to be graptolites.” Confirmation comes from Moore’s Geological Society obituary (written by John Judd): “... he was in communication with Charles Lyell, who identified the fossils found by him as graptolites.” In terms of modern stratigraphy, those graptolites were found within the Kirkcolm Formation, one of the Upper Ordovician successions overlying the Moffat Shale. Moore (1849) followed-up his initial

discovery with a remarkable traverse of the Rhins of Galloway, describing the graptolitic mudstone at Morroch Bay, 5 km SE of Portpatrick, now recognised as part of the Moffat Shale Group, and identifying several more graptolitic horizons within the Kirkcolm Formation.

At around the same time, other ‘amateur’ collectors were also busy elsewhere. Harkness (1851, p. 54) noted that “Some time ago Lord Selkirk presented the Geological Society with a suite of fossils which had been collected by Mr Fleming, of the Kirkcudbright Academy, on the east side of the bay of Kirkcudbright, and these fossils were named by the Geological Survey”. Fleming’s

A notice on “the Occurrence of Graptolites in the Slate of Galloway in Scotland,” by C. Lyell, Esq., V.P.G.S., was first read.

On examining some specimens of slaty sandstone and shale, collected by Mr. John Carrick Moore, on the shore of Loch Ryan in Galloway, Mr. Lyell discovered distinct remains of Graptolites, resembling those found in the Silurian strata of England and Sweden. As Mr. Lyell is not aware of these zoophytes having been before observed in Scotland, and as organic remains are exceedingly rare in the great range of slaty sandstone and shale which extends from St. Abb’s Head to Galloway, he considers the discovery of a fossil, affording a test of the relative age of those beds, not unimportant. The strata containing the Graptolites are nearly vertical, and their strike is west-south-west and east-north-east.

Figure 1 Charles Lyell’s 1839 announcement of the discovery of graptolites in the Southern Uplands of Scotland, as recorded in Proceedings of the Geological Society, London, volume 3, page 28

fossils—abundant graptolites and a sparse associated ‘shelly’ fauna including brachiopods and trilobites—were recovered from what is now known as the Raeberry Castle Formation (Riccarton Group); Wenlock in age, it is one of the youngest Silurian divisions in the Southern Uplands.

Meanwhile, graptolite studies in general had been driven forward by two palaeontological giants: the American, James Hall (1811–1898) who worked mostly in New York State, and the Frenchman Joachim Barrande (1799–1883) who was based in Prague from 1831 and thence worked extensively in Bohemia. Barrande became a hugely influential figure but, unfortunately, he developed the idea that graptolites were facies-dependent organisms that migrated into and out of any given area as the conditions changed. Moreover, as recolonisation could have occurred from a different graptolite ‘refuge’ (Barrande called them ‘colonies’), the apparent succession of graptolites had no biostratigraphical significance. Hence, many contemporary studies of graptolites simply focussed on defining species and paid little attention to their mutual relationships; for more on this see Rushton (2001). They were simply regarded as indicative of a general

Silurian age, at the time *sensu* Murchison but now spanning the Silurian and the Ordovician.

Back in Scotland, graptolite discoveries continued. In 1850, James Nicol (1810–1879) described them from Grieston Quarry near Innerleithen (his birthplace). The Grieston graptolitic beds are anomalously young for their structural position in the Southern Uplands and are now thought to lie within a tectonic outlier of mid-Llandovery (Silurian) strata surrounded by older Llandovery units. More extensive discoveries were made by Robert Harkness (1816–1878) (Figure 2) who ranged widely across the central Southern Uplands and published an extensive account of key localities encountered when tracing the outcrop of the graptolitic mudstone along strike from NE to SW (Harkness 1851). He identified three graptolitic ‘bands’, referring to the harder carbonaceous mudstones as ‘anthracite’ (and commenting on the levels for coal exploration seen in some places) and particularly noted the excellent exposures at, *inter alia*, Dob’s Linn, Hartfell, Craigmichan Scars and Glenkiln Burn. Twelve species of graptolite were described in detail (Figure 3), whilst a footnote (*op. cit.* p. 58) records: “At the meeting of the British Association at Edinburgh in July 1850, a list was



Figure 2 *Robert Harkness (1816–1878), a pioneer of graptolite palaeontology in the Southern Uplands, in an 1854 portrait by James Butler Brenan (1825–1889). Harkness lived in Dumfries for many years and from 1853 to 1876 was professor of geology at Queen’s College, Cork, Ireland. Image courtesy of the Department of Earth Sciences and Sedgwick Museum, University of Cambridge: Accession No 119.*

read drawn up by Prof. M’Coy, of fourteen species of Graptolites from the Silurian rocks of the south of Scotland.” Only two species were thought to be in common, so by 1850, it would seem that at least 24

graptolite species were known from the Southern Uplands.

Over the next twenty years information on Southern Uplands graptolites continued to accumulate, with about 25 relevant papers published between 1850 and 1870. Important contributors were Henry Alleyne Nicholson (1844–1899) and William Carruthers (1830–1922), with the growing database influencing successive editions of Sir Roderick Murchison’s *Siluria*. Hugh Miller (1802–1856) also took notice, and a chapter ‘On the ancient grauwacke rocks of Scotland’ was added to the later editions of *The Old Red Sandstone*. Harkness published several more papers in which he developed the idea that all the Moffat Shale outcrops were parts of a single original succession that had been split-up and duplicated by faulting parallel to the NE-SW regional strike.

Lapworth had arrived in Galashiels in 1864 and began to explore the local geology, most probably in the company of his friend (and future co-author) James Wilson. His first paper, ‘On the Lower Silurian rocks of Galashiels’, was published in 1870 in *Geological Magazine*, but by then he had expanded his activities towards Moffat, into the Moffat Shale outcrops identified by Harkness and most importantly into the exposures

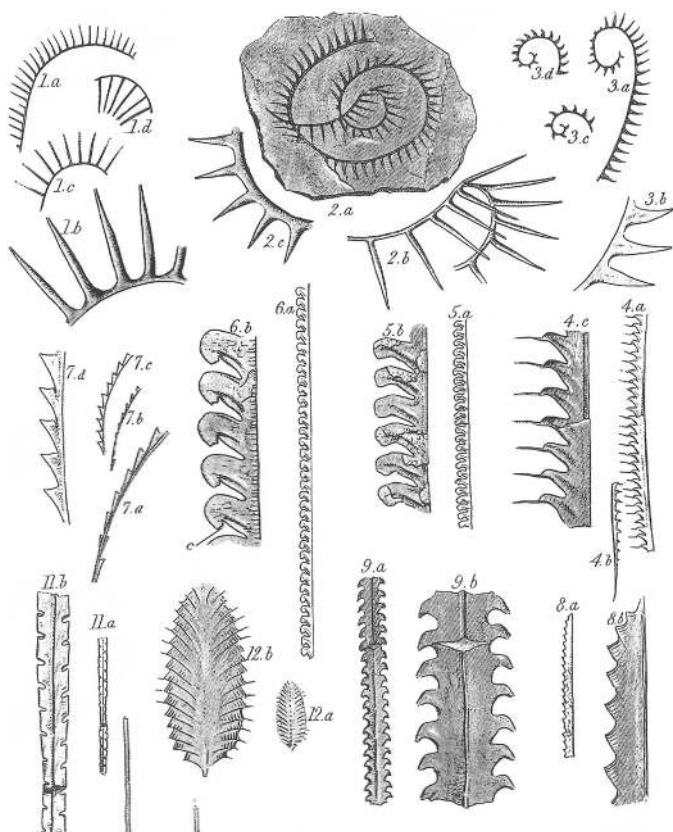


Figure 3 Some of the graptolites illustrated in fine detail by Harkness in his 1851 paper published in the *Quarterly Journal of the Geological Society, London*. The accuracy of the representations can be seen by comparison with the specimens shown in Figures 4 and 5.

at Dob's Linn. Other palaeontologists were also active in the area. John Hopkinson (1844–1919) published in 1872, in *Geological Magazine*, the details of some new graptolite discoveries “collected in the course of a few days’ walking tour in these districts, during part of which I had the advantage of the company of Mr. Chas. Lapworth, of Galashiels ...” from whom he anticipated imminent new publications. Significantly, Hopkinson affirmed that there was

“but one band of graptolitic shale ... there being in this band several distinct zones, each marked by a different assemblage of fossils, but with many species in common” (Hopkinson 1872, p. 501). Later in the same year Lapworth responded with his own *Geological Magazine* paper. He acknowledged Hopkinson and the influence of Harkness but noted that the latter’s proposal that the various Moffat Shale outcrops “were originally portions of the same

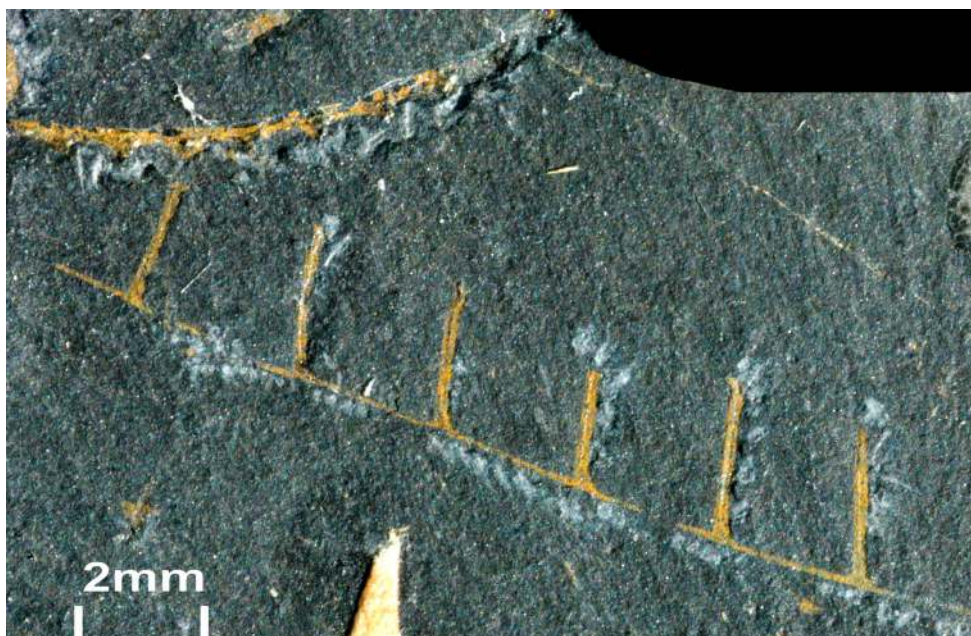


Figure 4 A specimen of *Rastrites abbreviatus*, one of the graptolite species illustrated by Harkness in his 1851 paper; see illustrations 1 and 2 in Figure 3. *R. abbreviatus* is a Llandovery (Silurian) graptolite and this example comes from the Moffat Shale Group at Clanyard Bay, Rhins of Galloway. BGS image P521153.

deposit” repeated by faulting had not met with general acceptance (Lapworth 1872, p. 534). Instead, it was more widely believed that there were several distinct Moffat Shale bands, at different levels in the stratigraphy, a view notably adopted by the Geological Survey for whose study of the region the fossil collector Arthur Macconochie had visited hundreds of localities and amassed thousands of graptolite specimens.

In his 1872 paper Lapworth supported the Harkness and Hopkinson view, but noting the prevalence of the alternative opinion (not to mention the continuing influence of Barrande) he admitted that “it will require no slight weight of contrary evidence to displace it” (*op. cit.*, p. 534). He went on to outline his interpretation of the Moffat Shale as a single succession that could be divided on lithological and palaeontological

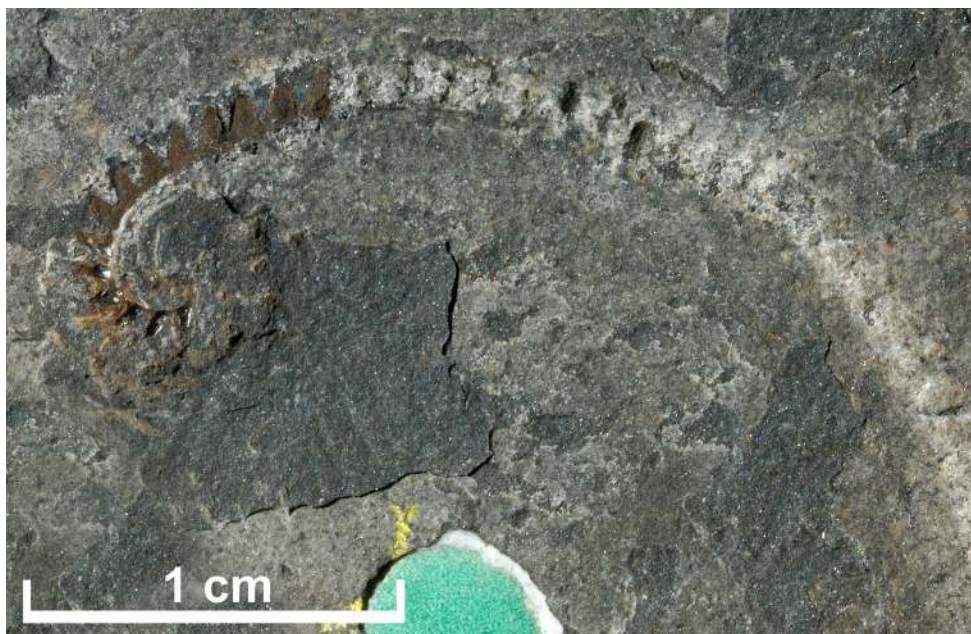


Figure 5 A specimen of *Monograptus triangulatus*, one of the graptolite species illustrated by Harkness in his 1851 paper; see illustration 3 in Figure 3. *M. triangulatus* is a Llandovery (Silurian) graptolite and this example comes from the Moffat Shale Group near Ardwell Point, Rhins of Galloway. BGS image P521160.

grounds into three divisions, further subdivided into zones on the basis of their graptolite faunas. Of the graptolites: “there are probably nearly a hundred different species in all (of which at least one third are as yet undescribed).” Rushton (2001) saw this 1872 paper as Lapworth’s assertion of his priority for establishing—or at least independently recognising—the Moffat Shale’s internal biostratigraphy in the face of perceived competition.

It took Lapworth several more years to complete his work on the Moffat Shale. During that time, he would have been encouraged by news from Sweden, where Johan Gustaf Linnarsson (1841–1881) had established the vertical distribution of graptolites from relatively undisturbed strata in the south of that country. In 1876 Linnarsson published an account of his findings in *Geological Magazine*, and in that same year Nicholson published

a comparison of the Scottish and Swedish faunas. Finally, in 1878, Lapworth was ready, and his monumental paper *The Moffat Series* was published in *Quarterly Journal of the Geological Society of London*. His work was so detailed, thorough and comprehensive that it presented an overwhelming case for the unity of the Moffat Shale and the biostratigraphic framework provided by graptolites. The Geological Survey's interpretation was recognised as inadequate, which soon prompted a re-examination of the Southern Uplands led by Ben Peach and John Horne. Only Barrande offered serious resistance, the fifth and final part of his *Défence des Colonies* appearing in 1881; he was defiantly composing a sixth when he died in 1883. The conclusion of the story, Lapworth's triumph, is now well known.

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Book reviews

The Lake District: Landscape and Geology. Ian Francis, Stuart Holmes & Bruce Yardley. The Crowood Press, 2022. Paperback, 176 pages, £18.99.



Question: What do the cinematic masterpiece *Brief Encounter* and this book have in common? Read on; all will be revealed in a timely manner!

The paperback *The Lake District: Landscape and Geology* is a delight to read. The authors, by following Einstein's razor, commonly stated as: *Make things as simple as possible, but not simpler*, keep their text tight and economical, and yet by no means superficial. With its straightforward descriptions of how Lakeland rocks formed and how they have affected the landscape, along with 230 illustrations including magnificent aerial photographs and well-chosen maps, the book will appeal to a wide audience.

Young science students, amateur earth scientists, lapsed geologists (like me), as well as visitors to the Lake District with an interest in how the landscape was shaped, all stand to gain from it.

The first six chapters explore the birth of Lake District rocks, their stratigraphy and tectonics, the sculpting of the landscape by ice and water, and the effects of geology on Lakeland scenery. The final four chapters tackle human influences, starting with the hunter-gatherers and the first farmers and leading through to current approaches to protecting Lakeland's fragile landscapes. Descriptions of seven Guided Excursions complete the book. (Several excursions are within easy reach of the M6 motorway and so readily accessible from Edinburgh.)

Additionally, a splendid companion website <https://www.lakedistrictgeology.co.uk/> is made freely available. Its varied supplementary materials are well worth visiting. The screenshot (Figure 1) shows one such feature—a specially created Google Earth project. Clicking on the coloured placemarks reveals photographs and descriptions of key locations mentioned in the book. Very impressive!



Figure 1
Screenshot of the associated Google Earth photographic guide describing all the book's main localities. Image published by permission of the authors.

My introduction to geology and landscape stemmed from schooldays in Ambleside in the early 1960s, and from being led deep into the fells by our mathematics and geography teachers. After a career in geophysics, I was intrigued to find out what advances had been made over the intervening years. I was not disappointed; here are three examples. First, the map of Cumbria's Roman roads has been vastly improved and recast. It now draws on modern airborne lidar imagery with its astonishing resolution and ability to discern old roads beneath trees. Secondly, under the heading 'A new role for old rocks', the vexed question of underground disposal of high-level radioactive waste is sensitively examined. This stubborn problem perturbs me, not least

as the radioactive cloud from the Windscale fire of 1957 is now known to have passed eastwards, directly over my school, rather than blowing harmlessly into the Irish Sea, as the public were originally told. Worryingly all the 'hot' waste in the Windscale atomic pile left over from the accident (~10 tonnes of melted radioactive fuel) still resides at the surface, awaiting safe disposal. Thirdly the recognition of huge collapsed volcanic calderas has followed painstaking mapping of the Borrowdale volcanic rocks. Large freshwater crater lakes with a thick sedimentary infill have been pinpointed. I now appreciate how the mini-turbidites, mud-draped ripples, truncated layers and miniature flame structures displayed on my 50yr old Coniston-slate coffee table arose!

In a stimulating break with the usual geological convention of describing rocks by starting with the oldest, the authors choose to begin with the youngest (last Glacial) and work backwards, but on reaching the middle (Old Red Sandstone age) they jump back abruptly to the beginning (Skiddaw slates), before moving forwards to reach the middle once again. Why? In telling a tale out of chronological order emphasis can be placed on how the different components of a story relate to each other and form part of a unified account. The film *Brief Encounter*, told in nonchronological flashbacks (as the storyline jumps back and forth in the narrator's memory), also uses this device. In the case of *Brief Encounter*, the film begins in Carnforth Railway Station's refreshment room (with the couple's final parting) but soon flashes back in time, thereafter, working its way forward through the affair to revisit the opening scene. On this second viewing the audience can appraise the parting from a more enlightened perspective. In the case of Lakeland's rocks, the nonlinear narrative prompts the reader to contemplate how the late-Palaeozoic and Mesozoic sediments, that encircle the Lake District, relate to the older sequences of the central fells. By visiting the Old Red Sandstone twice, the authors emphasise it as the pivotal period when the earlier mountain building and igneous activity of colliding plates gave way

to a world where erosion dominated with the deposition of conglomerates and proximal sediments. Eventually, as the Lake District domed up, the interior rocks were more deeply exposed and the sculpting of the landscape began, thereby initiating the classic radial distribution of Lakeland rivers. Ultimately glacial actions further scoured the landscape to generate the valley lakes and high tarns that characterise today's glorious Lakeland scenery.

It is impossible to close this review without singling out the illustrations for special praise. All are closely allied to the text to make a telling point about the geology or landscape. Stuart Holmes's aerial shots, many taken from his paraglider, have won numerous awards. It is easy to see how wild and mountainous landscapes are his passion. My favourite shot is taken hovering high above the church of St John's in the Vale, looking south to Thirlmere, with bright sunlight picking out the trap topography of the Borrowdale Volcanics. Far beyond lies the unmistakable skyline of the central fells, beneath a layer of low-altitude, fluffy cumulus clouds and a brilliant blue sky.

Roy Thompson,
GeoSciences,
Edinburgh University,
September 2022.

River Planet: Rivers from deep time to the modern crisis by Martin Gibling. Dunedin Academic Press Ltd., Edinburgh, 2021. Hardback, 222pp. RRP £28. ISBN9781780460994



Periodically your editor gets asked by our local earth science publisher, Dunedin Academic Press, if I would like to include a book review in *The Edinburgh Geologist*. I try and select books that are closely related to Scottish geology and are likely to be attractive to our members or highlight whether it is more suitable for one group or another. I offered this book to a couple of reviewers who for one reason or another turned me down. By this time, I had read the whole book and really enjoyed it and thought for once I could write a review.

If you are interested in rivers, then this book is for you, and if you are

not yet interested in rivers then this book will certainly stimulate your interest. It takes you on a journey from the first rain drops and the first river, through explanation of the different types of river systems, to a look at modern major rivers, and how they have evolved through geological time in response to evolution, plate tectonics and climate. There is a separate section on the tremendous impact on rivers of the Ice Age, and the book finishes with a look at how humans have used, damaged, and abused our rivers.

Through each chapter Gibling brings the rivers to life through fascinating stories of the early geologists, geographers and explorers who traced their routes and began to understand the processes controlling them. By page 2 Hutton and Lyell have a mention and the Torridonian is not far behind, closely followed by Hugh Miller and the Old Red Sandstone. But it is the intrepid explorers who first trekked up the great rivers of Africa, Asia, America, and Australia who really bring these rivers to life.

Gibling tells us about the oldest detrital zircons—about 4bn years old—found in Australia. Their composition indicates oxygen in the atmosphere and a granitic origin—first rain, first erosion and

first rivers occurred very early in Earth's history. About 3bn years ago the Rand conglomerates in South Africa had been deposited in braided rivers together with their huge and plentiful gold nuggets. Already there were continents and oceans. One major control on rivers was the origin of plants and the development of soils held together by roots—a key factor in the rise of meandering streams. Rivers would have looked very different before mosses and lichen evolved in the Ordovician and larger plants and trees during the Devonian. The author suggests these great steps in evolution and the capture of carbon could have contributed to the Ordovician and Carboniferous glaciations.

The largest section of the book is about our modern rivers. But this is very much a geologist's idea of 'modern' as their history takes us back to Pangea and the Carboniferous. It is a story of continental break up, rifting, subduction, and plumes; stories of river capture, diversion, reversing flow direction and new rivers forming. The oldest rivers? Think passive margin and large continents... the Mississippi (Carboniferous), the Orinoco (Cretaceous) the Volga (possibly Carboniferous). But not the Amazon (the most water flow) or the Nile (the longest)? Read the book to

find out why these are younger rivers. As a clue, think about the River Sanozama.

The section on the ice age demonstrates that ice has just as great affect on rivers as new rifts, continental collision and subduction along continental margins. With the onset of melting, huge glacial lakes developed across Canada and northern Eurasia and when the dams burst tremendous floods led to new river systems leading to major changes in topography. The Canadian islands are surrounded by river cut valleys that were flooded during post glacial sea level rise. As the ice began to melt the rivers of Western Europe—the Rhine, Thames, Seine all joined together to form the Channel River which broke through the eastern extension of the North Downs in a huge waterfall and deposited gravel bars across the channel passing on through the Hurd Deep to the continental margin.

The Thames moved to its current route during the ice age as it was pushed south by the ice sheet to the north. Gibling's map of the Thames in London shows 16 named tributaries, most of which are now buried underground. He describes their rather grizzly past of pollution, stench, and outbreaks of cholera. On my first visit to London after



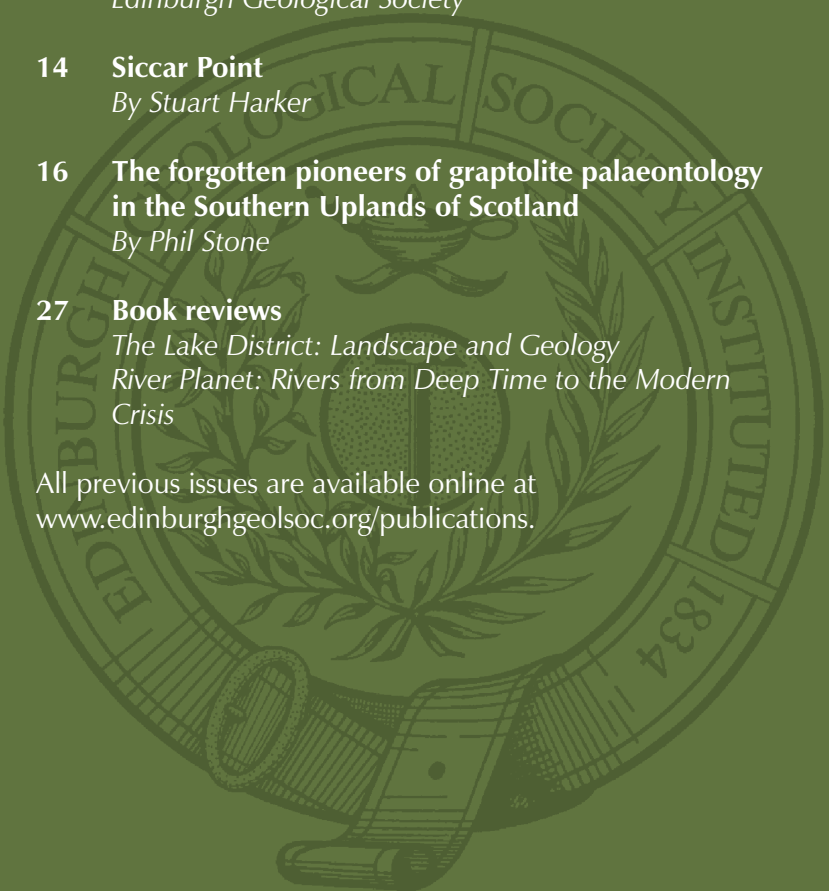
Figure 1 *The John Snow pub in London with the water pump that sourced a major cholera outbreak.*

reading this book, I visited the John Snow pub (Figure 1)— named not after a newsreader or a cricketer, but after the man who Gibling tells us demonstrated that the source of the largest cholera outbreak in London was from a pump from water from one of these underground streams. I have since discovered that the pub and the pump are a popular meeting point for hydrogeologists!

Gibling's tales add to a book that demonstrates the history of our rivers and the role geological processes have in their evolution. There is an excellent short glossary of geological terms and a comprehensive reference list for students and others who want to know more. I thoroughly recommend this book.

Robert Gatliff

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