



The Edinburgh Geologist

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Cover Illustration

Part of a composite image combining all of the Geological Survey's 'index to colours' charts, which illustrated the 497 standard colours (some with an ornament overlay) defined by the 1960s for the colouring of geological maps. For the full story see the article by Bob McIntosh and Fergus MacTaggart on page 5. BGS image P941837.

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www.edinburghgeolsoc.org

Editors

Phil Stone

psto@bgs.ac.uk

Bob McIntosh

rpm@bgs.ac.uk

British Geological Survey
The Lyell Centre
Research Avenue South
Edinburgh EH14 4AP

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From geodiversity to geomythology

An editorial ramble by Phil Stone

With 2017 being Scotland's 'Year of History, Heritage and Archaeology', this issue of *The Edinburgh Geologist* has an appropriate mix of articles and a suitably artistic front cover *sensu* Klee/Mondrian/van Doesburg (although like Mondrian we eschew the diagonal). It's a colourful section of the palette used in the production of Geological Survey maps—the culmination of parallel growth in the number of stratigraphical and lithological units recognised and the technical range of colours available, first as water-colour paint bases and then through colour printing. Bob McIntosh and Fergus MacTaggart explain a little more in the first of the following articles.

History, heritage and geodiversity

Our second article, by John Mendum and Anne Burgess, looks into the family history of John Horne, one of the giants of Scottish geology in the late 19th and early 20th centuries. But it comes with a sad rider in that John Mendum died in December last year, soon after he had provided the final touches to his and Anne's article. Both Johns were held in high regard by their contemporaries as outstanding field geologists, so their association

here seems apposite. They were also both very supportive of the Edinburgh Geological Society and some readers will undoubtedly have enjoyed field excursions to the Highlands led by John Mendum, often in the footsteps of John Horne. And of course John M was a regular contributor to *Edinburgh Geologist*, writing on Henry Cadell (EG48 & 49), Lionel Hinxman (EG49) and Ben Peach (EG57)—not to mention his forthright book reviews!



John Mendum was well-known for his demonstrations of Henry Cadell's 'mountain-building machine' at BGS open days in Murchison House. From BGS image P519123.

Moving on from history to heritage, or geoheritage to make the point, we have cause for celebration thanks to sterling work by Angus Miller which has resulted in a grant from the Heritage Lottery Fund. This enables a project to promote public engagement with the best of Scotland's extraordinarily varied geology at fifty sites that are easy to access and explore. Online and printed resources will be developed, building-up to a national geoheritage festival in October. Angus hopes to develop the theme in a contribution to the next issue of *Edinburgh Geologist* but in the meantime you can follow progress at scottishgeodiversityforum.org, whilst the final online content accumulates at scottishgeology.com. In a parallel development, Scotland's Geodiversity Charter is to be refreshed and then relaunched at a conference in November. So, there's plenty to watch out for.

One area in which Scotland's geodiversity has traditionally made its presence strongly felt is in the vernacular architecture of the built environment. I'm very pleased therefore that each of this year's two *EG* issues will carry parts of Andrew McMillan's account of building stone use in the Highlands and Islands. Our third article in this issue deals with the sedimentary and metasedimentary rocks; the use of igneous and crystalline metamorphic rocks will

be assessed in *EG62*, so completing a highly appropriate contribution to 'heritage year'.

I'm sure that most geologists have, at some time or another, been asked whether they have recently been on any 'interesting digs': archaeologists' activity is clearly an easier concept to grasp. Perhaps the closest we get to a 'dig' is in the systematic excavation of a fossil bed, rather like the project described in *EG60* as part of the hunt for Early Carboniferous terrestrial tetrapods in the Scottish Borders. So, extrapolating from that, fossils represent our culminating contribution to the 'history, heritage and archaeology' theme. For our fourth article in this issue of *EG*, Brian Bell (last year's Clough medallist) and Ian Williamson take a look at some rather unconventional fossils—tree trunks caught up in the Palaeogene lavas of Mull. They focus particularly on some relatively recent discoveries at Quinish, but the genre is probably best known from "MacCulloch's Tree", the famous example at Ardmeanach. In turn, John MacCulloch (1773–1835) is probably best known for his geological map of Scotland, published posthumously in 1836, but his discovery of the eponymous tree came earlier in his career and was first described in his 1819 book *Descriptions of the Western Islands of Scotland, including the Isle of Man*. Despite its relatively inaccessible

location, “MacCulloch’s Tree” has been much damaged by thoughtless collecting, so let’s hope the examples at Quinish don’t suffer a similar fate. Perhaps they’ll make it onto the ‘50 of the best’ geodiversity short list.

Fossils preserved in a rather more conventional manner feature in our final article, but are celebrated unconventionally. David Leather provides entertaining verses to illuminate the habits of the Devonian



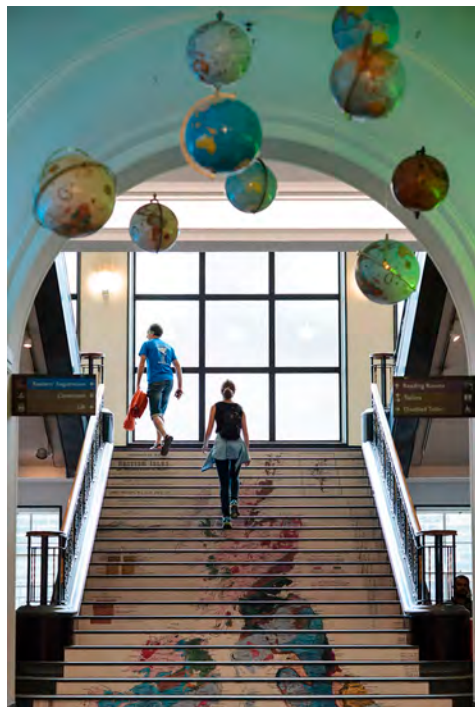
MacCulloch’s Tree: the cast of a 12 m long coniferous tree trunk caught-up in Palaeogene lava at Ardmeanach, Mull. BGS image P580468.

fish in the Orcadian Basin—and maintains the artistic quality of *EG61* with some illustrations by M J Newman and G N Reid. More of the work of Graeme Reid enlivens the exhibition at the Burray Fossil Museum in the south of the Orkney Islands: for an introduction check the ‘Orkney Fossil and Heritage Centre’ section at www.gnreid.co.uk.

Last chance to see ...

At a venue closer to home, did you get to see the John Phillips, 1862 geological map of ‘The British Isles and Adjacent Coast of France’ in the National Library of Scotland’s eclectic ‘You Are Here’ exhibition? If not, there’s still a chance as the exhibition runs until 3rd April. You can also enjoy the inspired touch that sees the John Phillips map reproduced in strips on the risers of the main library staircase, giving the geology of Scotland a prominent, if temporary, projection beyond the confines of the formal map exhibition.

On one of my visits, whilst browsing the map-related literature in the NLS bookshop, I came across *Britannia Obscura* by Joanne Parker, a Senior Lecturer in Victorian Literature at the University of Exeter. The book deals with the more idiosyncratic demands of niche mapping—of cave systems, the canal network, flight paths, that kind of thing. But in the preface I noted approvingly that geologists’ maps



The main staircase at the National Library of Scotland embellished with John Phillips' geological map of 1862. Photograph courtesy of the National Library.

were lauded as having no respect for national or county boundaries, so read on, only to be astounded by the following: “the Lake District mountain Helvellyn, for instance, is occasionally viewed as part of Scotland—on the grounds that in the distant prehistoric past, it broke off from the West Highlands, floated down the west coast of Britain, and eventually crashed into Cumbria.” An endnote gave the source

of this geomythology as a 1995–96 issue of a hillwalking “fanzine” called *The Angry Corrie*.

Now naturally, the National Library holds all the back copies of *The Angry Corrie* so I was able to reassure myself that the original account was a scurrilous spoof in a magazine that is, to say the least, militantly eccentric. To complete the assessment of “what we ironically refer to as the Cumbrian Mountains” (by Dr Ben MacDoohey of The Angry University)—Skiddaw is typically English, i.e. featureless and boring, whilst “slaggy” Scafell was ejected by the Chicxulub asteroid impact (see *EG60* for the real Chicxulub story). But given an origin for all of this as deliberate mock-geology, why would Joanna Parker resort to citing nonsense when the geological reality is more dramatic than anything anyone could conceivably invent? Clearly there are still a lot of people out there who still need to be initiated into the delights and fascinations of Scottish geology. Hopefully the activities planned for the ‘Year of History, Heritage and Archaeology’ will help.

And thinking of geomythology—well worth a visit will be “Fossil Tales”, a small exhibition at the National Museum of Scotland examining palaeontology’s role in folklore: 7 April to 10 September 2017.

Standard colours used on the maps of the Geological Survey of Great Britain

By Bob McIntosh and Fergus MacTaggart

The front cover of this issue of *The Edinburgh Geologist* shows part of a composite image of the Geological Survey's 'index to colours' charts from the 1960s. These illustrated the 497 standard colours that by that time had come to be used by the Survey Drawing Office in the production of geological maps. The charts were accompanied by a printed booklet entitled 'Geological standard colours' or later 'Explanations and memoranda relating to standard colours used on the maps of the Geological Survey of Great Britain'. In the composite image, the horizontal strips of colour blocks were originally issued on separate cards; these have been photographed individually and then digitally stitched together.

Many of the colours had initially been available as water-colour paint cakes that were specially formulated for the Survey and were individually numbered and specified to the standard colours text. Many have delightful names such as "Coral rag, pale (60) with a little Tunbridge Wells Green (41)" and "Weald, pale (43)

with overwash of Chrome Yellow, medium (355) stippled Crimson".



A selection of the water-colour cakes that were still being supplied to the Geological Survey as late as 1959 for hand-colouring unpublished Library copies of six-inch geological maps and field slips.

By 1832 when Henry De la Beche started detailed geological mapping in Devon and Cornwall, colouring geological maps according to stratigraphy was a well established activity. William Smith had produced his wonderfully coloured geological map of England and Wales and part of Scotland a good seventeen years earlier

in 1815 and George Bellas Greenough produced his version in 1819, so it was natural for De la Beche and the new Ordnance Geological Survey to adopt a similar colouring scheme.

The Ordnance Survey had originally produced a geological colour scheme in 1830: “An uniform System of Indicoclature...” of only seven colours, though this was not actually used. De la Beche produced his standard in 1832 for his forthcoming survey: “Colours to be employed in colouring geologically Sheets 21, 22, 23, 24, 25, 26 and 27 of the Ordnance Map of Great Britain” with 16 colours specified. After that and with the expansion of the Survey to new areas and as more formations were recognized, the numbers of colours rapidly increased: 53 by 1845, 180 by 1874, 367 by 1924, and 497 when the colour charts were last used in the 1970s.

Until the introduction of colour printing (c. 1900) all the one-inch geological maps were issued hand-coloured. Maps were printed ‘lines’ only and then painted individually for each sale copy using a ‘Colourists Copy’ of the original master coloured copy as a standard to follow. After the introduction of colour printing a hand-coloured, original coloured copy was still used to send to the Ordnance Survey printers as a specification for colours to be used, and hand-

colouring continued for some time until earlier sheets were revised and colour printed. The system remained largely unchanged for decades and even in the 1990s some larger scale non-published deposit maps were hand-coloured using the scheme.

Further information

Geological Survey colour charts
<http://www.bgs.ac.uk/data/maps/maps.cfc?method=listResults&mapName=&series=INDC&>

Geological Survey of Great Britain & Ireland 1:63 360 scale geological maps and sections—historical notes
<http://www.bgs.ac.uk/data/maps/aboutHistoricalMaps.html>

Bate, D. The origins of systematic geological mapping in Britain <http://www.bgs.ac.uk/data/maps/origins.html>

Geological Survey of Great Britain and Ireland, 1897. (includes description of the map production and colouring process) <http://www.bgs.ac.uk/downloads/start.cfm?id=2698>

Nowell, D. 2016. Victorian geological survey maps of Britain and Ireland *Geology Today*, **32**, 186–194. DOI: 10.1111/gto.12151

Bob McIntosh & Fergus MacTaggart, British Geological Survey, Edinburgh.

John Horne (1848–1928)

By John Mendum and Anne Burgess

John Horne is perhaps best known for his association with Benjamin Neeve Peach and their seminal work for the Geological Survey in the Northwest Highlands and Southern Uplands of Scotland in the late 19th and early 20th century. The two men had different talents that combined to good effect. In this short article we delve into Horne's professional and personal life, showing how the Survey benefited from his efforts.

Horne was a genial, patient, diligent, and hard-working man who invariably sported sideburns and a moustache, dark when young, but white and bushier in later years. He favoured the use of a bowler hat in the field. He patently derived great satisfaction from his geological mapping, which was accurate and scrupulous. In geological and administrative matters he was notable for his clear thinking, fairness and sound judgement; indeed, Flett (1929) described him as possessing a 'judicial mind'. These

qualities, together with his wide and long geological experience, were used to great effect, not only in the production of survey maps



John Horne, in signature bowler hat, in a light-hearted group photograph taken, probably in 1885, during a field excursion to the NW Highlands. The original caption reads: "The Bandits' Lair". The names of those desperadoes are, reading from left to right ... Back row – J B Hill; L W Hinxman; J Horne; G Barrow. Front row – J Linn; B N Peach; H Miller; W Gunn." BGS image P008715.

Note 1 ... The 'Bandits' Lair' almost certainly dates from 1885, probably in the Spring of that year. As recorded in *Summary of Progress* for 1885, Geikie had instructed the newly recruited members of the Scottish staff to attend a workshop in the NW Highlands with Peach and Horne. Barrow, Clough, Dakyns, Gunn and Miller had moved to the Scottish Office from northern England in 1884. Hinxman and Cadell were recruited in 1883. The photo was probably taken in Sutherland as they visited Loch Eriboll and the Scourie area. The two people missing are Dakyns and Cadell. It is suspected that Cadell was the photographer. The photo cannot be later as there is no recorded instance of the same body of people being in the field together subsequently.

and memoirs, but also in giving sage advice to both senior and junior officers. He was open to the opinions of his colleagues and academic geologists, and would incorporate or modify their ideas and work as appropriate. Unlike Peach, he was well-organised and adept at writing up lucid descriptions of the geology, thus making Scottish geology widely known and appreciated.

John Horne was born on 1st January, 1848 at Newmill, Campsie (now Milton of Campsie), the 8th of 10 children to James Horne of Newmill (1791–1860) (farmer) and Janet Braid (1806–1856). He attended Glasgow High School and went on to Glasgow University where he attended various classes but did not graduate. Showing an interest in geology, Horne applied to join the Geological Survey in 1867, passed the requisite Civil Service Examination, and at age 19 was appointed Assistant Geologist, based in Scotland. During his first decade in the survey Horne's main task was geological mapping in the southwest part of the Southern Uplands, an area mainly underlain by the Ordovician—Silurian 'greywacke' succession, intruded by the major plutons of Criffel–Dalbeattie, Cairnsmore of Fleet and Loch Doon. He proved to be an honest, competent and accurate field geologist, eminently

capable of delineating the main lithologies, stratigraphy, and overall structure. However, given the state of geological knowledge at the time, only a superficial interpretation was possible. A more detailed understanding of the stratigraphy and structure only became possible after the work of Lapworth (1878), who recognized that the graptolite faunas in the mudstone units acted as biostratigraphical markers, coupled with subsequent advances in sedimentology and tectonics.

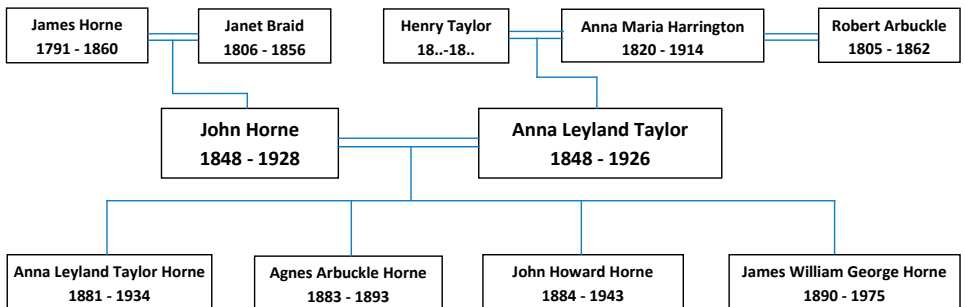
By the mid-1870s surveying in southern Scotland was winding down and geologists were progressively moved north to start mapping in the Highlands. Hence, in 1876 Horne commenced mapping in the Inverness—Nairn area and thereafter expanded his experience to include the Devonian rocks of the Orcadian Basin and the Dalradian rocks of the northeast Grampians with their extensive mafic-ultramafic intrusions. From 1876 onwards he took holidays with Peach in Shetland, Orkney and Caithness, resulting in papers on both the pattern of glaciation and the Old Red Sandstone succession.

In 1877 Horne married Anna Leyland Taylor (1848–1926) at Borgue in Kirkcudbrightshire. It is likely they met whilst he was mapping in the Kirkcudbright area in 1873. Anna was

born at Pernambuco (Recife) in Brazil but moved to Scotland in the 1850s. Once married, Anna accompanied her husband to NE Scotland where she gave birth to two daughters, Anna Leyland Taylor (1881–1934) and Agnes Arbuckle (1883–1893), at Banff and Huntly respectively. Their places of birth document where the family was resident and correspond to areas mapped by Horne during these years. Horne continued to map in NE Scotland through to 1884, when the family became resident in Inverness. Here, Anna gave birth to two sons, John Howard (1884–1943) and James William George (1890–1975). Horne had been promoted to Geologist in 1881 and during the 1880s and early 1890s he was effectively in charge of the mapping in the Inverness area, in Caithness, and in the NE Grampian Highlands. As such he actively supervised the work of Miller, Greenly and later, that of Pocock. His geological

versatility, experience, administrative abilities, and residence in Inverness meant that he acted as a lynch-pin, facilitating the prosecution of the field mapping, co-ordinating the results, and compiling many of the maps and memoirs. Indeed, his Inverness address appears to have become a de facto survey office.

Although Peach and Horne had collaborated previously in various ways, it was not until mapping was underway in the Northwest Highlands in 1883–4 that their different but ultimately complementary talents worked to such good effect. Another notable joint enterprise was their field revision of mapped boundaries of the Southern Uplands (assisted by Macconochie as fossil collector); when at full throttle in 1895 and 1896 this involved traversing some 500 miles of boundary together. Horne was well-organised and took



John Horne's family tree.

a careful and thorough approach to geological problems. This contrasted with Peach's more rapid and at times 'imaginative' interpretations of the geology. Horne was the first survey geologist both to appreciate and accept Lapworth's work in the Southern Uplands, and to argue (with A Geikie) in favour of his interpretation of the Moine Thrust Belt.

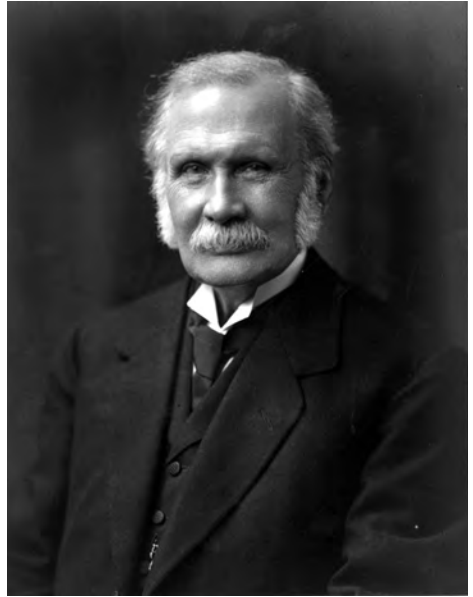
By the 1890s Horne was a senior member of the team that had mapped southwards along the Moine Thrust Belt between Ullapool and Kyle of Lochalsh. He was heavily involved with compilation and publication of geological maps for the Highlands and the revision of the Southern Uplands sheets. He was also the major author of the definitive Southern Uplands and Northwest Highland memoirs, and contributed significantly to other survey memoirs. He was a prolific author of papers on a wide range of geological subjects, mainly Scottish. Papers were published in major journals (*Nature*, *Quarterly Journal of the Geological Society*), but also in more local publications (e.g. *Transactions of the Inverness Scientific Society and Field Club*). Whilst resident in the NE Grampians and Inverness Horne was heavily involved with the Banffshire and Inverness Field Clubs to whom he gave numerous lectures. He was

also a leading player in the British Association and Chairman of the committee that reported on the Clava shell-bearing diamictites and related deposits. At home, normal life was disrupted by the sudden death of his daughter Agnes on 16th November, 1893 from meningitis.

In 1899 Horne was appointed Acting Director (Scotland), in charge of the Edinburgh office and hence he and his family moved south, and took up residence at 12 Keith Crescent in Blackhall. In 1900 Horne gave evidence to the Wharton Commission enquiry on the state of the Geological Survey in Scotland. Although he avoided direct criticism of Geikie, he did point out the highly unsatisfactory situation that had arisen regarding staff conditions (Oldroyd, 1990). The enquiry recommendations addressed most of the points raised, and as a result, pay, conditions, and the management in the Geological Survey moved into line with other Civil Service bodies. When Geikie retired in March 1901, the post of Director-General was abolished. Jethro J H Teall was appointed Director with Horne as Assistant Director (Scotland) and Peach and Gunn as his District Geologists.

After the survey's reorganisation Horne's main task was to expedite

memoir and map production, including the backlog that had built up during Geikie's time. Between 1900 and 1903 the Scottish staff complement was augmented by the recruitment of E M Anderson, E B Bailey, R G Carruthers, C B Crampton, G W Grabham and H B Maufe. This intake was significantly better educated than previous generations. Gunn retired in 1902 and Peach in 1905, their District Geologist posts being taken by Charles T Clough and Lionel W Hinxman respectively. Some Highland field work still continued, but the survey's focus had moved farther south to the Midland Valley, where detailed revision of the coalfield sheets had been recommended by a Royal Commission in 1901. In his ten years as Assistant Director Horne spent much time editing memoirs and overseeing map production. He was also assiduous in carrying out field inspections, resolving staff problems, and adjudicating on matters of disagreement regarding geological interpretations. Despite this workload, he did manage to contribute to some survey publications, notably the Northwest Highlands Memoir (1907) which, without his strenuous efforts, would never have seen the light of day. At home, his daughter Anna had married Thomas M Munro in 1903



John Horne in later life. The photograph was probably taken around 1905. BGS image P008724.

and departed to Calcutta (India). In 1907 his elder son John qualified in medicine and surgery (M.B., Ch.B.) at Edinburgh University and then joined the Army, serving in the Indian Medical Service.

Horne had been elected to fellowship of the Royal Society in 1900, and in 1901 he was President of the Geological Section of the British Association for its Glasgow meeting. He was actively involved with the Royal Physical Society of Edinburgh, the Geological Societies

of Edinburgh and Glasgow, the Royal Scottish Geographical Society and the Royal Society of Edinburgh. Following retirement in 1911 he took on onerous roles with various societies, becoming President of the Edinburgh Geological Society (1910–12), Chairman of Council of the Royal Scottish Geographical Society (1910–15), President of the Royal Society of Edinburgh (1915–19), and chairman of several British Association Committees. With Peach he wrote more papers but their ambitious project to write a comprehensive guide on the geology of Scotland remained unfinished at their deaths, with their descriptions of the Highland areas being incorporated into a book '*Chapters on the Geology of Scotland*', published in 1930.

In 1911 Horne and his extended family (including grandchildren) are recorded as resident at 12 Keith Crescent, but soon afterwards family members dispersed elsewhere and Horne moved to smaller premises at 20 Merchiston Gardens. In 1926, on the 5th August, Anna died suddenly of a heart attack while on a visit to Melrose. Horne died almost 2 years later on 30th May, 1928, the cause of death being stated as duodenal ulcer, influenza and pulmonary embolism. On January 26th 1894, shortly after the death of his daughter Agnes, Horne had purchased 2 lairs

in the Campsie Cemetery (by the large Parish Church at Lennoxton). Horne, his wife Anna, and their two daughters Anna and Agnes are interred there with the gravestone listing all members of the family. It lies adjacent to the grave of the Munro family.

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The late John Mendum (formerly BGS Edinburgh)
Anne Burgess (anne.burgess@btinternet.com)

Geology and building stones in the Highlands and Islands

Part 1 Sedimentary rocks and metasedimentary rocks

By Andrew McMillan

Reflecting the richly varied geology of the Highlands and Islands, many different sedimentary, igneous and metamorphic rock types have been exploited for building purposes. Intermittently over a period of over 5000 years, stone has formed the principal building material. From the Industrial Revolution the region became a major producer and exporter of sandstone, flagstone, slate and granite. Flagstone production and limited sandstone quarrying still continues at several quarries. Granites and metamorphic rocks are today primarily worked as sources of aggregate. Slate has not been quarried since the 1950s. In 2016 it was estimated* that 17 quarries in Scotland were then producing building stone, of which only 7 were active continuously. Before the days of rail and road transport, local sourcing of building stone was the norm, as testified by evidence of hundreds of small quarries. However, as in the rest of Britain, the building stone industry declined rapidly in the early twentieth century, displaced by brick and concrete for most construction.



Ring of Brodgar, dating from the third millennium BC, part of the Heart of Neolithic Orkney, inscribed as a World Heritage Site in 1999.

As a general rule, pre-1920s traditional stone buildings reflect the local geology. Thus, for example the districts around the Moray Firth are characterised by buildings

constructed of warm-coloured Mesozoic sandstones. Elsewhere the built heritage of Caithness and Orkney is dominated by Devonian sandstones and flagstones, and in Aberdeen by Palaeozoic silver grey granites. It is also common for buildings to incorporate more than one type of stone in their construction. This is partly pragmatic, since the physical properties required in a stone used for roofing or bridging (lintels) and portals may be quite different, and more demanding, than in those destined only for masonry walling. Also, the requirements for formal dimensioned stone ashlar as opposed to rubble dictated the specification of particular lithologies.

This account is divided into two parts: part 1 covers sedimentary and metasedimentary rocks; part 2 (to follow in the next issue of *The Edinburgh Geologist*) will focus on igneous and crystalline metamorphic rocks.

Sedimentary Rocks

Flagstone

Flagstone (thinly bedded dark grey, very fine-grained sandstone and organic-rich, laminated siltstone) and sandstone of the Lower to Middle Old Red Sandstone occupy the Orcadian Basin extending from Shetland and Orkney through Caithness and around the Moray Firth. Owing to their laminated

characteristics, strength and durability, flagstones provided excellent building materials. Over several centuries quarries supplied high quality flagstone for local building purposes and for pavement, walling (including the traditional Caithness Fences) and roofing. Originally slabs were sawn and split by hand. However, the lamination is tightly bonded and delamination on face-bedded slabs is rare. During the 19th century the harbour at Castlehill, near Thurso was established as the one of the earliest ports from which vast amounts of flagstone was shipped to cities throughout the United Kingdom and abroad. Today the Caithness flagstone industry is enjoying a revival as natural paving is becoming a popular choice for streetscape schemes, landscaping and



Pier near Castlehill Quarry, Castletown, showing how flagstones were used as slabs placed vertically in the structure.



Flagstone House, Halkirk, as newly built in 2002, with Caithness Flagstones.

indoor use. There are also examples of its use as masonry and roofing in new build.

Sandstone

Where available, many sandstones capable of easy working and dressing were employed for local building work. Consequently the Early to Mid-Devonian red-brown and yellow sandstones which crop out at the margins of the Orcadian Basin proved to be a valuable resource.

Some of the earliest examples of dry stone construction can be seen in the Northern Isles. In Shetland the Lerwick Sandstone was skilfully employed in this way for the 2000 year-old brochs of Mousa and Clickimin. Many of Lerwick's houses are built of stone from this formation. In Orkney, red and yellow sandstones

of the Eday Group proved suitable for mullions and decorative work. The 12th century St Magnus Cathedral, Kirkwall is built of these sandstones and many buildings in Kirkwall are built of fine-grained, yellow freestones from Fersness on the Island of Eday.



Drystone-constructed Broch of Clickimin, Lerwick, Shetland.

Early to Mid-Devonian sandstones have supplied many towns and villages including Golspie, Tain, Dornoch, Cromarty, Inverness, Nairn and Elgin. The Black Isle was a particularly productive source. Much of Beaulieu's sandstone came from quarries at Ruilick in the Sarclet Sandstone Group. Important quarries such as Milton at Redcastle on the northern side of the Beaulieu Firth supplied stone for buildings on the Black Isle and parts of Inverness; red-brown sandstone from Bay Quarry on the northern shore of Munlochy Bay was used for Fort George; and the

Millbuie quarries supplied stone for the Fortrose and Rosemarkie area.



Pale yellow and pink Devonian sandstone in coursed rubble wall with snecks (detail), Dornoch.



Locally quarried red sandstone of the Sarclet Group used in the Phipps Institute, Beaulieu

At Rhynie, Aberdeenshire, pink sandstone (Early Devonian) was used for local buildings such as Kildrummy Castle. Stone was quarried historically at Delgaty Wood near Turriff.

Sandstones were also quarried in Monquitter for building of the Tower of Teuchar and nearby Byth House.

On the south coast of the Moray Firth there has been a strong tradition of building with sandstone. Beds assigned to the Upper Devonian were extensively worked near Elgin. Here the disused quarries in the Rosebrae Beds at Quarry Wood and Bishopmill appear to have supplied the most building stone. The Alves Beds at Burgie, Alves and Newton, and the Cutties Hillock Sandstone (worked at Millstone Quarry in Quarry Wood) were more suitable for field walls and millstones. Notable quarries in Permian sandstones include Clashach, east of Hopeman (currently working) and Greenbrae, west of Hopeman. The former produced excellent durable siliceous sandstone (white, red and brown and variegated colours) both for local buildings (e.g. Elgin) and the cities (a recent use is the National Museum of Scotland, Edinburgh). The quarries were famous for yielding fossil reptilian fauna, specimens of which may be seen in the Elgin Museum and National Museum of Scotland. At Spynie, pale-coloured durable siliceous sandstone (Late Triassic) was used in Elgin. On the north coast of the Moray Firth siliceous sandstones of Jurassic age were worked at Brora. The stone was also used in Golspie

and buildings in the surrounding area including Dunrobin Castle.



Jurassic sandstone masonry in a Golspie building showing a cast of a fossil mollusc shell (detail).

On the western seaboard of the Highlands isolated outcrops of Old Red Sandstone were exploited as building stone. Early Devonian purple, brown and grey sandstones crop out on the Oban–Lorne coast and were used in Dunstaffnage Castle. Conglomeratic red sandstone was exploited locally on the Cowal peninsula, Argyllshire. The Late Devonian Bute Conglomerate Formation was worked at Toward. Small outcrops of Carboniferous strata were worked on the Island of Arran and at Campbeltown. At Bridge of Awe, white and pink sandstone was supplied for dressings for Fraoch Eilean Castle and Kilchurn Castle. At Inninmore, Morvern, coarse-grained

white and yellow sandstone, used mainly for millstones and gravestones, contributed to Ardtornish Castle, constructed mostly of basalt rubble. On Arran Carboniferous white freestone was worked during the 19th century and used in the construction of the Crinan Canal.

Permian red sandstone is confined to small outcrops on the west coast, notably at Corrie and around Machrie Bay on Arran. Used locally (including Brodick Castle) the stone was also shipped to other coastal areas in the Clyde and western Scotland including Rum (Kinloch Castle) and Oban. Mesozoic sandstones were exploited on the Morvern coast and on the islands of Mull and Raasay. Triassic buff sandstone from Morvern was used together with basalt rubble in Aros and Duart Castles on Mull. At Carsaig, Mull greenish or buff sandstone (Jurassic) supplied a ready source of building stone from medieval times (e.g. Ardchattan Priory). Cretaceous green glauconitic sandstone, possibly from Morvern, was used for Pennygown Chapel, Island of Mull.

Limestone

Limestone of Neoproterozoic to Ordovician age occurs locally in Shetland, the northern Highlands and the Grampians and has been long quarried for a range of agricultural and building purposes. The

Banffshire limestones, from Portsoy to Tomintoul were exploited for land improvement from the 1760s until the early 20th century (e.g. around Keith and Dufftown) and for house building. Across Argyll, including the islands of Lismore and Islay, extensive but discontinuous outcrops of limestones of the Argyll Group (Dalradian) proved a source for lime. A few quarries provided masonry stone: at Clyburn, Campbeltown, the Loch Tay Limestone was used both as building stone and aggregate. In north-west Scotland the Cambrian Durness Group, comprising dolomitic limestone and quartzite, crops out in Skye and in a narrow belt extending from Kylesku to Balnakeil. The limestones have been used locally both as a building stone (e.g. in Durness) and burnt for lime (e.g. around Loch Eriboll).

Metasedimentary rocks

Hard metasedimentary lithologies could also be successfully worked for building stone by utilising regular natural joint spacing, cleavage and bedding. Thus rock types such as metasandstones which might seem alien to the present dimension stone quarrying industry were a valuable building stone asset in the past.

Psammite

A commonly used stone across the Highlands was psammite of

Neoproterozoic to Cambrian age. Psammites are metamorphosed sandstones (Greek *psammos*, sand) composed largely of quartz with or without feldspar and mica and with less than 10% carbonate or calcium silicate minerals. Many psammites exhibit a thinly bedded or flaggy nature, a characteristic which, together with near vertical jointing, has been exploited to produce stone suitable for house building, general walling or even roofing.

In the north of Scotland coastal quarry sites such as at Port Vasgo, Talmine exploited Moine psammite to supply Tongue parish and surrounding districts with stone, during the 19th and early part of the



Coastal quarry in psammite at Port Vasgo, Talmine, north of Tongue. Note the thinly bedded, 'flaggy' nature of these metasandstones which aided the quarrying of blocks for building.

20th century. Many villages along the northern coast were well supplied with these materials which were used often in conjunction with softer, more easily worked sandstone for entrances and window surrounds.

Psammities were easily exploited at inland localities in the northern Highlands, especially where the superficial cover of glacial deposits was thin. Thus the older buildings of Altnaharra and Lairg commonly used this stone. Large quarries supplied the needs of expanding villages and towns, for example Raven Rock, near Strathpeffer, which supplied this developing Spa village during the 19th century. Generally such rocks were difficult to dress and they were

typically used in conjunction with sandstone for quoins, door and window surrounds. Similarly towns and villages which developed in the Grampian Highlands during the 19th century are built of psammite and sandstone. Examples include Newtonmore, Kingussie and Grantown-on-Spey.

Quartzite

Psammities containing greater than 80% recrystallized quartz are referred to as quartzites. Some quartzites have been used as local building material, their natural jointing yielding hard blocks suitable for masonry. In Banffshire most of the Dalradian quartzites were too hard to dress. However, the more flaggy units of the Cullen Quartzite were used locally around Cullen.

Torridonian Sandstone

Hard, blocky, red and brown, recrystallised sandstones of the Torridon Group (Neoproterozoic) crop out in the North-west Highlands from near Cape Wrath southwards to Skye and Rum. They have a high percentage of feldspar and are harder than the younger sandstones described above. The sandstones have been used locally as an exceptionally durable building material. Although difficult to work, roughly squared block can be obtained, the dimensions dependent on joint spacing. Examples of use may be seen throughout the north-west Highlands:



Detail of exterior of Free Church of Scotland, Strathpeffer, built of coursed, roughly dressed psammite (metamorphosed sandstone) with rough and polished pink sandstone used for the window surrounds.

several of Ullapool's older buildings are constructed of this stone.

Slate

Mention has been made above of flaggy strata which could be used locally for roofing. But the principal roofing material of the 19th and early 20th century was slate. Slates (metamorphosed mudstones) occur within the West Highland Slate Belt (Ballachulish and islands of Easdale), Northeast Scotland (Macduff and Banff) and the Highland Border (from Arran to Dunkeld) (see Hyslop et al., 2006 for a summary and Walsh, 2000 for a detailed account of these rocks). They were extensively exploited to meet the huge demand of growing towns and cities. The industry declined at the beginning of the 20th century with a depression in the building trade, and manpower shortages (during the 1st World War). Competition with cheaper tiles and importation of slate from Spain and elsewhere resulted in the last quarries at Ballachulish closing in the mid-1950s.

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Andrew McMillan
(aamcm98@gmail.com)

Tree Megafossils of the Palaeogene Mull Lava Field

By Brian Bell and Ian Williamson

Some 58 million years ago, the western seaboard of Scotland witnessed a violent period of volcanic activity: lavas flooded out over the land surface, in places flowing into river channels and shallow lakes. Volcanism wasn't, however, continuous, and from time-to-time conditions returned to normal and plants and animals were able to re-colonise the landscape. Geologists who have visited the Isle of Mull, off the west coast of Scotland, may be familiar with the famous Ardtun Leaf Beds, a sequence of clastic sedimentary rocks, including fossil-bearing silty claystones, interbedded with the lavas on the south shore of Loch Scridain, first described in detail by the Duke of Argyll in 1851, and subsequently by J Starkie Gardner in 1887. Bailey *et al.* (1924) paint a picture of river channels and lakes, the latter being sites in which perfectly preserved leaves accumulated; they also gave a graphic account of the renowned Fossil Tree of Burg, first identified by John MacCulloch, and described in his famous treatise, published in 1819.

More recently, in 1986, Peter MacNab published a brief article in the *Scots Magazine*, highlighting a new

discovery of fossil trees exposed along the coast just south of Quinish Point in north Mull. It is these remarkable megafossils we describe here. To access the site the nearest location on the public road is just NW of Dervaig, on the NE side of Loch a' Chumhainn. From there it is a pleasant walk along a fairly good track past Quinish House (from where the quality of the track progressively deteriorates) towards the *fort* on the coast at Dun Ban. The trees are located between the high and low water lines approximately 500m south of the *fort*, as far south as Dun Leathan (Figure 1).

Fossil trees within lavas, a very rare phenomenon recorded from ancient volcanic sequences, come in a variety of forms: they can be *moulds*, whereby the original trees are now absent, leaving near-cylindrical cavities; they can be *casts*, where moulds have subsequently been infilled with lava; or they can take the form of original plant material that has been variably replaced by minerals precipitated from aqueous fluids. At Quinish, all three types are represented. The most dramatic specimen is a prostrate cast, c. 4.3 m

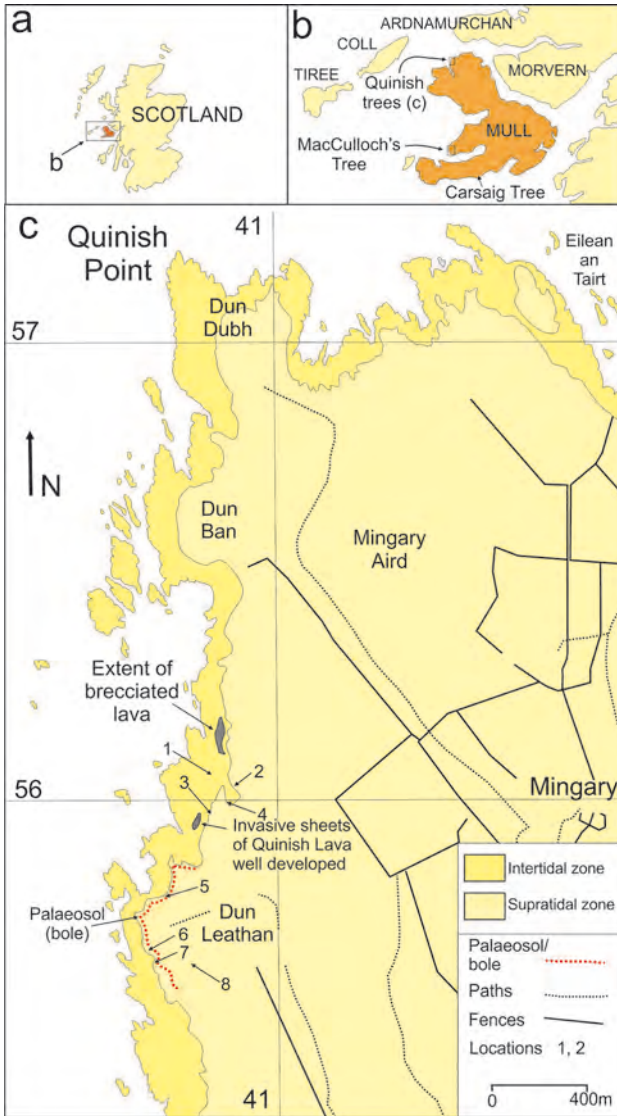


Figure 1 Location maps for the Quinish site. More fossil tree localities are indicated than are discussed in the text.

diameter, which may be interpreted as a lava crust that developed around the tree by the enveloping Quinish Lava, prior to subsequent deflation of the lava surface. The cast is oriented approximately NE-SW. Nearby, but only easily located at low tide and when there is not a substantial cover of seaweed, is a number of short casts (stumps) in 'life' position, suggesting that there was a fairly substantial number of trees growing on the contemporaneous land surface prior to the eruption of the Quinish Lava. North of the prostrate cast, the lava is dominated by a scoriaceous/breccia

in length, with a diameter of c. 65 cm, beautifully exposed at low tide (Figure 2). Towards the landward end of this cast is a larger ovoid mass of basalt c. 1.5 m thick and c. 1.4 m in

facies, remarkably well preserved given the age of the volcanic sequence; further south, similar material is invaded by lava lobes. Other internal features of the

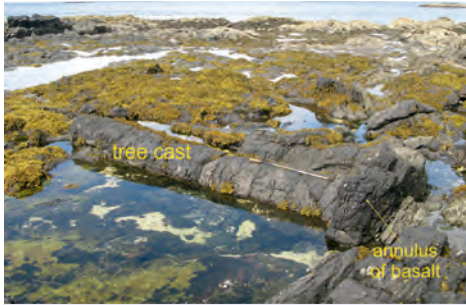


Figure 2 *Prostrate cast of the main tree (Locality 1).*

Quinish Lava—small lava tubes, lava blisters and tumulus-like rises—are also preserved (Figure 3). Another substantial cast is preserved nearby, close to the high water line, between flow lobes of the enveloping Quinish Lava. It is c. 80 cm long and c. 30 cm in diameter, also with a long axis trending NE-SW. Since we first visited the site, parts of this fossil have



Figure 3 *Internal features of the Quinish Lava (between localities 4 & 5).*

‘disappeared’. Nearby, in a small embayment close to the highwater line, is a mineralised piece of wood, c. 55 cm long and c. 10 cm across (Figure 4). Further south, in the small seaward facing crags at Dun Leathan, a third type of preservation can be seen: tree moulds, up to 1 m in length and c. 20 cm in diameter. Some are isolated, others are in clusters (Figure 5), and at least one appears to be composed of two overlapping preservations. As with the casts, the orientation of these moulds is approximately NE-SW.

We envisage a lava field landscape upon which a substantial number of trees grew and attained a maturity of several decades, but were then overwhelmed by a bulldozing compound or pahoehoe lava erupted from a fissure feeder system,



Figure 4 *Mineralised (calcite) wood fragment (Locality 4).*

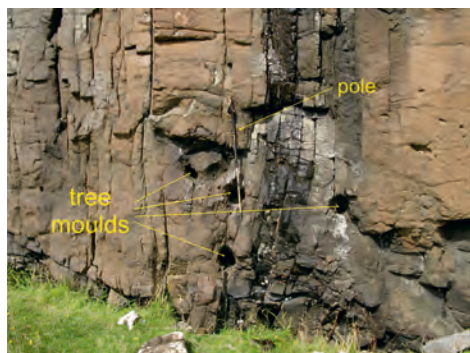


Figure 5 Four prostrate moulds (Locality 8).

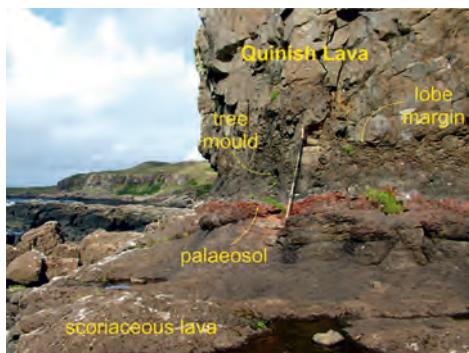


Figure 6 Palaeosol below the Quinish Lava at Dun Leathan (between localities 5 & 6).

now represented by the NW-SE-trending Mull Dyke Swarm. The local forest density may have been one tree per 350 m², or greater. The substrate to the Quinish trees is a well-developed lateritic palaeosol, the product of deep weathering of an older basaltic lava (Figure 6). Within this fossil soil are distinct horizons, typical of an illuvial (i.e. material displaced across a soil profile, from one layer to another one, by the action of rainwater) pedogenic profile that developed in a relatively dry, well-drained upland environment. This complements climatic indicators, which comprise the plant macro-fossils of the Ardtun Leaf Beds, and the pollen and spores preserved within fine-grained clastic sedimentary rocks interbedded with the lavas. Essentially, we can envisage a temperate, warm (mesothermal), humid to equable (largely frost-free)

climate, possibly becoming warmer and wetter (sub-tropical) in localised more sheltered areas (Boulter & Manum 1989; Boulter & Kvacek 1989; Cleal *et al.* 2001; Jolley *et al.* 2009; Williamson and Bell 2012).

Certain of the vertical preservations are essentially fossil stumps and do not tell us about the direction of flow of the lava. However, the remarkably consistent orientation, NE-SW, of the majority of the casts and moulds, orthogonal to the trend of the dyke swarm, is significant and is in keeping with observations made from the ongoing Pu'ū 'Ō'ō (Kīlauea) eruption on Hawaii. There, most trees have fallen in the direction of flow of the lava-front as it encounters forest. To a certain extent, this is controlled by earlier volcanically-created topography, whereby lava flows

down-slope away from the vent(s) or fissure system. For Quinish, flow was likely, therefore, from the NE.

It is impossible to state with certainty what types of trees are preserved at Quinish. We can, however, consider two related lines of evidence. MacCulloch's Tree on the Ardmeanach Peninsula in SW Mull, preserved within a spectacular, thick, columnar-jointed lava, is partially preserved as mineralised woody material. Seward and Holtum (1924) confidently asserted that the tree was a conifer of the fossil genus *Cupressinoxylon*. Earlier, Seward (1919) had stated that there was no significant difference between *Cupressinoxylon* and *Taxodioxyton* and considered that the latter, along with *Glyptostroboxylon* should be taxonomical synonyms for *Cupressinoxylon*. Hence the tree's attribution by Seward and Holtum (op cit.) to *Cupressinoxylon* does not disqualify it from belonging to one of those genera. An alternative approach is to examine indirect evidence in the form of pollen and spores from associated fine-grained clastic units. Jolley *et al.* (2009) identified a rich palynoflora of terrestrial origin from carbonaceous mudstones at approximately the same stratigraphic level as the MacCulloch's Tree Lava. The dominant taxon is derived from

swamp cypresses and *Metasequoia* (*Inaperturopollenites hiatus*), which suggest that the (source) trees have affinities to *Taxodioxyton*. Consequently, the association of this palynological evidence and the tree's large monopodial (single) trunk raises the possibility that MacCulloch's Tree might, along with the other woody macrofossils found nearby, and possibly those at Quinish, be conifers in the Taxodiaceae.

Perhaps we will never know for certain the precise nature of the Quinish trees, but it is a remarkable location, well worth visiting, to see not just these fabulous megafossils, but also to examine the extraordinarily well-preserved lava in which they are entombed.

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Brian Bell¹ & Ian Williamson²

¹ School of Geographical and Earth Sciences, University of Glasgow.
Email: brian.bell@glasgow.ac.uk

² Formerly British Geological Survey.
Email: ian@greenbee.net



The Devonian fish Osteolepsis macrolepidotus Aggasiz from Bay of Skail, Orkney. The fossil is about 15 cm long. BGS image P521200

Lake Orcadie and the Lobefin

By David Leather, Stancro, Westray, 25 May 2016

I'll tell you a tale of Lake Orcadie,
Removed by distance and time,
A thousand miles south of the Equator.
That Era was still in its Prime.

The land-locked Orcadian Basin,
Freshwater more likely than salt,
Was edged by Caledonide ranges
A graben half tilted by faults.

The Basin cut through Euramerica,
Just one of two masses of land
That grouped in the great southern hemisphere,
In heat that no icecap could stand.

The temperatures soared in the hothouse,
As proxies¹ in strata have shown:
With oxygen down and excess CO₂
The vertebrate life must have known.

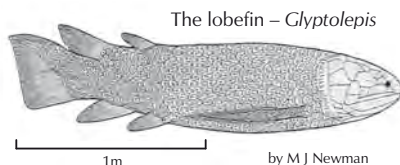
We're talking 'Old Red' and the great Age of Fish,
Which swam there and lived there and bred.
With little to eat but bacteria,
They ate up each other instead.

To avoid being prey to all sundry,
Each grew some tough plates like a shell,
Or spines which could ward off aggressors,
And thus they survived very well.

Each scale, finely covered in cosmine²,
Did shine in the sun like new jet;
And along with their strong armour plating,
They scared off whoever they met.

¹ Ancient climatic evidence preserved in rocks.

² The bony dentine-like material that covers the shiny scales of lobe-finned fishes.



The lobefin – *Glyptolepis*

by M J Newman



by G N Reid

ate up each



covered in cosmine

Now look at the huge *Glyptolepis*
 Its scales are like slates on a roof,
 Each covered with ornamentation,
 As it gobbled its meal on the hoof.

Small primitive plants were evolving
 And grew all along the lake shore.
 They didn't have flowers or pollen,
 But multiplied, spreading their spores.



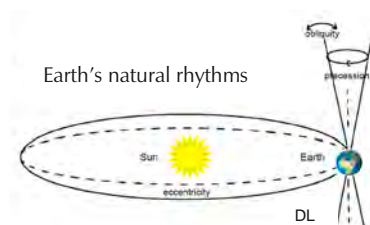
For ten thousand years the lake glistened,
 Until the same time-length of drought,
 When it shrank to small puddles and sandflats:
 The great inland sea had dried out.

The lungfish was best at surviving,
 While others succumbed to the heat.
 This was but a minor extinction,
 Since life in the lake was not beat.

Whenever the lake flooded over
 And found a new route to the sea,
 The fish there took up the advantage
 And swam in, as fast as could be.

The terrible change in the climate
 Was repeated again and again
 And went on for millions of years,
 Right up until goodness knows when.

Milánkovitch orbital cycles
 Are said to be mostly the cause,
 As part of the Earth's natural rhythms,
 According to physical laws.



And yearly the lake fluctuated,
 A dry season followed by damp,
 When silts and fine muds precipitated
 And laminated beds left their stamp.

As layer upon layer within cycles
 Were fully recorded in rock
 So the years and millennia are counted:
 A seasonal, cyclical clock.



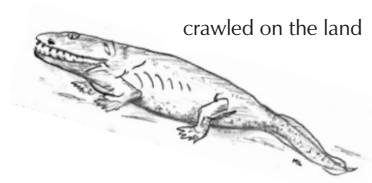
To return to the lake's good inhabitants,
The lungfish and rayfin and all,
The lobefin's the biggest sensation,
Our greatest ancestor of all.

The lobefins were fast swimming fishes
With two rows of needle sharp teeth;
The two big front fins were fantastic,
Like primitive limbs underneath.

Among all the species of lobefin,
Which dominated the scene,
Were *Op* and *Asperocephalus*
And others of sizes between.

– A fossil I found, *Gyroptychius*,
Large eyes in a small rounded head,
Some four hundred million years later,
Appeared as if recently dead –

On the Upper Devonian Equator
A tetrapod breathed in some air,
Completed a series of press-ups
And waddled along in the glare.



The lobefin, it paddled through water;
The tetrapods crawled on the land;
Then amphibians, reptiles and mammals.
At the end of this miracle: – MAN!

Man's ascent through life's evolution,
From Middle Devonian time,
Evolved from the beautiful lobefins,
Those millions of years down the line.

[Dedicated to the memory of Uisdean Michie of BGS (who died in June 2015) and also to Jan, Mike, John and John and others who still enjoy the fossil fish of the Orcadian Basin.]

³ The letters *Op* stand for *Osteolepis panderi*, a lobefin about 15 to 18cm long. *Asperocephalus milleri* was up to three metres in length, monster of the Lake

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