Geological Mapping: Stripping the Land Bare

An exhibition in the Sedgwick Museum to celebrate the bicentenary of the publication of William Smith's 1815 geological map

1815 was a momentous year with the April eruption (VEI-7 scale) of Tambora in Indonesia which produced worldwide climate aberrations, harvest failures and famine, followed by Napoleon's defeat at Waterloo on June 18th, which finally secured a shift in Europe's balance of power. Less well noticed was the September 1st publication of William Smith's great geological map but it had a lasting effect on the development of geology in Britain. The bicentenary of the map's publication is currently celebrated by an exhibit of historical maps in the Sedgwick Museum.

The Museum's third copy of William Smith's pioneering geological map of 1815. Numbered a91, it was signed off by Smith on January 23rd, 1816 and has been conserved under the direction of Nicholas Burnett of Museum Conservation Services.

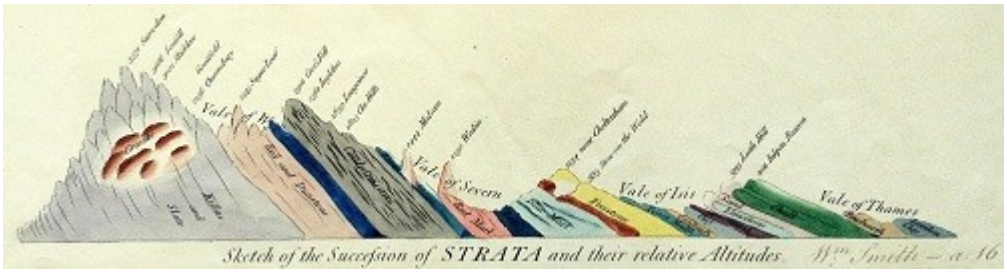
Entitled 'Geological Mapping: Stripping the Land Bare', the exhibit outlines aspects of the post-1815 history of geological mapping, using a selection of maps from the archives. The

centrepiece is one of the Museum's three copies of William Smith's magnificent 1815 *DELINEATION of the STRATA of ENGLAND and WALES with part of SCOTLAND; exhibiting the COLLIERIES and MINES; the MARSHES and FEN LANDS ORIGINALLY OVERFLOWED BY THE SEA; and the VARIETIES of Soil according to the Variations in the Sub Strata; ILLUSTRATED by the MOST DESCRIPTIVE NAMES.* This is probably the only copy on public display in the world today (for details of the map's conservation, see the Sedgwick Museum's website). Another, better preserved, copy will be displayed in the Department Library on Alumni Day.

Such historic geological maps, especially those which were hand-coloured with water-colours, are prone to fading through prolonged exposure to light and so have to be displayed with subdued and controlled lighting. This creates problems for display of geological maps, which often require close scrutiny. And since the theory-laden content of geological maps requires quite a lot of background knowledge, their display presents something of a challenge.

William Smith's illustration of the fossils which he found to be characteristic of the Lower Chalk.

The Museum's **Stripping the Land Bare** exhibit displays 17 maps illustrating the development of geological mapping from 1815 to the present day along with Smith's 1817 section from London to Snowdon and some of the fossils he used to characterize the formations of strata he mapped.



Smith's first attempt at a geological section from Snowdon to London illustrating the successive divisions of mappable rock formations

William Smith's geological mapping

Modern research on Smith is well covered by two websites – www.strata-smith.com and www.geolsoc.org.uk (and follow the links to Library-and information-services/Exhibitions) but still there is much to be rediscovered about his work. Looking at the '1815' map, it is evident from the indentations of the boundaries of gently inclined strata that he fully understood the relationship between topography and the outcrop of strata but how exactly he mapped the boundaries onto his topographical base map is not clear. That base map was a specially prepared version of John Cary's 1794 *New Map of England and Wales with part of Scotland* with less topographical and geographical detail so that the engraving of Smith's geological boundary lines was not obscured.

Two versions of Smith's depiction of the strata of the Isle of Wight, showing how he continually modified the map.

What can be seen from a close and detailed study of the surviving Smith maps is that he was constantly shifting some of the boundaries as he acquired new information. This is very well illustrated in his mapping of the Isle of Wight, which shows several changes in different copies of the map.

He insisted on signing off each completed copy and the map on display is numbered a91and was signed off by Smith on January 23rd, 1816.

For his publisher, John Cary, Smith must have been very difficult client. Each map took an expert colourist around 7 days to paint as each of the 23 rock formations had its own colour, a total palette which included 8 different blues. Smith wanted as far as possible to use colours which approximate the different rock formations so that what he calls the 'Red and Dunstone' (i.e. Old Red Sandstone) is a red-brown colour, older (Palaeozoic) strata are hues of grey and mauve, Coal Measures are grey-black etc. His colour scheme was broadly adopted by the Geological Survey when it was established in 1835.

The '1815' map is accompanied by a small and very simplified section from Snowdon to London, which nevertheless showed for the first time the sequence of strata from the oldest 'Killas and Slate' (of Cambrian age) to the youngest 'London Clay' (of Paleogene age). By 1817 Smith produced a series of improved and enlarged geological sections, including a new version of the Snowdon to London one which clearly shows the relationship of the different rock formations to the topography but still with a very simplified structure and succession without faults or folds.

Mapping the Lake District

Smith's expertise did not extend far into the more complicated geology of the ancient Lower Palaeozoic strata of upland Britain. Neither did that of his main rival, George Greenough and the

Geological Society network of some 47 informants. This early, relatively uninformed, state of knowledge is well illustrated by our display of early geological maps of the Lake District. Both Smith and Greenough only showed a basic subdivision of the older rocks into 'slaty killas' (generally today's Skiddaw and Borrowdale Groups) and 'grauwacke' (today's Windermere Supergroup), framed by the Eden Valley's Mountain Limestones (Carboniferous) and red sandstones (Permo-Triassic) in the northern Pennines. This situation was to change with the appointment of Adam Sedgwick to the Woodwardian Professorship in 1818.

Since the mid 18th century, paintings and prints of the 'picturesque landscape' of Lake District attracted some of the first tourists in the British Isles who were initially well-to-do aristocrats, followed by increasing numbers of the metropolitan middle classes. By the first decades of the 19th century there were several guide books extolling the romantic virtues of the scenery along with the work of the Lakeland poets, such as Coleridge, Southey and especially Wordsworth whose his first anonymous *Guide to the Lakes* was published in 1810. This was followed in 1814 by his poem '*The Excursion'*, whose success drew considerable attention to the region.

Wordsworth revised and extended his *Guide* in the 1820s, with what is generally considered the definitive 5th version being published in 1835. His stated aim was to describe and analyse the landscape for 'persons of taste, and feeling for Landscape'. However, thanks to his friendship with Adam Sedgwick, Wordsworth's understanding of geology continued to develop along with growing public interest in geology, which resulted in another edition in 1842 entitled '*A Complete Guide to the Lakes, Comprising Minute Directions for the Tourist, with Mr. Wordsworth's descriptions of the Scenery of the Country, &C. and Three Letters Upon the Geology of the Lake District, by Prof. Sedgwick* '.

Adam Sedgwick in the Lake District

Born and bred in Sedbergh, Cumbria, Sedgwick had strong emotional ties to the Lake District and once established as the Woodwardian Professor of Geology developed a professional interest in tackling the complex geology of the region. His Cambridge trained geometrical skills allowed him to cope with complex three-dimensional structures through the measurement of the dip and strike of a variety of geological structures from bedding to cleavage and fault planes. The current exhibition includes one of Sedgwick's hand-coloured field maps of the southern Lakes, which probably dates from this period of the 1820s.

Sedgwick was not alone in this pioneering work and he met local amateurs, such as Joseph Fryer (1777-1855) and Jonathan Otley (1766-1856), who were already developing an understanding of the geology. Fryer had drawn an outline geological map of the region by around 1814 and supplied the information to Greenough for the Geological Society map of 1819. And, Otley, who was a watch and clock repairer by profession, published in 1820 his 'Remarks on the succession of rocks in the District of the Lakes' (*Lonsdale Magazine,* 1, 433-8, reprinted in the *Philosophical Magazine,* 1823, 56, 257-61), in which he showed that '…the greater part of the central region of the Lake Mountains is occupied by three distinct groups of stratified rocks of a slaty texture…', which he called Clayslate, greenstone and Greywacke. He also made one of the earliest investigations of the relationship between bedding, cleavage and jointing. Otley made much of this geological information available in a more popular form in his 1823 *Concise Guide to the English Lakes*, which eventually ran to eight editions and sold over 8,000 copies (Smith, R.A. 2003, p.357).

Otley first met Sedgwick in the 1820s and introduced him to the geology of the northern Lakes in 1823 and 1824. Sedgwick acknowledged the geological 'debt' he owed to Otley in his 1831 Presidential address to the Geological Society of London and in his 1836 paper on the '…General Structure of the Cumbrian Mountains…' (*Transaction of the Geological Society,* 4 (ser.11) 47-68). In the latter, Sedgwick commented that '…we owe our first accurate knowledge of these subdivisions to Mr Jonathan Otley of Keswick…who gave their geographical distribution with a very near approach to accuracy'.

It was in 1824 that William Smith's *Geological Map of Westmoreland* (also to be seen in the exhibition), part of his incomplete County series, was published but geologically it shows little advance on his '1815' map.

Comparison of Sedgwick's field map of the 1820s with Smith's Westmoreland map demonstrates the advances being made by Sedgwick, especially his greater understanding of structure and cleavage. Just to the north of Coniston Water, Sedgwick clearly shows the outcrop of the fossiliferous 'Transition Limestone' (i.e. Coniston Limestone) with its northeast-southwest strike and dip at a high angle, which is barely displaced by the topography but is offset by some north-south trending faults. Interestingly, the limestone outcrop can still be traced through the remains of a series of lime kilns stretching from Stockdale southwest to Broughton (see http://www.geog.port.ac.uk/webmap/thelakes/html/topics/conlimkf.htm).

Sedgwick's friendship with Wordsworth began in the 1820s, probably through mutual friends in Trinity College where Sedgwick had been a student and was a Fellow. These friends included the poet's brother Christopher, who was elected Master of Trinity College in 1820 (until 1841), and the polymath William Whewell, who succeeded Wordsworth as Master.

Wordsworth's attitude towards geology and science in general has been much debated (see Wyatt 2005) as he famously complained in the '*Excursion*' about geologists '…who with pocket-hammer smites the edge/Of luckless rock or prominent stone,/…detaching by the stroke/A chip or splinter- to resolve his doubts;/And, with that ready answer satisfied,/The substance classed by some barbarous name,/And hurries on…'. Nevertheless Wordsworth maintained a close relationship with Sedgwick and in 1842 took up a promise made by Sedgwick in the 1820s to provide some geological notes for Wordsworth's *Guide*. It is the 1842 edition, which includes three letters by Sedgwick on the geology of the Lakes, some 60 printed pages and a geological cross-section.

By the 1840s, John Ruthven (1793-1868), a cobbler in Kendal, had become Sedgwick's most important local geological guide and informant. Ruthven was so adept at finding fossils that Sedgwick used him as a collector, not just in the Lakes but also on geological excursions to Wales in 1846 and 1851 and to Scotland in 1848. Sedgwick described Ruthven as '..once cobbler…now a geologist, whose fame will last longer than the stoutest shoe that ever came off his ancient last' (Smith, R.A., 2003) and further remarked to Harkness that '..as far as I know he is the only person to have found fossils in the Skiddaw Slates'.

Railways, tourism and Ruthven's geological map

On December 15th, 1846 the Lancaster to Carlisle extension of the railway line from London was opened and the following year a branch line from Oxenholme to Birthwaite (later known as Windermere) brought large numbers of tourists into the southern Lakes. And, by 1850 four passenger steamers plied the length of Lake Windermere from Waterhead to Newby Bridge (a distance of about 11½ miles). In the same year the Glasgow to Carlisle line completed the west coast connection between London and Scotland. There was a corresponding boom in maps and guides for tourists.

One of the most successful in the mid 19th century popular guides was by Harriet Martineau (1802-76), a well know social theorist and writer who lived in Ambleside from 1848 until her death. Entitled '*A Complete guide to the English Lakes; illustrated from drawings by T.L. Aspland and W.Banks and a Map Coloured Geologically by John Ruthven to which are added an account of the*

Flowering Plants, Ferns, and Mosses of the District etc' it was published in 1855 when the Victorian mania for natural history collecting was well under way. Effectively replacing Wordsworth's guide, it became one of the most successful of the Lake District guides for some 30 years.

Ruthven's geological map came folded in a neat linen envelope for the convenience of the tourist, especially those who took advantage of the new rail connections shown on the map, which was instrumental in popularizing the study of geology in the Lake District. The map clearly shows the basic threefold subdivision of the Lower Palaeozoic rocks, along with four structural sections. New subdivisions of Lake District strata are shown, based on Ruthven's fossil finds and Sedgwick's investigations, which had been published in the 1830s.

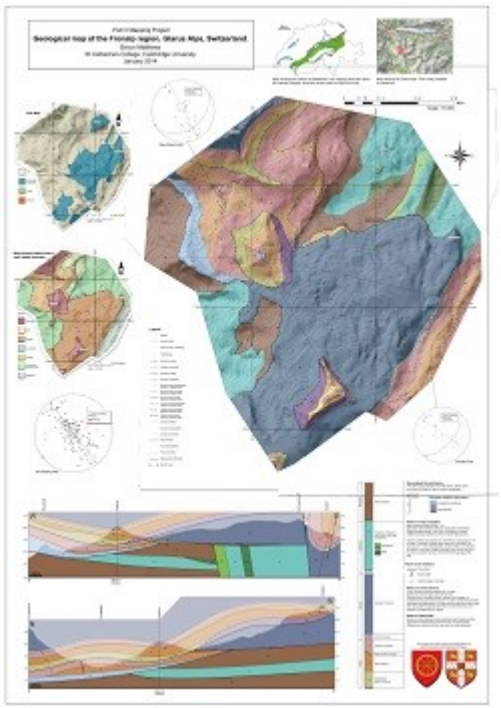
The Big Picture on a small scale

The exhibition also displays some of the general geological maps of the British Isles, which became increasingly popular during the mid to late 19th century as public interest in geology and geological education grew. The earliest versions were still hand coloured. The expertise of British colourists was such that it held back the introduction of commercial colour printing for geological maps until the 1850s.

Although plagiarism of geological information was an issue in the early 19th century, witness the accusations against Greenough and his Geological Society consortium over use of Smith's geological information, which eventually led to Greenough acknowledging Smith's work on later editions of his *Geological Map of England and Wales*, which was first published in 1819 with any such acknowledgment. Nevertheless there was little legal copyright protection and so rival, commercially minded, maps commonly copied information and could get away with it by changing the colour of the different geological formations, which produced some curious and rather garish maps such as Walker's *Geological Map of England, Wales, And Part of Scotland, Showing Also the Inland Navigation by Means of Rivers and Canals, With Their Elevation In Feet Above The Sea, Together With The Rail Roads & Principal Roads*, which first appeared on December 18th, 1835. Although unacknowledged, the geological compilation was by James Alexander Knipe (?1803-1882), who like William Smith was an itinerant surveyor who made a precarious living on the fringe of geological society and compiled geological maps.

Geological Mapping is still alive in some universities

Independent geological mapping has been part of degree-level training in university geology departments since at least the 1950s. It is a compulsory component of any Geology degree accredited by the Geological Society, and so is still very much a part of an Earth Sciences degree in the University of Cambridge. The Sedgwick Museum map exhibition includes a copy of a recent prizewinning undergraduate map by Simon Matthews.



A recent prize-winning geological map of a complex region of the Swiss Alps produced by Simon Matthews, an undergraduate in the Department of Earth Sciences.

Simon Matthews (1992-), a Department of Earth Sciences undergraduate, won the 2014 Reekie prize for his mapping of the Fronalp Region of the Glarus Alps in Switzerland. This structurally complex region was formed by the collision of the African tectonic plate with that of Europe and Asia, which produced intense folding and faulting of the Mesozoic and Paleogene age sediments deposited in the ancient ocean of Tethys.

Simon had 28 days to map an alpine landscape of 8 sq km whose topography ranges from 1300m to 2300m including vertical rock faces. He recognized eight different rock formations with a total

vertical thickness of around 650m. By measuring the changes in inclination of the strata and other geological features such as folds and faults, cleavage and joints, he determined the structure, as illustrated by his sections, and the tectonic history of the region, which includes several successive phases of deformation – a remarkable achievement.

Hopefully those of you who have an interest in geological mapping and its history will visit the Sedgwick Museum to see our current exhibit. However for those of you who cannot visit, I hope this account will provide some compensation. The 1815 Smith map will be on permanent display in the Museum.

Douglas Palmer, Sedgwick Museum