Yorkshire geology as seen through the eyes of notable British Geological Survey geologists 1862-2000

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The first pieces in the puzzle

Making a geological map is like doing a 3-dimensional jigsaw puzzle, but with 99% of the pieces missing and without the picture on the box to help. It involves looking at the lie of the land and piecing together various sources of evidence to put the rocks in order and visualise the result as a 3-dimensional model of what is hidden below the surface. It is "landscape literacy" and unlike a topographical map, such as those produced by the Ordnance Survey, it is largely an interpretation rather than the map of observable features. Each geologist and each new map update builds on what has gone before. Some geologists add more than others and some make ground-breaking observations. A few geologists have great insights in fitting the pieces together and fundamentally change the way we interpret Earth history, an example being the recognition of continental drift, a major advance built on many diverse observations.

Figure 1. William Smith, aged 68, portrait by Hugues Fourau, 1837, © The Geological Society (GSL/POR/15) Reproduced by permission of the Geological Society of London.

The first person to figure out the geological map puzzle of England and Wales was William Smith (1769-1839). The son of a blacksmith, he was a self-taught surveyor who was interested in fossils from his youth. While surveying the canals of Somerset

he recorded the type of rock and the fossils contained therein (Winchester 2001). Based in Bath and of humble background, he was up against the emerging establishment of wealthy London-based scientific establishment of the Royal Society and the Geological Society of London.

In contrast to the university-trained intellectuals, William Smith was a practical man who made a living advising on canals and mineral workings. This work with some support and encouragement from subscribers allowed him to produce the first geological map of England and Wales, engraved and printed by John Carey and published in 1815. Sadly his studies cost him dearly, resulting in Smith spending part of 1819 in a debtor's prison; he emerged to publish county geological maps, including one for Yorkshire in 1821. Smith's maps were hand-coloured in watercolour, many by himself. The colours he used are still familiar with us today as they are the basis for the colours used on the printed and digital British Geological Survey maps; some of his original colours are still used internationally, such as green for Cretaceous rocks. The colours include the greys of the Carboniferous, blues representing limestones (Carboniferous and Permian), reddish-brown for the Triassic, yellows and orange for the Jurassic, plus green for the Chalk.

Figure 2. Extract for Yorkshire from William Smith's "Map of the Strata of England and Wales" 1815 – British Geological Survey online http://mapapps.bgs.ac.uk/geologyofbritain/home.html

In 1805 Sir John Sinclair suggested that William Smith should be attached to the Ordnance Trigonometrical Survey (precursor of the Ordnance Survey), in a geological capacity, but it came to nothing (Bailey 1952). Some years later, around1814 saw the early incorporation of a limited amount of geological surveying in the mapping being undertaken by the Trigonometrical Survey. John MacCulloch was appointed in

Scotland with the rank of chemist to look at minerals that caused anomalous compass deflections; this involved making a basic geological map of Scotland (Bailey 1952).

In England, William Smith was effectively a one-man-band. From 1820 onwards he periodically lived in Scarborough and worked on its water supply, as well as becoming estate manager for Sir John Johnstone at Hackness Hall where he carried out a detailed geological survey (Cox 1942). Together with his nephew John Phillips (later to become Professor of Geology at Oxford) he designed the Rotunda Museum to illustrate the geology of the Yorkshire Coast. It was around the time that Smith's map was published that a young man called Henry De la Beche (1796-1855) was getting seriously interested in geology (McCartney 1977). He lived for part of his life in Lyme Regis where he was a schoolboy friend of Mary Anning the fossil collector. It is partly from these early encounters that his interest in geology stemmed. In contrast to William Smith, De la Beche was from a wealthy and well-connected family with a family sugar plantation worked by slaves in Jamaica. Like many wealthy people he could follow his passion and enhance his connections, both scientifically and socially. In 1817 at the age of 21 he was invited to join the Geological Society of London, a society that was then only 10 years old and which had sprung from an elite invited "*Geological Dining Club*". De la Beche, at his own volition, privately mapped Pembroke in 1822 and Devon between 1827 and 1830. Financial problems related to the collapse of his estate income encouraged him to offer his geological services to the Ordnance Trigonometrical Survey, who between 1832 and 1835 paid him £300 to complete the survey of Devon. When this was completed he lobbied and set up the

Figure 3. Sir Henry De La Beche (Geological Survey Archives photograph P718394)

Geological Survey as the "Ordnance Geological Survey", which from 1835 to 1839 had a staff of one – himself. For his efforts he was knighted in 1842 something that no doubt helped him establish the Geological Survey. The Survey was formally set up as a separate entity on 31st July 1845 with the passing of the Geological Survey Act - "*An Act to facilitate the Completion of a Geological Survey of Great Britain and Ireland under the Direction of the First Commissioner for the Time being of Her Majesty's Woods and Works*". It had 24 staff in total of which 6 were surveyors in England. Sir Henry De la Beche died in service in 1855 aged 59.

Murchison's boys

Following Sir Henry's death a geologist of standing and influence was required to take the Geological Survey forward. Sir Roderick Impey Murchison was proposed as the most suitable man, taking office in 1855 at the age of 63 (Bailey 1952). He was an apostle of William Smith and friend of De la Beche. He was already a famous geologist having published his *Silurian System* in 1839. He visited Russia in 1840 and 1841 at the Emperor's request to superintend a survey and in passing proposed the Permian System – named after the area of Perm. Soon after becoming Director he embarked on an expansion of the Survey staff and over the next decade appointed many geologists including some who would make a profound mark on the understanding of the geology of Yorkshire. Murchison's boys included: A H Green - 1861; J R Daykns - 1862; R H Tiddeman - 1864; J C Ward – 1865 and C E Fox-Strangways – 1867 (Table 1). The staff of 21 field geologists in 1866 was expanded to 57 by 1868 and the total staff reached 77 (Flett 1937). Murchison insisted on the surveyors writing up their observations and introduced the 'memoir' term to British geological literature. Murchison died in service in 1871 at the age of 79. The expansion of the Survey continued and in 1876 G Barrow joined the surveyors working in Yorkshire. Each of these geologists mapped, measured and recorded the strata to reach new understandings of Yorkshire geology. Each of them alone made remarkable discoveries, but as a team their contribution was formidable (Table 1).

Figure 4. Sir Roderick Impey Murchison (Geological Survey Photograph P064480)

Year	Memoir area or topic	A H Green	J R Daykns	R H Tiddeman	J C Ward	C E Fox-Strangways	G Barrow	Other co-authors
1869	Yorkshire Coalfield	X	X		X			
1870	Leeds & Tadcaster	X	X		X			Aveline, Russell
1871	Dewsbury, Huddersfield & Halifax	X	X		X			Russell
1873	Harrogate					X		
1878	Yorkshire Coalfield	X	X		X	X		Dalton, Holmes
1879	Bradford & Skipton		X			X		Dalton, Russell
1882	Whitby & Scarborough					X	X	
1884	York & Malton					X		
1885	Eskdale & Rosedale					X	X	Reid
1885	Bridlington Bay		X			X		
1886	Driffield		X			X		
1886	York & Hull		X			X		Cameron
1886	Northallerton & Thirsk					X	X	Cameron
1886	Holderness & the Wolds		X					
1888	Ingleborough		X	X		X		Gunn, Strahan, Goodchild
1890	N Lincs & S. Yorkshire					X		Ussher, Cameron Reid, Jukes-Brown
1892	Jurassic Rocks of Britain vols 1 & 2					X		
1904	South of Scarborough					X		
1908	Harrogate (2nd ed)					X		
1915	Whitby & Scarborough					X*	X	*Posthumously

Table 1 Memoirs published by the team of notable Yorkshire Geologists – Murchison's Boys

Alexander Henry Green 1832-1896

Green was one of the first staff taken on by Murchison as the survey of the country headed north into Yorkshire. He was educated at Ashby Grammar School and had an impressive knowledge of the local geology. In fact his knowledge was so good that when Andrew Ramsay (who later to become the Director) visited the area he acknowledged Green as the local authority and suggested he should join the Survey (British Geological Survey 2015a). Following his university education at Gonville and Caius College Cambridge, Green joined the Survey in 1861 (Miall 1896).

Figure 5. Alexander Henry Green (Geological Survey Photograph P575804)

Green embarked on mapping and understanding the Derbyshire and Yorkshire Coalfields, and the way he looked at and mapped the landscape was the same as we still do today (though now we use air photographs and computer generated surface models). The frontispiece of his coalfield memoir, engraved from one of his impressive field sketches shows the scarps, crests and dip slopes typical of coalfield geology, while his cross-section illustrated the basis for drawing the geological lines on the map. A number of his excellent watercolours of landscapes showing the geology are held in the British Geological Survey archives.

His recording was meticulous and it is sad to note that the 1973 disaster at Lofthouse Colliery near Wakefield could possibly have been averted if the relevant information held in one of Green's notebooks had been seen and understood (British Geological Survey 2015a). He recorded the deepening of a shaft that about 100 years later was tunnelled into flooding the mine with mud and water killing 7 men. Following that disaster all the British Geological Survey notebooks were indexed by two Coal Board surveyors Happs and Hall, which enabled these important information sources to be searched and thoroughly investigated before proceeding with coal extraction.

Green stayed with the Survey until 1874 when he took the professorship in Geology at the Yorkshire College – later to become Leeds University. In 1878 the Geology of the

Yorkshire Coalfield was published with co-authors Russell, Dakyns, Ward, Fox-Strangways, Dalton and Holmes. This memoir was far larger than any other, with 823 pages and a price of one guinea (£1.05); this was at a time when a normal memoir priced at about one shilling (5 new pence). Bailey (1952) commented that it was "the largest Survey memoir, I hope for all time", but it contains so much useful information that this statement is rather unfair. Green eventually moved in 1888 to become the Professor of Geology at Oxford.

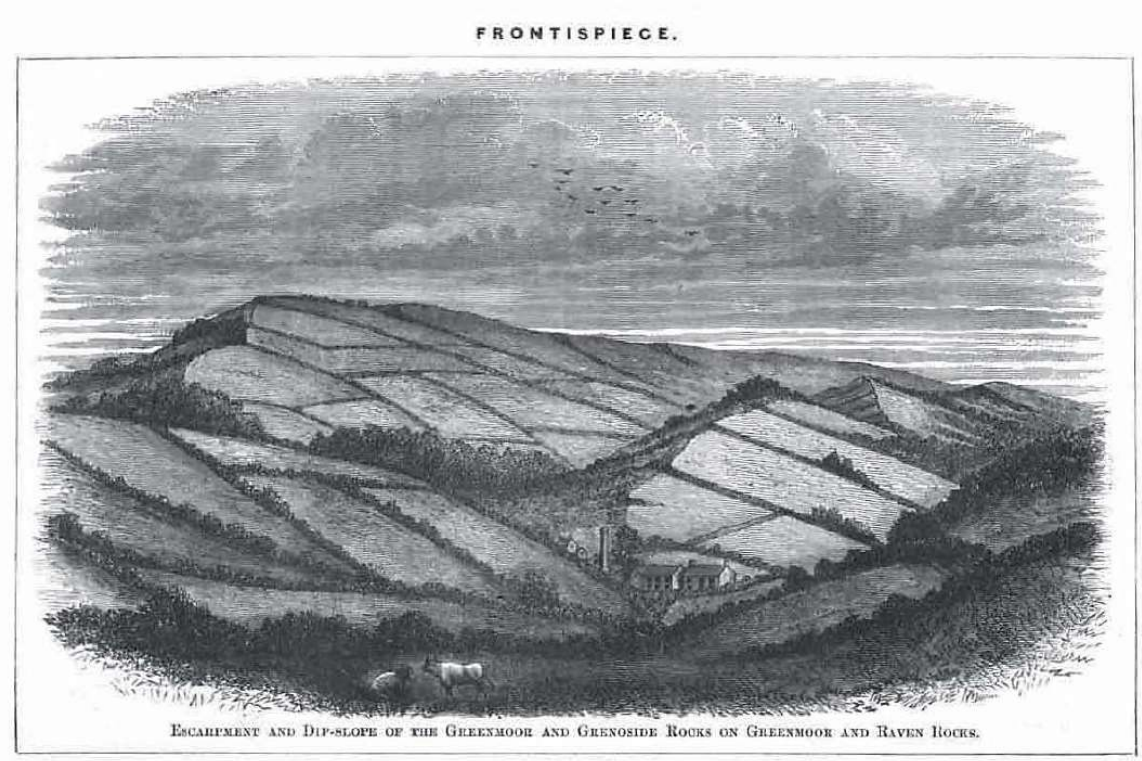

Figure 6. The landscape of a typical Yorkshire coal bearing sandstone escarpment and intervening mudstone/shale valley sequences - Green et al Yorkshire Coalfield Memoir 1878.

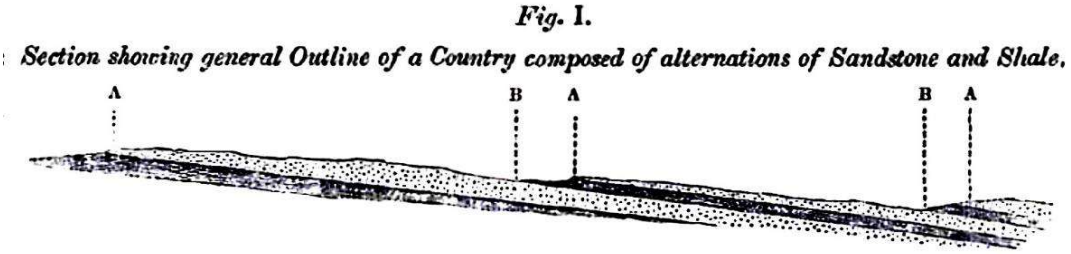

Figure 7. Cross section from Green et al., Yorkshire Coalfield Memoir 1878 showing how the sandstones form the escarpments and the mudstones/shales the valleys and slack areas.

John Roache Daykns 1836-1910

Daykns was educated at Rugby school and studied at Trinity College Cambridge (1855-1859) joining the Geological Survey in 1862 as an assistant geologist (Lamplugh 1910b). His early work was in Yorkshire as part of a team with Green and Ward surveying the Yorkshire coalfield. This and subsequent work took him through large areas of Yorkshire including Leeds, Tadcaster, Dewsbury, Huddersfield, Halifax, Bradford, Skipton, Bridlington, Driffield, York, Hull, Holderness, The Wolds and Ingleborough. He then moved on to Cumbria and Scotland. Along with Green his input into the understanding of the coal sequences of Yorkshire was considerable. With co-workers including Fox-Strangways, Cameron and Ward he helped the understanding of the Permian, Triassic, Jurassic, Cretaceous and Quaternary of Yorkshire (Table 1).

Figure 8. Sketch of J R Dakyns made by Miss Barrow (daughter of G Barrow?) from several photographs of him. Reproduced from Lamplugh, 1910b, Plate 21, by permission of the Yorkshire Geological Society.

Richard Hill Tiddeman 1842-1917

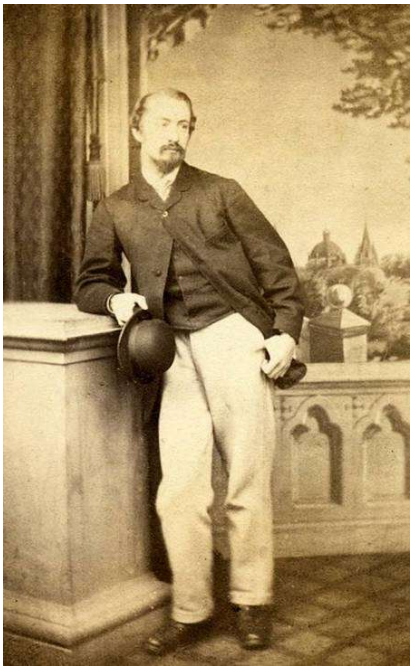

Figure 9. Richard Hill Tiddeman (British Geological Survey Archives photograph P575816)

On leaving Llanrwst Grammar School Tiddeman studied at Oriel College Oxford under Professor Phillips (William Smith's nephew). Tiddeman was appointed to the Geological Survey in 1864 as an assistant geologist (Harker 1918). He was chiefly employed with the survey of the Carboniferous rocks of North Lancashire, West Yorkshire and Westmorland, but also worked in North Wales and South Glamorgan (British Geological Survey 2015b). He is best known for his pioneering work on the Carbonifereous "reef knolls" and the Quaternary deposits of the Victoria Cave, both near Settle. His understanding of the fossil reef moundss fringing the Askrigg Block platform and the influence of fault movements during sedimentary deposition were presented to the International Geological Congress in 1888. His then controversial ideas are now accepted and illustrated by the modern diagram from the Pennines and adjacent areas regional guide which shows the juxtaposition of the reefs with the Craven faults on the edge of the Askrigg Block at the margin of the Craven Basin (Aitkenhead et al. 2002).

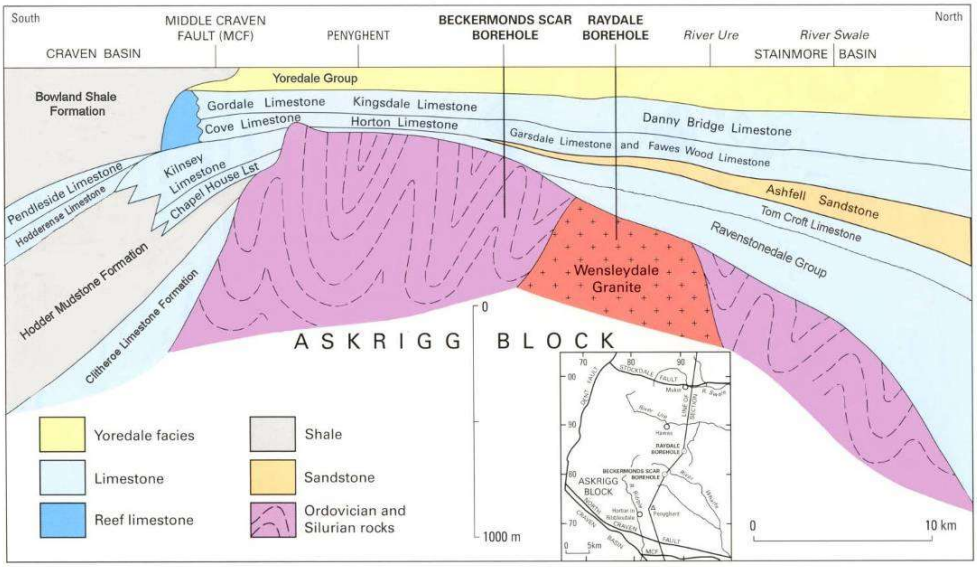

Figure 10. Cross-section through the Askrigg Block into the Craven Basin showing the fringing reefs (from Aitkenhead et al., 2002)

In addition to the obligatory Geological Survey memoirs, Tiddeman's study of the Victoria Cave near Settle recognised pre-glacial cave deposits with the bones of hippopotamus, hyena and humans (Lord et al. 2012; Tiddeman 1875). He supervised the excavations from 1873 to 1878 following on from William Boyd Dawkins (an eminent expert on Ice Age mammals), but the two had opposing views about ice ages and interglacial periods. Tiddeman was decried by Professor Dawkins, but he was eventually proved correct although it took another 30 years before Tiddeman's views were accepted. In 1881 the geologist James Geikie (brother of the Geological Survey director from 1882 - Archibald Geikie) described Dawkins as "…..a vain cocky humbug….It is monstrous that such a nincompoop in physical geology should be allowed to strut about as an authority…" (Museum of North Craven Life at the Folly 2012). Tiddeman obviously had an uphill struggle against the powerful professor.

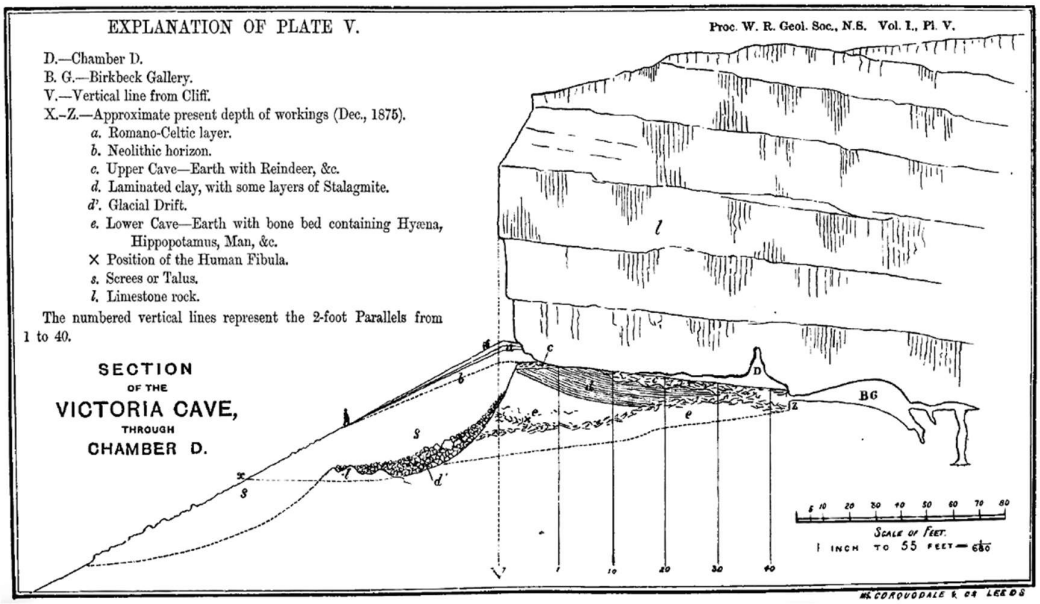

Figure 11. Cross section through Victoria Cave explaining the sequence proved by the excavations (Tiddeman 1875). Reproduced by permission of the Yorkshire Geological Society.

James Clifton Ward 1843-1880

Figure 12. James Clifton Ward (Geological Survey Archives photograph P575818)

Ward was educated at the Royal School of Mines, which was associated with the Geological Survey and shared the same offices in Jermyn Street, London (Bailey 1952). He joined the Survey in 1865 as one of the team that Murchison put in place working alongside Green, Aveline, Dakyns and Russell on the Yorkshire coalfield until 1869. Subsequently, he moved to the Lake District where he surveyed until his retirement in 1878. His final work was as a church curate in Keswick, becoming the vicar of Rydal in 1880, unfortunately he died soon after. Many of his field sketches

illustrate the 2nd edition of the Harrogate memoir published in 1908 (Table 1 and Figure 13)

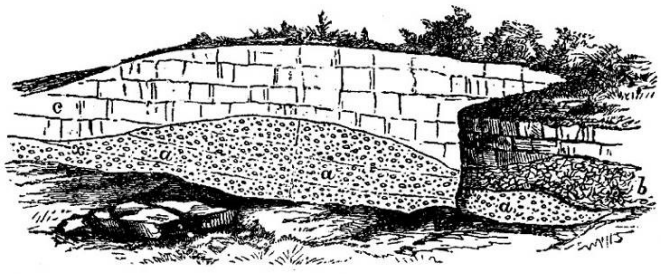

Fig. 1. *Newsome Bridge Quarry.* Drawn by J. C. Ward.

a. Whitish grit (Millstone Grit). About *x* it contains, in quite its upper part, little horizontal patches of a soft unctuous marl.

b. Grit and limestone confusedly mixed together.

c. Yellow limestone, with included fragments of grit at its base (Permian).

Figure 13. Field sketch drawn by J. C. Ward and used in the 2nd edition of the Harrogate Memoir

Charles Edward Fox-Strangways 1844-1910

Figure 14. Informal and formal pictures of Charles Edward Fox-Strangways (informal- Geological Survey Photograph P575820, formal Yorkshire Geological Society obituary - Lamplugh 1910a) Reproduced by permission of the Yorkshire Geological Society.

Fox-Strangways hailed from Reive near Exeter. The son of the Rev Henry Fox-Strangways, he was educated at Eton and went on to study chemistry, mineralogy and physics at the University of Gottingen (Lamplugh 1910a). While there, war was declared in 1866 between Prussia and Austria, and he is recorded to have assisted Sartorius von Waltershausen, the professor of geology and mineralogy, to bury his precious collection of minerals, so as to prevent them falling into the hands of the belligerents (Woodward 1910). He joined the Survey in 1867 and initially worked on the Carboniferous rocks of Yorkshire around Todmorden, Halifax and Bradford. From here he moved on to the Harrogate anticline and Knaresborough areas studying not only the stratigraphy and structure, but also the mineral springs that made Harrogate famous as a spa town. His surveying career then carried him across the Vale of York on to the Jurassic and Cretaceous rocks of the North York Moors and Wolds. He wrote some 22 memoirs including many for Yorkshire (Table 1) and two volumes on the Jurassic rocks of Britain. These and his scientific publications attest to a productive and innovative geologist who laid the foundations for much of the understanding of Yorkshire geology that went on past his retirement in 1904. He died at his desk in 1910 while completing an exhaustive bibliography of Yorkshire Geology that was completed by T Sheppard and published in 1915.

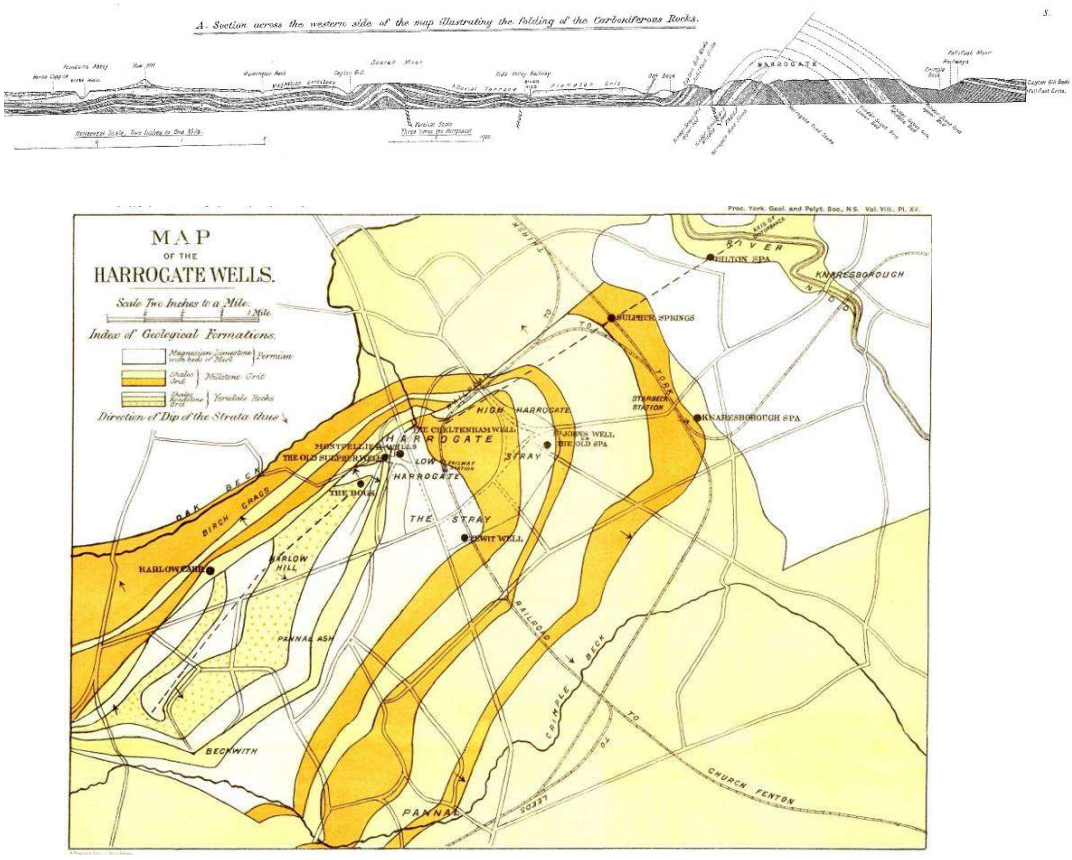

Figure 15. Map and cross-section of the Harrogate Anticline and its associated mineral springs. Map reproduced from the Proceedings of the Yorkshire Geological Society, 1884, Plate 24 by permission of the Yorkshire Geological Society. Cross section Harrogate Memoir 1908 (see Table 1).

George Barrow 1853-1932

Figure 16. George Barrow (Geological Survey Photograph P575834)

George Barrow was one of the younger members of the team working with Fox-Strangways, who was by then in his later years at the Survey. Barrow was educated at Kings College, graduating at the age of 18 and becoming the private secretary of George Julius Poulett Scrope, an eminent volcanologist, magistrate and one time Secretary of the Geological Society (Thomas 1933). Poulett Scrope recommended Barrow to Ramsay the Survey director (from 1872-1881). Upon the death of his employer in 1876, Barrow was invited to fill a vacancy on the Survey staff and was appointed as a geologist. During his Yorkshire years from 1876 to 1881, Barrow surveyed the Mesozoic strata of East Yorkshire and worked from Whitby and Scarborough though Eskdale and Rosedale westwards to Northallerton and Thirsk (Table 1). Around 1882 the then director Archibald Geikie re-organised parts of the Survey placing a greater emphasis on surveying the highlands of Scotland. Barrow was transferred north and immortalised his name in geological literature by discovering the metamorphic zonation of the Highlands, since referred to as the Barrovian Zones (Barrow 1893). He retired in 1915.

The need for minerals and World War 2

During the Second World War there was a pressing need for minerals to fuel the war effort. Geologists were exempt from being called up and spent their time surveying for coal, iron ore, fluorspar and water. Survey geologists including Kingsley Dunham, Robert Sherlock and George Mitchell worked in the UK particularly in Yorkshire. Other Survey and university geologists helped with strategic planning for geological problems related to war activities such as the selection of landing sites, landscape trafficability, tunnelling and water supply.

Robert Lionel Sherlock 1875-1948

Figure 17. Robert Lionel Sherlock (Geological Survey Photograph P810107)

Sherlock joined the survey as a geologist in 1903 coming straight from his education at the Royal College of Science, South Kensington. He worked with Fox-Strangways and Lamplugh, but found his forte studying strategic evaporitic minerals including rock salt and brine ((Sherlock 1921)), gypsum and anhydrite ((Sherlock and Hollingworth 1938)). He was also expert on the Permian strata that host many of the evaporites publishing a major correlation paper in 1926 and a world review in 1948 (Sherlock 1926, 1948). He wrote an interesting book in 1922, way ahead of his time, entitled *Man as a geological agent*. In this he looked at how man had changed the landscape through excavation, mineral production and construction presenting figures to illustrate the impact of man on the environment (Sherlock 1922); this is an early example of the importance of what some geologists are now calling the Anthropocene.

George Hoole Mitchell 1902-1976

Figure 18. George Hoole Mitchell (Geological Survey Photograph P511115).

Mitchell joined the Survey in 1929 as a geologist surveying from the York office of the Survey. He worked extensively on the Magnesian Limestones of Yorkshire and toured the area studying the building stones. His work included wartime activities on the coal-bearing sequences and he co-authored memoirs on the Wakefield, Barnsley and Leeds areas. His son Murray Mitchell followed him into the Survey working as a Carboniferous palaeontologist.

Sir Kingsley Charles Dunham 1910-2001

Figure 19. Sir Kingsley Dunham 1967: by Walter Bird © National Portrait Gallery, London

The son of an estate manager, Kingsley Dunham gained his education at Durham Johnston School, moving on to Hatfield College at Durham University. A talented musician he gained an organ scholarship and played the organ at his college. He had intended to read Chemistry, but came under the spell of Professor Arthur Holmes a renowned geologist and changed to a degree in geology. On graduation he continued with Arthur Holmes supervising his PhD (gained in 1932) on the distribution of vein

minerals in the Northern Pennine Orefield, a topic he studied for the rest of his life (Johnson 2002). After a brief spell at Harvard University and the New Mexico Bureau of Mines he returned to England in 1934 to join the Geological Survey.
He worked initially around Chepstow, then in south Cumbria investigating the hematite ores of that area. During the Second World War, he was engaged on detailed investigations of the mineral resources of his former field area, the Northern Pennines (with the help of a Canadian Army drilling rig and crew). During the war he identified a forthcoming shortage of the mineral fluorspar, essential for iron ore smelting and helped look for further resources to support the war effort. While based in London he was also a Captain in the Home Guard in charge of E company, 4th Battalion. His wartime work in northern England culminated in the publication of *The Geology of the Northern Pennine Orefield,* Volume 1, 1948 an encyclopaedic account of the origin and development of the mineral field between the Tyne Valley and Stainmore. He was awarded an Honorary D.Sc. by Durham University in 1946 and became Chief Petrographer of the Survey in 1948 (Johnson 2002).

When offered the post of Professor in 1950, he could not resist a move back to his former department at Durham. During this time he expanded the department and worked with industry on both the North Pennines and the Permian evaporites of north-east England. In 1967 he accepted the post as Director of the Geological Survey (then called the Institute of Geological Sciences after being attached to NERC). His time as Director saw great expansion of the Geological Survey with staff numbers around 1200. He was a prolific author of more than 100 papers and was presented with numerous scientific accolades with the civil accolade of a knighthood in 1972. He retired in 1975, but never gave up his studies of the Pennines and in 1985, with A A Wilson, published the *Geology of the North Pennine Orefield* Volume. 2 covering the area north of Settle to Stainmore; he also revised Volume 1, which was republished in 1990. His son Ansell Dunham born in 1938 was also a geologist, the Professor of Industrial Mineralogy at Hull University. Sadly both his wife and son died in 1998 (Johnson 2002; Wilson 1998) followed by Sir Kingsley a few years later in 2001.

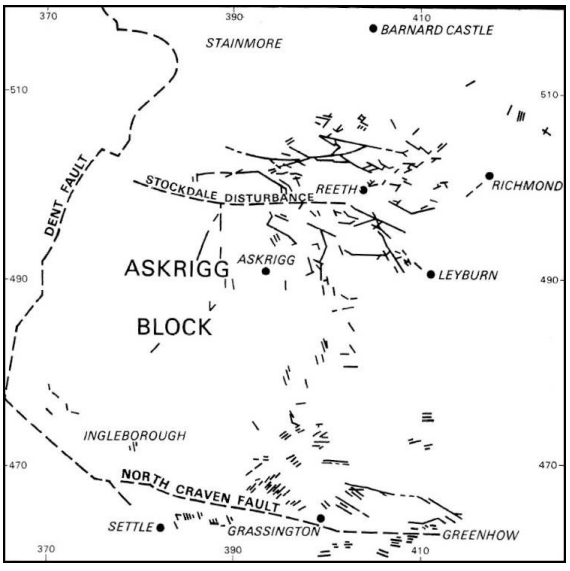

Figure 20. The main structural elements and mineral veins of the South Pennine Orefield from the Geology of the North Pennine Orefield Vol 2, Dunham and Wilson 1985.

Denys Barker Smith 1929-2007

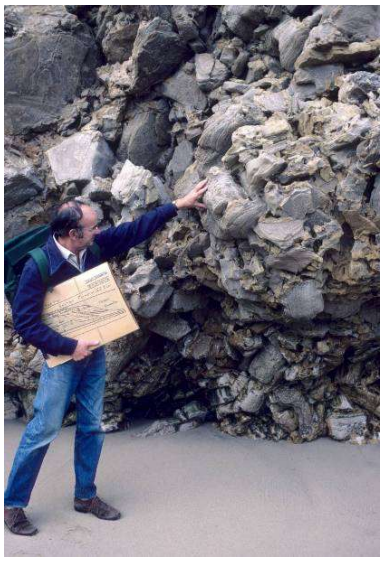

Figure 21. Dr Denys Smith demonstrating collapse breccias caused by the dissolution of the underlying Permian gypsum/anhydrite at Marsden Bay, Tyne and Wear. Note the diagram under his arm is similar to Figure 22. Photo A H Cooper.

Denys Smith was the son of the local village headmaster at Wybunbury Cheshire. He attended his father's school then moved on to Nantwich and Acton Grammar School where he excelled in geography and geology. His interests in geology took him to the University of Birmingham where he graduated with a first class honours degree in 1950. This was a time when National Service in the Army was obligatory and Denys spent the years from 1951-1953 as a Captain in the Royal Engineers where he was responsible for compiling mobility maps. In 1953 he joined the Geological Survey based in Newcastle, but he remained on the Army reserve until 1964 (McLean 2008). Based in Newcastle he was engaged in surveying the Permian and Carboniferous rocks of Sunderland and Durham setting the scene for his life-long interest in the Permian rocks and the evolution of the Permian Zechstein basin. Stemming from this work in the north-east he published numerous papers and memoirs including the *Geology of the country around Durham and West Hartlepool* with E Francis in 1967 (Smith and Francis 1967).

In 1961 the Newcastle office closed and Denys was transferred to the Leeds office, a move that saw him living on the Permian rocks at Aberford allowing him to study literally in his back garden. These included numerous papers on the Yorkshire Permian succession, sedimentology and correlation along with 2 chapters in the *Geology of Yorkshire* published in 1974. That same year saw him being awarded a DSc from the University of Birmingham for his work on the Permian rocks. In 1975 he was moved to London to head the South Wales and West Midlands unit, a post he held until 1981 when he moved back to Newcastle to head the new office there. This outpost was created when the Leeds office closed and most of the Survey staff moved to Keyworth near Nottingham. This placed him back in his old stomping ground and for 3 years he was in charge of the north of England survey teams and able to study the Permian in the local area. Another reorganisation of the Survey in 1984 meant that

he would have to move to Nottingham, a pressure that prompted him to resign and set up his own consultancy company GeoPerm, he also became an Honorary Senior Research Fellow at Durham University. Well placed with his industry contacts and his location he continued to research the Permian and in 1989 published an overview paper in the Proceedings of the Yorkshire Geological Society entitled *The late Permian palaeogeography of north-east England (Smith 1989)*. This paper established the carbonate platform and ramp into deep water model as the dominant structure of the Permian strata of north-east England and Yorkshire.

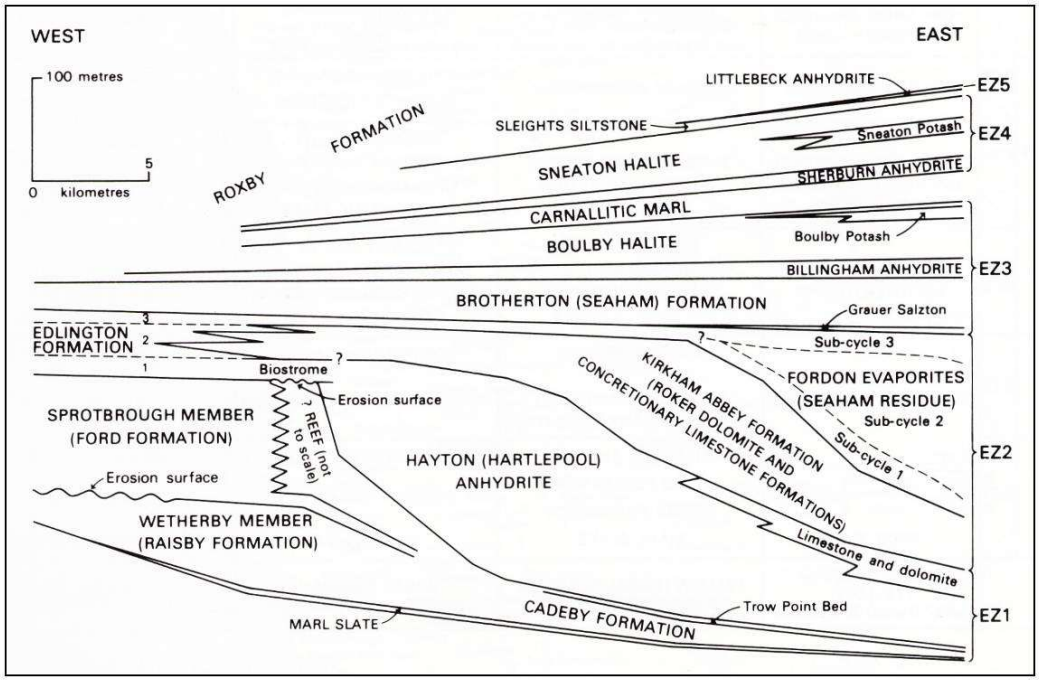

Figure 22. The stratigraphical and sedimentological framework of the Permian rocks of north-east England from the Proceedings of the Yorkshire Geological Society, Smith 1989. Reproduced by permission of the Yorkshire Geological Society.

This was followed by more papers and The *Marine Permian of England* (Smith 1995) a Geological Conservation Review Series book published in 1995 describing the English sequences in detail. Due to the hard work of Denys, many of the sections he described were already protected as Sites of Special Scientific Interest. One of the last papers he published was in 2006 as co-author of the Permian chapter in the Geology of England and Wales. He died in 2007 aged 78. Over the course of his career he published more than 70 papers and numerous maps, mainly on the Permian, but also covering the Quaternary and Carboniferous of north-east England.

A note from the author

I have been fortunate in my geological career to have followed in the footsteps of the geologists I have mentioned in this text. From my early surveying in the Harrogate area I have followed Fox-Strangways, Ward, Dakyns, Barrow, Aveline and Cameron across the Carboniferous, via the Vale of York and on to the North York Moors. I have also followed Ward and Aveline through the northern Lake District. My studies of the Permian strata, gypsum and sinkhole problems have been heavily influenced by

Sir Kingsley Dunham, Sherlock and by Denys Smith who was my senior officer for some of the time I was based in Newcastle. I have walked in awe following in their footsteps; hopefully, I have added some more pieces to the great puzzle of Yorkshire geology that they have put together.

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References

Details of many of the geologists mentioned here can be found at the British Geological Survey website by browsing the Pioneers of Geology pages: http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/archives/pioneers/pioneers.cfc?method=search

Aitkenhead, N., Barclay, W.J., Brandon, A., Chadwick, R.A., Chisholm, J.I., Cooper, A.H. & Johnson, E.W. 2002. The Pennines and adjacent areas. British Geological Survey, Nottingham.

Bailey, E. 1952. Geological Survey of Great Britain. Thomas Murby & Co, London.

Barrow, G. 1893. On an Intrusion of Muscovite-biotite Gneiss in the South-eastern Highlands of Scotland, and its accompanying Metamorphism. *Quarterly Journal of the Geological Society*, **49**, 330-358.

British Geological Survey 2015a. Alexander Henry Green. World Wide Web Address: http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/archives/ahgreen/home.html.

British Geological Survey 2015b. Richard Hill Tiddeman. World Wide Web Address: http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/archives/pioneers/pioneers.cfc?method=viewRecord&personId=151&currentTab=tab_T.

Cox, L.R. 1942. New light on William Smith and his work. *Proceedings of the Yorkshire Geological Society*, **25**, 1-99; 98 Plates.

Flett, J.S. 1937. The first hundred years of the Geological Survey of Great Britain. His Majesty's Stationery Office, London.

Harker, A. 1918. Obituary - Richard Hill Tiddeman, born 1842, died 1917. [In Anniversary Address.] - Proceedings of the Geological Society *Quarterly Journal of the Geological Society*, **74**, liv-lvi.

Johnson, T. 2002. Obituary - Sir Kingsley Charles Dunham (1910-2001). *Proceedings of the Yorkshire Geological Society*, **54**, 63-64.

Lamplugh, G.W. 1910a. In Memoriam: C Fox-Strangways. *Proceedings of the Yorkshire Geological Society*, **17**, 156-158.

Lamplugh, G.W. 1910b. In Memoriam: John Roche Dakyns, M.A. *Proceedings of the Yorkshire Geological Society*, **17**, 159-162.

Lord, T., Lundberg, J. & Murphy, P. 2012. A guide to work at Victoria Cave - from the 19th to 21st Centuries. *In*: O'Regan, H.J., Faulkner, T. & Smith, I.R. (eds.) *Cave Archaeology and Karst Geomorphology of North West England p QRA/BCRA joint field meeting Cumbria, North Lancashire and Yorkshire Dales, June 21st-24th 2012*. Quaternary Research Association.

McCartney, P.J. 1977. Henry De la Beche: observations of an observer. Friends of the National Museum of Wales.

McLean, S. 2008. Obituary - Denys Barker Smith (1929-2007). *Proceedings of the Yorkshire Geological Society*, **54**, 63-64.

Miall, L.C. 1896. In Memorium: Professor A H Green FRS, FGS. *Proceedings of the Yorkshire Geological and Polytechnical Society*, **12**, 232-233.

Museum of North Craven Life at the Folly 2012. Victoria Cave Revisited; Exhibition 2012. World Wide Web Address: http://www.ncbpt.org.uk/folly/exhibitions/exhibitions_2012/panels/panels.pdf.

Sherlock, R.L. 1921. Rock-salt and brine. Special reports on the Mineral Resources of Great Britain No 18. Memoirs of the Geological Survey. His Majesty's Stationery Office, 122.

Sherlock, R.L. 1922. Man as a geological agent. H F & G Witherby, London.

Sherlock, R.L. 1926. A correlation of the British Permo-Triassic rocks. Part 1 North England, Scotland and Ireland. *Proceedings of the Geologists' Association*, **37**, 1-72.

Sherlock, R.L. 1948. The Permo-Triassic Formations - A World Review. Hutchinson's Scientific and Technical Publications, London.

Sherlock, R.L. & Hollingworth, S.E. 1938. Gypsum and anhydrite & celestine and strontianite. His Majesty's Stationery Office, London.

Smith, D.B. 1989. The late Permian palaeogeography of north-east England. *Proceedings of the Yorkshire Geological Society*, **47**, 285-312.

Smith, D.B. 1995. Marine Permian of England. Chapman & Hall, for The Joint Nature Conservation Committee, London.

Smith, D.B. & Francis, E.A. 1967. Geology of the country between Durham and West Hartlepool. London, H.M.S.O.

Thomas, H.H. 1933. Obituary - George Barrow, born 1853, died 1932. [In Anniversary Address.] - Proceedings of the Geological Society *Quarterly Journal of the Geological Society*, **89**, lxxxvii-lxxxix

Tiddeman, R.H. 1875. The work and problems of the Victoria Cave exploration. *Proceedings of the Yorkshire Geological and Polytechnical Society*, **6**, 77-92 and Plate 75.

Wilson, A.A. 1998. Obituary - Ansel Charles Dunham (1938-1998). *Proceedings of the Yorkshire Geological Society*, **53**, 120.

Winchester, S. 2001. The map that changed the world: the tale of William Smith and the birth of a science. Viking, London.

Woodward, H.B. 1910. Obituary - Charles Edward Fox-Strangways by H.B.W. *Geological Magazine*, **7**, 235-238.