"STRATA" SMITH: The Surveyor Whose Map Changed the World!

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ABSTRACT

The title of Simon Winchester's best-selling book "The Map That Changed The World" sums up the momentous impact that Surveyor William Smith's Geological map of part of Britain had on the Geological Community of the whole planet! At last, likely deposits of oil or mineral bearing ore could be readily identified by the analysis of the layers of surviving fossil specimens prevalent within the core samples extracted within the vicinity of the countryside tested. No longer was it necessary to engage in hit and miss wholesale and excessively costly excavations vandalizing the pristine environment to hopefully strike a rich vein of metal bearing material or aquifers holding underground water supply or oil/gas bearing cavities for future exploitation. Surface reconnaissance could be carried out to investigate the occurrence of any fossil remains which could lead to deeper archaeological searching in lower, older tiers of the ground strata pointing towards the likely probability of the surrounding area to contain those materials which would provide raw fuel and metals for refinement, development and refined fuel resources for domestic and commercial usage. The fact that "Strata" Smith was trained as a cadastral surveyor with practical experience in sub-surface mine and canal excavation measurements provided him with the necessary analytical qualities and alert mind to formulate his revolutionary method of matching the fossil record with the evolution of the earth which produced the creation of various types of geological deposits over millions of years. It would then be subjected to sedimentary and metamorphic processes which would naturally manufacture the different categories of material capable of being processed into the invaluable resources coveted by the human occupants to carry out construction and fuel the modern media of transportation and home warming desired by modern human inhabitation of our planet. Follow William from primary school through his early years practising as a land and mining surveyor into his formative period of land drainage and canal construction during which he most ingeniously derived his

Wm Smith LL.D
aged 69.

"The Father of English Geology."

Fig. 1

brilliant methodology of geological strata prediction through the diagnostic consideration of prevailing fossils which brought about the bestowal upon him of the title "Father of English Geology". There is also a fascinating and thrilling added Australian connection to this story which features Simon Winchester's visit to the Australian National University in Canberra and how this institution came to possess one of the best preserved prints of this legendary 1815 Smith Map in the World.

INTRODUCTION

Born at The Forge in Churchill, Oxfordshire on March 23 in 1769 William Smith was the son of the town blacksmith John Smith who died when his son was only seven (7) years old to be cared for by his mother Ann who lived for another 30 years after her husband's passing.

As a young boy William was fascinated by the fossils which he was able to collect around his own rural neighbourhood which was to give him a keen eye to identify collections of like fossils occurring in other areas through which he would later move. His early school education was at a very basic village level but his amazing memory gifted him with the power to store more than an average amount of what he learnt. At the age of twelve he had witnessed the quarrying of chalk at Henley-on-Thames on a trip to London. Staying for two years with his uncle (also William) on his estate at Over Norton, NE of Churchill, the younger William badgered the elder to purchase him geometry and surveying books from which he self-taught himself this art. However to the great satisfaction of his relation the young man was also able to extract engineering techniques which would eventually allow him to develop skills in map drafting and colourisation as a critical component in his later creation of geological strata identification through fossil presence.

MASTER SURVEYOR WEBB IMPARTS HIS SKILL TO WILLIAM

In 1787 master land surveyor Edward Webb from Stow–on-the-Wold (6 miles/9.6 km) from Churchill was so impressed with young William's self-tutelage that he gave him employment to assist with his large engagement of preparing plans for the proposed Programs of Enclosure of small holdings into bigger estates. Working with

Figs. 2 & 3 Daylesford House and Warren Hastings, former Governor-General of India.

Fig. 4 Lady Elizabeth Jones

Webb for five years gave him a solid grooming in surveying with much of his time entrusted to carry out work in his own right with one of his first assignments in 1788 to landscape the 650 acre property of the former Governor-General of India, Warren Hastings, connecting him very early on with the highest levels of the English aristocracy. Webb had an elite platform of clientele coupled with an impressive log of Enclosure Plans as listed in the catalogue compiled by Kain et al (2004) such projects being located in the Counties of Berkshire, Gloucestershire, Oxfordshire, Wiltshire and Worcestershire, consisting of 10 such large works comprising a total area of some 28,225 acres (11,422 hectares). As a result he was given the opportunity to study the soils of each of these counties as well as Hampshire and Warwickshire while observing the workings of the new coal mine at Plaitford in the north of New Forest. By the age of 22 he had noted the Lias, the Trias and the Carboniferous rocks of mid-Somerset. Sent to value an estate at Stowey (SW of Bath), William walked the sixty (60) miles (100 kms) from Stow to High Littleton keeping a close eye on the extant geology on the way. He would lodge nearby at Rugbourne Farm from 1791 until 1795 for half a guinea a week, plus half a crown for his horse, sharing this lodging with the Lady Elizabeth Jones' farmer Cornelius Harris. This building still survives today. He was later to refer to this humble dwelling as "the birthplace of his geology." In 1792 Smith was asked to survey Mearns Colliery where he took a keen interest in the excavations taking place there leaving a sketch of his "Observations of my first Subterranean Survey of Mearns Colliery in the parish of High Littleton" among his papers opened by his nephew John Phillips upon his uncle's passing.

Fig. 5 Rugbourne Farm where Smith lodged from 1791-95 called by him "the birthplace of his geology."

Shortly after in 1793 Smith was requested by his landlady, the glamorous socialite Lady Jones, to make a detail survey and map of the tithing of High Littleton during

which he collated the names of owners and tenants along with the total acreage, types of cultivation and the value of her ladyship's property. The country mansion Stowey House was also part of her total estate holdings. His final connections with this High Littleton area came in 1802 when the Vestry issued a commission to Surveyors Smith and Cruse, surveyors of Bath, to carry out a survey of Hallatrow, in a similar way to that made at High Littleton in 1793 with the majority of the survey work performed by Jeremiah Cruse, Smith's partner. The Smith and Cruse Surveying Practice had commenced in 1802 being based at 2 Trim Bridge, Bath, the aforesaid building still existing today as a Grade II listed building.

On a 1794 fact-finding expedition with Perkins and Palmer, of the Canal Committee, Smith carried on with his ground-breaking (literally and figuratively!) studies of canal and colliery installations during which he included the "lie of the land" in his mapping between two sub-parallel valleys separated by about two miles (3 kms). Throughout this area of investigation the excavated zones revealed a regular occurrence of gently dipping strata allowing him to compare the differences existing between them.

SURVEYING THE SOMERSET COAL CANAL

Fig. 6 Survey plan of part of proposed Somerset Coal Canal.

John Rennie, a reputed canal builder was contracted to make a survey of the route for the proposed Somerset Coal Canal running from Limpley Stoke to Radstock and Paulton. Swiftly hiring William as his assistant this enabled the young man to make the remarkable observation of the recurring order of succession of fossils within the

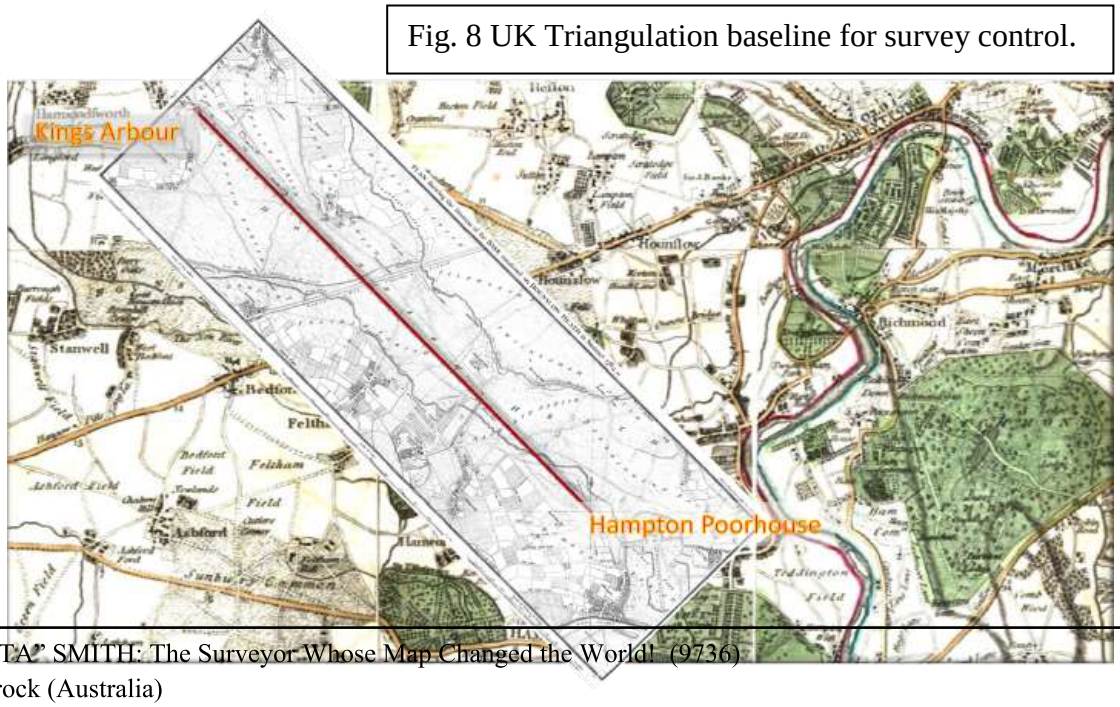
excavated layers with the same appearances of chalk to coal present in other areas of the country being dug out. Moving from High Littleton to Bath in 1795 Smith's notoriety as a drainage engineer solving problems to reclaim inundated farmland combined with his fine surveying skills and predictive geological techniques brought his performances to the attention of some recognised high flyers in the English Society not the least of which was Sir Joseph Banks himself! Continuing to set out and supervise the canal construction he was able to build up his data base of prevailing rock strata which would later be developed into his amazing fossil categorisation linkable to reliable predictions of mineral and oil deposits.

Fig. 7 Noted canal builder John Rennie

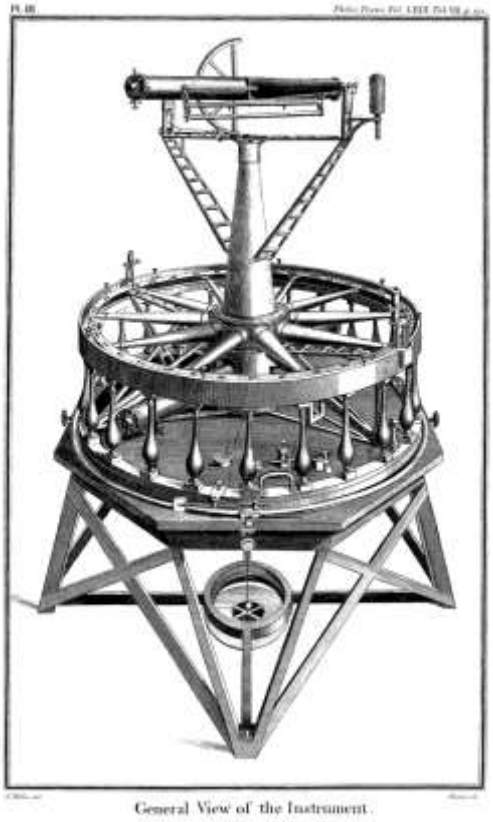
FIRST UK TRIANGULATION AIDS THE SMITH MAP

Scottish Surveyor par excellence General William Roy commenced the first Principal Triangulation of the United Kingdom in 1783 with the first action to determine the difference in longitude between the Greenwich and Paris Observatories. Upon Roy's death in 1790 the survey network was extended under the direction of Generals Mudge and Colby and Colonels Williams, Hall and finally Henry James all contributing to a much more accurate mapping coverage which allowed Alexander Clarke to compute a spheroid with density determinations.

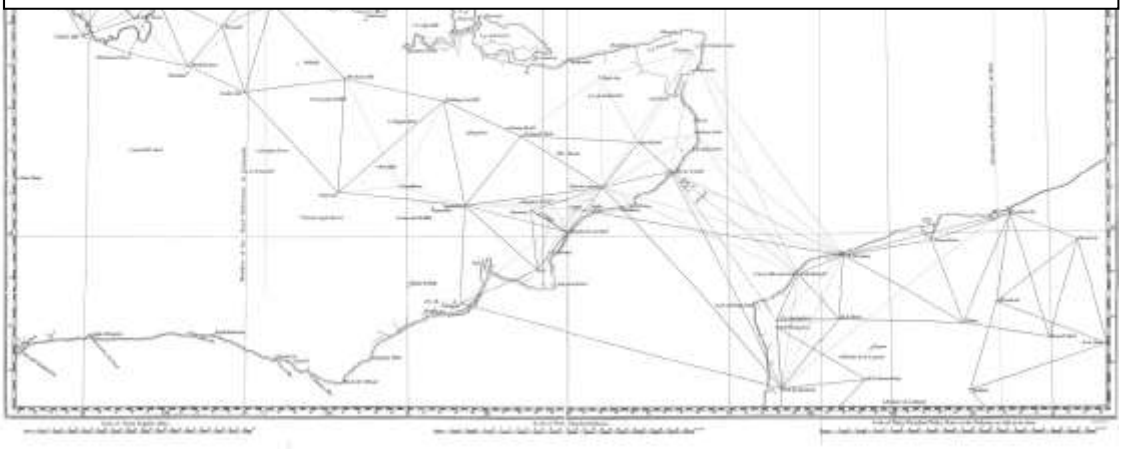
Fig. 8 UK Triangulation baseline for survey control.



The first stage of this momentous undertaking was to measure a precise baseline from Kings Arbour (where Heathrow Airport now stands) to the Poor House at Hampton (see Figure 8) carried out with iron bars and deal rods, remeasured with glass tubes to achieve a remarkable one inch in 27,400 feet (about 1 in 330,000!). The angle observations were honed to a minute specification of fractions of a second of arc using a specially commissioned large geodetic theodolite built by Jesse Ramsden the renowned English scientific instrument manufacturer. As a result of this very high precision triangulation the existing maps in the UK were proven to be seriously erroneous and thus William benefitted greatly due to being able to map in accordance with this superior more reliable data set from well controlled framework linked rigidly together by the final adjusted Ordnance Survey figure.



Figs. 9 & 10 Jesse Ramsden Great Theodolite for the UK Triangulation Survey and Map showing the triangles measured to determine the longitude variation between Greenwich and Paris Observatories.



FINDING FOSSILS AND A FORMULA

In 1796 his notes on fossils written on January 5 recognised that while they had been collected and studied with much curiosity no one had been astute enough to discover that the same sequences of fossil presences had a "wonderful order and regularity." Searching for commissions on all types of drainage or surveying work gave him more opportunity to consolidate his theory of fossil repetition. During this period he dictated a list: the "Order of the Strata round Bath" to two local supporters, Reverends Joseph Townsend and Benjamin Richardson as well as writing a book called "Water Meadows" (1806) on draining bogs which was unprofitable.

His initial work to add colour coding to maps for geological descriptions was made in 1799 when he added colour to a map published by Billingsley and Davis titled by Smith "Geological Map of Bath" where he had overlain his colours onto a copy of Taylor and Meyler's "Map of Five Miles around the City of Bath." (1798), representing the first true geological map ever produced.

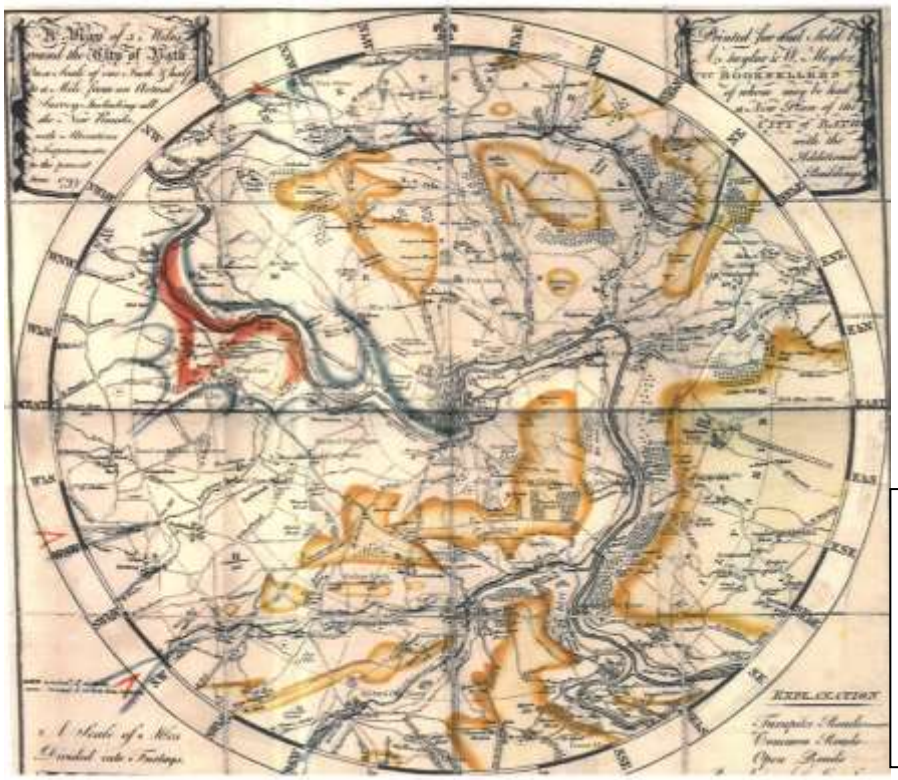


Fig. 11 Smith's first attempt at colouring a map with geo-coding from 1799.

A short time after this first in UK mapping, Smith produced his prototype of a geological map of England and Wales in 1801 when he used Robert Wilkinson's 1794 map of this area to add his colourisation naming this work "General Map of Strata found in England & Wales being the culmination of the accumulation of the knowledge he had absorbed from the 900 mile (1440 kms) return journey between Bath and Newcastle-on-Tyne.

Nevertheless his work in and around Bath had allowed him to form a close association with the polymath John Farey who greatly supported his innovative postulations. Early in 1802 he brought Smith's work to the notice of president of the Royal Society, Sir Joseph Banks, who became a loyal supporter of Smith. Although the Geological Society of London was founded late in 1807 many of its members were sceptical of Smith's ideas and even tried to derail him by publishing a rival map! Such foul deeds rendered them no credit and with the 1812 offer of London mapmaker John Cary the first version of Smith's epic production was published in September 1815 with specially engraved plates for which Smith designed the topographic details. Dedicating this production to Banks his mentor was immediately cognizant of its economic importance being continually modified until at least 1818 with some copies of the mid 1830's bearing watermarks still surviving.

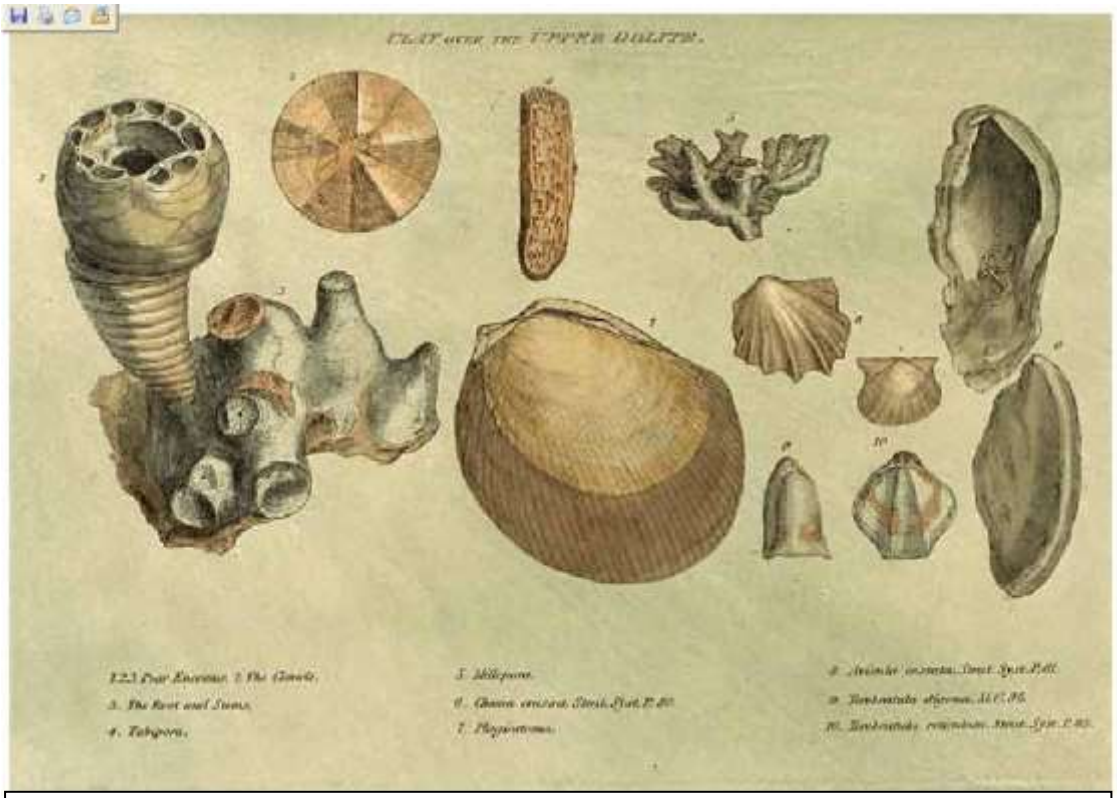


Fig. 12 Artists impression of fossils found in the Clay over Upper Oolite layer.

Smith wrote: "… each stratum contained organised fossils peculiar to itself, and might, in cases otherwise doubtful, be recognised and discriminated from others like it, but in a different part of the series, by examination of them." Within this statement lies the "principle of faunal succession" from which layers of sedimentary rock at any location bore fossil deposits of a certain age in a definite sequence with the older depositions being lower down in the stratigraphic profile with the fossils of a similar age and type present where identifiable deposits of organic fuel could be found with surety. With previous maps only describing rocks by their inorganic qualities like sandstone, marls and chalk, further differentiation was only permitted by colour or minor properties. Smith created his alternative application of geological deposition that is able to distinguish rocks without any doubt whether or not they appear similar. His maps were further accentuated with a colour scheme which even more readily illustrated what was present in the localities he had studied. His overall analytical division of prevailing topography also included crustal deformations caused by geo-thermal and seismic events modified by erosion caused by wind, water and ice which ultimately sculpted the terrain into valleys, lakes and inclines all of which contributed to the disruption of the originally horizontal depositions laid down by hundreds of millions of years of sedimentary actions.

In his earlier years he was inspired by the work of John Strachey (1671-1743) who had an estate at Sutton Court (8 miles/13 kms from Bath). He espoused the concept of the regularity of strata within coal mines also observing that these layers were dipping towards the east as well as uniquely identifying an individual coal seam via its associated fossil remains.

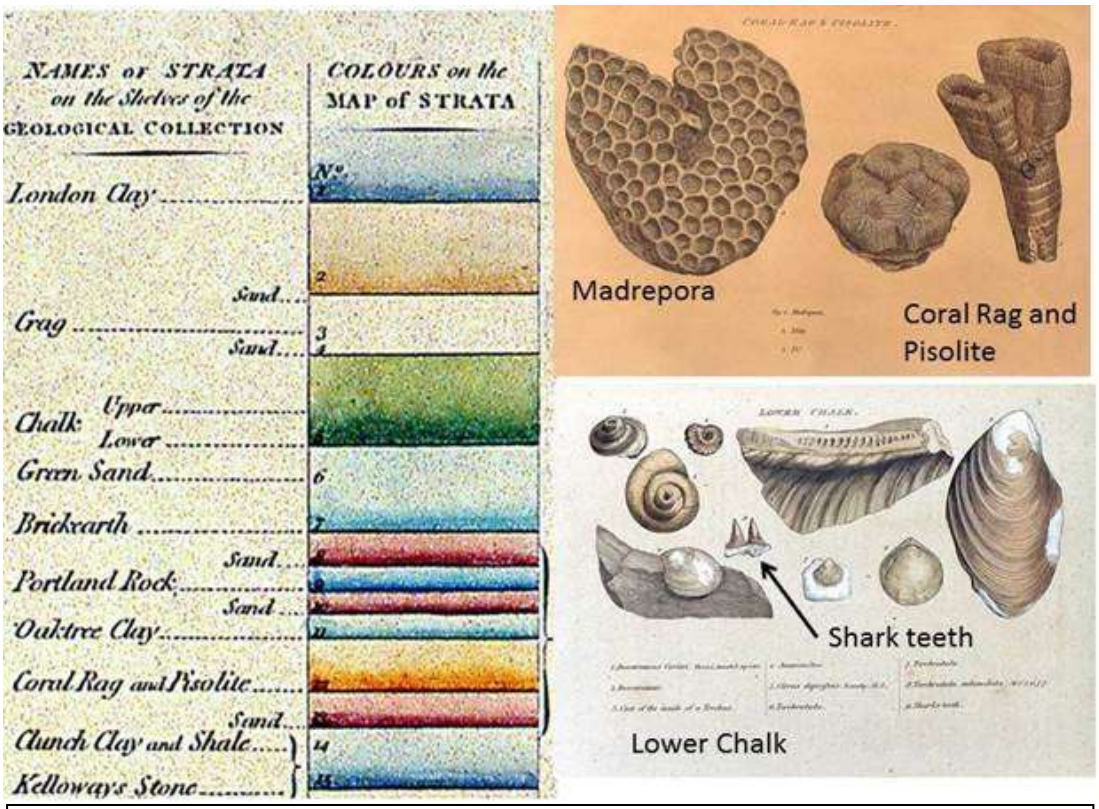


Fig. 13 Key for sub-strata identification of layer type with colourised codes

His map provided the diagnostic tools for the interpretation of surrounding environs which could and usually would yield expected outcrops and reefs of coal punctuated with cavities bearing oil and gas as a by-product of the organic material prevalent itself liberally sprinkled with fossilised remains of creatures solidified within the identifiable tiers of the geological era from which it originated.

He titled the map "A Delineation of the Strata of England and Wales, With part of Scotland" and it bore the dedicatory statement: "To the Right Hon^{ble} Sir Joseph Banks, Bart., F.R.S., This map is by Permission most respectfully dedicated by his most obliged servant, W. Smith Aug. 1, 1815."

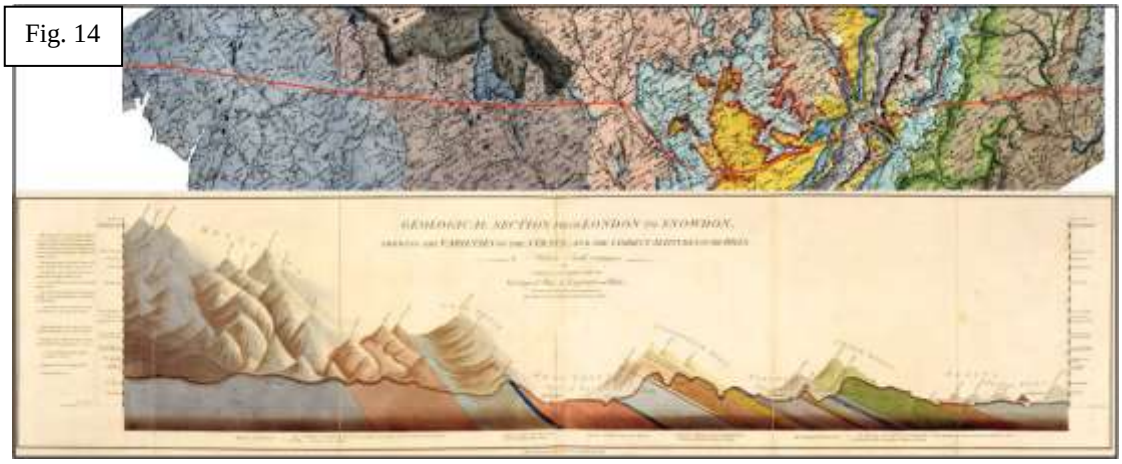
SELLING HIS MAP AND ATLAS

In 1810 Smith was called to restore the Hot Springs in Bath which had failed. Opening up the spring to its base, at much opposition, he found that the sinking of a nearby pit to find coal in Batheaston had caused the hot mineral flow into another channel. Successfully plugging the leak Smith brought back the Hot Springs to Bath reinforcing his well gained name as an hydraulic engineering specialist.

Despite skating on thin financial ice he persisted in the belief motivated by his exciting new scientific system which he considered to be of great benefit to the society as a whole as well as a tool to minimise unnecessary desecration of the countryside in vain attempts to "strike" black gold in localities which had no likelihood of bearing such natural riches. With strong support from Banks, Farey and Cary the money to facilitate the publication of the ingenious Map came slowly,

ultimately through 400 subscribers who were underwriters for the project, map production starting in 1812 to be released in 1815. Edition One of the map was sold at five (5) guineas each (i.e 5.25 pounds) but this would barely cover the expenses of production so despite a total run of 400 in all only around 43 copies of the first batch are known to be extant. The complete production consisted of fifteen sheets.
Along with this astonishing cartographic work Smith prepared a portfolio of geological sections from 1817 to 1819 with hand-coloured horizontal cross sections of various regions of England and Wales, such as the example below extending from London to Snowdon, the highest mountain in Wales (figure 14).

Fig. 14



In addition to this large sized 1815 map Cary published geological maps of 21 English counties in six (6) parts from 1819 to 1824 calling the work Cary's "New English Atlas", described as remarkable for their accuracy and brilliantly engraved." Thus William had a masterwork of cartography upon which to draft his geological ground pattern. Each sheet was 584 mm by 714 mm being framed within an engraved and coloured border 480 mm by 530 mm showing roads, rivers, parks etc. by John Cary as well as another cartouche declaring: "Geological Map of [county name], by W. Smith, Mineral Surveyor." The collaboration between Cary and Smith produced this major atlas work in six parts but the county maps, apart from Yorkshire, do not bear the stratigraphically coloured key with each layer singled out by name and number in tinted boxes around the county boundary abutting the outcrop. Noted at the bottom of each map was that "The numbers attached to the description of each Stratum, refer to the Geological Table of British Organized Fossils, which may be had of the Publisher at the price of 1 s 6d." Part I (1819) had maps of Norfolk, Kent, Wiltshire and Sussex; Part II Gloucestershire, Berkshire, Surrey and Suffolk (also 1819); Part III had Oxfordshire, Buckinghamshire, Bedfordshire and Essex (coming in 1820); Part IV with Yorkshire in 4 sheets (out in 1821); Part V containing Nottinghamshire, Leicestershire, Huntingdonshire and Rutland (published in 1822) and Part VI with Cumberland, Durham, Northumberland and Westmoreland finally in 1824. Part I was on sale for 1 pound 5 shillings while the maps could be bought separately for 5s 6d ea. The final complete atlas was never available even though some of the maps for the Counties of Lincolnshire, Northamptonshire and Somersetshire (ironically the area most studied by Smith!) were close to finalisation but never issued. Despite bearing no geological shading these maps were issued in colour to designate the political boundaries. Some County maps like Cambridgeshire, Cheshire, Derbyshire, Hampshire, Herefordshire, Lancashire, Monmouthshire and Staffordshire were only in draft condition and these can be found in Smith's archive in Oxford University.

Fig. 15 One of the superb pages of Cary's masterwork of the "New English Atlas" (showing Gloucestershire County) with the map sheets coloured and coded by Smith for their fossil content.

SMITH'S LAST DAYS IN NORTHERN EXILE

Upon release from a brief stint in debtor's prison Smith retreated away from London in 1819 during the time that Cary was publishing his "New Atlas", being accompanied by his nephew John Phillips, who was most probably the first apprenticed geologist in England? Smith's last major project was titled "Stratification in Hackness Hills" prepared while undertaking a field study as a land steward for Sir John Johnstone being one of the earliest large scale geological maps of its time. Lithographed by W. Day of Lincoln Inn Fields in London it was a rougher quality than those previously issued by Cary but his colour system was still present. In an

accompanying memoir Smith put forward explanatory notes of the principal object of the map to delineate the Geological structure of some of the hills and valleys (1829). Like all of Smith's work the goal of his plans was to make the geology readily discernible for the purposes of mineral extraction and agricultural utility best described in his own words: "That a knowledge of Geology is the only infallible guide to determine correctly the value of land … To know what plants are best suited to the soil a knowledge of the varieties of soil is necessary, which can only be obtained by an acquaintance with their subsoils and beds of strata upon which they rest, and from which they are respectively formed."

Returning to Scarborough on many occasions Smith had clearly developed a fond relationship with the congenial locals giving him the motivation to conceive the design of a most ingenious museum within which his fossils could be displayed in their contemporary relationships. Completed in 1829 the building adopted a Doric design with the round structure a rotunda fifty feet high (15.24 m) of a forty feet (12.19 m) diameter accessed via a spiral staircase and topped by a graceful dome. Cleverly arranging his exhibition of fossil specimens with the youngest layer (Cretaceous) on the top level viewers could descend physically downwards on a journey backwards in time to the oldest items of the Triassic Period at the bottom of the time tube. This museum is still standing in Scarborough today and around the walls can be seen a diorama painted by William's nephew John Phillips.

Fig. 16 Scarborough City Museum in which Smith's fossils exhibition is set out from top to bottom with the youngest age specimens at the top level descending in time to the oldest samples at the bottom.

William Smith died in Northampton on 28th August 1839 and his grave is situated in St. Peters Churchyard in Marefair.

THE AMAZING AUSTRALIAN CONNECTION

You have got to give it to we Aussies when it comes to negotiating a "great deal" (aka a steal!) from our English entrepreneurs. In the mid 1960's the Geology Department was in its embryonic early stages at the Australian National University in our Australian Capital Territory (which had been founded in 1913!) but our astute academics are always on the look out for artefacts to procure from anywhere on the planet to add real substance to the material available to its students in such a far off land. Such was the case when the first Head of the Department, Prof. David Brown, caught wind of an auction in England which contained one of the original prints of the 1815 first run of Smith's brilliant map. The price is said to have been about 25,000 pounds which was a very sizeable sum at that time and the purchase was not without its difficulties, particularly when considering the long distance communication which made everything about the exercise most formidable. However, undaunted the Prof. pulled off one of the most eminent transactions in Australian academic history when the map finally arrived in Canberra. This item is now valued at $ 350,00.00 and when Simon Winchester paid a visit to inspect it he proclaimed it as the best surviving example of Smith's Map anywhere in the world. Now it hangs most proudly in the foyer of Building J8 of the School of Earth Sciences in our nation's capital freely available for anyone to view and read the excellent signage surrounding it. An ironical feature of Simon Winchester's close encounter with this fully hand-coloured map is that he is colour blind so declares himself that he really cannot appreciate its true magnificence despite his adulation of its excellence!

CONCLUSION

Despite the commercial significance of Smith's Map and its consequences for the identification of likely deposits of the black gold of the era (coal) and oil Smith suffered serious financial problems resulting in his incarceration in June 1819. Partial alleviation of his debts were made at the instigation of Banks through the sale of Smith's fossil collection between 1815 and 1818 along with disposal of his library. Having been shunned by the Geological Society (formed in 1807) it is indeed ironic that the inaugural Wollaston Medal awarded by this elitist cohort in 1831, being its highest honour, was bestowed upon the man they had spurned, Smith himself. They have even introduced another accolade to geologists of note called the Smith Medal itself a product of the valuable metallic ore that his own pioneering work in fossil recognition provided the tool to locate the land bearing it. Another accolade came with his receipt of an honorary LLD degree from Trinity College, Dublin in 1835.

His brilliant new system of geological detection was revolutionary and unique, making organic fuel discovery more fail-proof than ever before and rightfully earning him the title of the "Father of English Geology" with his superb geological map most certainly "The Map That Changed The World" as so aptly described by Simon Winchester.

Fig. 17 William Smith gazes proudly at his Map of England, Wales and part Scotland with its amazing fossil distribution and map colourisation.

Fig. 18 William Smith Medal awarded by the Geological Society of London for Applied Geology.

Fig. 19 William ”Strata” Smith’s 1815 cartographic jewel of England, Wales and part of Scotland showing its abundance of colour and innovation.

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BIOGRAPHY

Private land surveyor since 1973, **Bachelor of Surveying** (UNSW 1978), **MA** (Egyptology) from Macquarie Uni., Sydney (2000), **Registered Surveyor NSW** 1981. Now Director of Brock Surveys at Parramatta (near Sydney). Papers presented on six continents inc. Egypt, Jasper in Canada, Brunei, Hawaii, PNG, Nigeria, Morocco, Bulgaria and Colombia as well all States & Territories in Australia. 2002-2017 regular column *Downunder Currents*, RICS magazine (London) *Geomatics World*. Stalwart of FIG Institution: History of Surveying & Measurement awarded **FIG Article of the Month March 2005, January 2012, June 2014** & **April 2017.** Institution of Surveyors NSW Awards – **Halloran Award 1996** for Contributions to Surveying History, **Fellow ISNSW 1990 & 2002 Professional Surveyor of the Year**. First international **Life Member** of the Surveyors Historical Society (USA), Rundle Foundation for Egyptian Archaeology & Parramatta Historical Society, **Foundation Member** Australian National Maritime Museum & Friends of National Museum of Australia. **Member** of Bradman Crest, International Map Collectors Society, Royal Australian Historical Society, Hills District Historical Society, Prospect Heritage Trust, Friend of Fossils (Canowindra), **Friends** of May's Hill Cemetery and St. John's Cemetery.

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