William "Strata" Smith

by
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In August 1815, a surveyor and geologist with the very ordinary name of William Smith published an extraordinary map (fig. 1). Drawn on a scale of five miles to the inch (about 1:300,000) and consisting of 15 separate sheets, each approximately 21 inches high by 25 inches wide that, when fitted together into a single sheet, measured more than six by eight feet. The map was a depiction of the geology of England and Wales, and it was the first geologic map of an entire country ever made. That fact alone makes it noteworthy, but what really set Smith's map apart from all the rest were the geologic principles, formulated by the man himself, upon which it was based. Smith looked at rocks in ways that would revolutionize the study of stratigraphy and geologic time. In the field and on paper his work set the standards for modern geologic mapping, and turned mineral exploration from an exercise in random guesswork into a proper science. And besides its importance as a scientific document, William Smith's great map is, quite simply, a work of art.

Figure 1. William Smith's 1815 geologic map of England, Wales and southern Scotland. (Reproduced by permission of the Geological Society of London)

The eldest son of the local blacksmith, William Smith was born in 1769 in the village of Churchill in Oxfordshire, England at a time when geology was just starting to emerge as a science in its own right. He attended the village school until he was 11 and then went to work on his uncle's farm where he began to learn the practicalities of surveying and civil engineering, and took an interest in geology. In 1787 Edward Webb, a professional surveyor, hired Smith as his assistant. He turned out to be so good at his job that Webb was soon sending him out on his own and it was not long before landowners, impressed with the quality of Smith's work, were commissioning him for projects of their own. He built canals; drained marshland; and prospected for minerals, especially coal; and as Smith the surveyor went about his work, Smith the geologist studied the rocks around him, recording his observations in meticulous detail.

Some of Smith's observations had also been made by others: that sedimentary rocks are arranged in layers and may or may not contain fossils, for example. But Smith was the first to realize there was an order to it all and, moreover, that the order was predictable (this fundamental rule still holds but nowadays we know it is not invariable, as Smith envisaged). He described the gently dipping layers of rock, or strata as he referred to them, exposed in some canal excavations in southwest England as resembling "superposed slices of bread and butter" and found that by plotting the locations of outcrops on a map he could reliably forecast what rocks the canal would cut through at other points along its course. Over time Smith became remarkably adept at visualizing subsurface geology based solely on its above-ground expression – a very useful talent for a geologist to have.

Smith's greatest breakthrough, however, was his conception of what today is known as the law of faunal succession: the principle that fossil organisms succeed one another through geologic time in a distinct and systematic order. In the eighteenth century fossils, or "figured stones" as they were then called, were generally regarded as nothing more than curiosities, to be collected at great expense then displayed and admired in the drawing rooms of the wealthy as a sign of their owners' intellectual enlightenment. But to Smith they were the solution to a geologic problem. Many rocks with similar lithologies look alike and when he started building canals this proved to be a recurrent source of confusion. Although Smith knew from their strike and dip that not all the layers of seemingly identical strata exposed in places along the canal bed as work progressed were part of the same "slice of bread and butter," he sometimes found it extremely difficult to tell them apart. But when he began to look more closely at the rocks' fossil assemblages, Smith realized he had discovered the key. Earlier in his career, miners at a Somerset colliery had shown Smith how they could differentiate between one coal measure and another by their stratigraphic position and the subtle contrasts in their physical character and also the fossils they contained. Smith had wondered at the time if this might apply to other rocks besides coal and was right on not just the first, as we have seen, but both counts.

Two or more strata, similar in appearance, but separated by time. Similar fossil assemblages – but not quite. Like the ones in the coals, there were subtle, crucial differences that Smith realized made each assemblage, and therefore its host rock, unique. Some fossils would persist through several layers essentially unchanged; others would evolve, growing increasingly more complex with time. New, never-before-seen animals would appear and existing ones vanish, never to return. Smith amassed a huge fossil

Background. Abandoned locks on the Somerset Coal Canal in southwest England. The layers of rock exposed during the canal's construction were the inspiration that led William Smith, its principal surveyor, to the discovery of one of geology's most fundamental laws (see text). The canal opened in 1805 and remained in operation for more than 90 years before competition from the railways forced its closure in 1898. (Image by Spoonfrog used under Wikimedia Commons License CC BY-SA 4.0.)

collection that confirmed his hypothesis over and over again: that to determine, with absolute precision, the identity of a layer of rock, one need only look at the fossils enclosed within it. Now he was ready to make his map.

It was not a spur of the moment decision. Smith had been considering the possibility of making a geologic map of England ever since his coal mine days. He already had a lot of data from various parts of the country that he had gathered on his travels as a surveyor and was well acquainted with some of its geology. Nevertheless, it took Smith a further fifteen years to complete his field work. During that time he covered more than 50,000 square miles of England, Wales, and southern Scotland; sometimes traveling as much as 10,000 miles in a single year; alone with only the most basic of equipment and nothing but his own knowledge of geology to guide him. He became a familiar and well-liked figure among the patrons of the roadside inns up and down the country and even earned himself a nickname – "Strata Smith" – on account of his almost obsessive passion for rocks.

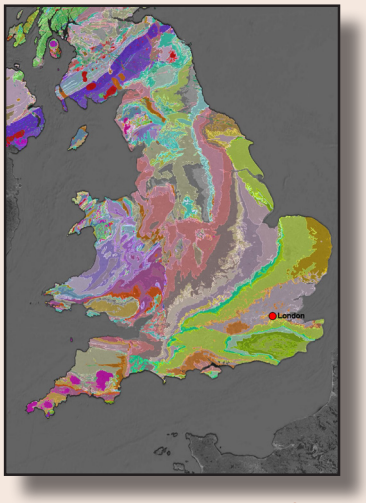

Figure 2. A 2007 edition of the British Geological Survey's geologic map of Great Britain. Based upon DiGMapGB-625 data with the permission of the British Geological Survey.

Smith's map, when it was finished, was a masterpiece and accurate to a degree that is really quite astonishing. Figure 1 shows a 2007 edition of the British Geological Survey's geologic map of Great Britain and the similarities between it and Smith's map of 1815 are remarkable. His map is also beautiful to look at. It is hand-colored in shades inspired by the rocks themselves – yellow for certain limestones, gray-blue for others; a pinkish-brown for the Precambrian granite tors of Cornwall and so on. To give the map a more three-dimensional aspect he colored the base of each formation a darker shade than the rest as an indicator of its line of dip. There was a key and also a cross-section, another first by Smith, extending southeastwards from the mountains of Snowdonia in north Wales to the Thames Valley and London, to illustrate his view of the unseen structure of Britain's subsurface. At the top of the map its title reads: "A 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 substrata, illustrated by the most descriptive names." Even after its publication, Smith continued to revise his map and at least five different versions were published between 1815 and 1836. About 370 copies were produced altogether, 40 or so of which are known to still exist.

Smith may have been a brilliant geologist but he did not manage his finances well. By 1816, mounting expenses from the making and publication of his map, a bad investment, and a run of sheer bad luck had pushed him to the verge of bankruptcy. He sold off everything he could; including his books and his precious fossil collection, but the bills kept coming and in 1819 poor Smith was sentenced to 11 weeks in a debtor's prison. A year later, any remaining hopes he may have had of receiving the honors that were so deservedly his were crushed when George Bellas Greenough, president of the Geological Society of London, published a map of his own containing material clearly plagiarized from Smith's 1815 map. This, after an application by Smith to join the society shortly after its foundation in 1807 was thrown out owing to what its elitist members perceived as his socially inferior status. As soon as Smith was released from prison he moved to the north of England and seemed destined to fade into obscurity.

Sir John Vanden Bempde Johnstone was the owner of a large estate in the county of Yorkshire. He was also a Member of Parliament and of the Geological Society, but unlike Greenough and his cronies, Sir John was a great admirer of William Smith. In 1828 he hired Smith as his land steward and was instrumental in seeing to it that the society grant his employee the recognition it had denied him for so long. By this time the Geological Society had changed and was on its way to becoming the highly respected institution it is today. A new generation of scientists was taking over who valued the society's members for their merits as geologists rather than their wealth and social standing. In 1831 Smith became the first recipient of the Wollaston Medal – the society's most prestigious accolade – and a new title, "The Father of English Geology," coined at the awards dinner by past president and Woodwardian Professor of Geology at the University of Cambridge, Adam Sedgwick. He had his portrait painted (fig. 2). More honors were to follow including an honorary doctorate and a lifetime pension granted by no less a person than the King of England himself. In 1977 the Geological Society introduced the William Smith Medal, an award for outstanding research in applied or economic geology. There is also an annual William Smith meeting and lecture, which this year will celebrate the 200th anniversary of the publication of his great map.

Figure 3. William "Strata" Smith (1769-1839). Portrait by French painter Hugues Fourau (1803-1873). (Image by Woudloper used under Wikimedia Commons License PD-old-70-1923.)

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