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A tribe of jobbing ditchers

Ted Nield

Earth science, a field in which science and profession have been intimately linked, has grown through the practicalities imposed by industrialization and war but must now revamp to address climate change.

The celebrated English engineer and entrepreneur Matthew Boulton had a low opinion of the emerging profession of canal engineer. But for all this, the despised tribe would soon include the great William Smith, 'the father of English geology'. By 1799, Smith had spent almost six years as a 'jobbing ditcher', laying out the Somerset Coal Canal and superintending its building. In that year, he took a circular map of the district of Bath and shaded the different rock types (now widely cited as the world's first geological map), and similarly coloured the geology of England on a small-scale map. This map of England was the precursor of his great geological map of 1815, known (since Simon Winchester's best-selling book) as "the map that changed the world".

Smith's ditching activities were the ideal experiment — digging a continuous trench through gently dipping fossil-rich rocks — enabling him to prove a hypothesis that he had been forming since earlier work in the coal mines of Somerset. This theory held that all sediments of the same age would carry the same fossils. This became the 'law of the identification of strata by contained fossils', which — combined with the 'law of superposition' (old stuff is on the bottom, and young stuff is on the top) — enabled Smith to identify rocks of the same relative age. He then coloured their outcrop patterns on a topographic map from one side of the country to the other. Stratigraphic mapping was born.

But why was it left to the son of a Somerset blacksmith with little or no formal education past the age of 11 to come up with these simple but powerful ideas? The world had hardly been short of geological savants in preceding centuries. In 1807, some years before Smith finally published his great map and fossil album, the Geological Society of London had been founded. With an admirable disregard for superstition, 13 men put their names to its founding document after a meeting on Friday, 13 November. They inaugurated a society dedicated to observation and objective description and eschewed airy and overambitious 'theories of the Earth' that they felt (along with their French contemporaries Georges Cuvier and Alexandre Brongniart) had bedevilled attempts to understand the Earth's deep history.

Yet the society's much-imitated commitment to objective description within a stated research agenda, although intellectually down to earth, was still far from being 'applied science'. Many of the founders — and those who later joined the growing society — may have been practical men, but they lacked one vital spur. They either had money or earned their living elsewhere. They were gentlemen, after all.

To give them credit, when Smith exhibited his map, they recognized its worth, bought a copy and, in modern parlance, plagiarized it (using it uncredited as the basis for their own, much improved, map of England and Wales). But this act, which seems unbelievably callous today, did not mean that they were immoral. Their interaction with Smith was dictated by the class gulf between them, and the concept of intellectual property was in its infancy. They had paid him for his labour — what more did a man of his class expect? To be sure, it was not long before they began to feel embarrassed about this, and eight years before his death, they presented Smith with the first Wollaston Medal, the society's highest honour.

Theory and practice

Smith received his apology in the form of the Wollaston Medal, but his real revenge was that he, and not the society gentlemen, was granted the honour of the breakthrough. Smith was pioneering a profession, as well as a science. And, to any applied geologist, the idea of a geological map is almost self-evident. That is, before you can do anything, you need to know what rocks lie where, and what they are like.

This brings us to a central fact about scientific geology: its essential practicality. Everything we need — all raw materials and nearly all energy — comes from the planet. This means that a geoscientist needs first to find these things and then to extract them economically. Human societies today simply could not survive without geology. It is therefore no surprise that the intellectual revolution that was the emergence of scientific geology was tied to industrial revolution. If industrialization had been more advanced in France than the United Kingdom, then the history of geoscience would undoubtedly be much less anglocentric than it is.

Geology is thought of, not quite wrongly, as belonging to the Victorian era. Victorian battles over evolution and the age of Earth are the stuff of modern legend. Charles Darwin and Thomas Huxley were both geologists — Darwin, by his own admission, was a geologist primarily, and Huxley, secondarily (although only Huxley, co-founder of the journal *Nature*, became president of the Geological Society of London). It is clear that the public correctly senses geology's inherent congruence with industry, manufacturing and empire.

The British Empire sent trade, military and scientific envoys across the globe. Darwin's eyes were opened as the gentleman-naturalist companion to the captain of HMS *Beagle*. The man who would become his champion, Huxley, sailed aboard a leaky frigate called HMS *Rattlesnake*. Scientists felt the spur of the British Empire as they accompanied such Royal Navy expeditions bent on creating accurate charts for trade and defence.

The biogeographer Philip Lutley Sclater was another such traveller, perhaps less known today. In his journeys, he saw that lemurs had a scattered geographical distribution that did not make sense. Lemurs might have crossed from Africa to Madagascar on rafts of vegetation, but was it probable that they had crossed all the way to Sri Lanka or the Malay Archipelago? No, there must once have been land between. Sclater had (although he never knew it) found early evidence for continental drift and was glimpsing Gondwanaland, the ancient southern lobe of Pangaea.

Or take the brothers William and Henry Blanford (born in a London house that would become Charles Dickens's editorial office), who in 1856 were recruited by Thomas Oldham to the nascent Geological Survey of India. They quickly discovered mysterious glacial deposits near Cuttack, only a few degrees from the modern Equator. Similar rocks were soon found on all the parts of Gondwanaland, including Australia, South Africa and Antarctica. How glaciers could have extended over an entire hemisphere, mostly occupied by ocean, puzzled geologists for decades. Like Sclater's lemurs, these rocks were too similar to be so far apart.

"The map that changed the world": William Smith's great map of 1815.

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By contrast, at the same time Alfred Russel Wallace, who was travelling to feed the appetite for exotic beasts, discovered animal species that were too different to be so close together. Why was the fauna of Eurasia suddenly replaced by that of Australasia across the narrow strait between Bali and Lombok? An invisible line between these islands delineated two great faunal realms. How was this so? The correct answer was the same — lateral motion of continents. But all these facts, won by empire and trade, would lie waiting through two world wars before scientists would get the tools needed to understand them.

Rules of law

Rules, names and boundaries are effective means of colonization, and the Victorians mapped and codified everything they could get their hands on. Charting the world and naming its sounds and mountains are acts of possession, which efface indigenous history. Victorian geologists, for their part, set about conquering and colonizing the past. The Cambrian, Ordovician, Silurian and Devonian periods were all named after localities in the United Kingdom (or their pre-Roman inhabitants). Although the Permian was named after the Russian city of Perm, it had been identified by Roderick Impey Murchison, on his imperially sponsored 'geologizing' campaign across Russia. The names of the Tertiary epochs — Palaeocene, Eocene, Miocene and so on — were coined by University of Cambridge polymath William Whewell. 'Carboniferous' was just a fancy way of saying 'coal measures'. Barring a few French interlopers (Jurassic and Cretaceous), the British parcelling of time was effectively a result of imperialism.

War footings

Imperial concerns provided the world with the main driver for geological exploration throughout much of the twentieth century — the oil and gas industry. Until the British Empire's trade was threatened by the rise of imperial Germany, oil had been a cottage industry. It was Winston Churchill who put it on a war footing and set it on the road to greatness, during the First World War.

The great dreadnought battleships were coal powered, because other fuels would have needed to be sourced abroad. But the disadvantages were starting to outweigh the advantages. Coaling could only be done in port; it was filthy, exhausting and required huge numbers of stokers. Oil, by contrast, had a larger calorific value. Ships could travel farther and faster on smaller boilers, and they could refuel at sea. The Royal Navy needed more efficient ships, and that was that.

Where was the oil to come from? The British government sent a delegation to the Gulf. Two companies took the lead: the Anglo-Dutch company Royal Dutch/Shell, and the Anglo-Persian Oil Company, a much smaller firm that was the forerunner of BP. Eventually, the UK government took a 51% share in the Anglo-Persian Oil Company and appointed two members to the board — so began the industrial–military complex. Geology is, of course, vital to war — sediment sampling in preparation for the Normandy landings is a famous example of heroism in the Second World War. But the two world wars, through the boost they gave to the British oil industry, did more for Earth science than anything else had done.

The benefits of bringing the resources of a cash-rich, highly capitalized industry to bear on geoscientific problems cannot be overestimated. The cutting edge of geoscientific thinking moved towards industry, which — with its facilities and intellectually adventurous environment — drew many of the best brains out of academia. Oil companies could not help but become geological institutes. As Wallace Pratt, a founder of the American Association of Petroleum Geologists (AAPG), was soon to say, "Oil is found in the minds of men".

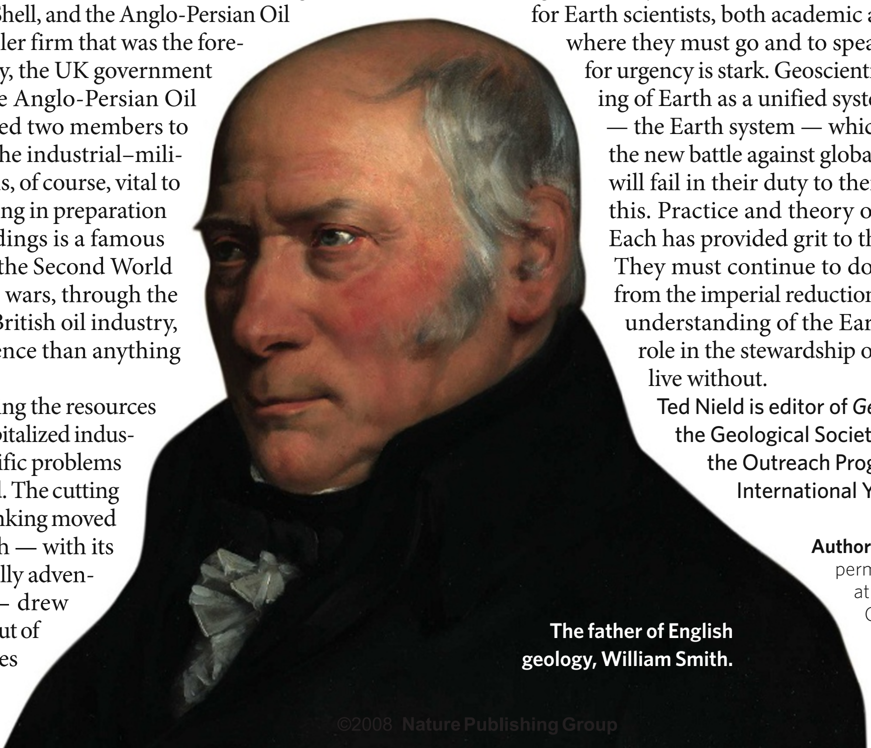
The AAPG — currently the world's largest professional geological society — also backed Alfred Wegener's hypothesis of continental drift, at a time when the United States was the greatest bastion of anti-continental-drift thought. In 1926, Willem van Waterschoot van der Gracht, who had left Europe after being dismissed by Shell and was also an AAPG founder, convened a scientific meeting to discuss continental drift, putting the fledgling organization's reputation on the line. On North American shores, however, van der Gracht found himself a lone 'drifter'. This European idea was almost universally condemned, to the extent that van der Gracht had to commission extra 'pro-drift' contributions from people who were not at the meeting and had to write a pro-drift commentary that took up 43% of the published volume. This report marked the establishment of a beachhead of progressive thought in the United States, with immense implications for hydrocarbon exploration, and it eventually paved the way for the reality of continental drift to be confirmed by the geophysicists who had formerly been most vociferously against it.

The conversion of geophysicists to continental drift came about because, as a result of the Second World War, they discovered the most convincing proof that any scientist can find — evidence from their own field. Suddenly, geophysical objections (which had largely centred on the assertion that there was no adequate mechanism) evaporated. During the First World War, the picture of the topography of the sea floor had been greatly improved by the introduction of echo-sounding devices. The ruggedness of the sea floor came as a surprise, as did the continuity of the Mid-Atlantic Ridge. But greater surprises lay in store. Magnetic surveys carried out in the years after the Second World War, using magnetometers adapted from airborne submarine detectors, began to find magnetic variations. It was these 'zebra stripes', symmetrically positioned across the axis of the worldwide mid-ocean ridge system, that finally convinced almost all geoscientists that the oceans were young and expanding (F. J. Vine and D. H. Matthews *Nature* **199,** 947–949; 1963). Continental drift became plate tectonics. Barely 150 years after the formation of the Geological Society of London, the much-despised ditchers had arrived at the Grand Unifying Theory of their field.

Science and profession

The coincidence of a rash of unifying events in 2007–2008 — the United Nations International Year of Planet Earth, International Heliophysical Year, International Polar Year, Electronic Geophysical Year and the Geological Society of London's 200th birthday — provides opportunities for Earth scientists, both academic and professional, to see clearly where they must go and to speak with one voice. The reason for urgency is stark. Geoscientists have a unique understanding of Earth as a unified system of interacting components — the Earth system — which they must communicate. In the new battle against global climate change, geoscientists will fail in their duty to their fellow citizens if they fail in this. Practice and theory owe each other an equal debt. Each has provided grit to the other's oyster for 200 years. They must continue to do so, as geoscientists move on from the imperial reductionist past, apply the new holistic understanding of the Earth system, and have a proper role in the stewardship of a planet that humans cannot live without. ■

Ted Nield is editor of *Geoscientist*, the magazine of the Geological Society of London, and chair of the Outreach Programme Committee for the International Year of Planet Earth.



GEOLOGICAL SOCIETY OF LONDON

The father of English geology, William Smith.

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