Miscellaneous commentary

Bicentenary of the first national geological map (*January 2015*)

It's good to know that the geosciences have had revolutionising developments to match those of the rest of science. Forget the Battle of Waterloo in 1815, which of course was '*the nearest-run thing you ever saw in your life*' when the Brits were saved from defeat by the timely arrival of the Prussians: This year we can celebrate one that literally put geology on the map, kicked-off the systematic exploration for every kind of physical resource, thereby putting a great deal of money in the pockets of coal, petroleum and metal moguls and making geology a career rather than a pastime. In 1815 William Smith published *A Delineation of the Strata of England and Wales with part of Scotland*, which despite the title was a map showing the basic geology and structure of the whole of England and Wales: the first ever map showing accurately the distribution of rocks for an entire country. The original, at 2.6 by 1.8 m, dominates the main staircase at Burlington House, the home of the Geological Society of London.

William Smith's A Delineation of the Strata of England and Wales with part of Scotland (1815)

Tom Sharpe has nicely summarized the key facts surrounding Smith's masterpiece (Sharpe, T. 2015. The birth of the geological map. *Science*, v. **347**, p. 230-232; DOI: 10.1126/science.aaa2330). One feature that I certainly did not know was that the colour scheme for the different stratigraphic units was based on the dominant colour of the rocks themselves, such as purples for the abundant slates of the Lower Palaeozoic, brown and red for the Old- and New Red Sandstone, greys and blacks for the Coal Measures and green for

the Greensand, which until quite recently remained widely used to signify Cambrian, Ordovician and Silurian; Devonian and Permian; Upper Carboniferous and Cretaceous.

Although celebrated today, Smith's map was panned by the gentlemen geologists of the Geol Soc, who attempted to do a better job, but failed ignominiously. William Smith was not a leisured chap of the Enlightenment, but worked for a living surveying coal mines, navigating canals and draining fens. Despite their antipathy, the Fellows of the Geological Society of London knew a good earner when they saw one and plagiarized Smith's work and undercut his regular price for his map. As a result he ended up in a London debtors' prison. Even on the day of his release in 1819, bailiffs seized his house and its contents. The Geol Soc eventually did honour Smith with its Wollaston Medal in 1831, its then president Adam Sedgwick dubbing him 'the Father of English Geology': by that time geology had become a profession…

Bibliometrics: the numbers game (*January* 2015)

In mid-December, British universities, their constituent units and departments, and most academics experienced the same kind of traumatic day familiar to 18-year olds awaiting the examination results on which their advancement to higher education, or not, depended. December 18th, 2014, was REF-Day. Since its predecessor (RAE-Day), 8 years before, a vast – by university standards – effort went into preparing bids on a department-by-department basis to rank them nationally and conflate individual assessments to build a sort of institutional league table for research excellence; hence REF stands for Research Excellence Framework (the RAE was the less meritorious-sounding Research Assessment Exercise). It resembled the Guide Michelin or Automobile Association star system for restaurants and hotels or guest houses. The reason for the 8-year frenzy of activity was that the outcomes aimed to inform the selective allocation of governmental research funding. Unsurprisingly, this kind of competition stemmed from the Tory government of Margaret Thatcher, which in 1986 set the scene for 'performance-related' funding rather than that based on peer review of each individual bid for major grants, which preceded it.

To itemise each aspect of the way the REF worked could take the majority of Earth Pages readers to an early and ignoble grave. It centred on departmental selection from its full-time researchers of those who were deemed to be 'research active' and those who were not, the former having to select four recently published works or 'outputs'. They had to self-assess each according to its 'impact', defined as '*an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia*'. Institutions vetted and bundled individual submissions, collated them in the subject areas designated by the REF, then sent them off to 'REF Central', where they were to be reviewed by subject-specialist panels that gave out the stars for each submitted item of work: **** = world-leading (30% were deemed to be); *** = internationally excellent (46%); ** = recognized internationally (20%); * = recognized nationally (3%); unclassified = below the standard of national recognition (1% – presumably those obviously lacking star quality were weeded out at institution level). There were more than 190 thousand 'outputs', which begs the questions; Were all of them read by at least one specialist panel member? Against what standards were they judged?

On average, each of the roughly 1000 panelists would have had to consider about 190 outputs in greater depth than a casual skim, or more if some were read by several panelists.

Outputs were rated '*in terms of their "originality, significance and rigour", with reference to international research quality standards*', '*the "reach and significance" of impacts on the economy, society and/or culture*' and the part they played in their department's contribution to '*the vitality and sustainability… of the wider discipline or research base*'. On paper – and believe me, REF Central produced plenty of wordy PDFs of guidance – this level of scrutiny makes the adjective 'daunting' seem a bit of an understatement. Entering into this spirit of things in the gleeful manner of a Michelin or AA assessor does seem to me a bit hard to grasp. I wonder if the panels in reality just checked each submission for signs of an overly hubristic vision of self-worth.

To some extent, the issue of each output's citation count or other bibliometric measure must at some stage have come into REF reckoning, and here is what spurred me to defy normal cautions about boredom as a contributor to general organ failure. Physicist Reinhard Werner of Leibniz University in Hanover, Germany believes that deciding on funding and hiring, or firing, needs to steer well-clear of impact factors, citations and other kinds of bibliometrics (Werner, R. 2015 The focus on bibliometrics makes papers less useful. *Nature*, v. **517**, p. 245). Scientists cite other works for many reasons, some worthy and some less so. But it is rare that in doing so we express any opinion on the overall significance of the work that we choose to cite. Yet, conversely, a researcher can choose a field, phrase some findings and submit to such and such journal that will boost their citation frequency and impact. Just by writing about some mundane topic in a publicly accessible way, reviewing the work of lots of other people, or simply writing about this or that topic as observed or measured in an especially highly populous country where science is really booming does much the same thing. Werner makes a telling point, 'When we believe that we will be judged by silly criteria, we will adapt and behave in silly ways'. Although he does not touch on the absurdities of the REF – why on Earth would he? – Werner comments on distortion of the job market, and peer-reviewed journals. He also pleas for a return to proper scrutiny of scientific merit and, I suspect, for cutting hubris off at the roots.

Related articles: Struggle for top research grades fuels bullying among university staff (The Guardian); Anthem for Doomed Academics (Telescoper blog) Against Excellence (The Guardian)

Anthropocene: what (or who) is it for? (*March 2015*)

The made-up word chrononymy could be applied to the study of the names of geological divisions and their places on the International Stratigraphic Chart. Until 2008 that was something of a slow-burner, as careers go. It all began with Giovanni Arduino and Johann Gotlob Lehman in the mid- to late 18th century, during the informal historic episode known as the Enlightenment. To them we owe the first statements of stratigraphic principles and the beginning of stratigraphic divisions: rocks divided into the major segments of Primitive, Secondary, Tertiary and Quaternary (Arduino). Thus stratigraphy seeks to set up a fundamental scale or chart for expressing Earth's history as revealed by rocks. The first two divisions bit the dust long ago; Tertiary is now an informal synonym for the Cenozoic Era; only Quaternary clings on as the embattled Period at the end of the Cenozoic. All 11 Systems/Periods of the Phanerozoic, their 37 Series/Epochs and 85 Stages/Ages in the latest version of the International Stratigraphic Chart have been thrashed out since then, much being accomplished in the late 19th and early 20th centuries. Curiously, the world body

responsible for sharpening up the definition of this system of 'chrononymy', the International Commission on Stratigraphy (ICS), seems not to have seen fit to record the history of stratigraphy: a great mystery. Without it geologists would be unable to converse with one another and the world at large.

Yet now an increasing number of scientists are seriously proposing a new entry at the 4th level of division after Eon, Era and Period: a new Epoch (see *Epoch, Age, Zone or Nonsense* March 2008) that acknowledges the huge global impact of human activity on atmosphere, hydrosphere, biosphere and even lithosphere. They want it to be called the Anthropocene (see *A sign of the times; the 'Anthropocene* May 2011). For some its eventual acceptance ought to relegate the current Holocene Epoch, in which humans invented agriculture, a form of economic intercourse and exchange known as capital and all the trappings of modern industry, to the 5th division or Stage. Among others, I have been muttering darkly about the Anthropocene for the past decade. Last week things became sufficiently serious for another comment. Simon Lewis and Mark Maslin of the Department of Geography at University College London have summarised the scientific grounds alleged to justify an Anthropocene Epoch and its strict definition in a *Nature* Perspective (Lewis, S.J. & Maslin, M.A. 2015. Defining the Anthropocene. *Nature*, v. **519**, p. 171-180; DOI: 10.1038/nature14258), which is interestingly discussed in the same Issue by Richard Monastersky.

Lewis and Maslin present two dates that their arguments and accepted stratigraphic protocols suggest as candidates for the start of the Anthropocene: 1610 and 1964 CE, both of which relate to features that are expressed by geological records that should last indefinitely. The first is a decline and eventual recovery in the atmospheric CO_2 level recorded in high-resolution Antarctic ice core records between 1570 and 1620 CE that can be ascribed to the decline in the population of the Americas' native peoples from an estimated 60 to 6 million. This result of the impact of European first colonisation – disease, slaughter, enslavement and famine – reduced agriculture and fire use and saw the regeneration of 5×10^7 hectares of forest, which drew down CO_2 globally. It also coincides with the coolest part of the Little Ice Age from 1594-1677 CE. They caution against the start of the Industrial Revolution as an alternative for a 'Golden Spike' since it was a diachronous event, beginning in Europe. Instead, they show that the second proposal for a start in 1964 has a good basis in the record of global anthropogenic effects on the Earth marked by the peak fallout of radioactive isotopes generated by atomic weapons tests during the Cold War, principally ^{14}C with a 5730 year half life, together with others more long-lived. The year 1964 is also roughly when growth in all aspects of human activity really took off, which some dub in a slightly Tolkienesque manner the 'Great Acceleration'. [There is a growing taste for this kind of hyperbolic trope, e.g. the 'Great Oxygenation Event' around 2.4 Ga and the 'Great Dying' for the end-Permian mass extinction]. Yet they neglect to note that the geochronological origin point for times past has been defined as 1950 CE when nucleogenic ^{14}C contaminated later materials as regards radiocarbon dating, which had just become feasible. Lewis and Maslin conclude their Perspective as follows:

> *To a large extent the future of the only place where life is known to exist is being determined by the actions of humans. Yet, the power that humans wield is unlike any other force of nature, because it is reflexive and therefore can be used, withdrawn or modified. More widespread recognition that human actions are driving far-reaching*

changes to the life-supporting infrastructure of Earth may well have increasing philosophical, social, economic and political implications over the coming decades.

So the Anthropocene adds the future to the stratigraphic column, which seems more than slightly odd. As Richard Monastersky notes, it is in fact a political entity: part of some kind of agenda or manifesto; a sort of environmental agitprop from the 'geos'. As if there were not dozens of rational reasons to change human impacts to haul society back from catastrophe, which many people outside the scientific community have good reason to see as hot air on which there is never any concrete action by 'the great and the good'. Monastersky also notes that the present Anthropocene record in naturally deposited geological materials accounts for less than a millimetre at the top of ocean-floor sediments. How long might the proposed Epoch last? If action to halt anthropogenic environmental change does eventually work, the Anthropocene will be very short in historic terms let alone those which form the currency of geology. If it doesn't, there will be nobody around able to document, let alone understand, the epochal events recorded in rocks. At its worst, for some alien, visiting planetary scientists, far in the future, an Anthropocene Epoch will almost certainly be far shorter than the 10^4 to 10^5 years represented by the hugely more important Palaeozoic-Mesozoic and Mesozoic-Cenozoic boundary sequences; but with no Wikipedia entry.

Not everybody gets a vote on these kinds of thing, such is the way that science is administered, but all is not lost. The final arbiter is the Executive Committee of the International Union of Geological Sciences (IUGS), but first the Anthropocene's status as a new Epoch has to be approved by 60% of the ICS Subcommission on Quaternary Stratigraphy, if put to a vote. Then such a 'supermajority' would be needed from the chairs of all 16 of the ICS subcommissions that study Earth's major time divisions. But first, the 37 members of the Subcommission on Quaternary Stratigraphy's 'Anthropocene' working group have to decide whether or not to submit a proposal: things may drag on at an appropriately stratigraphic pace. Yet the real point is that the effect of human activity on Earth-system processes has been documented and discussed at length. I'll give Marx the last word in this 'The philosophers have only *interpreted* the world, in various ways. The point, however, is to *change* it'. A new stratigraphic Epoch doesn't really seem to measure up to that…

A certain shyness about research misconduct in the UK (*May 2015*)

Since Earth Pages was launched at the start of the 21st century there have been highly publicised cases of gross academic misconduct by researchers, including plagiarism, 'massaging' data and even sabotaging the work of others, as well as lesser cases where publications were withdrawn or removed from journals. The most notorious have been from the USA, Japan, the Netherlands and a number of other advanced countries. But sharp practices in science are not well known in the UK; indeed I can't recollect more than one case that reached the same degree of coverage as the most notorious instances. Yet, in 2009, Daniele Fanelli of the University of Edinbugh reported the results of her analysis of accessible information from the UK about this matter. She found that about 2% of British scientists, who had been interviewed or answered questionnaires, answered 'Yes' when asked if they ever fabricated or falsified research data, or if they altered or modified results to improve the outcome. Up to one third admitted other questionable practices or knew of

them having been committed by colleagues. Fanelli doesn't refer to more grievous matters such as sabotage or exploitation of students' work.

The silence from British Universities on research misconduct has become such an embarrassment that it was a subject of an Editorial and a News In Focus Report in the 21 May issue of *Nature*. While there are guidelines that urge British universities to publish annual reports of their investigations into misconduct, for 2013-14 only 12 such reports have been published: of the 88 universities contacted by the informal UK Research Integrity Office, 30 institutions responded to UKRIO's survey. These reports covered 21 investigations, mostly unspecified, with 5 cases of plagiarism, 2 of falsification, 2 concerning authorship, 1 of fabrication and 1 breach of confidentiality. Three were upheld and 3 are pending.

These figures speak loudly for themselves: misconduct by researchers (and academics in general) is something about which the halls of British academe are shy. As the author of UKRIO's survey observed, 'It's just not credible', although many of the universities that she contacted claim that such reports were in progress. A likely story… We all know that the 'filthy snout' (Tom Wolfe *The Bonfire of the Vanities*) does 'come popping to the surface', but is buried in confidentiality by university Research Committees, leaving any victims dangling in a sorry psychological state and allowing journals' peer review system to catch any perpetrators before they reach the press, which it is rarely able to do or even tries to. It takes a case as severe as that of Andrew Wakefield's fraudulent 1998 paper in the Lancet associating the MMR vaccine with autism to see justice done.

Global Tectonics Centenary: Any Inspiring Papers? (*December 2015*)

Although Alfred Wegener first began to present his ideas on Continental Drift in 1912 his publication in 1915 of *Die Entstehung der Kontinente und Ozeane* (*The Origin of Continents and Oceans*) is generally taken as the global launch of his hypothesis. Apart from support from Alexander du Toit and Arthur Holmes, geoluminaries of the day panned it unmercifully because, in the absence of evidence for a driving mechanism, he speculated that his proposed '*urkontinent*' (primal continent) Pangaea had been split apart by a centrifugal mechanism connected to the precession of Earth's rotational axis. This '*polflucht*' (flight from the poles) is in fact far too weak to have any such influence. Wegener's masterly assembly of geological evidence for former links between the major continents was ignored by the critics, suggesting that their motive for excoriation of his suggested mechanism was as much spite against an 'outsider' – he was primarily a meteorologist – as a full consideration of his hypothesis. It must have been hurtful in the extreme, yet Wegener defended himself with a series of revised editions that amassed yet more concrete evidence. What is often overlooked, even now that his ideas have become part of the geoscientific canon, is that in his initial Geologische Rundschau paper in 1912 he mused that the floor of the Atlantic is continuously spreading by tearing apart at the mid-Atlantic Ridge where 'relatively fluid and hot sima' rises. Strangely, he dropped that idea in later works. Anyhow, neither 2012 nor 2015 was celebrated in the manner of the centenary-and-a-half of Darwin's *On the Origin of Species*: 2009 was marked by palaeobiologists and geneticists metaphorically dancing in the streets, if not foaming at the mouth. There have been a few paragraphs, and some minor symposia about Wegener's dragging geology out of the 18th century and into the 20th, but that's about it. The best centenary item I have seen is by

Marco Romano and Richard Cifelli (Romano, M. & Cifelli, R.L. 2015. 100 years of continental drift. *Science*, v. **350**, p. 916-916; DOI: 10.1126/science.aad6230).

In the shape of plate tectonics the Earth sciences hosted what was truly a revolution in science, albeit 50 years on from its discoverer's announcement. It was through the persistent agitation by his tiny band of supporters, that the upheaval was unleashed when the revelations from palaeomagnetism, seismology and many other lines of evidence were resolved as plate tectonics by the discovery of ocean-floor magnetic stripes by Vine, Matthews and Morley in 1963. Despite an explosion of papers that followed, elaborating on the new theory and showing examples of its influence on 'big' geology , counter-revolutionary resistance lasted almost to the first years of the new century. By then so much evidence had emerged from every geological Eon that opponents looked truly stupid. Even so, the skepticism among those sub-disciplines that were 'left out' of geodynamic thought continued to blurt out with the emergence of other exciting aspects of the Earth's history. I remember that, when three of us in the Open University's Department of Earth Sciences proposed in 1994 that the influence of impacts by extraterrestrial objects ought to figure in a new course on the evolution of Earth and Life we were sneered at as 'whizz-bang kids' by those more earth-bound. Trying belatedly in 1996 to introduce students to another revolutionary development – the use of sedimentary and glacial oxygen isotopes in unravelling past climate change – became a huge struggle in the OU's Faculty of Science. It went to the press eventually and for 2 years our students had the benefit. But the starling-like murmuration of dissent ended with a *force-majeur* re-edit of the course – by someone who had played no role in its development – expunged the lot and changed the 'offending' section back to the way it had been a decade before. As they say: ho hum!

Oddly, in the last 15 years or so of trying to follow in Earth-Pages what I considered to be the most exciting developments in the geosciences, it has become increasing difficult to find papers in the top journals that are truly ground-breaking. Of course that may just be ageing and a certain cynicism that often companies it. From being spoiled for choice week after week it has become increasingly difficult from month to month to maintain the standards that I have set for new work. Has Earth science entered the fifth phase of a 'paradigm shift' predicted by philosopher Thomas Kuhn in his 1962 book *The Structure of Scientific Revolutions*? According to him once a science has entered a period when there is little consensus on the theories that might lie at the root of natural processes there is a drift in opinion to a few conceptual frameworks that seem to work, albeit leaving a lot to be desired. Weaknesses at the frontier between theory and empirical knowledge become increasingly burdensome as a result of the steady plod of 'normal science' until the science in question reaches a crisis. If existing paradigms fail repeatedly, science is ripe for the metaphorical equivalent of a 'Big Bang': maybe an entirely new discovery or hypothesis, or an idea that has been suppressed which new data fits better than any others that have been common currency. Plate Tectonics is the second kind. After the revolution much is re-examined and new lines of work emerge, until in Kuhn's 5th phase scientists return to 'normal science'. That looks like a pretty good story, on paper, but other forces are at work in science; external to scientific objectives. Most of these are a blend of economics, political ideologies and managerial 'practicalities'. If the Earth sciences have entered the doldrums of novelty, I suspect it is these forces that are bearing some kind of glum fruit.

The old concept of academic freedom has gone by the board. Institutions demand that research is externally funded – the more the better as the institution, at least in the UK,

demands a kind of tax (40% of that proposed to the funding body) supposedly to cover corporate overheads including salaries of support staff. If an academic doesn't pull in the dosh, she is not much favoured. If the individual doesn't publish regularly either, there is a weasel sanction: Josephine Soap is declared 'research inactive'. Consortia of researchers are more and more in vogue: managers and funders like 'team players', so individuals who are bright and confident enough to 'stick their necks out' cannot do that in a consortium publication and as often as not are 'left on the bench'. Risk taking is more dangerous now and to stay 'research active', and in many cases of non-tenured posts getting a salary, an individual, even a few like-minded colleagues have to publish 2 or 3 papers a year.

It's worth mentioning that open-access publishing is becoming more or less compulsory. Of course, it has some benefits for scientists in less well-heeled countries, but there is a downside. You have to raise the cash demanded by journals for the privilege of potentially universal access – at least US$1000 a pop, depending on a journal's Impact Factor, and that of course is an odiously essential corporate consideration – and, having done that, woe betide those who spend it and do not publish. Academic publishing is the most profitable sector of the trade, the more so as print is supplanted by electronic delivery – the 50 free reprints is a thing of the past. So there are more and more journals and each of them strives to get out more issues per year, and of course those have to be filled. To me, this all adds up to more and more 'pot-boiler' articles and a tendency to maximise the flesh rendered from the body of research work and into the pot. Taken together with the stresses of commodification in higher education and the now vertical corporate structures from which it is constituted, it shouldn't be a surprise that excitement and inspiration are at a premium in the weekly and monthly output of such a supposedly 'marginal' science as that concerned with how the world works.