Miscellaneous commentary

Geoscience education: a cautionary tale from the Open University (*February 2013*)

Despite global recession, worldwide job opportunities for geoscientists are increasing faster than the number of available applicants. In the US the Bureau of Labor Statistics predicts 21% growth in this sector in 2010-2020 (Perkins, S. 2011. Geosciences: Earth works. *Nature*, v. **473**, p. 243–244; DOI: 10.1038/nj7346-243a). That figure does not include jobs freed-up by retirement: the demographics of employed geoscientists in the petroleum and mining industries are skewed markedly to the over-40s, peaking at age 50.

The American Geological Institute's Geoscience Workforce Program has reported that the regions that produce most geoscience graduates, the US, Europe, Russia and China, are not meeting their domestic needs let alone global requirements. The demand stems from the traditional petroleum and mineral industries that are booming, together with the renewable energy sector and growing concern about environmental hazards and impacts attending global warming.

An editorial (*Rare Earth scientists*) in the December 2012 issue of *Nature Geoscience* is headlined, '*Not enough young people enter the geosciences. A passion for the subject should be sparked early on*.' It then comments that the decline in young people studying the geosciences at school stems from Earth science not being taken seriously, under-education of their teachers and budgetary sacrifice of geoscience to preserve the more 'traditional' science subjects. The leading article concludes, '*On an increasingly vulnerable planet, governments need to teach the young people of their country an understanding of the Earth's basic make-up and dynamics, along with inspiring a fascination for its age and beauty. How else can we expect humanity to survive the Anthropocene?*'

Creative work on the Open University campus (credit: ianonline)

For over 40 years the Open University has been a key UK educator in geoscience. Since 1971 a total of about 170 thousand, mainly British students have studied at home through the OU for a science-based degree. Discovering tectonics, Earth structure, geology and palaeontology through studying the *Science Foundation Course* must have been a thrilling experience because since 1972, when the OU began to offer a level-2 course in *Geology*, around 30 thousand of its science 'beginners' decided to find out more; an average enrolment of 760 per year. The OU's Department of Earth Sciences added more level-2 courses so that by 2000, students could also study economic geology (*The Earth's Physical Resources* – 18 500 students from 1974 to 2009, averaging 544 per year), planetary science (*The Earth: Structure, Composition and Evolution*- 14 100 students from 1981 to 2005, averaging 590 per year) and Earth-system science (*Earth and Life* –7121 students from 1997 to 2006, averaging 712 per year*)*.

After 1981 Open University students could, and many did, aim for a geoscience-oriented degree that also took in three, more advanced, level-3 studies. These were *Oceanography* (12 121 students from 1989 to 2012, averaging 505 per year), stratigraphy (*The Geological Record of Environmental Change* – 7968 students from 1976 to 2012, averaging 295 per year) and Earth's internal processes (*Understanding the Continents* – 6994 students from 1976 to 2012, averaging 259 per year).

In this way the Open University became one of the world's largest single providers of geoscience education, if not *the* largest: in the whole of the United States fewer than 3000 first degrees majoring in geoscience are awarded annually. Yet from its inception the OU's Department of Earth Sciences had never claimed to be training *professional* geologists: had it been, its graduates would have significantly affected the world's employment opportunities in the discipline. In fact that claim could never have been made, for one simple reason: distance learning for part-time students would always struggle to provide the amount of hands-on *practical* training that is the quintessence of this pre-eminently field- and lab-based discipline. Nevertheless the OU's range of residential schools where practical activities were intensively provided for went a good way towards filling this gap.

Open University students at the now defunct Geology summer school, inspecting a fault.

So, to those unfamiliar with the realities of the OU milieu it will seem odd that in 2012 the world's largest provider of distance learning axed all residential courses right across the science spectrum, including those in practical geoscience. But to those directly involved this move was the logical final step in a series of changes since 2001. Before that, for those courses that included a residential component attendance had been compulsory, except in special circumstances. Yet after 2001 university authorities deemed that the residential schools continue only as *optional* components for degree study and should carry an additional registration fee. Not surprisingly, in the case of the core level-2 *Geology* course attendance at the re-branded residential school declined by 70% after 2001.

Two other important developments attended this change in the Earth Science degree programme. After 2001 pass rates fell abruptly. For example, in the *Science Foundation Course* the rate fell from an annual average of 69 to 54%, and in level-2 *Geology* from 65 to 55%. Because residential schools played a vital role in boosting confidence and reinforcing home studies, equally as important as transferring practical skills, this dramatic fall in performance was only too predictable.

The other post-2001 development was an across-the-board fall in new registrants for Earth Science level-2 courses, especially in those that had previously not been served by residential studies: *The Earth: Structure, Composition and Evolution* from a pre-2001 average of 680 registrants per year to 470 thereafter; *Earth and Life* from 866 to 558; *The Earth's Physical Resources* from 795 to 456. The majority of those who enrolled for these courses having previously studied the core *Geology* course such dramatic declines are easily explained. Those who had opted out of the residential course missed its undoubted boost to confidence and enthusiasm, and reinforcement in basic geoscientific principles. More likely to underperform in the *Geology* course, they would not have felt equipped to deal with other level-2 courses, and 'voted with their feet'.

Since its launch, *The Earth's Physical Resources* course had been acclaimed by geoscience teachers internationally for having made economic geology fascinating rather than a chore. In 2005-7 it had been completely refurbished and rising registrations bucked the downward trend. Yet in 2009, it was axed with little discussion. Declining enrolment for *The Earth* and *Earth and Life* course prompted management to withdraw both and combine parts of their content in a single course *Our Dynamic Planet: Earth and Life.* Launched in 2007, by 2012 it attracted a mere 217 applicants. In 2013 it too will be withdrawn from the curriculum.

In late 2010 the OU's Department of Earth Sciences held a celebration of its 40-year existence; yet only a year later in 2011 the department, which had brought plate tectonics, advanced palaeontology, unravelling past climates, physical resources; planetary science and much besides to the widest student audience ever achieved, ceased to be. It was merged into a restructured entity called the Department of Environment, Earth and Ecosystems. There seems to have been a failure of nerve and leadership that may have important consequences not only for the future of geoscience as a discipline and among the wider public but for the very knowledge necessary for our national and human survival. The future availability of remaining geoscience courses is uncertain, with all being expected to start for the last time within the next year or two. Perhaps some major transformation to meet increased needs for general public awareness of the way our planet works is being planned – let's hope so – and that any new offerings have as much impact as the earlier courses did before the start of the 21st century. It will be a hard task, as the Open University tripled its fees for students entering the OU system from 2012 onwards.

NOTE: (added 11 February 2013) The Open University has been offered the right of reply to this item.

Related articles: Open University under threat by Nick Rogers in *The Geoscientist* November 2012 issue; Geology is Going Digital and Getting Way More Fun (onlinecollege.org);

Geology and creationism (*February 2013*)

Creationist car in Athens, Georgia (credit: Amy Watts)

Creationism is a topic about which I would not normally comment for much the same reason that once prompted pub landlords to have a sign behind the bar reading 'No politics, no religion'. Yet geology has played an historically central role in the debate about Genesis vs Science. An excellent summary of how this emerged and was fundamentally resolved in favour of scientific endeavour, even if the 'Genesisists' have not been entirely rooted out, appeared in the Geological Society of America's GSA Today in November 2012 (Montgomery, D.R. 2012. The evolution of creationism. *GSA Today*, v. **22**, p. 4-9).

Starting with Steno's break with a literal acceptance of Genesis in 1669, the dominant view grew among clerics as well as scientists – 'back in the day' often one and the same – that the Earth was far older and its history one of changing natural processes. That outlook prevailed to strengthen through the late-18th and 19th centuries. Of course there was a tendency among 'people of the Book' somehow to blend their religious and scientific views, along the line that 'scientific revelations that contradicted biblical interpretations provided natural guidance for better interpreting scripture'. But by the end of the 19th century there were very few literal creationists though a great many Christians who endorsed attempts to reconcile biblical text and geology. Yet long after the Reverend William Buckland finally admitted in the mid-19th century that his imagination had ruled his zealous quest for evidence of a Noachian Flood and abandoned a literal idea of that and other aspects of Genesis there remained a persistent dribble of creationism.

A wry view of Young-Earth Creationism (credit: seriouscher)

That minor current split in the 20th century into a 'tanky' tendency that defended young-Earth creation and a global flood in the last ten thousand years, and a more 'moderate' wing of 'old-Earth' creationists. 'Old-Earthers' happily accept geological evidence of great antiquity, but maintain that God made it for eventual use by humanity; i.e. it had just sat around awaiting Adam and Eve being expelled from Eden. Both wings evolved along equally bizarre paths using a logic that boils down to a blend of perversity and simply ignoring any contrary evidence, such as that unearthed by Buckland long before. For instance when confronted by the fact that the deepest parts of the oceans contain less sediment than has accumulated on the continents, they defy gravity by insisting that ocean basins were eroded out by the Flood and then deposited with all their internal structures intact on higher ground.

Unsurprisingly, most creationists believe that there has been a centuries-long conspiracy by scientists to mislead the rest of humanity. Were it not for the fact that more than 40% of people in the United States believe in young-Earth creation, David Montgomery's account of what is now a somewhat one-sided yet stupidly lively debate as regards true evidence would be amusing. His concluding sentence, 'How many creationists today know that modern creationism arose from abandoning faith that the study of nature would reveal God's grand design for the world?' is probably one of the best ways of enraging any creationist who tries to enlighten you: he/she will certainly not just go away, but in the mouth foam they generate you should be able to make good your escape.

Related articles: Creationism vs. Evolution: Ground-Breaking Discovery by Physics Engineer Solves Vital Facet of Origins Debate. (prweb.com); NO! Christians do NOT believe the Earth is 5,000 years old! (mbtimetraveler.com)

The Time Lords of Geology

Because it is the ultimate historical discipline, the essence of geology centres on time, measuring its passage and establishing correlations in time on a global scale so that an interlinked story of Earth evolution can be told. In fact geology is not just about a record of what happened in the four dimensions of place and time; it is a great deal more multidimensional, involving temperature, strain, chemistry, erosion, deposition, sea-level , the course of life and much more besides. Ever more multifaceted and, sadly, divided into subdisciplines and interfaces with other aspects of natural science that few if any individuals can grasp, an almost legally enforceable set of rules is needed to keep the order orderly. Unlike history and more akin to archaeology geological time is of two kinds, its precisely quantitative measure being a relative newcomer.

Time Lord, possibly outside the offices of the International Commission on Stratigraphy (credit: Sorcyress via Flickr)

Since it emerged in the Enlightenment that began in the late 17th century geology has been dominated by a *relative* sense of timing: Steno's Law of Superposition, and those relating to deformation, igneous eructations, erosion and deposition, first addressed systematically by James Hutton, being the most familiar. The notion of an *absolute* time scale into which events separated relative to one another could be fitted with confidence is a real latecomer. Although first attempted between 1650 and 1654 by Archbishop of Armagh James Ussher – he reckoned from the Old Testament that everything began at dusk on Saturday 22 October 4004 BCE – the only useful and broadly believable approach to absolute time has been based on the decay of radioactive isotopes incorporated into minerals once they had formed within a rock. But that is no panacea for the simple reason that most of them form

through igneous or metamorphic processes and only rarely in the course of sedimentation. It also has only become reliable and precise in the last two or three decades.

Tying together global records of all the kinds of process that have made, shaped and changed the Earth has therefore become an increasingly complex blend between local relative dating, burgeoning regional to global means of correlation and the odd point in absolute time. What has arisen is a dual system that, if truth were told, is often used in a cavalier fashion. Equally to the point, the rules have of late become unfit for purpose and are in need of revision, which is a task for the Time Lords, properly known as the International Commission on Stratigraphy (ICS). The trouble is, the rules have themselves evolved somewhat episodically while their subject is appropriately in continual motion and change, if not anarchic. To the outsider things can seem very odd indeed. Most reasonably well-read souls will have heard of the Cambrian and the Jurassic, largely because of the popularity of trilobites that blossomed in the one and dinosaurs that strutted the land in the other. What is less well known is that the two names have different usages as adjectives: one to signify an interval of time called a Period, the other a System of essentially piled-up sedimentary rocks.

There are greater dualisms that group the Period/System divisions: the largest Eon/Eonothem groupings of Archaean, Proterozoic and Phanerozoic; the Era/Erathem signifiers such as Palaeoproterozoic, Mesozoic and Cenozoic. Incidentally, the time between the formation of the Earth and the first palpable rocks, from about 4550 to 4000 Ma, has been called the Hadean but has no designated status, possibly because it has no rock record whatsoever. Divisions of Periods/Systems apply only to the time since fossils became abundant 541 Ma ago, and in order of fineness of division are Epoch/Series and Age/Stage. Example of the first can be Lower, Middle and Upper – to spice things up, Middle maybe omitted from some Periods/Systems – or they might be given names derived from type areas, such as the ever popular Llandovery at the base of the Silurian Period/System. Helpfully, the Cambrian contains Terreneuvian, Series 2, Series 3 and Furongian from early to late/bottom to top. The final global division has always floored undergraduates and shows little sign of relief – there are a great many Ages/Stages, in fact a round 100 (I may have miscounted), 98 with names, 2 currently unnamed and 4 in the Cambrian called Stages 2 to 5: confusing, that… has anyone spoken of the Stage 3 Stage or the Stage 5 Age of the Cambrian?

Worryingly, in my hasty overview of the ICS International Stratigraphic Chart above I have reversed the official designation of chronstratigraphic/geochronological nomenclature: is this likely to have me committed to the geoscientific equivalent of Guantanamo Bay, or merely limbo?

I have by no means exhausted officialise. Readers may not be surprised to learn that the Time Lords have bent Heaven and Earth literally to concretise the *double entendre*s of geology. The base of almost every Age/Stage in the Phanerozoic Eonothem/Eon is defined at a suitably agreed point on the ground by, in a few cases, a real golden spike (I may be mistaken on this, as the only one I tried to visit was at the base of a Welsh cliff suitable only to be visited by – in the timeless phrase – ‘a strong party’). More prosaically there are monuments of various ethically appealing designs that go by the sonorous name Global Boundary Stratotype Section and Point. I have it on reasonably good authority that ICS delegates have, on occasion, needed to be physically restrained from fist fights over which nation shall host a particular GSSP (the ‘B’ in the acronym is aspirated).

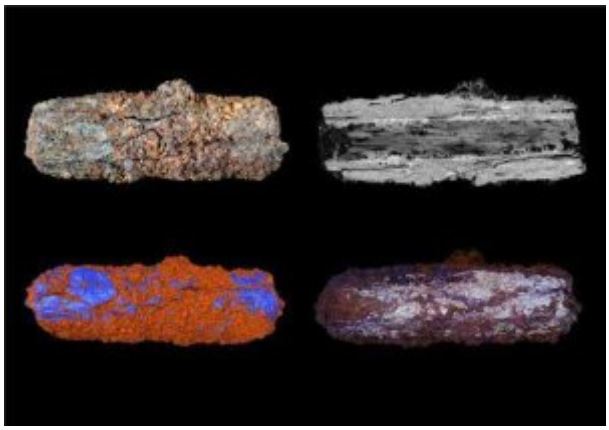
This is the point that all readers will have been waiting for: it has been suggested to ICS that the whole edifice is looked at very closely and perhaps revised (Zalasiewicz, J, *et al*. 2013. Chronostratigraphy and geochronology: A proposed realignment. *GSA Today*, v. **23** (March 2013), p. 4-8). For professionals this is an obligatory read, for others optional: there is no excuse as it is downloadable for free – click on the title. While you are about it, you can also download from GSA Today the famous proposal for an entirely new series/epoch called the Anthropocene (see also A sign of the times: the 'Anthropocene' May 2011).

Bling from space (*May 2013*)

People have a keen eye for unusual objects and an even keener one for the aesthetic. Fossil echinoderms with their five-fold starry shape have been enduringly popular as trinkets since the Palaeolithic. Astonishingly, the gravel terrace at Swanscombe that yielded skull fragments of 400 ka *Homo erectus* plus many Acheulean tools also contained a flint bi-face 'hand axe' with a near perfect echinoid in its blunt grip. It cannot be proven, but the object seems to refute the idea that an artistic sense only arose with anatomically modern humans in the last 100 ka. Our immediate ancestors of the Neolithic sometimes took collecting to extremes in graves half full of fossil sea urchins (McNamara, K.J. 2007. Shepherds' crowns, fairy loaves and thunderstones: the mythology of fossil echinoids in England. In: Piccardi, L. & Masse, W.B. *Myth and Geology*. Geological Society, London, Special Publication **273**, 279–294; DOI: 10.1144/GSL.SP.2007.273.01.22).

Before the invention of metal smelting native gold, iron and copper appear in the archaeological record, undoubtedly because they look and indeed feel so different from the usual pebbles on the beach or just lying around. It is just that element of the odd that continues to draw people, including scientists, into a perpetually stooped posture when the walk across surfaces scattered with pebbles and boulders. The habit is especially hard to shake off for the meteoriticist whose hunting grounds are desert plains and ice caps where oddities are easy to spot, even when rare. So it is interesting when such dogged searchers encounter evidence of long-dead people having done much the same.

By 5300 years ago people had settled in small farming communities in the Nile Valley eventually to develop on the shores of lake – now represented by several smaller water bodies – what is regarded as the world's first city near modern Faiyum. These Predynastic people buried their dead nearer to the Nile at Gerzeh, often sending them off with grave goods. The site has been continually excavated by professional archaeologists for more than a century, beginning with Sir Flinders Petrie. Two of the graves contained metallic iron beads, which presented a puzzle as iron smelting is only known from the 6th century BCE onwards. Unsurprisingly, the beads came to be regarded as artefacts wrought from an iron meteorite, though their highly altered nature and intrinsic value thwarted attempts at full analysis. Geochemists from the Open and Manchester Universities, and the Natural History Museum have now resolved the issue (Johnson, D. *et al*. 2013. Analysis of a prehistoric Egyptian iron bead with implications for the use and perception of meteorite iron in ancient Egypt. *Meteoritics and Planetary Science*, v. **20**, p. 997-1006; DOI: 10.1111/maps.12120). Non-destructive electron microscopy and X-ray tomography reveal, respectively, clear signs of the banded Widmanstätten structures and traces of nickel-rich iron alloy (taenite) that typify iron meteorites but are absent from smelted iron. The beads were clearly beaten and rolled into shape, but this working did not destroy the tell-tale evidence of their origin.



Optical, microprobe and CT-scan images of Predynastic iron bead from the Nile Valley (credit: Open University)

This provenance tallies with the appearance in early New Kingdom hieroglyphs of the term biA-n-pt – literally iron-from-the-sky – which was adopted for smelted iron when first made in the 26 to 27th Dynasties. But pharaonic iron was not a poor relation of gold, regarded as flesh of the gods and hence featuring in the masks of Pharaohs such as Tutankhamen, but supposedly what their bones were made from.