The Edinburgh Geologist

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Cover Illustration

Early Carboniferous volcanic rocks at Seacliff Harbour, North Berwick, East Lothian. In the foreground are tuffs from the lower part of the Garleton Hills Volcanic Formation (Strathclyde Group), with the associated volcanic plug of the Bass Rock in the background.
BGS photograph P001097

Acknowledgements

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Back to the Moon and on to Mars — conspiracies notwithstanding — with a few last words on 2009 and a vote of thanks.

An editorial ramble by Phil Stone

The Charles Darwin anniversaries rather overshadowed any other event that had the misfortune to deserve celebration last year. So in this, the first issue of *The Edinburgh Geologist* for 2010, we shall try to make amends to one such worthy endeavour, where the geology was, quite literally out of this world. First, a question for more mature readers: Where were you on 20 July 1969? Probably glued to a small, flickering, black and white television screen watching Neil Armstrong make one small step for [a] man, one giant leap for mankind. Astonishing as it may seem, it is now more than 40 years since the first, Apollo 11, moon landing.

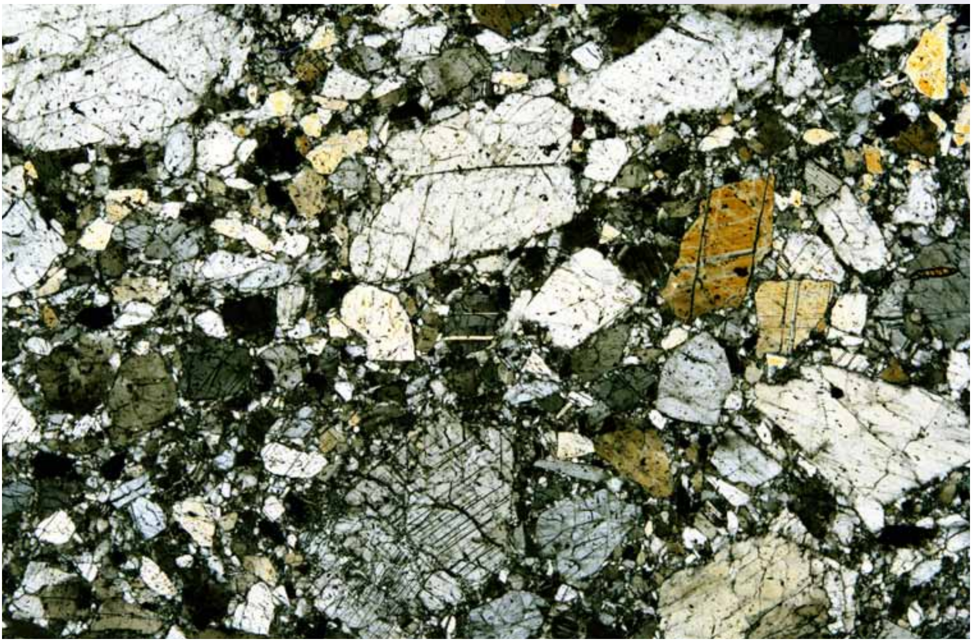
The Apollo 11 mission returned to Earth with 22 kg of lunar rocks and to the surprise of many the moon proved not to be made of primitive, meteoritic material but, instead, was formed of rather similar stuff to the Earth. An even bigger surprise was the ages obtained once the rocks had been radiometrically dated, a process that is still producing refinements as techniques improve. The story that developed was of a collision about 50 million years after the solar system began to form, between Earth and a Mars-sized planet. The resulting debris was thrown into orbit around the Earth and eventually coalesced to form the Moon, which initially was covered in a global magma ocean. A plagioclase-rich crust formed as the magma cooled and solidified, and recently acquired dates on associated zircons date the cooling to 4.417 billion years ago. The plagioclase-rich anorthosite crust was then thoroughly smashed up and reworked by meteorite impacts during the 'late heavy bombardment' of 3.8 to 4 billion years ago, basalt flooded out into the larger craters to produce the lunar mares, and by about 3.5 million years ago things were pretty much all over.

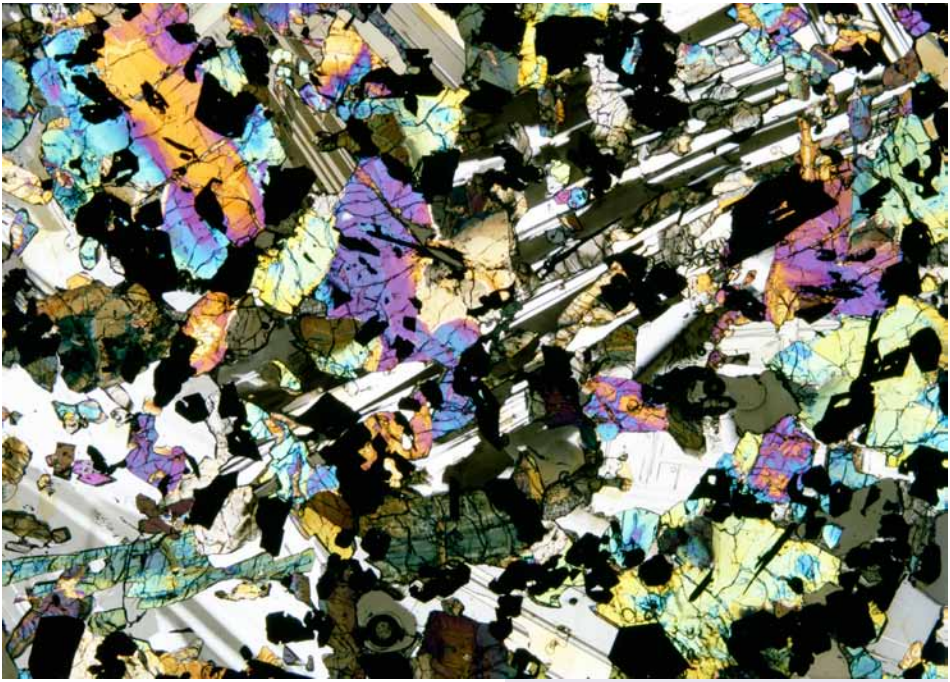
So far, so scientific; with six more Apollo missions, five of which made successful moon landings, you might think that an irrefutable body of evidence had been amassed. But that doesn't take human nature into account, and it was not long before a popular conspiracy theory began to take hold, to the effect that all of the Apollo missions had been faked on a film set in the Nevada Desert. Things seem to have got out of hand after the 1977 Hollywood movie *Capricorn One* which explored just such a premise. By 1999, a Gallup poll found that 6% of Americans—that's about 12 million people—favoured the conspiracy theory. On that basis you can probably guarantee that a couple of million people in Britain also believe that the moon landings were a hoax.

Most of the 'evidence' presented in support of the conspiracy theory hinges on the photographic record of the event and has been thoroughly and repeatedly demolished—for an excellent review I recommend Philip Plait's *Bad Astronomy* (2002) —without, of course, denting the popularity of the CT. Surprisingly though, through all the argument, I've not seen either side make use of the rocks. By the time the Apollo programme ended some 382 kg of lunar rock, comprising about 2 200 numbered samples, had been returned to Earth. Since the rock is real, solid and visible stuff it would, to satisfy the hoax proponents, have to be terrestrial. Could the combination of lithology, texture and age be duplicated on Earth? Not a chance. A couple of thin sections of lunar rocks are illustrated here. One shows the smashed and brecciated anorthosite and the other a mare basalt. It is the pristine freshness of the minerals that is most striking; these rocks have suffered no hydrous alteration for the last 4 billion years (although we now know there is water on the Moon—as ice and trapped in apatite and beads of volcanic glass). So, as a minimum requirement of the conspiracy theory, all of the radiometric ages would have to be faked since terrestrial rocks of similar freshness would be very young, thus requiring collusion by laboratories all over the world. And of course it wasn't just the Apollo missions that recovered lunar rock. It's often forgotten that unmanned Russian probes recovered about 300 grams of the lunar surface material. Not much, but enough to independently confirm the results from the Apollo rocks. Would the Russians have been party to a giant international conspiracy aimed at faking an American moon landing? I rather think not.

Someone once said 'You can't argue with a rock' and that certainly holds for the lunar samples. I remember the excitement when they first went on public display, with long queues at museums where tiny fragments of grey rock were to be seen encased in plastic and displayed behind armoured glass. A little later, once the novelty had worn off, 'educational' packs were available containing encapsulated rock chips and a selection of thin sections. One of these was held by the UK's Natural Environment Research Council and could be borrowed by negotiation with the splendidly named *Solar System Committee Secretariat*; it got even better because their address was Polaris House, North Star Avenue. We arranged a loan to BGS at Murchison House on a couple of occasions and had to have our security arrangements inspected, approval being given to an arrangement whereby the samples were chained up in a large metal box inside the walk-in, fireproof and waterproof—and double-locked of course—archive safe.

A thin section of lunar anorthosite, the plagioclase crystals smashed and brecciated by meteorite bombardment. Apollo 16. Crossed polarisers, approximately x 20.
BGS image PMS 394





A thin section of lunar basalt, mostly intergrown plagioclase, clinopyroxene and ilmenite with some olivine. Apollo 17. Crossed polarisers, approximately x 20.
BGS image PMS 392

Enough of my Apollo reminiscences. The 11 July 1969 was the day that field geology went extra-terrestrial, a feat that is definitely worthy of some commemoration—and with the cancellation of NASA's Constellation project one that seems unlikely to be repeated in the near future. But 1969 didn't just see one moon mission. In the same year the Mariner 7 spacecraft captured the first images of Phobos, one of Mars' two moons. So what could be more appropriate than to consider the next step, with Paul Henney's article on the geology of Mars as a celebration of those Mariner missions. With subsequent advances in remote sensing, unmanned probes and mobile landers complete with in-situ analysis, we now have a wealth of data from the Martian surface—not to mention results from the exhaustive study of the few Martian meteorites that have made it here. We may soon get more. The Russians plan to recover samples from Phobos next year with their Phobos-Grunt mission (I'm told that grunt is Russian for soil). NASA's Mars Science Laboratory should arrive on the planet's surface in 2012, followed by two more rovers in 2018 with the joint NASA-European Space Agency ExoMars mission. Then, pencilled in for launch around 2020–2022, is the Mars Sample Return mission. All of these are unmanned of course and despite their best efforts, somehow I suspect that when the first package of hand-picked rocks arrives back we'll still be in for a few surprises. I certainly hope so – but don't expect the labels to be written in English!

Darwin . . . a post script.

The great 2009 Darwin-fest didn't come to an end when *The Edinburgh Geologist* number 46 went to press, and a couple of local events from the end of the year are worthy of comment.

Our Dynamic Earth put on a good show with a set of hands-on activities aimed at children, all being well used whilst I was there. In the marquee outside, and continuing the theme of *Evolution Revolution*, was staged a short play written by Margaret Hubbard in which Darwin, admirably portrayed by Nick Cheales, explained how he came about his discoveries. Again, the target audience was young, but there was no ducking the serious issues, with a sensitive handling of the science versus religion debate, and a head-on confrontation of the political manipulation inherent in some 'social Darwinism' philosophies: 'survival of the fittest does not mean murder of the weakest'. Great stuff, which I hope reappears, perhaps in this years' Festival Fringe. If it does, go.

Edinburgh University staged two linked exhibitions in the Talbot Rice Gallery: *An Entangled Bank* took its title from the conclusion of Origin of Species and presented the work of five contemporary artists "interpreting the legacy and continuing relevance of Darwinian ideas in art and imagination"; *Darwin's Edinburgh* was a historical examination of his time at the university between 1825 and 1827. Now, I confess to being puzzled by much contemporary artwork and that was certainly the case with *An Entangled Bank*. I wasn't much impressed by the garden shed or the plastic skeleton, and elsewhere was left wondering whether it was the circumstances of exhibition that make something 'art' rather than any intrinsic quality added to the exhibit itself. The work of American artist Ilana Halperin held most promise, claiming as its inspiration the poetic impact of geology. Her work on display arose from field experiences in Hawaii and attempted interpretation, in different media, of lava flow, the creation of new landmass, and geological time. Interesting at least, but I was left wondering whether, if I put on display enlarged copies of my field notes, would I be hailed as a great artist?

Much more to my old-fashioned tastes was the *Darwin's Edinburgh* exhibition. Here was fascinating material contemporary with Darwin's student days, and all the more poignant for being housed in what was then Professor Jameson's natural history museum. Here it was that the young Darwin first encountered the more exotic wonders of the natural world and, more prosaically, learnt how to stuff birds. From the exhibition I learnt that the lower floor of the original museum accommodated a great range of stuffed animals, including the first llama seen in Britain, whilst the upper galleries housed no less than 3000 birds with myriad shells and mineral specimens, and various ethnographic items. No wonder Charles was impressed, and perhaps more importantly was exposed to the possible taxonomies by which this array of creatures could be ordered. Not all of the animals were stuffed either. Apparently, for the first six months of 1827 a live ocelot was kept in a room under the university library and taken for walks by the janitor. Happy days.

Haste ye back

Then of course 2009 was also the year of Homecoming. Geology got a look in with a lecture at *Our Dynamic Earth* by Professor Ian Dalziel, Edinburgh graduate and now at the University of Texas, entitled 'Supercontinents, Scotland and the Scots'. Resplendent in his kilt, Ian laid out the case for geological research and outlined the role that Scottish geologists and the geology of Scotland—overlapping but not coincident phenomena—played in our modern understanding of global tectonics. Hopefully there is still more to come from both categories.

In praise of Alan Fyfe . . . Let's raise a glass of greywacke!

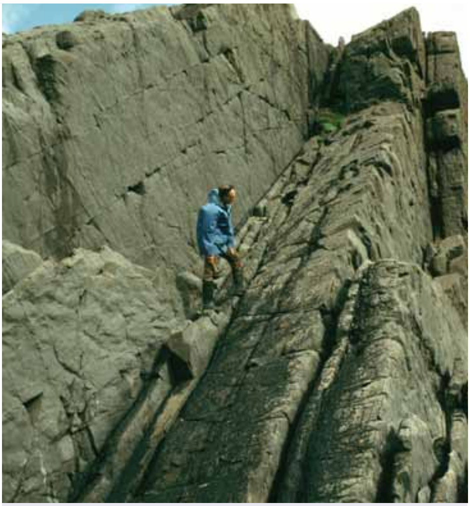
There was one serious omission from the last *Edinburgh Geologist*, and that was a sincere vote of thanks to Alan Fyfe, who had kept the magazine going for many years as editor, contributor, compositor and just about everything else. The current team is beginning to realise just how much effort it all required, and it's only proper that the Society's gratitude to Alan is recorded. It will be hard work sustaining the high standard that he set.

Amongst the several long-running themes that Alan sustained was the series of geologically inspired wine labels. So what better way to celebrate his contribution than with a bottle or two of Sauvignon Blanc—with inspiration from Rose Murray Brown in the Scotsman Magazine last October 24th. She reported developments from the New Zealand wine scene that had resulted in two new SBs: Greywacke and Stonewall. The former name "derives from the hard grey sandstone found everywhere in New Zealand's mountains and rivers". Presumably they use it to make walls as well. Rose provided the following tasting notes:

Greywacke . . . intense lime and passion fruit with vivid acidity and fine length.

Stonewall . . . rich, creamy, vibrant and well-balanced.

Now, what we need are a few second opinions. Any volunteers willing to report on a glass or two? ■



***The editor sampling more conventional greywacke on the Rhins of Galloway.** BGS image P008459*

***Bottoms up! An array of flute and load casts—'bottom structures'—on the underside of a thick greywacke bed.** BGS image P008461*

Salt . . . a rock for winter

One beneficial side-effect of the transport chaos caused by last winter's snowfall was the sudden interest in geology shown by all sections of the media. Everyone wanted to know where the salt spread on the roads—or which should have been spread there—came from. Remarkably, and probably thanks to some good PR by the producers, most of the resulting press cover was more-or-less right. The BBC's web-site was pretty typical, describing rock salt as a brownish gravel dug out of underground mines: the Salt Union's Winsford mine in Cheshire, the Cleveland Potash mine in Teeside, and the Irish Salt Mining and Exploration Company's mine in County Antrim. These mines we were told all exploited deposits formed millions of years ago when parts of the UK and Ireland were covered by inland seas. As the seawater slowly evaporated, vast salty residues were left behind which were then buried beneath subsequent layers of sediment.

Not surprisingly, just about everything we know about the stuff known as halite in geological circles comes from borehole records and underground workings. The deposits are of Permian and Triassic ages, with formation about 275–225 million years ago. Of the Permian deposits, those at Teeside (part of the Zechstein Group) formed in the Zechstein Sea, those in County Antrim (within the Belfast Group) in the Bakevellia Sea; the two marine areas were separated by a proto-Pennines land ridge. The Triassic deposits in Cheshire (part of the Mercia Mudstone Group) seem to be a bit more complicated, with an aeolian origin apparently more likely than formation as *in situ* marine evaporites. Naturally enough 'The Media' didn't get into that debate, but were keen to tell us about the other use of salt mine workings, with their dry environment and restricted access, as sites for secure document storage. If you have a criminal record it could well be deep underground in Cheshire.

Finally, the inevitable piece of comparative statistics: from the Salt Association, via the BBC, we learn that there are about 225 km of tunnels in the UK's salt mines, which makes them cumulatively almost as long as the M5. ■

The Geology of Mars: How the Mariner Missions changed our view of the Red Planet

By Dr Paul J Henney

In a day and age where we can log onto the internet and download the latest images beamed back from Mars it is sobering to remind ourselves just how recent a development this is. Indeed much of our current knowledge of Mars is due entirely to the advent of spaceflight and the dispatch of numerous probes to the Red Planet.

Mars has long fascinated humankind, the waxing and waning of the bright red 'star' as it moved across the heavens being seen as a harbinger of war in early civilisations. With the advent of the telescope more details about the nature of the planet became known. There were seasonal colour variations, polar caps, a thin atmosphere, hints of clouds and possibly even artificial channels constructed by 'Martians'. The ambiguity surrounding interpretations of some of the telescopic features of Mars led to a wide range of theories as to what these variations and markings represented, particularly if they indicated the presence of life upon the surface of Mars.

With the launch of Sputnik 1 in October and the resulting advent

***Figure 1** The launch of Mariner 4 on Atlas-Agena. Courtesy of NASA.*

of the 'Space Race' between the US and USSR, the scene was set for huge strides in rocketry and spacecraft development. Although the emphasis was upon manned spaceflight, the drive for space 'firsts' resulted in a blossoming of unmanned spaceflight, with robot craft being sent as probes to the Moon and nearby planets.

Figure 2 ***Mariner 4 image of Martian craters. Courtesy of NASA.***

The USA got their ball rolling with Mariner 3, launched in early November 1964. Unfortunately a failure in the Atlas-Agena rocket meant that the probe was unable to unfurl its electrical power generating solar panels and it went silent when the on-board batteries ran out of power. Undeterred, Mariner 4 was successfully launched at the end of November 1964 and sent on its way to fly past Mars (Figure 1). At only 260 kg in weight, the probe was minimalist in design compared to present day spacecraft with only a few simple instruments fitted, including a television camera fitted to a rotatable scan platform under the vehicle. All went well with the flight and in mid July 1965 Mariner 4 shot past Mars at just over 18 430 kph taking 21 pictures with its TV camera, all of which were saved to tape; this played back to mission control after the flypast.

These 21 pictures (Figure 2) transformed our knowledge of Mars and shattered the dreams of many Martian enthusiasts. Instead of canals, lush vegetation and Martian civilisation, a world covered in deep impact craters, bitterly cold at minus 100 degree centigrade and with an un-breathable atmosphere of carbon dioxide, so thin that an unprotected astronaut's blood would boil if they stood on the Martian surface. No magnetic field or radiation belts were found. Mars was more like the Moon than Earth. Interestingly the total volume of data sent back by Mariner 4 during its mission, which fundamentally changed our understanding of Mars, was 634 kB, less than the space available on a standard floppy disk!

After a short hiatus, during which NASA was pre-occupied with the Apollo programme, the USA returned to Mars with Mariners 6 and 7. These were much bigger spacecraft, weighing in at over 410 kg and carrying both wide and narrow-angle cameras as well as infrared and ultraviolet spectrometers and both craft also had programmable onboard flight computers. This was possible as they were launched on the much more powerful Atlas-Centaur rocket, a launcher that would play an important role in the future exploration of the Solar System (Figure 3). Mariner 6 launched in February 1969, with Mariner 7 following in March, the idea being that data from Mariner 6's flypast could be used to refine the approach of Mariner 7 as it followed its sibling past Mars 4 days later. This proved a wise approach as, on approach, contact was temporarily

***Figure 3** Launch of Mariner 6 on the powerful Atlas-Centaur.*
Courtesy of NASA.

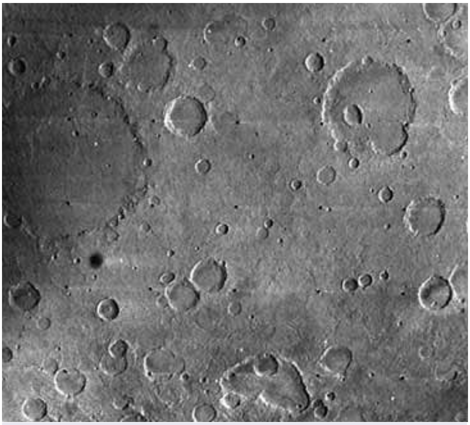


Figure 4 Mariner 6 image of craters on the surface of Mars. **Courtesy of NASA.**

lost with Mariner 7 and only regained shortly before flyby during which Mariner 7's path was slightly modified, allowing it to actually record more data than Mariner 6. Both craft took a total of 143 pictures, with the closest approach at around 3400 km above the Martian surface. These images (Figures 4 & 5) confirmed the findings of Mariner 4 in that Mars was a frigid desert planet, pockmarked by impact craters and that the dark albedo features observed from Earth were nothing to do with 'canals' but were brightness variations on the surface. Ironically both spacecraft flew over

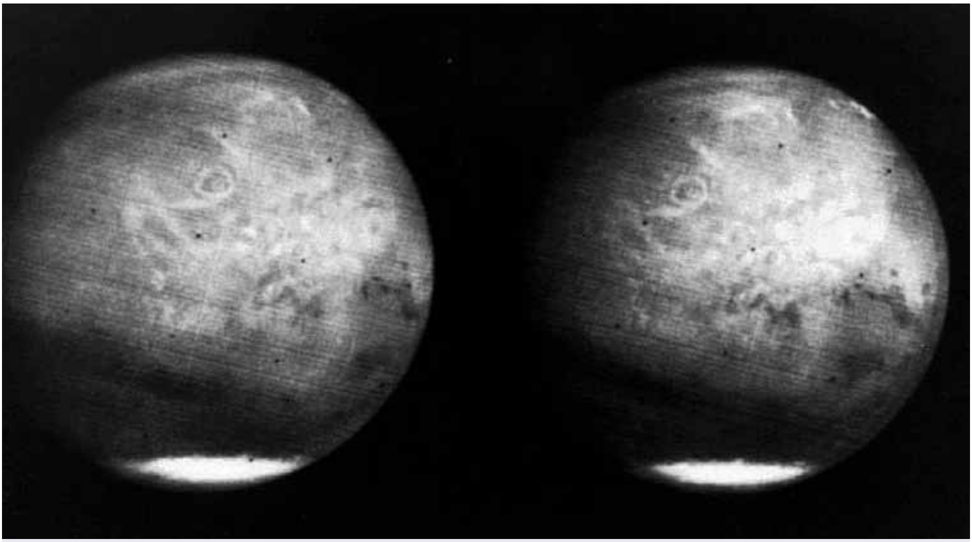


Figure 5 Mariner 7 image of Mars on its approach. **Courtesy of NASA.**

the southern hemisphere of Mars, as had Mariner 4, meaning that 80% of the surface was not imaged. One particularly interesting feature captured by Mariner 7 was Nix Olympica, a bright, high albedo area, that had been glimpsed previously from Earth and was thought by some to be a mountainous area.

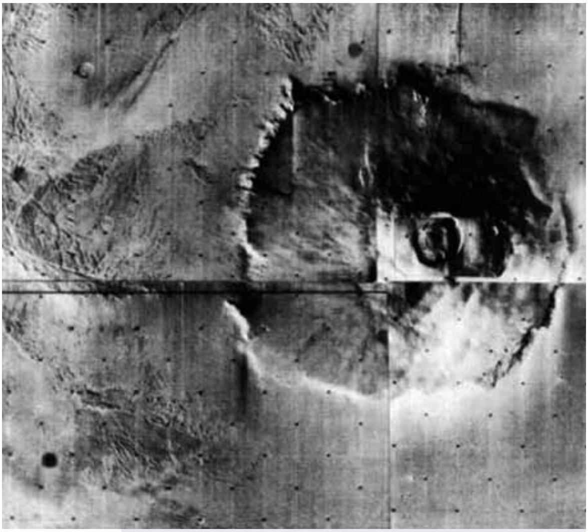


Figure 6 ***Mariner 9 image of Olympus Mons.*** ***Courtesy of NASA.***

Mariners 8 and 9 were, again, bigger spacecraft, weighing almost 1000 kg, by far the biggest probes the US had ever sent to Mars. This increase in mass reflected their changed mission as these probes would not simply fly past Mars, snapping pictures as they went, but would actually enter orbit around the planet. This would allow them to fulfil their primary mission objective of mapping up to 70% of the surface of Mars, with high resolution cameras, in a detail never seen before. In addition they would carry with them one of the most sophisticated onboard computers yet flown on a space probe by the USA. As is not uncommon with missions to the Red Planet, things did not begin well, with the rocket carrying Mariner 8 failing some 6 minutes after launch and dumping the payload into the Atlantic. Mariner 9 was now tasked with not only its own mission but also trying to cover as much of Mariner 8's as was possible. Mariner 9 was launched in late May 1971 and arrived at Mars in November the same year. Upon arrival at Mars it successfully fired its engine to slow down and settled into a 12hr orbit around the planet, 900 km above its surface. However the probe had to bide its time before it could start its mission, the entire planet below was obscured by a gigantic global dust storm which lasted until late January 1972. In the meantime, the flight controllers were able to reprogramme the spacecraft's computer to hold off

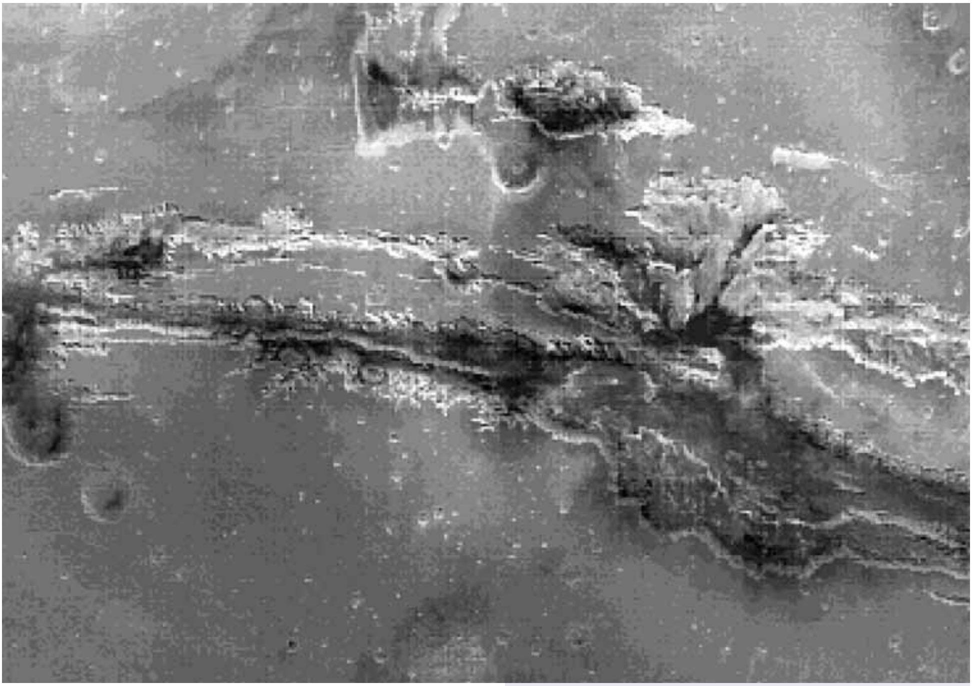


Figure 7 ***Valles Marineris. Courtesy of NASA.***

snapping pictures until conditions had improved. Again, with one of those twists of fate which seem to characterise the exploration of Mars, some of the first images taken by Mariner 9 were also some of the most fascinating. Mars had volcanoes! As the dust started to settle out of the atmosphere as the dust storm waned, several dark spots appeared poking through the gloom (Figure 6). It was quickly realised that these were the tops of a group of huge volcanoes. The largest was Olympus Mons, 27 km high above the mean surface elevation, 3x higher than Mt Everest, some 550 km wide at its base, with a summit caldera up to 85 km wide and 3 km deep. Olympus Mons, together with 3 other gigantic mountains, crowned what became known as the Tharsis Bulge; they are by far the largest volcanoes so far seen in the Solar System. In the following months the probe uncovered a further 20 volcanic structures, indicating that Mars had been a dynamic and volcanically active planet in the past. Mariner 9 continued to supply surprises with further images revealing the presence of a huge rift valley system which was quickly labelled Valles Marineris, spanning a 4000 km length along the Martian equator, and hence the largest canyon in the Solar System (Figure 7). Clearly there were tectonic processes and forces that had operated on the Martian crust in the past which had hitherto been unsuspected and perhaps these process were still active. The third great surprise supplied by the orbiter was the discovery of large numbers of channels on the surface of Mars (Figure 8). The shape and density of these channels strongly suggested their formation by the action of flowing water so there was clear evidence that liquid water had existed on the surface of Mars at some point in its history.

Figure 8 Mariner 9 image of a channel on Mars. Courtesy of NASA.

Mariner 9 was an outstanding success and continued its mission until late 1972 when it ran out of attitude control gas and was shut down. During its mission it was able to image all of the Martian surface as well as photograph the Martian moons Phobos and Deimos, returning over 7300 images to mission control. Mariner 9, although mute, continues to orbit the Red Planet.

If monuments are ever built to commemorate spacecraft then the Mariner missions to Mars must be close to the front of the queue for consideration. From 1964 through to 1972, barely 8 years, they transformed human understanding of the fourth planet in our solar system and laid the foundation for the future exploration of Mars. ■

Reflections on a week's stay at Little France—in The Royal Infirmary, Edinburgh.

By Norman E Butcher

Entering the five-year old Royal Infirmary building at Little France just before 7 am on Tuesday 16th December 2008 for a total hip joint replacement, the first date I observed inscribed on the left-hand wall of the entrance corridor was 1726. That date records the founding of the Faculty of Medicine of the University of Edinburgh. It is also the year that James Hutton (1726–1796), Founder of Modern geology was born in Edinburgh. In his first publication in 1777, Hutton describes himself on the title page as 'Physician in Edinburgh' and this now rare thirty-eight page small book was, I believe, much influenced by Adam Smith's *Wealth of Nations*, first published the year before in 1776.

Little France with its Queen Mary's Tree (Speedy 1892, p139) was traditionally where Mary Queen of Scots' French retainers were lodged though Stuart Harris (1996) casts doubt on this. Situated on the Old Dalkeith Road, Little France today is primarily a re-fuelling station. The area around near Craigmillar castle, where things got pretty uncomfortable for Queen Mary in November 1566 (Fraser 1970) is one of the most interesting parts of Edinburgh geologically. I found this out when chairing the Lothian and Borders RIGS Group between 1992 and 1998.

The modern Infirmary and other medical buildings at Little France sit directly on the south-west edge of the Midlothian Coal Basin, first shown in a drawing by the artist John Clerk of Eldin accompanying Hutton in 1786 (McIntyre and McKirdy 1977 pp23–24). The Pentland Fault must run very close to the site of the modern hospital buildings.

With a former coal miner in the bed next to mine in Ward 208, the view I got out of the window was towards Gilmerton where the modern colliery, working very steeply-dipping edge coals, opened in 1928 and closed in 1961 (Oglethorpe 2006, pp222–223). I believe the earlier coal mine at Gilmerton was at one time managed by John Williams who, in his two-volume work published in Edinburgh in 1789, *The Natural History of the*

Mineral Kingdom, criticised Hutton's Theory of the Earth.

Gilmerton is a fascinating area in its development of the different members of the Carboniferous cyclothem. The well-known Gilmerton cave was hewn out of a thick sandstone bed by George Paterson, a local blacksmith, and finished by him in 1724 (Speedy 1892, p237). The underground working of the Gilmerton Limestone by the pillar and stall (or stoop and room) method of extraction caused serious subsidence in November 2000 (Figure 1). The subsidence affected mostly old people's single-story homes built on top of the old workings in the 1960's. I recalled showing Paul Cullen, Q.C. Chairman of the Inquiry set up by the Council, a copy of the textbook *Geology and Cities* by the renowned Canadian engineering geologist Robert Legget, which I got especially from the University Library!

In November 2008, in the Western Link corridor case of the National Galleries of Scotland, was exhibited a pencil on paper drawing, purchased in 2006 of 'Gilmerton Lane Quarry Near Edinburgh 1809' by the remarkable Edinburgh artist Alexander Nasmyth (1758–1840) which I had not seen before. Alexander Nasmyth lived and worked at 47 York Place in Edinburgh. He had a large studio at the top of his house looking over to Fife. He and his wife Barbara Foulis had eleven children of whom at least eight were gifted artists also! A small plaque by the door of 47 York Place today commemorates both Alexander Nasmyth and his father, James Nasmyth, inventor of the steam hammer.

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Subsidence damage caused by collapse of old workings in the Gilmerton Limestone. ***BGS image P100363***

Fishy fornication follow up

By Ian Rolfe

The racy article 'Fishy fornication' in the last *Edinburgh Geologist* (46, pp.22–23) reported the important recent discovery of unborn embryos preserved inside Devonian fossil fish. This implies internal fertilisation, and the early origin of sex as we know it. Some confusion seems to have arisen via the media concerning the name of the fish involved. Was it to be called *Incisoscutum ritchiei* or *Materpiscis attenboroughi*? In fact,

Early morning breakfast at Stromatoporoid Camp for some of the 1967 Gogo Expedition team, L–R: Ian Rolfe (Hunterian Museum, University of Glasgow); David Cliff (Western Australian Museum, Perth); Harry Toombs (British Museum (Natural History), London). The oil-cans doubling as seats were used to transport the 3300 collected fossils. Photograph by the late Howard Brunton.

similar evidence of embryos has been found in both of these quite different fish species, as well as in a third, *Austroptyctodus gardineri:* all come from Gogo, Western Australia.

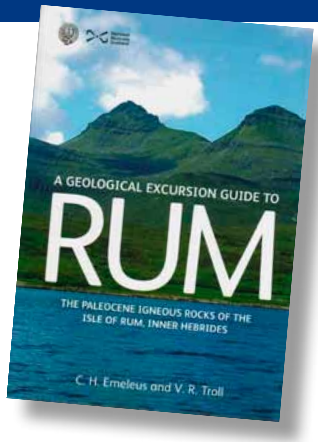
There are interesting Scottish connections with one of these fishes: *I. ritchiei* was named after Dr Alex Ritchie, Edinburgh geology graduate, well-known palaeoichthyologist and Curator of Fossils at the Australian Museum, Sydney. It was named and described by Kim Dennis and Roger Miles in 1981, and the embryo-yielding specimen was one of those collected by the 1967 expedition to Gogo in Western Australia, in which this writer took part. Incidentally, in 1967 while he was at the then Royal Scottish Museum, Edinburgh, Roger Miles redescribed a fossil fish, *Rhamphodopsis threiplandi* from the Devonian of Ross & Cromarty, whose "pre-pelvic claspers may have been capable of being erected... presumably permitting internal fertilisation to take place, as implied by the better term intromittent organs". He even noted that this fish might have been viviparous: able to give birth to live young. He was unable to prove this though: young may have hatched from eggs released into the water, or from eggs while still inside the mother. It was not until *Materpiscis attenboroughi* was later discovered, with its embryo and, astonishingly, fossilised umbilical cord attached, that true viviparity was proved. This fish, which belongs to the same group of *Chimaera*-like fishes as *Rhamphodopsis*, was described in 2008 by John Long, then Head of Science at Museum Victoria, Melbourne, and his collaborators.

Readers can view John Long discussing *M. attenboroughi*, with colour close-ups of the key specimen, at:

www.youtube.com/watch?v=m18sGLBdPGU&feature=player_embedded#; an animation of M. attenboroughi giving birth at: http://museumvictoria.com.au/about/mv-news/2008/mother-fish/; and a picture of the Natural History Museum's specimen of I. ritchiei, together with an animation of this species mating, at: http://museumvictoria.com.au/about/media-releases/2007-archive/sex-more-ancient-and-common-than-thought/

For a lively account of collecting fossil fishes at Gogo, and their scientific significance, see John Long's *Swimming in stone: the amazing Gogo fossils of the Kimberley* (Fremantle Arts Centre Press, 2006). ■

Book reviews



Geological Excursion Guide to Rum — The Palaeogene Igneous Rocks of the Isle of Rum, Inner Hebrides by C H Emeleus and V R Troll with contributions by E P Holohan and G R Nicoll. Edinburgh Geological Society in association with NMS Enterprises Limited — Publishing, Edinburgh, 2009. Paperback, 150 pp. Price £12.99. ISBN 978-1-905267-22-4.

Graduates of Earth Science degree courses have usually enjoyed the experience of a month or so of independent fieldwork, mapping in detail the geology of an area they selected or were assigned. For my mapping project, a few years ago now, I chose the south-eastern corner of the Isle of Rum. Rum is the largest of the Small Isles in the Inner Hebrides of Scotland, and I chose this place partly because it was remote and mountainous, and partly because on the published large-scale geological maps it is a kaleidoscope of colours representing different rock types. Rum is a rocky island about 12 km across with spectacular scenery, superbly exposed rock formations, frequently stormy weather, ferocious midges and ubiquitous sheep ticks. For all these reasons and more, mapping the bedrock geology in the deep glen of Dibidil and its ring of mountains was a 'character-building' experience.

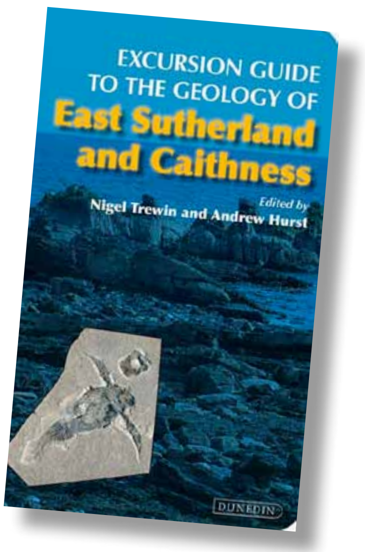
Henry Emeleus, one author of this new guidebook, encouraged my geological explorations in Dibidil and incorporated my linework into the first detailed bedrock geology map of the island. As stated on the back cover of the guide, Henry was attracted again and again to Rum during his career at Durham University, since the four-dimensional jigsaw provided by the island's complex geology continually raised fresh challenges and problems. The other principal author of the guidebook, Valentin Troll, was also captivated by the island's magic. He and others have re-interpreted some of the curious felsic igneous rocks as subaerial deposits within a volcanic caldera which pre-dated the emplacement of the layered gabbros and peridotites for which Rum is deservedly famous.

The mountainous central and southern part of Rum is a dissected 'fossil' magma chamber that fed basaltic lava flows, some of which are preserved in the nearby island of Canna, during the Paleocene around 60 million years ago. Following an introduction, the guidebook outlines the Pre-Paleocene and Paleocene geology of Rum in chronological order. The main body of the book comprises 9 excursions starting with the easily accessible Kinloch and surroundings, and finishing with the least accessible Southern Mountains around Dibidil. For each excursion there is a short summary ('highlights') followed by information on the route and distance, and details of the geological features at a series of localities for which precise grid references are provided. One or more small-scale geological maps enhance each section along with captioned photographs and stratigraphical sections where appropriate. Annotated panoramic views are a particularly useful feature. The guide concludes with an up-to-date list of References and a key to the colours and symbols on the maps.

Although mineral collecting opportunities don't really exist on Rum, aside from bloodstone and agate pebbles on Guirdil beach, the geology is plain to see and well worth the effort of getting there. Emeleus and Troll's guidebook is thoroughly researched and wonderfully detailed. I learnt that Mesozoic sandstone, ironstone and limestone occur within my mapping area, something I had never suspected! The descriptions are fabulous: the ironstone 'weathers to give an extremely distinctive, splintery or flaky, rusted appearance (like the hull of an old ship)'. The guidebook is designed to be practical with a water-resistant cover and colour-coding of page edges so that a particular excursion can be found quickly. I have one quibble — some of the geological maps labelled with routes and localities are printed too small, and are therefore difficult to navigate by: Figure 13, the map for excursion 2, being a prime example. I guess that owners of the guide would also purchase the 1:20 000 scale map *RUM — Solid Geology*, obtainable from the Scottish Natural Heritage office at Kinloch on Rum, to guide their exploration of the island. Overall this is a top quality publication at a very affordable cost, and I recommend it highly.

by Norman Moles

Excursion Guide to the Geology of East Sutherland and Caithness by Nigel Trewin and Andrew Hurst (eds). Dunedin Academic Press, Edinburgh, 2009. Paperback, 191 pp. Price £14.99. ISBN 978-1-906716-01-1.



This is a very welcome second edition of the excursion guide first produced by Nigel Trewin and Andrew Hurst in 1983. The format has become taller and thinner, to match the standard size of OS topographic and BGS geological maps—a growing trend in field guides—but it is otherwise testament to the quality of the first edition that most of the excursion itineraries have made the transition with only minor amendments. Changes have been largely forced either by deterioration or redevelopment of exposures, or by circumstances of access. Most of the original figures have moved on to the second edition in full colour rather than black and white, and the inclusion of a splendid array of colour photographs is a general enhancement.

The geological introduction has perhaps seen the most changes, which bring it up to date with recent research. New dating results and the consequent reinterpretations are included in the section on metamorphic and intrusive history, whilst there is expansion of the accounts of Devonian stratigraphy to accommodate new data from North Sea boreholes and the better understanding of Milankovitch cyclicity. An unfortunate confusion is introduced into the Permo-Triassic versus the Jurassic sections by the reversal of the stratigraphy tables, but there is additional description in compensation. The revival of the flagstone industry since publication of the first edition is noted, as are the recent details of the offshore Beatrice oilfield, visible from the eastern shores of Caithness.

The excursion itineraries follow the successful pattern established in the first edition, being grouped into three geographical sets covering the Mesozoic geology, two sets addressing the Devonian rocks, and a final itinerary offering gold panning in Kildonan. The Mesozoic excursions cover the mainly coastal outcrops at Golspie, Brora, Helmsdale and Ousdale and bring out their fascinating, and in places dramatic, geological story. Who could see the Helmsdale Boulder Bed without being impressed by the awesome, fault-scarp processes that it reveals? Sadly, it is the series of itineraries culminating at Helmsdale that has suffered most from access restrictions so that the six routes originally described in the first edition have now been reorganised into four. Farther north, excursions to the Devonian outcrop cover the extraordinary features of the Old Red Sandstone in the Orcadian Basin. The itineraries described range from the marginal unconformities, across the fluvial, aeolian and playa deposits to the deep-lake laminites with their renowned fossil fish. Here are world-famous localities such as Achanarras Quarry, which benefits from an expanded and updated description, changes being particularly apparent in the taxonomic nomenclature of the fossil fish. One happy result of this revision is the presence in the nearby Spittal Quarry of a fish now graced with the singularly appropriate name *Trewinia magnifica*.

Elsewhere, quite apart from the geology, the itineraries that focus on the northern coastline take in the spectacular scenery of Duncansby Head and its sea stacks, Dunnet Head and, to the west, Red Point where the basin margin unconformity is revealed in astonishing detail. Red Point would definitely feature in my top ten geological visits so it is a particular pleasure to see it so well described and illustrated. And as a bonus, a complementary itinerary is included for the Devonian strata seen nearby at Sandside Bay, a locality that did not feature in the first edition.

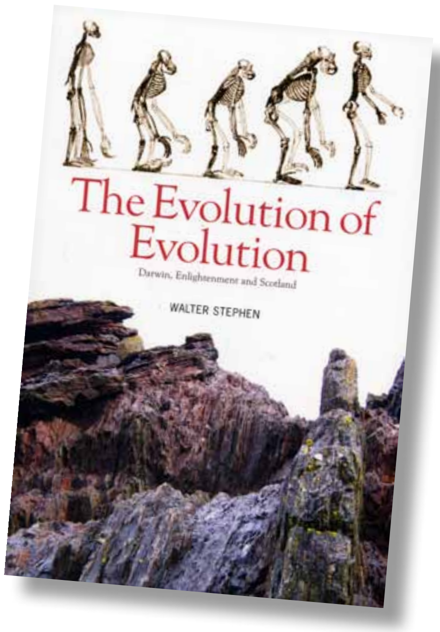
It is hard to fault the organisation of this splendid excursion guide. Quite apart from the excellent geological descriptions it is an eminently practical book, with plenty of up-to-date information on access, walking distances and the likely time and/or tidal conditions necessary to do justice to the rocks. Added interest is provided by historical information, and in this respect the excursions dealing with the Caithness flagstone and Brora coal industries and with the Kildonan gold rush are particular beneficiaries. So, congratulations to Nigel Trewin and Ian Hurst for a job well done, and let's not forget the contributions of Clive Rice and A. C. McDonald, nor the support of the Aberdeen Geological Society and their sponsors for that matter. This is a first-rate guide, with a broad appeal, and will provide much pleasure for many people.

If you were familiar with the first edition of 'The Geology of East Sutherland and Caithness' you will most certainly want to invest in this second edition and revisit the extraordinary geology of the far north-east of Scotland; if unfamiliar, buy a copy of the second edition immediately and discover what you have been missing.

by Phil Stone ■

The Evolution of Evolution — Darwin, Enlightenment and Scotland by Walter Stephen. Luath Press, Edinburgh, 2009. Paperback, 164 pp. Price £12.99. ISBN 978-1-906817-23-7.

In the previous issue of *The Edinburgh Geologist* (No. 46 for Autumn 2009) Walter Stephen gave us an entertaining assessment of Edinburgh's influence on Charles Darwin. If you enjoyed that article you will certainly find much interest and entertainment in his broader account of the Scottish background to Darwin's ideas, which has itself evolved from the working title *Darwin and the Vestiges of Creation* that was cited in association with the earlier article. The book is an astonishingly eclectic piece of work and takes the reader into some unexpected and neglected intellectual niches. It is, fundamentally, an attempt to trace the initiation of Darwin's theory of evolution back to the Scottish Enlightenment.



Some sections are on familiar territory, with chapters examining the historical importance for evolutionary theory and an appreciation of geological time of Chambers' *Vestiges of Creation* and the famous excursion to Siccar Point made by Hutton, Hall and Playfair. Darwin's experiences on the Beagle voyage are discussed, with emphasis on the South American leg, and integrated with his earlier, very different, geological tuition at the hands of Jameson in Edinburgh, and Henslow and Sedgwick in Cambridge. A taste of that controversy, with the evidence for large-scale glaciation as a background, was provided in *The Edinburgh Geologist* article. The relationship with Charles Lyell is considered in some detail. The initial impact on Darwin of Lyell's *Principles of Geology* is undoubted, but it is interesting to learn how the relationship changed with Darwin becoming increasingly frustrated at Lyells' hesitation in committing to the cause. And then there was Agassiz. Quite apart from their differences over the glacial origin of Glen Roy's 'parallel roads'—explored quite literally by Walter Stephen as background to Darwin's own admission of his 'one long gigantic blunder'—and Agassiz's opposition to Darwin's evolutionary ideas, there was the divisive question of slavery*. Darwin was strongly opposed, Agassiz in favour, whilst Charles Lyell equivocated in the middle trying to remain on good terms with everyone, especially after his North American tours.

All of these disparate threads are skilfully interwoven by Walter Stephen to provide a fascinating account of the social and cultural influences that underpinned Darwin's developing ideas on evolution. As further illustration, the author again takes the path less trodden and examines in some detail the background to Darwin's less-well known work *The expression of the emotions in men and animals*, published in 1872. For this, the origin is traced back to the Plinian Society of Darwin's Edinburgh University days and the personalities therein. The account is enhanced by the results of a re-run of a couple of Darwin's original experiments—with surprisingly similar outcomes.

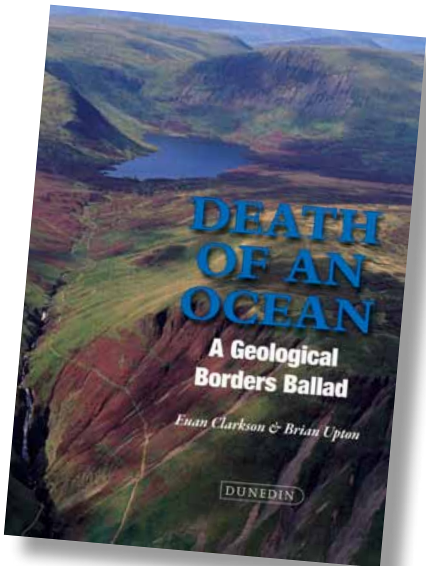
* For a deep and scholarly investigation of this influence on Darwin I can recommend another book that came out in 2009: **Darwin's Sacred Cause—Race, slavery and the quest for human origins** by Adrian Desmond and James Moore. Allen Lane, London.

In his final two chapters Walter Stephen produces another unusual angle on the Darwin story by integrating the work of the Scottish polymath Patrick Geddes. Geddes' early development was, we learn, much influenced by Darwin, and also by his association with Thomas Huxley. Geddes repaid the debt by his popularisation of Darwinian ideas in contributions to encyclopaedias—*Chambers* and *Britannica*—and in so doing established those ideas as cultural axioms. Tellingly, it seems that one of the principal effects that Darwin had on Geddes was to instil in him 'excitement and enthusiasm in the face of the natural world'. The events of the last eighteen months have amply demonstrated that this is something that Darwin can still manage posthumously.

Amongst last years' deluge of Darwin literature, *The Evolution of Evolution* certainly provides something a bit different. It covers some familiar ground of necessity, but also ventures into the most unexpected nooks and crannies and makes novel connections in the most unlikely places. The style is a touch idiosyncratic, and may not appeal to everyone, but there is plenty here to make one think and perhaps reconsider a few prejudices. And can we trace *The Origin of Species* to unique roots in the Scottish Enlightenment? Well, I'm not wholly convinced—but that didn't stop me enjoying the book immensely.

by Phil Stone ■

Death of an Ocean—a Geological Borders Ballad by Euan Clarkson and Brian Upton. Dunedin Academic Press Ltd., Edinburgh, 2009, £25 hardback, 224 pages



The Chambers 20th Century Dictionary defines ballad (Scot. ballant) as a song accompanying a dance: a simple narrative poem in short stanzas: a popular song often scurrilous referring to contemporary persons or events. So the subtitle (as well as the title) of this book intrigued this reviewer. Without adhering strictly to the definition the authors have indeed written a narrative that brings together the intricate and fascinating geological history and the lives of the people who have worked it out. There is even a brief introductory reference to the Borders ballad writers of the 18th and 19th century which perhaps could have been expanded to include an excerpt from William Wordsworth's evocative poem *Yarrow Revisited* (see page 29), written as Sir Walter Scott was about to leave for Italy on account of his health.

It is always a difficult task for a fellow-geologist to assess how successfully his peers, in this case two eminent specialists and enthusiastic teachers, have conveyed quite complicated geological processes to a wide readership. In this case, as with their previous volume *Edinburgh Rock—The Geology of Lothian*, the aim is broad with amateur, student or professional and people living in the district. But, in opinion of this reviewer, the authors have succeeded in bringing to life the geology of the Borders. In a very readable account they take us on a deep time journey across the long-departed Iapetus Ocean, linking the development and death of the latter with the 20th century theories of continental drift and plate tectonics which evolved from our understanding of modern ocean floors.

The authors envigorate this Early Palaeozoic story with a personal style, explaining how the seemingly undistinguished grey rocks of the Southern Uplands, amongst other things, hold the evidence for early life, volcanic episodes and deep water sedimentation. This in itself is quite an achievement, since anyone otherwise familiar with the rolling turf and heather covered hills will be quite astounded to discover what an extraordinary geological history is recorded in the rocks beneath their feet. Separate chapters are devoted to modern plate tectonic theory, its application to the Southern Uplands with its surprisingly wide variety of lithologies, the lithostratigraphy, and the biostratigraphy which has been determined by detailed studies of fossil forms including radiolarians, graptolites and trilobites. Chapter 9 'Small fry of the surface waters' is particularly helpful and provides an excellent comparison of modern and ancient marine plankton.

All the fossils are beautifully drawn in colour but throughout the book the geological sketch maps (e.g. figures

3.2, 5.4, 12.1, 12.4, 14.4, 15.11) are less successful. Poor proof-checking has resulted in spelling mistakes and map face colours cannot always be correlated with the keys. Field and specimen photographs are well chosen to illustrate structure and lithology but unfortunately one or two copyright credits are inaccurate (figure 6.5) or missing (figure 6.7). Of more concern to this reader is that references in the text and in captions for illustrations to authors of key papers are not to be found in the Select bibliography. Granted that a reader might nowadays be able to search online bibliographic databases (although Broadband is still not available everywhere in the Borders!), a fuller bibliography would have greatly aided the reader interested to pursue the subject matter.

Later chapters describe the no less volcanically active terrestrial, fluvial and shallow marine environments of the Devonian and Carboniferous. Again the well-illustrated fossils enable the reader to visualise the conditions under which the Tweed Basin formed. There are excellent sections on the Cheviot and St Abbs volcanic hills, the Kelso Traps, the sharp miniature mountains of the Eildon Hills, and other prominent, yet even smaller volcanic remnants, all quintessentially Scottish Border country. An informative chapter on Quaternary processes and climate, with conditions fluctuating many times from arctic to temperate, provides a fitting conclusion to the explanation of this varied and beautiful landscape.

Death of an Ocean is a valuable addition to the geological literature. It provides a very readable account of the geological history of southern Scotland in the context of local and global geological processes, and conveys how geology, as always, underpins the landscape.

by Andrew McMillan ■

Verses from *Yarrow Revisited*

This verse appropriately shows Scott about to exchange views of his local volcanic hills with those of Italy!

In the second verse, there is perhaps a hint of timelessness and hidden histories.

'For thee, O SCOTT! compelled to change
Green Eildon-hill and Cheviot
For warm Vesuvio's vine-clad slopes,
And leave thy Tweed and Tiviot
For mild Sorrento's breezy waves;'

'For Thou, upon a hundred streams,
By tales of love and sorrow,
Of faithful love, undaunted truth,
Hast shed the power of Yarrow;
And streams unknown, hills yet unseen,
Wherever they invite Thee,
At parent Nature's grateful call,
With gladness must require Thee.'

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