GeoCam

EARTH SCIENCES ALUMNI MAGAZINE

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Monitoring Bárðarbunga

UNIVERSITY OF CAMBRIDGE

RESEARCH NEWS

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Geologists discover ancient buried canyon in South Tibet

A team of researchers from the UK, USA, Germany and China has discovered an ancient, deep canyon buried along the Yarlung Tsangpo River in south Tibet, north of the eastern end of the Himalaya. The geologists, including Cambridge's Jean-Philippe Avouac, say that the ancient canyon – hundreds of metres deep in places – effectively rules out a popular model used to explain how the massive and picturesque gorges of the Himalaya became so steep, so fast.

READ MORE www.cam.ac.uk/research/news/geologists-discover-ancient-buried-canyon-in-south-tibet#sthash.Ts7IXIM6.dpuf

PING WANG

And now, the volcano forecast

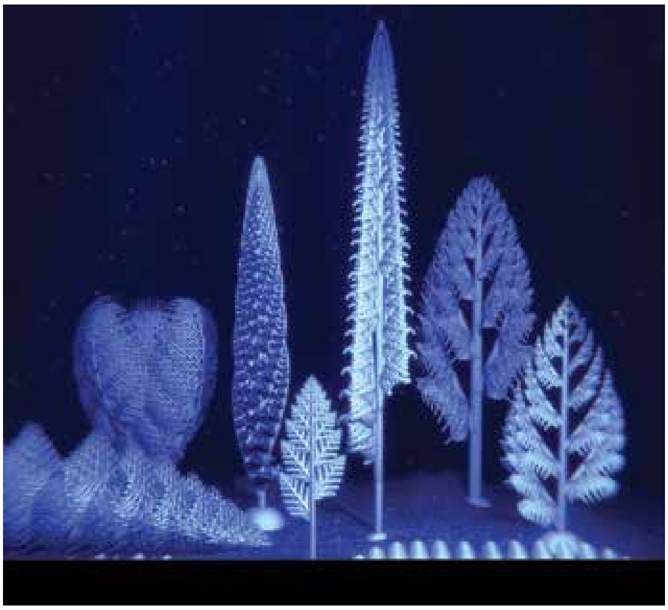
Volcanoes are the vents through which our planet exhales. Yet, not all volcanoes experience spectacular releases of energy, or even erupt at all: of the 500 or so volcanoes that are currently active worldwide, 20 might be expected to erupt in any one year. But, when volcanoes do erupt, they can cause almost total destruction in the immediate vicinity and the ash clouds they release can affect areas thousands of kilometres away.

NICK SAFFELL

Fortunately, the ability to monitor volcanoes has dramatically improved in recent years, thanks in part to the work of scientists like Marie Edmonds from Earth Sciences.

READ MORE www.cam.ac.uk/research/features/and-now-the-volcano-forecast#sthash.JsIEyl56.dpuf

COVER AND INSIDE COVER PHOTOGRAPHY: RICHARD HERD



How some of the first animals lived – and died

New three-dimensional reconstructions show how some of the earliest animals on Earth developed, and provide some answers as to why they went extinct.

A bizarre group of uniquely-shaped organisms known as rangeomorphs may have been some of the earliest animals to appear on Earth, uniquely suited to ocean conditions 575 million years ago. A new model devised by Jenny Hoyal Cuthill and Simon Conway Morris has resolved many of the mysteries around the structure, evolution and extinction of these 'proto animals'.

READ MORE http://www.cam.ac.uk/research/news/how-some-of-the-first-animals-lived-and-died#sthash.uZmZFhtZ.dpuf

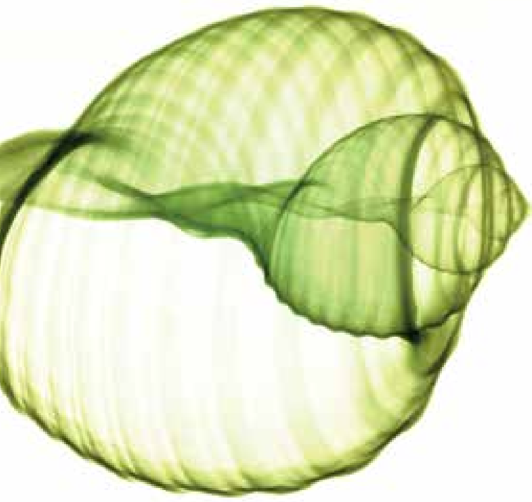
Misunderstood worm-like fossil finds its place in the Tree of Life

One of the most bizarre-looking fossils ever found - a worm-like creature with legs, spikes and a head difficult to distinguish from its tail – has found its place in the evolutionary Tree of Life, definitively linking it with a group of modern animals for the first time.

The animal, known as Hallucigenia due to its otherworldly appearance, had been considered an 'evolutionary misfit' as it was not clear how it related to modern animal groups. Researchers from the University of Cambridge have discovered an important link with modern velvet worms, also known as onychophorans, a relatively small group of worm-like animals that live in tropical forests.

READ MORE http://www.cam.ac.uk/research/news/misunderstood-worm-like-fossil-finds-its-place-in-the-tree-of-life#sthash.X86wfwvS.dpuf

Metabolism may have started in our early oceans before the origin of life



In a study funded by the Wellcome Trust and the European Research Council researchers at the University of Cambridge reconstructed the chemical make-up of the Earth's earliest ocean in the laboratory. The team, including Earth Sciences' Sasha Turchyn, found the spontaneous occurrence of reaction sequences which in modern organisms enable the formation of molecules essential for the synthesis of metabolites. These organic molecules, such as amino acids, nucleic acids and lipids, are critical for the cellular metabolism seen in all living organisms.

It was previously assumed that the complex metabolic reaction sequences, known as metabolic pathways, which occur in modern cells, were only possible due to the presence of enzymes. However, the team's reconstruction reveals that metabolism-like reactions could have occurred naturally in our early oceans, before the first organisms evolved.

READ MORE www.cam.ac.uk/research/news/metabolism-may-have-started-in-our-early-oceans-before-the-origin-of-life#sthash.0obr4QxN.dpuf

KEN MCNAMARA DIRECTOR, SEDGWICK MUSEUM

A DAY IN **THE FIELD**

The Sun was setting fast. Only about half an hour before it sunk beneath the horizon. But that was perfect. For that's when the Sun's low, raking rays clipped the surface of the Early Silurian Tumblagooda Sandstone, perched high above the Murchison River gorge in Western Australia. And there, running across the surface, like sets of miniature railway tracks, were three sets of parallel rows, each as wide as my hand – footprints made by multi-legged arthropods for maybe just 20 seconds of their lives about 430 million years ago.

SO HOW WERE SUCH DELICATE FOOTPRINTS PRESERVED? IT IS LIKELY THAT THE WIND BLEW FINE, DRY DUST OVER THE WET SURFACES, CAREFULLY COVERING THE DELICATE FOOTPRINTS.

Seeking such trackways and other trace fossil evidence of early life on land is why I decided to spend the student-free summer months some 600 km north of Perth in Western Australia. Assisted by my wife, Sue Radford, and funding from National Geographic, our aim was to find evidence for the first animals to colonise the land.

The first few days were spent exploring the upper strata in the gorge for fossilised tracks and burrows made by arthropods living in a marginal marine environment, sometimes in the water, at other times venturing onto land. It didn't take us long to start finding many trackways. The largest were 24cm across that meandered for many metres. These were probably made by the giant scorpion-like eurypterids more than a metre long; other smaller tracks and burrows, some only a centimetre in width, were made by a range of other arthropods. We also began finding evidence of microbial mats, the base of the food chain.

One of our more intriguing finds was a fossilized pond into which an arthropod had slid into the water on a bodyboard made of microbial mat. Many of the trackways show exquisite detail and must have been made by animals walking out of water on wet sand surfaces. So how were such delicate footprints preserved? It is likely that the wind blew fine, dry dust over the wet surfaces, carefully covering the delicate footprints. More and more sand covered them and eventually, over vast tracts of time, the sand grains were cemented together by silica to become sandstone. For hundreds of millions of years the seas rose and fell, periodically covering the sandstone with other sediments. A mere 30 million years ago the land began to rise, creating the gorge. The younger sediments were stripped off, the sandstones suffered the ravages of weathering until eventually the thin layer of windblown sand was peeled off to reveal the arthropods' footprints to a whole new world.

Whether wandering along the outcrop at the top of the gorge or venturing down to the riverbed, we encountered many types of fossil arthropod burrows. Smaller ones had churned through the sand processing it for organic material. Other, much larger, horizontal burrows ploughed through the smaller ones and were probably hunting burrows. Slowly we are building up a picture of early life on land, a time before vascular plants had appeared, when the world was dominated by a panoply of arthropods.

www.sedgwickmuseum.org

www.esc.cam.ac.uk/escfieldwork/?p=87

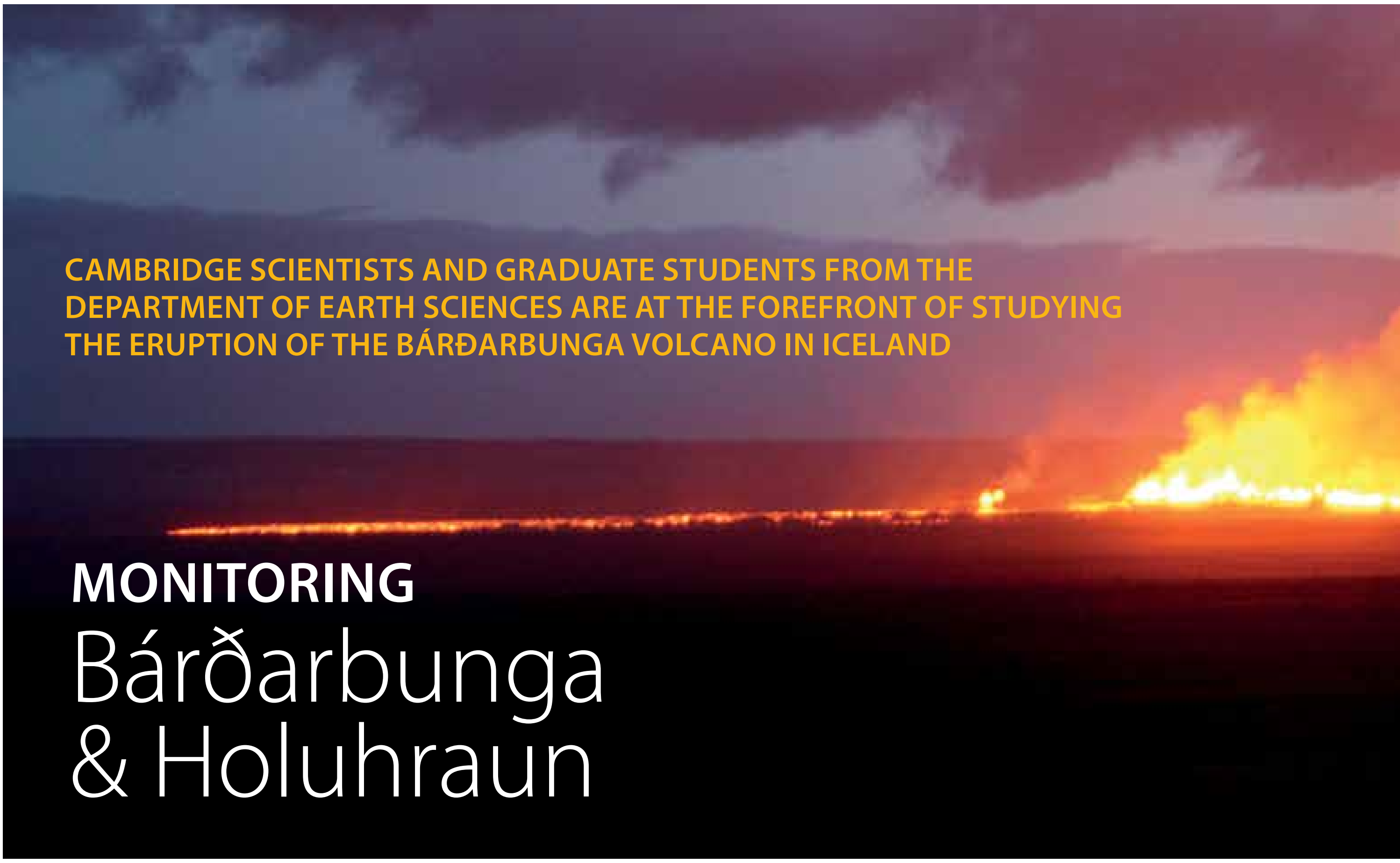
HIDDEN DEPARTMENT –
The Picking Room

DUDLEY SIMONS

Foraminifera, informally known as forams, are present in all marine environments. Single celled with calcite shells, they are either planktonic (surface of ocean dwellers) or benthic (seabed dwellers). There are thousands of species in the ocean and Linda Booth (pictured), Senior Research Technician, and the team pick and identify certain species for chemical analysis. This work informs the research undertaken by Professor David Hodell, Woodwardian Professor of Geology, Dr Luke Skinner and Professor Harry Elderfield, Fellow of the Royal Society, providing a geological basis for understanding both our present climate and rapid changes in global temperature in the past.

Linda has been picking forams for over 20 years, initially as part of the Department of Plant Sciences, moving to the Department of Earth Sciences in 1998.

For further details of the research of Professor David Hodell, Dr Luke Skinner and Professor Harry Elderfield: **www.esc.cam.ac.uk/research/climate-change**



CAMBRIDGE SCIENTISTS AND GRADUATE STUDENTS FROM THE DEPARTMENT OF EARTH SCIENCES ARE AT THE FOREFRONT OF STUDYING THE ERUPTION OF THE BÁRÐARBUNGA VOLCANO IN ICELAND

MONITORING Bárðarbunga & Holuhraun

The research group, led by Professor Bob White, is monitoring the on-going eruption through its array of seismic instrumentation – never before has such an event been so well documented. The data will yield new insights into how molten rock moves underground, and eventually erupts. Here, Bob White outlines the team's ongoing work in Iceland.

Magma moved underground at depths of 7–9 km from its source in the Bárðarbunga volcano under the Vatnajökull ice cap to its eventual eruption 45 km away at Holuhraun. The melt took two weeks to migrate north. We watched its progress remotely from the tens of thousands of small earthquakes generated as the dyke pushed its way forward.

Since 2006, we have been monitoring the area where the volcanism is occurring using up to 75 broadband seismometers. The location and timing of the eruption was immaculate: this is a remote area of Iceland, only easily accessible in the summer months. Our team had serviced all the seismometers in July, so they were all working perfectly. They were poised to go back in late August for a final check before leaving them recording over the winter.

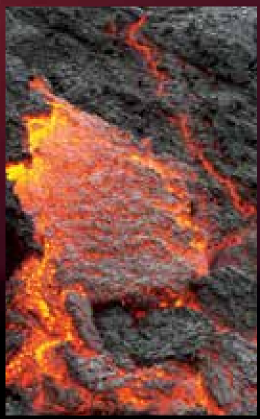
The volcanic unrest started on 16 August. Fortuitously, our team had recently recovered 15 seismometers from the Vatnajökull ice cap where they had been used for a study of small quakes caused by ice cracking. So they were able to redeploy these extra seismometers at the location where we guessed (correctly) that the eruption would eventually occur. They finished deploying the last instrument at 10 o'clock at night: the eruption started just after midnight and they were amongst the first of only a handful of people on the scene.

Within 24 hours of the start of this magmatic intrusion, Cambridge PhD student Tobba Ágústsdóttir had joined others from the Icelandic Meteorological Office (IMO) and the Earth Sciences Institute of the University of Iceland on a helicopter flight to the Vatnajökull ice cap. There she deployed one of our seismometers close to the site of the underground seismic activity. Over subsequent days, using snow scooters, she and IMO colleagues deployed three more seismometers on the ice cap to track the movement of the molten rock northwards. These are crucial for the 24/7 real-time tracking by IMO of the seismicity and for giving aviation and civil hazard warnings.

As I write in early 2015 the eruption continues unabated. The volumes are huge. Over a billion cubic metres have erupted forming a lava field

Follow Professor Simon Redfern on **twitter@Sim0nRedfern**
Follow graduate student Tobba Ágústsdóttir on **twitter@fencingtobba**

Background: 'Eruption lighting up the dusk sky'
(L to R) Profs Bob White and Simon Redfern at the lava front; The iconic Herdubreið mountain; Fresh lava; Seismometer deployment on Vatnajökull ice cap



PHOTOS:
TOBBA ÁGÚSTSDÓTTIR AND BOB WHITE

extending across 85 square kilometres. This is already an order of magnitude larger than the Eyjfjallajökull eruption in 2010 which forced the cancellation of more than 100,000 airline flights. It is now the largest volcanic eruption in Iceland since the 1783 Laki eruption, which itself was the biggest historic eruption in the world.

Every second more than 400 tons of molten rock at over 1200 degrees Centigrade is being spewed out of the fissures in the ground. This eruption is continually producing the same amount of thermal energy as Hiroshima-sized nuclear bombs detonated every two minutes for hour after hour, day after day, week after week. Every day 35,000 tons of sulphur dioxide are spewed into the atmosphere, forcing those around Iceland with asthma and respiratory problems to stay indoors.

As scientists we were privileged to be part of just a handful of people allowed in to the exclusion zone around the eruption. At night a wall of deep red flames confronted us as lava fountained up 100 metres and more. Molten rock tumbled down as balls of glowing crimson which exploded in flashes of orange as they hit the ground. A stream of glowing lava spilled over and coalesced into a flowing river of deep red molten rock.

The raw power of a volcanic eruption assaults all the senses simultaneously: the eyes with the depth of the colours; the ears with the sound of jet engines generated by the fire fountaining, superimposed by the continual tinkling of breaking glass as the lava front chilled and avalanched forward; the nose by smells reminiscent of the smelliest chemistry lab at school.

The eruption was awesome in the proper sense of the word. Our experiences of it sustain us through the many hours and late nights as we sit in front of computer screens analysing the wealth of data we have collected, teasing out new insights into volcanic processes.

READ MORE ONLINE
www.esc.cam.ac.uk/escfieldwork/?p=95

onlinelibrary.wiley.com/doi/10.1002/2014EO390005/pdf

NICK BUTTERFIELD
PROFESSOR OF EVOLUTIONARY PALAEOBIOLOGY

On the origin of animals

LIFE IS A REMARKABLE PHENOMENON AND, SO FAR AS HAS BEEN DEMONSTRATED, IS UNIQUE TO PLANET EARTH.

What's more, palaeontological and geochemical analysis of early sedimentary rocks has revealed its terrestrial presence for at least the past three and a half billion years – just the kind of deep evolutionary time that Darwin had called on to sustain his theory. Even so, there remains a profound divide between the richly fossiliferous strata of the past 540 or so million years – the Phanerozoic – and the much more cryptic record of pre-Cambrian life. Both animals and our modern uniformitarian biosphere emerged rather suddenly, some might say 'explosively,' during the transition between these two fundamentally different worlds. What exactly went on at this time, and why did it happen so late in the day?

One of the longstanding explanations, famously embraced by Darwin, is that the fossil record simply can't be trusted. Preservation is fickle, and the disappearance of signal near the base of the Cambrian may be entirely capricious. After all, most fossils are biomineralized shells and bones, but most organisms have neither – think jellyfish or worms. There are, however, complimentary methods of detecting early animals, including much more readily preservable trace fossils, microfossils and geochemical signatures, all of which point to a revolutionary change of state at the base of the Phanerozoic. This certainly doesn't rule out the presence of earlier animals, but the Cambrian explosion is demonstrably real – and demands some sort of explanation.

Proper explosions, of course, have triggers, and there is a turn-away business in explaining the Cambrian phenomenon in such terms. Perhaps it was set off by a meteorite impact, or a bout of cosmic radiation, or severe glaciation. Perhaps… but few of these suggestions are accompanied by convincing analysis. Somewhat more reasonable, and potentially testable, are various threshold or 'permissive environment' hypotheses.

Above: Eifellia globosa, a fossil sponge from the middle Cambrian Burgess Shale, SE British Columbia

Right: Fossilized track-ways of a hunting trilobite and a hunted worm from the early Cambrian Mickwitzia Sandstone, Sweden (courtesy of Soren Jensen)

Far right: Ottoia prolifica, a fossil priapulid worm from the middle Cambrian Burgess Shale, British Columbia (courtesy of Martin Smith)

Maybe animal evolution was held back by nutrient availability, or the ions necessary for biomineralization, or the oxygen required to support their (purportedly) high metabolic demand? Again, many of these models simply don't hold up to scrutiny, though the idea of an oxygen fuelled radiation remains a perennial favourite.

Geochemists have done an excellent job of documenting extensive deep-water anoxia in pre-Cambrian oceans, but the connection to early animal evolution involves some rather problematic assumptions. One is that deep-water anoxia tells us something useful about biology in oxygenated shallow water settings. Another is that basal animals contribute little more to the oxygen balance than voraciously burning it off. Another is that major evolutionary innovations are easy and will snap automatically into place as soon as permissive external conditions are met. None of these is true. Indeed, there is a strong case for viewing the oxygenation of the late-Precambrian oceans as the consequence rather than the cause of early animal evolution.

One of the major themes in current Earth-system science is recognizing the pervasive effects of organism activity on physical environment – 'ecosystem engineering.' Burrowing worms, for example, have a profound impact on both the structure and chemistry of modern sediments and soils. By the same token, the earliest animals (probably suspension feeding sponges) would have hoovered up suspended organic matter from seawater, substantially expanding aerated conditions quite independently of changes in atmospheric oxygen. Animals are also powerful 'evolutionary engineers,' driving the co-evolution of other organisms through predator-prey interactions and niche partitioning. As such, early animals were in a position to set off a host of cascading chain-reactions involving reciprocal co-evolutionary and engineering feedbacks. As the system went critical, it would have experienced penetrative radiation, not only of animals, but also phytoplankton, biomineralization and burrowing – the planetary revolution now known as the Cambrian explosion. The trigger, it seems, was simply the evolution of animals themselves.

Current estimates for the evolutionary first appearance of animals bottom out at around 750 million years ago, at least a billion years too late to invoke oxygen availability as a determining factor. At the same time, it is worth appreciating just how fundamentally complex animals are, and that they only ever evolved once, despite the longstanding availability of permissive environments. This is very much the signature of an internal, genetic control on evolutionary appearance, in particular the astronomically complex nature of the gene regulatory networks necessary to assemble even the most simple animals.

In my opinion, there is no particular trigger here, just an evolutionary random walk and the unlikely discovery of a transformative new technology. Nor should we be surprised by the ~ 200 million year separation between the first evolutionary appearance of animals and the Cambrian explosion. Just like our own reverse engineering of the modern biosphere, there will have been a long and complicated history leading up to the tipping point.

FURTHER READING:

Butterfield, N. J. 2009. Oxygen, animals and oceanic ventilation: an alternative view. *Geobiology*, 7, 1–7.

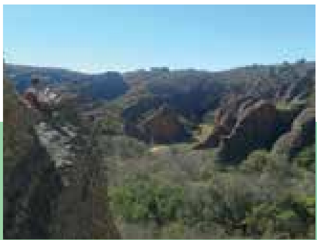
Butterfield, N. J. 2011. Animals and the invention of the Phanerozoic Earth system. *Trends in Ecology* and *Evolution*, 26, 81–87.

Butterfield, N. J. 2015. Early evolution of the Eukaryota. *Palaeontology*, 58, doi: 10.1111/pala.12139

UNDERGRADUATE

Mapping Projects

Our extensive fieldwork programme is central to the teaching within the Department. From studying gigantic millipede tracks on Arran, to ancient reefs and volcanoes in Spain, fieldwork greatly enriches the undergraduate experience. In their third and fourth years, the freedom to choose imaginative mapping projects and explore their own ideas builds students' research skills and exposes them to the wealth of possibilities geology can offer. This year's mapping projects included trips to: **Scotland; Wales; Sweden; New Zealand; Brazil; Iceland; France; Nicaragua; Spain and China.**



BRAZIL

Parnaiba Basin

I did not expect the basin sediments to be so perfect. The contact between units of starkly contrasting colour dipped gradually into the ground to the North for kilometres! It was the most impressive display I've seen of the scale of our subject, and the processes and great timescales it encompasses.

Memorably, we worked in a gorge that had walls forty metres high and was pitch black in places. The air was cool, and there was a sense that you were completely alone. It made you wonder how long it had been since someone else stood there – years, centuries?

Geraint Norwood-Smith

ICELAND

Steinadalur

One of the most memorable features of the trip was the Holuhraun eruption which started while we were in Iceland. We knew some of the geologists working on the island so were able to see footage of the eruption and hold samples of 1 day old lava!

Bethany Vickers

WALES

Blaenau Ffestiniog

The xenoliths in microgranite, pumice cobbles in tuff, polygonal cooling patterns in rhyolite, intense cordierite spotting, and abundant soft sediment deformation structures were some of the unplanned highlights of our trip. We had next to no rain; incredible, considering that Blaenau Ffestiniog is one of the wettest places in the country.

Peter Thompson

SCOTLAND

Kerrera

Kerrera exceeded our expectations. The coastal exposure was amazing and the landscape was incredible. The only issue with the island was a lack of roads and paths, so we did battle with the bracken a lot!

We won the Class of 2005 Mapping award, so a big thank you to the alumni who donated to that, it was very much appreciated.

Laura Briggs

CHINA

I particularly remember the people I met along the way: the shepherd I had lunch with in the jungle; the fisherman with a net of crabs, gastropods and jelly fish along the beach; the environmental workers collecting radioactivity data from a factory site in the valley. Such conversations explored the lives of people from different walks of life and expanded my general knowledge.

Qi Ou

FRANCE

Briancon

We were concerned that the area may be too complicated and metamorphosed to identify anything, but it was manageable. The ophiolite sequence was just perfect, with the most obvious pillow basalts you would ever see; whole cliff faces of them.

Claire Bond

FRANCE

Alp d'Huez

We chose the area because it has perhaps the best preserved ophiolite – a fragment of oceanic crust – in mainland Europe. It was quite different from anything we had seen on field trips. Whilst some bits of an ideal ophiolite sequence were missing, it was largely intact. The variety was great – some deformed metasediments and later intrusives too.

On the last morning we got up at 5.45 to head to the highest summit of the mapping area for sunrise. With snowy 4000m peaks only 20 miles away, the alpenglow was simply stunning, turning everything a wonderful hue of pink and orange. To top it all off, porridge and a brew on top!

Tom Hare

SWEDEN

North Uto Island

For me, the most memorable but painful part of the trip was when we went riding waves in kayaks and capsized. I also enjoyed the few times Johnny fell into the sea when we were working along the coastlines!

Matty O'Toole Howes

NEW ZEALAND

Raglan

We hiked the Tongariro Alpine Crossing: 20km over a mountain and an active volcano in the snow. It was very beautiful. We also got to see active geothermal parks, which was a big treat as there is nothing like that in the UK. And of course we went to the Hobbiton movie set, and dressed up as Hobbits!

Ayala Donegan

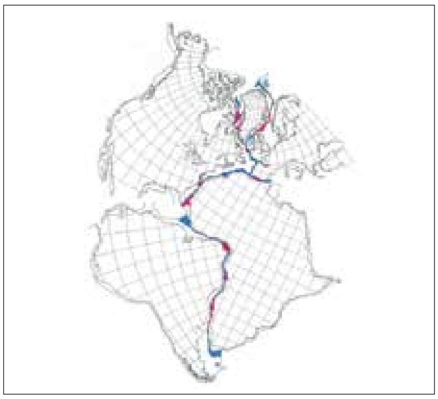
The opportunity to see and interpret examples of the geology taught in lectures is often a transformative experience for students. By funding the fieldwork programme we ensure that no geology student is excluded on financial grounds.

The Earth Sciences Fieldwork Fund exists to ensure that we can continue to make geology fieldwork for Cambridge undergraduates an exceptional experience. For further details, please visit: **www.esc.cam.ac.uk/news/resources-news/earth-sciences-fieldwork-fund**

RECENT NEWS & AWARDS

The Geological Record

01



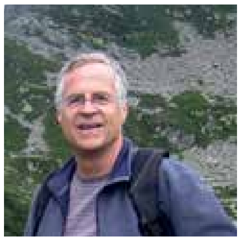
Celebrating the 50th anniversary of 'Fitting the continents'. The apparent jig-saw-like geometrical fit of the continents on either side of the Atlantic had been noticed for well over a hundred years. However, it was only 50 years ago that the question of the fit was first quantified by three Cambridge geophysicists. In their widely cited 1965 paper on 'The fit of the continents around the Atlantic', Sir Edward Bullard, J.E. Everett and A. G. Smith used numerical methods to produce the best fit possible, which they thought 'not to be due to chance'. They also suggested that such geometrical fits could be used to compare 'the stratigraphy, structures, ages and palaeomagnetic results across the joints'. Alan Smith is an active, emeritus member of the Department.

www http://www.esc.cam.ac.uk/news/research-news/celebrating-the-50th-anniversary-of-fitting-the-continents

http://rsta.royalsocietypublishing.org/content/258/1088/41

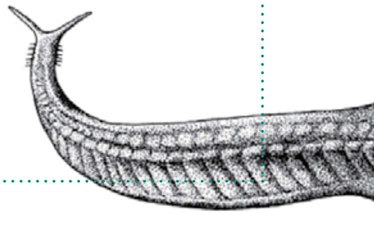
02

Tim Holland has been elected a Fellow of the Royal Society. Tim has worked on the petrology of high-pressure rocks by making advances, together with Roger Powell, in thermodynamic modelling of metamorphic and igneous systems. This work together with the software THERMOCALC now underpins a large proportion of current research in metamorphic petrology.



03

Congratulations to **Nick Butterfield** who has been promoted to a Professorship. Nick's research is focused on the early evolution of life on Earth, including the Proterozoic rise of eukaryotes and the Ediacaran-Cambrian 'explosion' of animals. He is especially interested in exploring the fundamental divide that separates the first three billion years of (mostly) microbial life from the peculiarly macroscopic world that we currently occupy – the Phanerozoic. Nick writes *On the origin of animals* on page 8.



04

ANNE PURKISS

Dan McKenzie (Kings' 1960) received an Honorary Degree, the highest honour that the University can bestow, from the Chancellor in June 2014 in a special ceremony that included six other distinguished individuals.

05

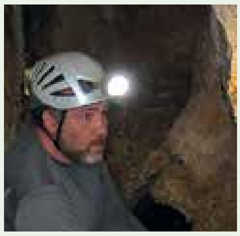
We welcome **Professor Jean-Philippe Avouac** as the first holder of the new BP Foundation McKenzie chair in Earth Sciences. The chair, named after Dan McKenzie, CH, FRS, Emeritus Professor of Earth Sciences, was established with funding awarded by the BP Foundation in recognition of Professor McKenzie's contributions to Earth Sciences.

Jean-Philippe will lead a research team developing an innovative approach to understanding the physical processes which generate destructive earthquakes and tsunamis. He has an international reputation for crossing traditional academic boundaries in his research and is the former Director of the Tectonics Observatory at Caltech.

06 **Alex Copley** (Queens' 2004) received the Fowler Prize in geophysics awarded by the Royal Astronomical Society. The prize, which acknowledges early achievement in Astronomy and Geophysics, was awarded to Alex in recognition of his important contributions to our understanding of lithospheric stress and deformation. Alex returned to the Department from Caltech in 2010, becoming a Lecturer in 2012.

Ollie Shorttle (Queens' 2005), Junior Research Fellow at Trinity College, was one of three recipients of the 2014 Geological Society President's Award, awarded to young geoscientists who have made a notable early contribution to the field. Ollie's work focuses on understanding the chemistry of the deep Earth and the physical processes associated with mantle melting, transport of magma and magma storage in the crust.

08 **Sally Gibson** was awarded The Hallimond Lecture in 2014 by the Mineralogical Society for her outstanding contribution to mineralogy and petrology. Previous Hallimond Lecturers from the Department of Earth Sciences were Stuart Agrell (1974) and Dan McKenzie (1991). Sally's lecture, delivered at the Mineralogical Society's Annual Meeting, was entitled 'Continental rifting & mantle exotica' and included a discussion of the geodynamic significance of microscopic textures that have recently been found in 3 billion year old mantle xenoliths from Africa.



09 **Albert Galy**, Senior Lecturer, left the Department at the end of 2013 to take up a new role as Professor at the Université de Lorraine in Nancy, France. Albert had taught in the Department since 2000. We wish him well in his new position.

10 **Ed Tipper** (Magdalene 1998) returns to the Department, from the University of St Andrews, as a University Lecturer and Fellow of St John's College. Ed is currently working on a range of projects such as using Mg isotope ratios to better understand chemical weathering processes and the evolution of the continental crust. Recent fieldwork has taken Ed to Australia to sample the Murray and Darling Rivers, Vietnam to sample the Red River, the Arctic Circle of Canada to sample the Mackenzie and Yukon Rivers, and most recently to the Mekong River in Cambodia.

11 **John Maclennan** (Emmanuel 1993) in addition to being promoted to a Readership in 2014, has been awarded both the 2014 Bigsby Medal of the Geological Society, in recognition of his research, and a Pilkington Teaching Prize for excellence in teaching. John explains, on the BBC website, how the Harker collection, held by the Sedgwick Museum, throws light on the interior of the Earth: **www.bbc.co.uk/news/science-environment-27678862**

In 2014 research was undertaken at the Sedgwick Museum with an Arts Council England (ACE) grant to investigate members of the Sedgwick Club who saw active (and non-active) service during WW1, and the ways in which they contributed to the war effort, geologically or otherwise.

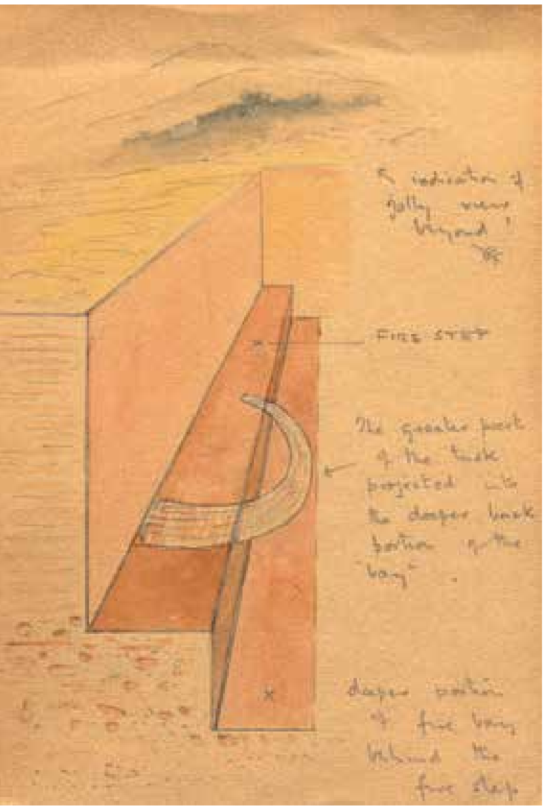
Left to right: WBR King, Archibald Don, T-C Nicholas

For Club and Country:
The Sedgwick Club and WW1

The exhibition opened at the Sedgwick Museum in February. Archivist, **Sandra Freshney,** details some of the findings.

The project was conceived following the donation in 2012 to the Sedgwick Museum archives of material from the family of Professor W.B.R. King (1889–1963). King was a student at Jesus College (1908–1912) and 11th Woodwardian Professor (of Geology) from 1943 until his retirement in 1955.

During WW1 WBR King supervised and interpreted many of the 400 borings which were put down behind the Western Front, which had been investigated for water supply. He was subsequently awarded an OBE for his services, which is now in the care of the Museum. The Archive, which includes notebooks, maps and a photograph album was catalogued with the kind assistance of the late Dr Colin Forbes, and is now available online: **archiveshub.ac.uk/data/gb590-wbrk.**



Tusk diagram from original letters

The Sedgwick Club ceased its regular meetings with the outbreak of war, as indicated in the minute book for 1914, and would not meet regularly again until 1919. A 'war-list' was written in 1915 and displayed in the Museum; College affiliation and the military rank of members were provided. Of the 43 members listed (all men), 7 sadly lost their lives. This original list is on display in the exhibition.

One photograph in Professor King's archive (from a Sedgwick Club excursion to Wales, 1911) led staff to look more closely at Archibald Don, who had been a natural sciences student at Trinity College. From reading Don's biography, it was discovered that he had written to Professor Thomas McKenny Hughes in 1916, after sending mammoth bones and other items to the Museum. The 10th Battalion Black Watch had found these in the trenches in Salonika [Thessaloniki] where Don was stationed. The bones were subsequently displayed in the museum, as were the original letters and sketches, still in their envelopes.

"The top lay 5 feet 9 inches from the middle of the thick end, and this line (joining the tip to the thick end) was 3 feet 4 inches from the furthest point of the cm've. The measurement of the outer curve of the tusk worked out at almost exactly 10 feet … I hope this fragmentary relic reaches the Sedgwick Museum all right, and that I shall some day, not too distant, see it there"

Sadly Archibald Don succumbed to malignant malaria (originally presumed to be dysentery) 11 September 1916, aged 25. He therefore never got to see in-situ the materials that he had carefully and dutifully sent back to the Museum.

Graptolite expert, and Newnham College student, Getrude 'Gertie' Elles (1872–1960), was awarded an MBE in 1920 for her work with the Red Cross. During WWI she commanded Wordsworth Grove Hospital for injured soldiers in Newnham. Photographs of Gertie from Cambridge University Library will also feature in the exhibition.

The Museum Archive has records documenting hundreds of years of Earth Sciences and the history of the Sedgwick Museum: correspondence; notebooks; maps; photographs; and hand-written specimen catalogues. For further information or to arrange a visit please contact the Archivist, Sandra Freshney:

sjm259@cam.ac.uk

www.sedgwickmuseum.org

OBITUARIES

EDWARD A IRVING 1927–2014

After his National Service Edward (Ted) Irving came up to Cambridge in 1948 to read Geology. He did not find the lectures very interesting and did not do well, obtaining only a Lower Second Class degree.

His research career started when Keith Runcorn, who was on the staff of the Department of Geodesy and Geophysics, took Ted on as a research student in 1951. Keith's background was in Physics: he had been a graduate student of Patrick Blackett. He wanted to use paleomagnetism to study the variation of the Earth's magnetic field, but he realised he needed to work with someone with a geological background. Ted collected a suite of samples from the Torridonian in Scotland and used Blackett's magnetometer in Manchester to measure their direction of magnetisation. This was a completely new area of Geophysics, and Ted had to learn which rocks produced reliable results and a procedure for obtaining them.

He was aware of the controversies surrounding the idea of Continental Drift, and realised he could use paleomagnetic measurements to determine the past location and orientation of continents. He persuaded R.A. Fisher, who had provided Ted with the statistical framework for interpreting his paleomagnetic observations, to bring back some orientated samples of Deccan basalts when Fisher visited India. Ted measured and found that they had been magnetised far to the south of their present location.

In retrospect this work was the start of what is now called Plate Tectonics.
Ted wrote up all these results for his Ph.D., which, astonishingly, he failed. But his Ph.D. work formed the basis of his outstandingly successful career in paleomagnetism, a field which he came to dominate. Henry Frankel (2012) gives a detailed account of Ted's career, with some wonderful anecdotes, in *The Continental Drift Controversy*.
Ted's research led to his election to the Royal Society, the U.S. National Academy and the award of the Wollaston Medal of the Geological Society.

I will miss him deeply: he remained scientifically sharp and critical to the end.

Dan McKenzie

Frankel H.R. 2012 The Continental Drift Controversy. Paleomagnetism and Confirmation of Drift, Cambridge University Press

COLIN LACHLAN FORBES 1922–2014

Dr Colin Forbes (Clare 1940) – former curator and major benefactor of the Sedgwick Museum – died on 12 May 2014, aged 92.

Colin read Natural Sciences at Clare in 1940–1 and again, after war service in India, in 1947–49. He did a PhD on fossils from Spitsbergen in 1949–53 and became Assistant Curator of the Sedgwick Museum in 1954. He was Curator from 1966 to his retirement in 1982. In parallel with his curatorship, Colin was geological consultant to the Cambridge Water Company. Both jobs required an intimate knowledge of local geology.

Colin became a director of Cambridge Water and then, thanks to a modest inheritance, a significant shareholder. When the company was privatised in 1999, Colin was surprised to find himself wealthy beyond his modest needs.

He was able to make large benefactions both to the Sedgwick Museum and to Clare College, a generosity recognised by membership of the University's Guild of Benefactors. In retirement, Colin continued to live simply, and to help in the museum archives.

He is commemorated by his initials engraved on his favourite rhomb porphyry cobble in Clare Old Court and by the clean and reliable water supply that Cambridge enjoys.

Nigel Woodcock

COLIN PILLINGER 1943–2014

Professor Colin Pillinger, CBE, FRS – Senior Research Associate in the Department of Earth Sciences, University of Cambridge 1978–1984 – died in Cambridge aged 70 on 7 May 2014.

Colin was best known for his 2003 attempt to land Beagle-2 on Mars. His professional career began with analysing rock samples picked up on the moon by Neil Armstrong during the Apollo 11 mission in 1969, and continued after his death with his involvement in the successful ESA mission to deliver the Philae lander to the surface of Comet 67P/Churymov-Gerasimenko from the spacecraft Rosetta.

Alumni Events

We are reviewing and expanding our events programme for alumni. Please check the website and our e-newsletters for further details.

Alumni Day and Dinner 2015: 9 May

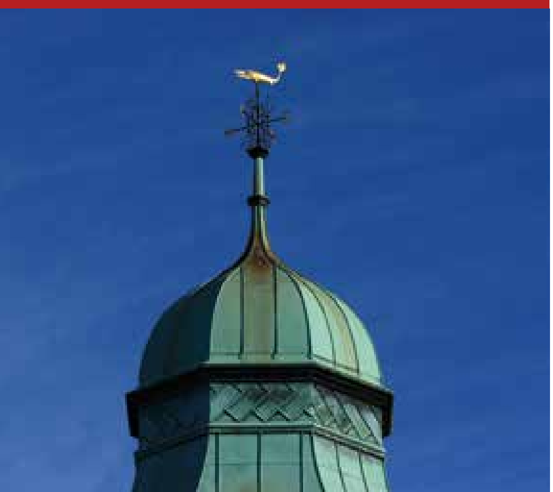
The biennial Alumni Day and Dinner will be held on Saturday 9 May 2015. We warmly invite all alumni to attend. The dinner will be held in St John's College following a drinks reception in the Sedgwick Museum.

Alumni Festival 2015: 25–27 September

We hold a number of events at the annual Alumni Festival, further details of the full weekend programme: **www.alumni.cam.ac.uk/events**

Research Talks and Seminars

Alumni are welcome to attend the Department of Earth Sciences talks and seminars: **http://www.esc.cam.ac.uk/news/talks-and-seminars**. Please do let Alison know if you are able to join us.



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Keep in touch…

We are very keen to keep in contact with our alumni across the world and list below some of the many ways of staying in touch and being involved with our alumni community.

Alison Holroyd, Alumni Co-ordinator, is happy to answer any questions you may have. Do please contact us if you wish to re-establish contact with the Department, are interested in business and/or research collaboration opportunities, have work placement opportunities, would like to offer careers advice to our current students or would like to support one of the Department's initiatives.

We look forward to hearing your news and are always delighted to welcome alumni back to the Department, do let us know if you are planning a trip to Cambridge.

Alumni of the University of Cambridge are entitled to a range of benefits and services. More information can be found at **www.alumni.cam.ac.uk/benefits**

Do you receive our termly e-newsletter?

To be added to the mailing list, contact us at **alumni@esc.cam.ac.uk**

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Earth Sciences on YouTube: http://www.youtube.com/watch?v=sUj4as55658

A brief look at the earth sciences course to encourage the next generation of earth scientists.