GeoCam

EARTH SCIENCES ALUMNI MAGAZINE

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NEWS
Measuring volcanic gas emissions using drones

FEATURE
Geology for Global Development

RESEARCH
Preparing to meet other planets

UNIVERSITY OF CAMBRIDGE


Welcome

Coming, as I do, from the "South Wing" end of the Department, I feel most comfortable with my feet on solid rock, preferably igneous or metamorphic. Surely, I suggest, it is much better (at least for finding your footing) than shifting sands or sticky mud, although I realise that these have captivated many in the North Wing over the years. As I write this, in late January 2019, the UK is trying to find a way forward through the mire that is our future with, or without, Europe. Shifting sands and sticky mud lie around and ahead. By the time you read this you will have the benefit of hindsight, so almost anything I say on the matter is redundant. I will, however, take the chance to reflect on how much the Department has long benefited from collaborations, interactions, and friendships with colleagues across Europe and beyond.

In GeoCam a year ago I highlighted how science serves society in solving immediate and emerging problems that affect us all. Geoscience has historically provided the tools to find the resources on which communities depend: energy, metals, minerals, the stone, concrete, steel and glass from which cities are built. Our science also seeks to enable societies to develop sustainably and securely in harmony with the planet. But a further important facet of science is in the realm of "soft power", through its very culture of cooperation and internationalism. Although competition and national pride surely play a part in how we operate, seeking answers is increasingly through teams of complementary and often international geoscientists. As a graduate student, one of the best conferences I attended was funded by the NATO "Science for Peace and Security" programme – demonstrating that even feldspars have significance beyond their mineral complexities. In recent decades the European Union has enthusiastically promoted scientific interaction, most notably through its "training and mobility of researchers" activities. This Department has enjoyed the immense benefits of such interactions, building collaborations and networks that will last well into the future. The European Research Council has emerged as a leading sponsor of much of our most creative and cutting-edge science, favouring as it does ground-breaking and potentially risky ideas. Such projects are the ones that are most likely to yield unexpected benefits and change the way we understand and think about our planet.

The fear of shunning such positive forces in science has led UK learned societies to raise concerns at the risks of a future outside the EU. I hope that a route through the mire will be found that benefits all, embracing international cooperation and teamwork.

Staying with that theme, I reflect on my time walking the Pennine Way last summer, around 30 years after first completing it. In the meantime, the upland peat sloughs and bogs that once acted as atrocious barriers to progress have been "improved" by the addition of flagstone paths. Even I began to appreciate the beauty and utility of a good Carboniferous sandstone underfoot. May the road rise up to meet you …

Simon Redfern Head of Department

IN THIS ISSUE

COVER IMAGE: FROM THE LEFT, PENNY WIESER, DR EMMA LIU AND EMILY MASON IN FRONT OF LAVA FLOWS DURING THE ERUPTION OF KĪLAUEA IN SUMMER 2018. LAVA FLOW SPEEDS WERE ESTIMATED AT 30 METRES PER SECOND.

The Crombie Seismological Laboratory

Nestled behind the Bullard Laboratory buildings at Madingley Rise is the Crombie Seismological Laboratory. This small, unassuming building is filled with many geophysical instruments, components and photographs, ranging from nineteenth-century gravimeters, to sonobuoys and ocean-bottom seismometers.

Mel Mason and Tim Owen worked in the Department for many years, developing seismic equipment and supporting seismic surveys around the world from the mid 1960s until the early 2000s. Since their retirements they have returned as volunteers, conserving and cataloguing the instruments and their stories for future generations of Earth Scientists.

If you are interested in finding out more about the objects in the instrument archive, or volunteering time or knowledge please contact **alumni@esc.cam.ac.uk**.

RESEARCH **NEWS**

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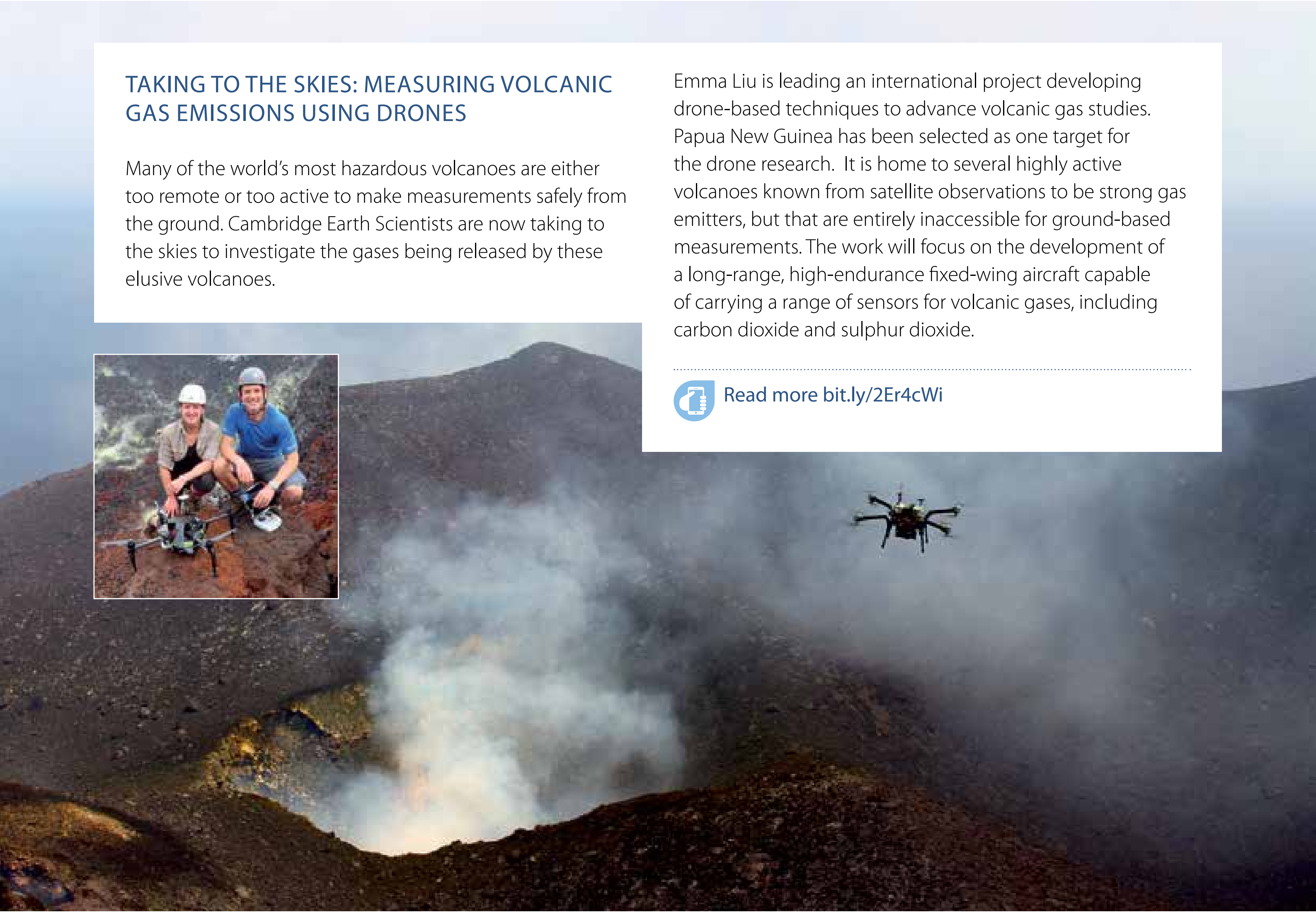
TAKING TO THE SKIES: MEASURING VOLCANIC GAS EMISSIONS USING DRONES

Many of the world's most hazardous volcanoes are either too remote or too active to make measurements safely from the ground. Cambridge Earth Scientists are now taking to the skies to investigate the gases being released by these elusive volcanoes.

Emma Liu is leading an international project developing drone-based techniques to advance volcanic gas studies. Papua New Guinea has been selected as one target for the drone research. It is home to several highly active volcanoes known from satellite observations to be strong gas emitters, but that are entirely inaccessible for ground-based measurements. The work will focus on the development of a long-range, high-endurance fixed-wing aircraft capable of carrying a range of sensors for volcanic gases, including carbon dioxide and sulphur dioxide.

Read more bit.ly/2Er4cWi



SCIENTISTS MEASURE SEVERITY OF DROUGHT DURING THE MAYA COLLAPSE

A new study, with lead author former Earth Sciences' PhD student Nick Evans, quantifies the severity of drought conditions during the demise of the Maya civilisation about 1,000 years ago. The results represent another piece of evidence that could be used to solve the longstanding mystery of what caused the downfall of one of the ancient world's great civilisations. They build on the evidence first presented by David Hodell, Director of Cambridge's Godwin Laboratory for Palaeoclimate Research.

The team developed a new geochemical method to measure the water trapped in gypsum from Lake Chichancanab in Mexico's Yucatán Peninsula, and built a complete model of hydrological conditions. They found that annual precipitation decreased between 41 and 54 per cent relative to today during the period of the Maya civilisation's collapse. These results can be used to better predict how drought conditions may have affected agriculture, including yields of the Maya's staple crops, such as maize.

Read more bit.ly/2PXF276

MAGNETIC PROPERTIES OF METEORITE 'CLOUDY ZONES' REVEALED

Research by Joshua Einsle and Richard Harrison has explored the enigmatic iron-nickel meteoritic composite known as the 'cloudy zone' which formed in the early days of the solar system, in planetesimals with molten cores like Earth.

Studying the nanostructure of these magnetic recorders will not only improve understanding of the magnetic fields generated during the formation of solar system bodies. The same magnetic properties could provide a model for sustainable permanent magnets for industry, free from rare-earth elements.

Read more bit.ly/2MyKvgn

LESSONS ABOUT A FUTURE WARMER WORLD USING DATA FROM THE PAST

Selected intervals in the past that were as warm or warmer than today can help us understand what the Earth may be like under future global warming. A latest assessment of past warm periods, by an international team of scientists including Earth Sciences' Eric Wolff, shows that in response to the warming ecosystems, climate zones will spatially shift and on millennial time scales ice sheets will substantially shrink.

The compiled evidence from the past suggests that even with a global warming limited to within 2°C above preindustrial levels, as aimed at in the Paris Agreement, climate zones and ecosystems will shift, rapid polar warming may release additional greenhouse gases, and sea-level will rise by several metres over several thousand years. These observations show that many current climate models designed to project changes within this century may underestimate longer-term changes.

Read more bit.ly/2C5LPUB

'TREASURE TROVE' OF DINOSAUR FOOTPRINTS FOUND IN SOUTHERN ENGLAND

More than 85 well-preserved dinosaur footprints – made by at least seven different species – have been uncovered along the cliffs near Hastings, East Sussex, representing the most diverse and detailed collection of these trace fossils from the Cretaceous Period found in the UK to date. The footprints, identified by Cambridge Earth Sciences' researchers, range in size from less than 2cm to over 60cm across and are so well-preserved that fine detail of skin, scales and claws are easily visible.

"Whole body fossils of dinosaurs are incredibly rare," said PhD student Anthony Shillito, the current study's first author. "Usually you only get small pieces, which don't tell you a lot about how that dinosaur may have lived. A collection of footprints like this helps you fill in some of the gaps and infer things about which dinosaurs were living in the same place at the same time."

The footprints described in the study, which Anthony co-authored with Neil Davies, were uncovered during the past four winters, when strong storms and storm surges led to periods of collapse of the sandstone and mudstone cliffs.

Read more bit.ly/2ST2Tmb

EMILY MASON AND PENNY WIESER
VOLCANOLOGY PHD STUDENTS

A DAY IN **THE FIELD:**
Sampling emissions from Kīlauea, Hawai'i

Emily (left) and Penny (right) sample a recent lava overflow next to the Fissure 8 cone.

The team of Cambridge, Leeds and USGS scientists trek across the tephra field to sample emissions behind the main eruptive vent.

Since 1983, volcanic activity at Kīlauea Volcano, Hawai'i, has been largely focused at Pu'u 'Ō'ō cone. This changed abruptly in March 2018, when tiltmeters and GPS stations recorded pressurization at Pu'u 'Ō'ō and Kilauea's summit. On 28 April, the summit lava lake subsided rapidly to depths of below 300m, and Pu'u 'Ō'ō cone collapsed on 1 May.

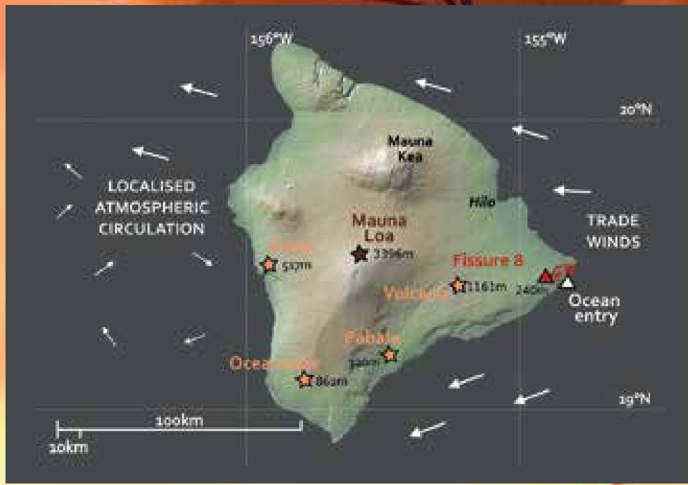
Main image:
USGS scientists film Fissure 8 at night.

This event was followed by the propagation of a dyke down to the Leilani Estates subdivision, a peaceful green neighborhood perched precariously on the Lower East Rift Zone. The first fissure opened on 3 May, and over the next month, a total of 24 fissures opened, with activity eventually localizing at Fissure 8, producing a prominent volcanic cone.

While the Hawaii Volcano Observatory closely monitored seismicity, deformation and gas chemistry, they were missing a crucial part of the story. Alongside huge volumes of gases (e.g. H_2O, SO_2, CO_2), volcanoes also emit significant fluxes of aerosol. These have substantial health and environmental effects, but are rarely researched. Thus, the United States Geological Survey (USGS) invited volcanic aerosol specialists to put together a team to investigate the distribution and composition of aerosol across Hawai'i.

Within two weeks of receiving the invitation, an all-female team of five volcanologists from Cambridge and Leeds University were en-route to Hawaii with over 250kg of scientific kit. The aim of the project was to characterize aerosol emissions from the Fissure 8 vent, and investigate how the chemistry and strength of the aerosol plume changed as it travelled to exposed communities around Hawai'i.

Fieldwork on active volcanoes often requires scientists to carry heavy instruments up steep slopes. In contrast, as this eruption initiated within a

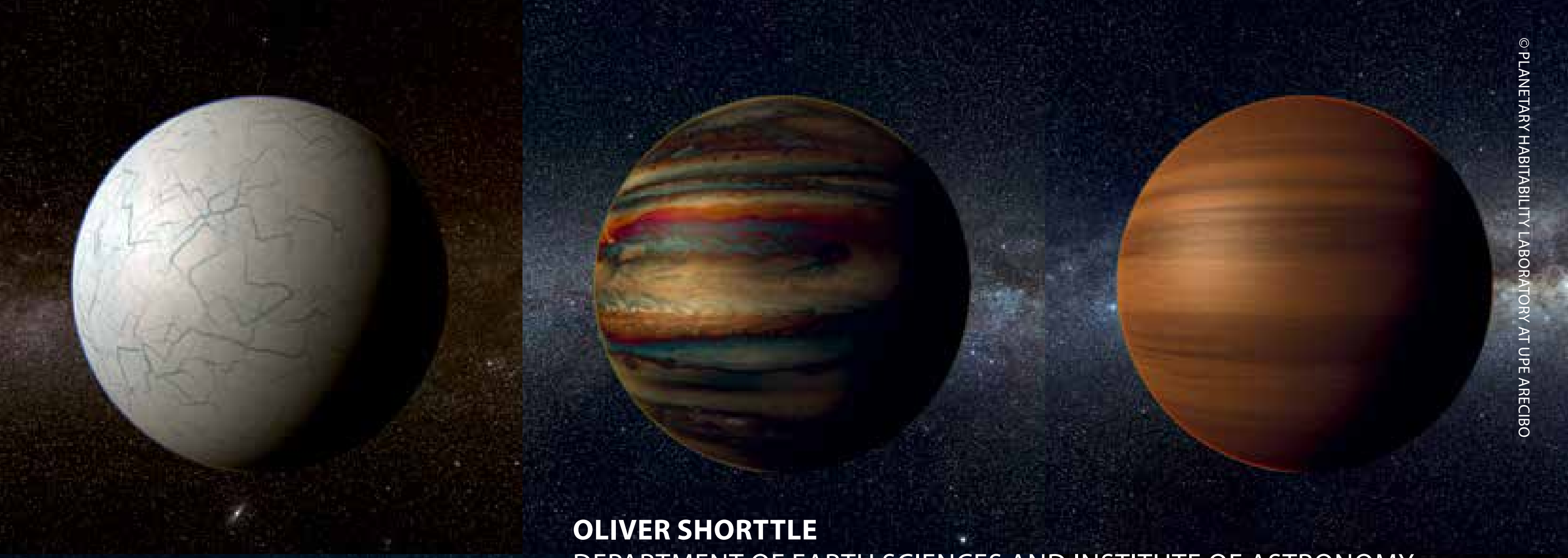


Map of plume locations (triangles) and sampling network sites (stars) around the Island of Hawaii during the 2018 field campaign. Wind directions are indicated by white arrows.

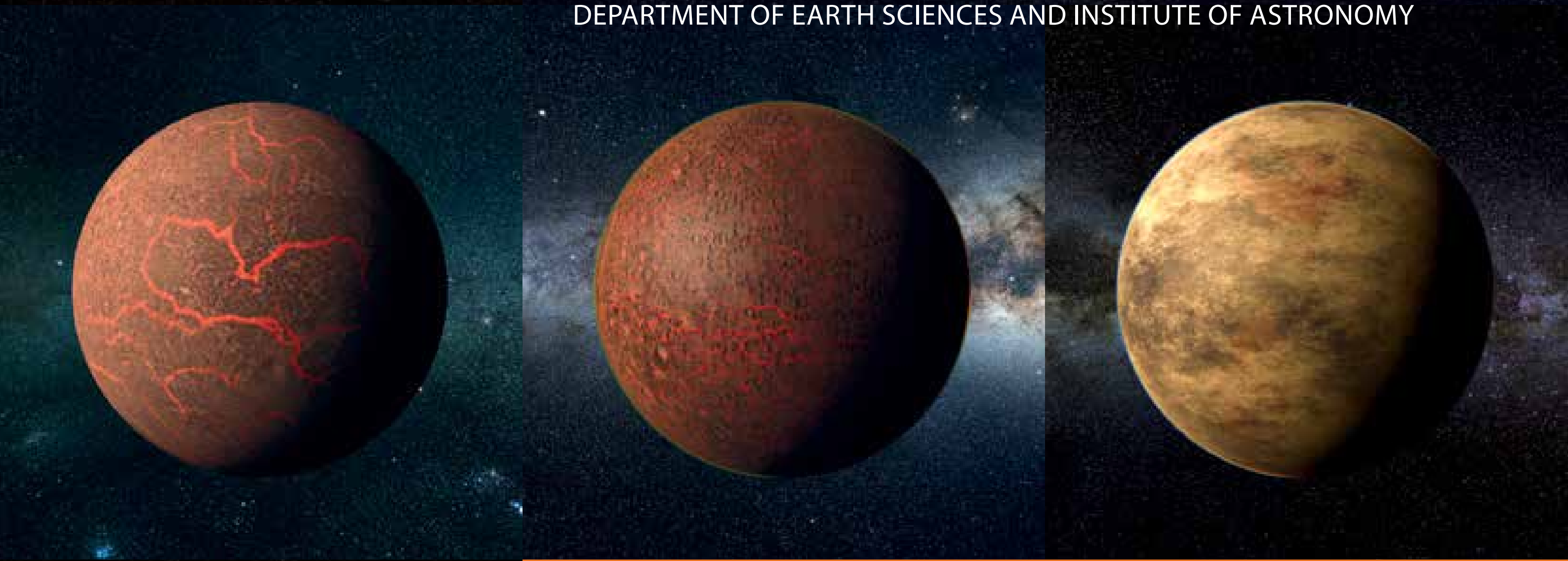
residential estate, we were able to drive on tarmacked roads to within 100m of the Fissure 8 cone! However, sampling the volcanic plume was still challenging. It rarely "grounded", instead rising vertically upwards from the unstable cone. Fortunately, the USGS had a team of dedicated drone pilots to aid with monitoring the eruption. To our surprise, they were excited to fly their expensive drones with our instruments attached into the extremely acidic and corrosive plume, allowing us to get concentrated samples of the plume directly at its source. To capture the intermittent grounding plume at the back of the Fissure 8 cone, but avoid exposure to high concentrations of gas, we built a "drop and run" sampling instrument using a back frame rucksack and lots of duct tape and cable ties. This was named Harry, after the intrepid volcanologist of the 1997 film "Dante's Peak".

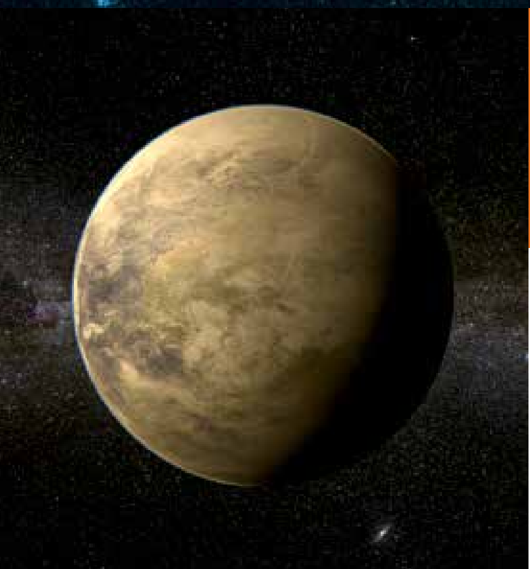
Where the Fissure 8 lava flow meets the ocean on the south-east coast of Hawai'i, a "laze" plume is created by the explosive interactions of hot lava and seawater. However, as the area downwind of this plume was completely surrounded by lava flows formed in May, we used a USGS helicopter to gain access. Upon landing, we were met by a desolate and unforgiving landscape, corroded and worn out by the acidic rains forming from the 'laze'. This also stung exposed skin, requiring us to wear Hazmat suits!

Sampling the plume as it aged, at seven sites dispersed across the island, required seven hours of driving every 48 hours. This, alongside our temperamental instruments, lead to many long days. Highlights of each trip were coffee pit stops (especially the Kona affogato), and eating our weight in pretzels. As the final station was dismantled in preparation for flying home, we received the news that lava was no longer flowing from Fissure 8. Between May and 7 August, the Lower Puna eruption had created 3.5km^2 of new land, and covered ~35km^3 of existing land, destroying over 700 homes along the way. Working on this new phase of Kīlauea's eruptive history, we saw breathtaking lava flows and immense volcanic emissions. However, our excitement at seeing such dramatic physical phenomena was always subdued by the immense loss felt by the community of the Leilani Estates.



OLIVER SHORTTLE
DEPARTMENT OF EARTH SCIENCES AND INSTITUTE OF ASTRONOMY





Preparing to meet other Earths

NEW EXOPLANET-HUNTING TELESCOPES WILL START SEARCHING THE SKIES FOR OTHER WORLDS IN THE NEXT FEW YEARS. IN THE BUILD-UP TO THESE OBSERVATIONS, DR OLIVER SHORTTLE – ONE OF A NEW GROUP OF INTERDISCIPLINARY PHYSICAL SCIENTISTS IN CAMBRIDGE – IS DEVELOPING GEOLOGICAL METHODS TO REVEAL WHETHER ANY OF THESE WORLDS RESEMBLE OUR OWN.

Left: Computer-generated images of exoplanet types.

Integrating Earth sciences with astrophysics is one part of a major new initiative in physical sciences to promote interdisciplinary activity; six new tenure-track researchers have been recruited across various disciplines to enable a wave of new discovery.

Earth is amazing. Over its 4.5 billion years of life, the planet has been redistributing heat and myriad chemical species between its deepest interior and its outer surface. It's a cycle of rejuvenation and replenishment that produces our climate, atmosphere and the nutrients to sustain life. Volcanic eruptions supply gases to our atmosphere, put fresh rock on the surface and add nutrients to the oceans. Carbon is drawn out of the atmosphere, locked away in the sedimentary crust and pulled into the Earth's deep interior by tectonic plates.

Amazing... but is it unique? "When we consider the question 'is Earth unique in the universe?' we come up against the n=1 problem: our understanding of Earth is limited by it being the only Earth-like planet we have to study," says Oli. He is fascinated by the history – and the future – of our planet and its oceans, atmosphere and biosphere. Like others, he is trying to reconstruct how the planetary system developed and works, using the tangible record we have of the Earth's past: its rocks.

"In some respects, being an Earth scientist is like being a zoologist with only one animal to study. What if we could change the n=1 problem to n=10 or n=100? Suddenly we come closer to answering major questions about how Earth-like planets evolve," Oli says. "Understanding Earth's own history requires us to leave Earth and look elsewhere."

Oli is a new type of Earth scientist – one whose focus is not just on the planet on which we stand but also on planets that orbit suns other than our own, so-called exoplanets.

A new generation of telescopes will make these detailed observations of exoplanets possible: NASA's Transiting Exoplanet Survey Satellite (TESS), which launched in April 2018, and the James Webb Space Telescope (a collaboration between NASA, the European Space Agency and the Canadian Space Agency), which is due to launch in 2021.

The first exoplanet, 51 Pegasi b, was discovered as recently as 1995 by Professor Didier Queloz from Cambridge's Department of Physics when he was a PhD student in Geneva. Until then, although astronomers had speculated as to the existence of these distant worlds, no planets other than those in our own solar system had been found. Now, over 3,500 exoplanets are known.

"Now we are on the cusp of a second revolution in exoplanetary science," says Oli. "Thanks to the new telescopes, we'll be able to characterise these planets beyond their mass and orbit – we'll be able to study their atmospheres."

OLI IS A NEW TYPE OF EARTH SCIENTIST – ONE WHOSE FOCUS IS NOT JUST ON THE PLANET ON WHICH WE STAND BUT ALSO ON PLANETS THAT ORBIT SUNS OTHER THAN OUR OWN, SO-CALLED EXOPLANETS.

But, he says, just knowing what the atmospheric conditions are like on an exoplanet isn't enough. "Many of the exoplanets we already know of are remarkably unlike anything we've seen in our own solar system. We will need to be able to interpret what any particular atmosphere means by understanding the fundamental geological processes that could have formed it. So in the build-up to receiving the space observations, we need to model what these 'geological signatures' mean."

His research focuses on volcanism – a universal planetary phenomenon that on long timescales forms atmospheres and on short timescales perturbs them. He and colleagues are building models to explain how different atmospheres are formed. "The idea is to use observations from the new space telescopes to 'work backwards', opening up a window into the interiors, tectonics and geological history of terrestrial exoplanets," he explains.

Oli is also working with physicists to understand the geological environment needed for life to begin. "Any small twist of fate could have stopped life from forming on Earth… not enough wet and dry, the wrong kind of light… the simplest things place constraints."

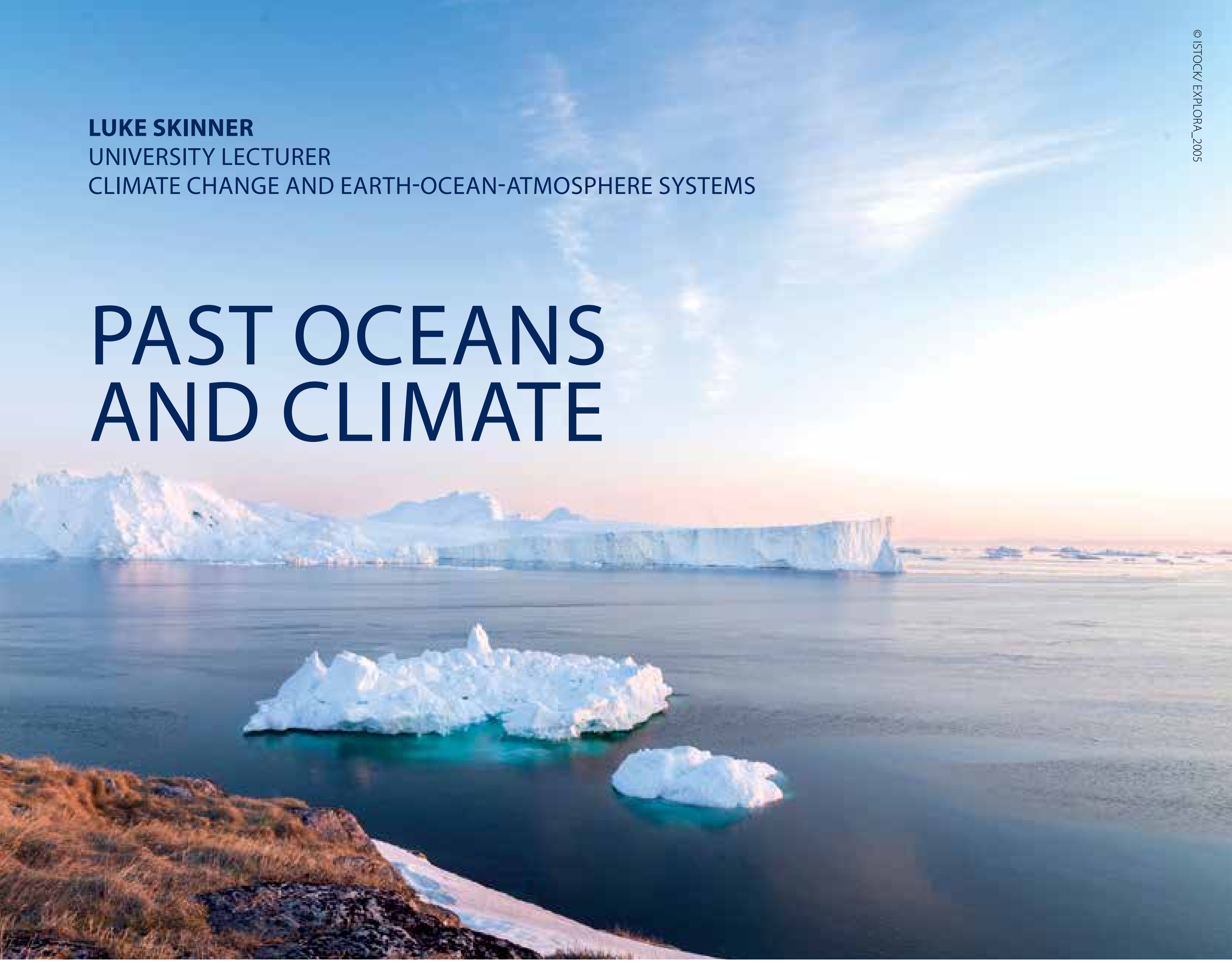
Integrating Earth sciences with astrophysics is one part of a major new initiative in physical sciences to promote interdisciplinary activity; six new tenure-track researchers have been recruited across various disciplines to enable a wave of new discovery.

"On paper my remit is absurdly interdisciplinary," enthuses Oli. "Trying to understand how Earth operates already requires a collection of disciplines. The study of exoplanets is taking this further. An even broader menagerie of understanding of physical, chemical and biological processes will be needed simply because we don't know what's out there." He adds: "I see my role as making connections that will turn astronomical observations into a picture of the geology of these new worlds, and in turn help our understanding of Earth's own evolution.

"Exoplanets might shed light on the events that brought Earth to its present. What, for instance, if we find a planet that looks just like Earth but that never evolved life – that would tell us something truly profound about our own existence."

Louise Walsh

This is an edited version of an article that first appeared in *Research Horizons*, Issue 37.



LUKE SKINNER
UNIVERSITY LECTURER
CLIMATE CHANGE AND EARTH-OCEAN-ATMOSPHERE SYSTEMS

PAST OCEANS AND CLIMATE

THE OCEAN IS A VAST AND DYNAMIC RESERVOIR OF HEAT AND CARBON THAT PLAYS A KEY ROLE IN THE GLOBAL CLIMATE SYSTEM. THE OCEAN EXERTS ITS INFLUENCE ON CLIMATE PRIMARILY THROUGH THE EXCHANGE OF HEAT AND CO_2 WITH THE ATMOSPHERE, WHICH IN TURN IS CONTROLLED BY THE PHYSICAL AND CHEMICAL PROPERTIES AT THE SURFACE OF THE OCEAN.

We can think of the surface ocean's properties (such as its dissolved CO_2 content, or its CO_2 partial pressure) as representing some deviation from the 'average ocean', where the extent of deviation is largely controlled by the combined influences of biology and ocean dynamics (see Fig.1). Together these processes constitute a 'leaky biological pump', where biological production in the surface ocean 'pumps' carbon into the deep ocean (away from the atmosphere), while the ocean's overturning circulation slowly leaks it back out.

On very long timescales (millions of years), the slow drift in the ocean's average composition will tend to represent the main control on surface ocean chemistry. Volcanoes and mountain weathering will prevail as controls on ocean/ atmospheric chemistry on these long timescales. However, on shorter timescales (i.e. $<10^5$ years), it is the efficiency of the 'biological pump' and the chemical gradients that it produces in the ocean that tend to exert the main control on surface ocean chemistry, and therefore the ocean's influence on global climate. Currently, we are engaged in an unprecedented climate experiment, pumping carbon dioxide from the solid Earth into the atmosphere at an exceptional rate, and waiting to see what the effects will be. However, there are good reasons for trying to understand more precisely (and perhaps avoid) the likely impacts of our climate experiment before they transpire. In this respect useful insights can be gleaned from the geological record of past climate change, by 'coaxing history to conduct experiments' (E.S. Deevey, 1969).

The record of climate change over the late Quaternary (e.g. the last ~500,000 years) provides a particularly useful set of 'natural experiments' through which to investigate carbon cycle/climate feedbacks. These 'natural experiments' include, for example, repeated global-scale glacial-interglacial cycles (10^4-10^5 yr timescale), as well as more abrupt shifts in global and regional climate (10-10^3 yr timescale) (see Fig.2). Recent work focusing on the role of the ocean in these climatic changes has served to emphasize the importance of the 'leaky' marine biological carbon pump alluded to above (Fig.1), including its direct connection to both regional- and global energy balance. Thus, emerging radiocarbon data demonstrate that the time it took for dissolved CO_2 to cycle through the deep ocean was on average ~700 years longer at the height of the last glacial period (Skinner et al., Nature Communications, 2017). This increased residence time would have allowed more carbon to accumulate in the deep ocean, due to the rain of biologically fixed carbon from the surface- to the abyss (i.e. a more efficient biological carbon pump – Fig.1). Supported by emerging reconstructions of deep ocean oxygenation, these findings suggest that more than half of the total glacial-interglacial CO_2 change (i.e. ~60ppm) could be accounted for by ocean circulation changes. Most canonical explanations for glacial-interglacial CO_2 change have placed greater emphasis on the biological pump's 'strength' (i.e. biological export production, driven by changes in nutrient supply), whereas these new findings instead focus attention on its 'leak' (i.e. the influence of overturning rates and air-sea gas exchange). Similar analyses have been performed for more abrupt changes in climate that occurred during the last glacial period (Fig.2), which again point to deep convection (especially in the Southern Ocean) as a particularly effective way to release both heat and carbon from the ocean to the atmosphere.

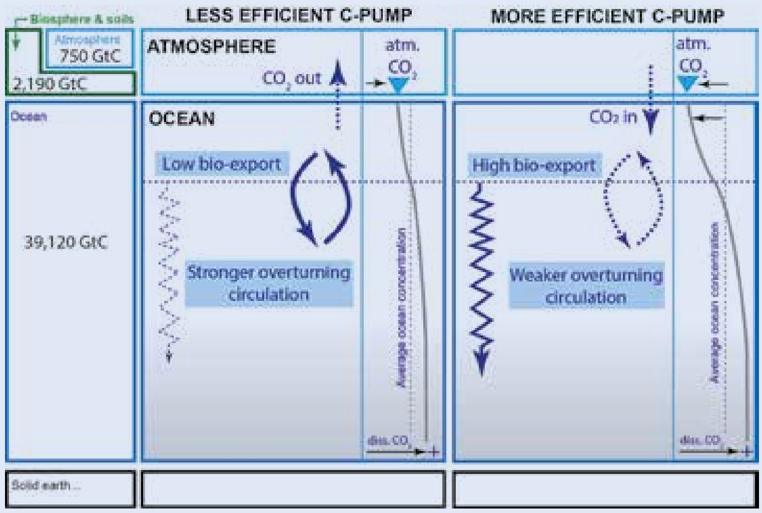


Fig.1 *Illustration of the ocean's 'leaky biological carbon pump'. Boxes at left indicate approximate magnitudes of the 'active' carbon reservoirs, including the ocean, atmosphere and terrestrial biosphere (GtC is gigatons of carbon). Boxes at right illustrate two scenarios, characterized by a less- and a more efficient biological carbon pump. The vertical grey line indicates characteristic vertical carbon concentration gradients in each case, whereby the surface concentration is drawn closer to or further away from the global mean in each case.*

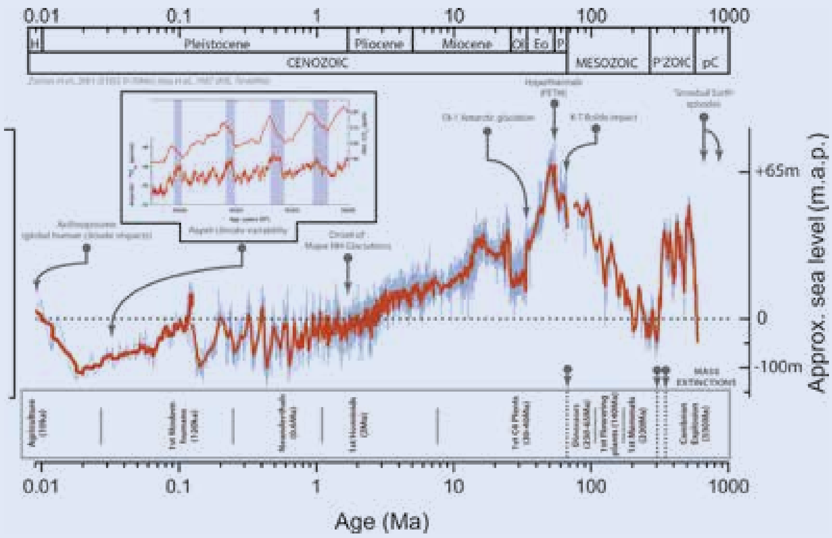


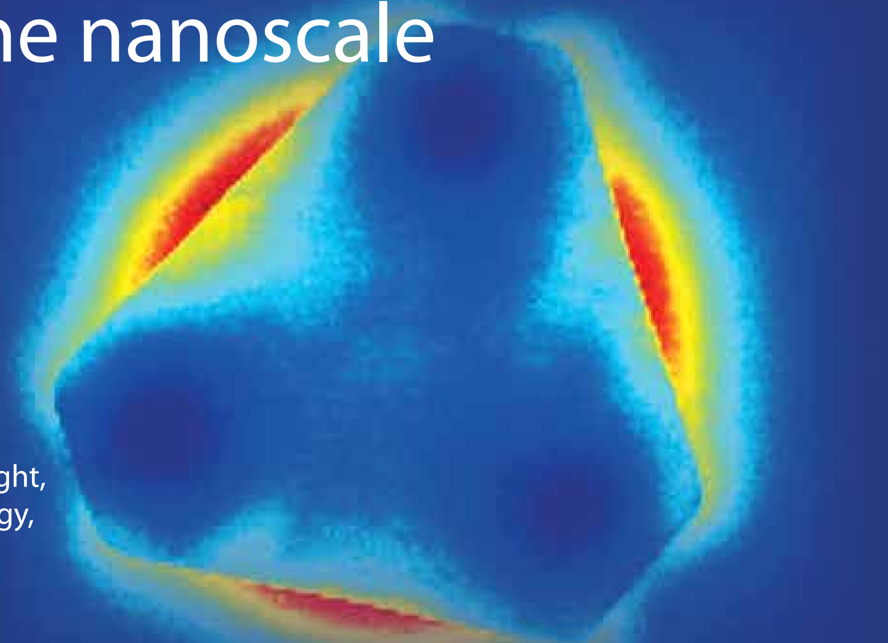
Fig.2 *Figurative illustration of climatic changes, characterized here in terms of approximate ice-volume/ sea level changes, as well as associated geological time periods and events over the last 1 billion years (note the logarithmic time scale). The late Pleistocene (0-500ka BP) includes glacial-interglacial cycles, and more subtle centennial/millennial-scale climate changes (e.g. as illustrated in the inset figure, depicting atmospheric CO_2 and Antarctic temperature variability during the last glacial period, ~25-60ka BP).*

CURRENTLY, WE ARE ENGAGED IN AN UNPRECEDENTED CLIMATE EXPERIMENT, PUMPING CARBON DIOXIDE FROM THE SOLID EARTH INTO THE ATMOSPHERE AT AN EXCEPTIONAL RATE, AND WAITING TO SEE WHAT THE EFFECTS WILL BE.

This research raises some general points that are relevant in the context of anthropogenic (human induced) climate change. Firstly, although the 'natural' 20-90 ppm CO_2 changes of the late Pleistocene pale in comparison to the ~120 ppm of anthropogenic CO_2 accumulated since the industrial revolution (let alone the >600ppm change that could accrue by the end of the century), they were nevertheless associated with major climate upheavals. Accordingly, a recurring lesson that emerges from the study of past climate change is that a little climate forcing can go a long way, in particular due to strong feedbacks in the Earth's climate system (Skinner, Science 2011). On the other hand, if we consider the 'ticking clock' of anthropogenic climate change, whereby we will likely be committed to ~2°C of global warming within ~20 years, the 'small' natural climate-carbon cycle feedbacks described in this article are essentially equivalent to a decade or two of extra time, or indeed lost time depending on which way the Earth system wandered. Thus, it is the ebb and flow of natural variability, especially in ocean carbon/heat uptake, that will determine the ups and downs of our bumpy ride into an inevitable anthropogenic future.

Understanding light-matter interactions at the nanoscale

EMILIE RINGE, UNIVERSITY LECTURER JOINTLY APPOINTED WITH MATERIALS SCIENCE AND METALLURGY



Light-matter interactions are ubiquitous in nature, technology and everyday life, underpinning everything from the laser in a CD reader to the colour of gemstones. But light, more specifically sunlight, is also full of energy, and could be key to a sustainable future.

A new initiative from the University of Cambridge led to the cross-departmental appointment of several lecturers, including Dr Emilie Ringe, who recently moved from Rice University to join the Earth Science Department jointly with the Department of Materials Science and Metallurgy. Her group works on understanding how to manipulate light-matter interactions in materials by designing structures at the nanoscale, where a nanometer is 10^{-9}m. "This is a new frontier for science. We've understood for a while that both atomic packing and microstructure matter, but just in the last decades the gap between these two has been bridged and we can now access the size range in between, the nanoscale".

At this scale, spectacular properties can emerge. In fact, most properties, including optical, catalytic, mechanical, and electronic, can be fine-tuned through choice of composition, size, and shape of nanoparticles. A striking example of this is gold. Always shiny and yellow in bulk, nanoscale gold displays an array of colors depending on the nanoparticles' size and shape. These particles are, in fact, what gave rise to red stained glass in medieval times and the color of the Lycurgus cup on display at the British Museum.

More specifically, nanoparticles made of free electron metals, such as gold and silver, can sustain coherent oscillations of their electron cloud known as localized surface plasmon resonances (LSPRs). LSPRs occur at visible frequencies, so they can be driven by light, leading to wavelength-dependent photon absorption and scattering (hence colour, as in medieval stained glass). They also generate strong electric fields close to the particle's surface: a few nanometers away the field's energy density can be four orders of magnitude larger than the incident lights.

"My group's research goals related to plasmonic particles are two-fold. First, we want to understand how the electric field concentration created by LSPRs can be used to capture light's energy and use it to drive chemical reactions. This would let us power industrial processes with sunlight rather than fossil fuels. Second, we want to do this using earth-abundant, i.e. cheap, metals rather than gold and silver."

Toward this goal, while an assistant professor at Rice University, Emilie initially worked on nanoscale aluminium nanoparticles, and showed they trap UV and visible light. Just prior to moving to Cambridge, she discovered that she could make magnesium nanoparticles that also interact strongly with light, this time across the entire UV, visible, and infrared range, ideal for application using sunlight as the energy input. "This is very exciting. Everything we do with magnesium is new, opening so many opportunities for control of light-matter interactions."

While she continues her work on magnesium nanoparticles, supported by the European Research Commission, Emilie is quickly establishing new research areas in collaboration with researchers in Earth Sciences. Together with Professor Marian Holness and her group, for instance, she aims to investigate crystal growth and crystal shapes, drawing on her experience with nanoscale crystal growth and Wulff constructions. Together with Professor Richard Harrison, she investigates nanoparticles of various iron oxides, correlating their complex shapes with their magnetic properties. Lastly, Emilie is keen to share the suite of optical characterization instrumentation she brought with her from the United States to investigate local properties of, among others, olivine to determine micro-structural properties that can be linked to history.

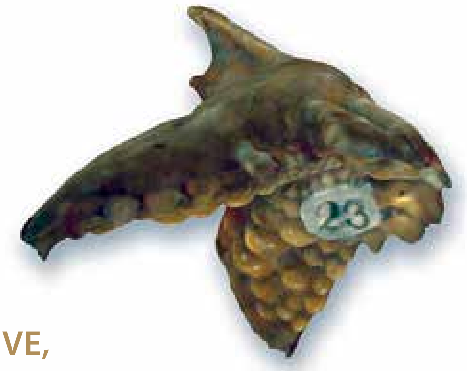
"The diversity and relevance of samples analyzed in Earth Sciences is amazing, and I am thrilled to now be part of this community."

Electric field enhancement around a gold nanoparticle.

DAN PEMBERTON, SEDGWICK MUSEUM COLLECTIONS MANAGER

AGOSTINO SCILLA:

The art of pure observation of things



THE VIRTUAL SCILLA COLLECTION, A NEW GALLERY INTERACTIVE, AND WEB-RESOURCE, FOR THE SEDGWICK MUSEUM

2028 will see the 300th anniversary of the Sedgwick Museum, founded on the collection of London physician Dr John Woodward (1665–1728). His collection of British rocks, fossils and minerals was bequeathed to the University in 1728, his foreign specimens purchased by the University a year later. Woodward assembled his collection to help him develop theories concerning the formation of the Earth, and the rocks, minerals and fossils of which it is composed. Comprising about 10,000 specimens, the Woodwardian Museum grew in size over the succeeding 176 years, relocating to the current building (named after Adam Sedgwick) in 1904. Housed in its original c.1710 collectors' cabinets, the *Museum Woodwardianum* display is one of the jewels of the Sedgwick Museum's crown and one of the world's oldest intact geological collections. However, it remains one of the Museum's many hidden collections; indeed only about 45–50,000 of almost two million items in the Museum's collections are ever on display (about two and a half per cent). One way of celebrating the 300th anniversary under consideration is a large scale conservation, digitisation and interpretation project of Dr Woodward's collection.

To explore the possibilities for such a project and the resources required, the Museum secured an Arts Council England Designation Development Fund grant to create a pilot virtual collection. Specimens collected by the Renaissance artist Agostino Scilla (1629–1700) were chosen. This collection, purchased by Dr Woodward from Scilla's family after his death comprises about 340 specimens. Scilla's collection was of interest to Woodward because many specimens had been described and illustrated by Scilla in his book *Vain Speculation Undeceived by Sense* (1670). In this book Scilla argued that fossils are the remains of living things not 'Jokes of Nature' thought to grow in the ground as some believed. Woodward also acquired the pencil drawings of fossils made by Scilla for his book illustrations.

The small number and almost unprecedented survival of published specimens and artwork of the period makes Scilla's collection an ideal and attractive subject for such a project. The brief was for a website-based virtual collection available in the Museum gallery as an interactive exhibit and also over the internet. A requirement was that users should be able to explore the collection on their own or through a guided tour. Self-guided exploration enables the user to view 2D images and 3D models of specimens and read Scilla's and Woodward's comments about them alongside a modern interpretation by Museum staff. Gamification in the form of sorting games and a quiz are included to demonstrate how observation skills are common to both artists and scientists. Museum staff worked with Brighton-based consultancy Surface Impression to design and build the virtual collection website.

Scilla's collection underwent 2D photography, and 3D models of key specimens were created through photogrammetry, laser scanning and micro CT-scanning. Converting 3D models into Open CTM files enables them to be displayed and manipulated using current web browsers.

The project required translation of Scilla's book from Renaissance Italian into English (available to download at bit.ly/2Re5Ig9). As Scilla primarily used illustrations of specific specimens to support his scientific arguments, this offered a unique opportunity for users of the interactive exhibit to be guided round the collection in the words of someone from 300 years ago.

sedgwickmuseum.org

'Impossible that Nature, when jesting in stone, could jest so accurately in all things'

Please pay particular attention to certain stones, or rather certain petrified sea creatures, that I have selected from the myriad objects dug up in the hill that towers above the headland near the city of Milazzo, and kindly sent to me by Doctor Giovanni di Natale, an expert of impeccable character and exquisite taste, and a master of fine writing. Look most closely at the small operculum of a sea-snail (A) known as a St. Margaret's stone; and at the petrified Millipore coral (B). I consider it impossible that Nature, when jesting in stone, could jest so accurately in all things, or behave with such insufferable eccentricity as to make vast numbers of minute opercula and attach them to petrified snails that lack them!

Agostino Scilla (1670), *Vain Speculation Undeceived by Sense.*

IN CONVERSATION WITH Sally Gibson

Geochemist and petrologist Professor Sally Gibson joined the Department of Earth Sciences as a University Lecturer in 1995. She has recently served as Acting Director of the Sedgwick Museum, alongside her research and teaching roles. Sally discussed her life and work with Greg Palmer.

How did you get in to Earth Sciences?

I grew up in beautiful countryside in West Yorkshire. I loved the outdoors and from an early age was interested in the natural world. In sixth form at school I had the opportunity to study geology and immediately realised that understanding what lay beneath Earth's surface explained so much about the landscapes around me. I had a really inspirational teacher and everything clicked. From that moment, I was totally hooked on geology.

So, you applied to study geology at University?

When I first started wondering what to study at university, I wanted to read geology. I was advised against this by the careers officer at school because he was concerned that jobs in geology were mainly in the oil industry and male dominated. So instead I applied for an environmental sciences degree. I got the grades but realised this wasn't what I wanted to do. I went back to school and took an extra A-level in Chemistry before applying to study geology. That was one of the first times in my life I decided to follow my passion, to study what I enjoy most and see what happens.

Did you always love hard rock geology?

I studied geology at the University of Sheffield, which I absolutely loved. We had great lecturers, especially in hard rock petrology. I was in a very vibrant year of geology undergrads and we spent endless evenings in the lab looking at thin sections and listening to 80's music. My first scientific discovery was during my mapping project in Pembrokeshire. I spotted a huge trilobite head looking up at me in some newly formed screes. It was beautifully preserved and so I took it back to palaeontologists in Sheffield who realised it was a new species.

This was just before I did my third year research project. I could have thought "wow, it's really easy to find new species of fossils. This is what I should do". But I stuck to petrology, and did my third year project on igneous layering in a classic intrusion from the Shiant Isles, in NW Scotland. That actually led on to my PhD at Kingston, which was on an extension of the same sill complex in northern Skye. My research examined how magmas with dense crystal cargoes reach shallow levels in the Earth's crust.

Oxbridge Alumni trip to Galapagos in 2018.

Tiny volcanic vent on the Colorado Plateau, Western USA – the only surface expression of continental rifting.

What led you to Cambridge?

Following my PhD, I became a PostDoc at the University of Durham. This was a hugely exciting time involving international research projects on magmatism associated with the formation of the Rio Grande continental rift in the USA, the Baikal rift in Siberia and small fraction melts associated with flood basalts in South America and Africa. We went to incredible remote places and met the most fascinating people. And for me, that sense of adventure was, and still remains, a really exciting part of what I do.

There was a huge synergy between my research in Durham and what others were doing in Cambridge. For example, Dan McKenzie and Bob White were looking at the relationship between continental rifting and flood basalts. When I arrived as a lecturer, myself and research students began testing their models using field observations and geochemistry of volcanic rocks in remote parts of East Africa, South America and India.

You work on the Galapagos – how did that come about?

Until the mid-2000s, I very much worked on continental volcanism, except for an expedition to the South Atlantic Island of Trindade with the Brazilian navy in the late 1990's. One day in 2006, I received a midday phone call from David Norman. He asked if I would be interested in leading an expedition to Galapagos with some science historians to retrace the steps of Charles Darwin. It didn't take long to say yes!

The expedition was hugely successful. We used the locations of Darwin's samples of volcanic rocks to link his zoological and botanical observations back to his field notebooks. I also collected some samples of my own and realised how important James Island (now known as Santiago), where Darwin made some of his most important observations on diversity, is to our understanding of what controls Galapagos volcanism and the formation of ocean islands in general.

Galapagos is a truly unique natural laboratory and I've been back for several further field seasons, and collected more samples across the archipelago. At the heart of my current research is how deep Earth processes have controlled its evolution and now influence surface systems. This work involves students here in Cambridge as well as colleagues in the US and Ecuador. In 2018, I was lucky enough to return to Galapagos again to share my experiences as a trip scholar on an Oxbridge alumni tour.

Left: The interaction of deep Earth processes and surface systems, such as in Galapagos, form the heart of Sally's research.

What else is keeping you busy?

I'm currently Chair of the Geological Society's Volcanic and Magmatic Studies Group, and Vice President of the Mineralogical Society. It's an honour to have the chance to give back to organisations from which I've benefitted hugely. You can use your experience to help others, whether it's creating funds for fieldwork or opportunities for people to interact and discuss science in a convivial environment. It's important to attend these events: you can't just be a scientist in your office, you need to get out there.

And what about your time in the Sedgwick Museum?

One of the joys of being Acting Director of the Sedgwick Museum was finding out so much about what goes on behind the scenes. The museum is an absolute treasure trove and I was constantly discovering new things we have in the collections. The museum has such an important role in research and teaching, and is very special to the Department because it's such a fantastic way to showcase ourselves and our subject to the wider community.

Finally, did anything change when you became a Professor?

When I started out in geology becoming a Professor wasn't something I aspired to or ever thought I would achieve. Since my promotion the frequency with which I'm asked to sit on all sorts of committees and international panels has certainly increased. During my career I've been very privileged to interact with great scientists and bright students. I'm so lucky to have a job doing what I enjoy. As I say to the students "if you see an opportunity, take it, because you just don't know where it might lead".

Find out more about Sally's alumni tour to the Galapagos on the Cambridge Earth Sciences blog.

GEOLOGY FOR Global Development

After graduating, Joel Gill (Homerton, 2005) spent time supporting research and non-governmental organizations in Tanzania. These experiences prompted him to found *Geology for Global Development* (GfGD), a charity championing the role of geoscience in sustainable development.

The world faces many challenges – poverty, food and water security, decarbonising energy, inequality, urbanisation, climate change, and geohazards. These themes are at the heart of the UN Sustainable Development Goals (SDGs), a 15-year strategy to end poverty, improve social wellbeing and protect the planet. Geoscience is central to this agenda. Actions to understand, monitor, protect, manage, and enhance the environment are critical to delivering the SDGs. Long-lasting, positive impact, however, will require us as geoscientists to broaden our thinking, skills, and partnerships. These two themes were particularly evident when I was in Tanzania:

1. Geoscience matters and can improve the future of the world's poorest communities, but this is not always recognised. In rural Tanzania, basic geoscience could have a transformative effect. I visited water projects where initial surveys were completed in rainy season, but as the water table dropped during dry season these wells became dry and unusable. Women and children would revert to hand-dug holes for half the year, sometimes taking five hours to fill a 20 litre bucket with water. Integrating geoscience into non-governmental organisation (NGO) decision-making could have resulted in thousands more hours at school, in work, or nurturing family.

2. Business-as-usual is not enough. The skills and knowledge that geoscientists have place them in a good position to engage in sustainable development, but this is hindered by the minimal exposure to socio-economic sciences and interpersonal skills within geoscience training. In Tanzania, I saw failed water supplies resulting from weak development understanding, where projects had not incorporated location-specific cultural and societal information, or talked to the right people.

These two themes equally apply to projects relating to hazards, natural resources, infrastructure development, or environmental management. In 2011, I founded GfGD to address these gaps, working in partnership with others to both *mobilise* and *reshape* the global geoscience community to support sustainable development. Our strategic priorities fall into three groups of activities:

- **Inspiration:** We have championed geoscience at key UN events, and published diverse articles through blogs, journal articles and commissioned reports to resource geoscientists and development professionals.
- **Education:** We have developed groups in universities across the UK and coordinated six conferences, engaging 700+ participants, Parliamentarians, NGOs, industry, and researchers. We have also designed and delivered training in India, Tanzania and South Africa, as well in Europe and North America.
- **Action:** We aim to model good practice through our own activities, encouraging geoscientists in all sectors to get involved and to do so in a responsible manner. Our current international programmes aim to improve disaster risk reduction in Guatemala, and water resource management in Tanzania.

GfGD has an exciting future. We have achieved a lot on minimal resources and through a volunteer team. As we explore sustainable funding mechanisms, we are confident that we can have a global impact that benefits many of the world's poorest communities.

Above: Ladakh, India. Education initiatives can help to reduce vulnerability to natural hazards, and are critical to disaster risk reduction.

Above: Cambridge students with Joel at the recent GfGD Conference.

Inset left: Tanzania: Women and children in this village would spend 5–10 hours collecting water during the dry season when their shallow well failed.

Inset below left: Tanzania: An improved water source can improve access to education, health, income generation, and gender equality.

Responsible Earth stewardship is at the heart of sustainable development. GfGD's work puts geoscientists at the centre of that dialogue. Our hope is that geoscientists equipped with a passion for, knowledge of, and skills to support sustainable development will be working in governments, intergovernmental agencies, industry, research, education, and civil society around the world, to shape a better future for all.

Dr Joel C. Gill leads the work of GfGD, and works full time as International Development Geoscientist at the British Geological Survey (joel@gfgd.org/ @JoelCGill).
Find out more: **gfgd.org/strategy.**

GfGD in Cambridge

Cambridge was the first University to establish a GfGD group in 2012, with an active student society running in the Department since. In Michaelmas 2018, Joe Duncan-Duggal (Homerton, 2015) and Lizzie Knight (Fitzwilliam, 2015) took on coordination of the group, organising activities and an annual trip to the GfGD Conference in London.

One recent project is a series of mapathons, where students improve the maps available for global development causes. A few hours spent tracing roads and footpaths in a room in Cambridge can be invaluable in helping NGOs, often working in remote parts of the world, to navigate successfully to where their help is needed most.

Many students also value being involved with GfGD for the insight it gives into career options for Earth Scientists. The group have worked with the Sedgwick Club to invite speakers working on sustainable development. They also attend the annual Earth Sciences careers event to highlight what they are up to in Cambridge, and some of the diverse career opportunities for graduates looking to make a real impact on the world using their geology skills.

RECENT NEWS & AWARDS

The Geological Record

01

Liz Hide (St John's 1988) has been appointed Director of the Sedgwick Museum. Liz was a graduate student in the Department, and has served in the past as a curator of the National Museums of Scotland and more recently as the University of Cambridge Museums Officer and an independent consultant specialising in museum strategy and advocacy. Liz will provide strategic leadership for the Museum, enabling it to provide greater support for its research and teaching activities through its collection, and build its public audiences.

02

We welcomed **Daniel Field** at the beginning of the academic year as a University Lecturer. Daniel is a vertebrate palaeontologist and joins us from the University of Bath. His research aims to use the vertebrate fossil record to help answer questions about how, where and when the Earth's modern biodiversity arose. **danieljfield.com**

03

Congratulations to **Sally Gibson** who has been promoted to a Professorship. Sally's research combines state-of-the-art analytical techniques, including laser-ablation inductively-coupled-plasma mass-spectrometry and ion probe, with numerical modelling to study deep Earth processes. Current research activities are focused on the fundamental causes of volcanism, and also the formation and long-term evolution of Earth's mantle. Sally has recently been elected as Chair of the Volcanic & Magmatic Studies Group of the Geological Society of London and Vice-President of the Mineralogical Society. She has also been Acting Director of the Sedgwick Museum.

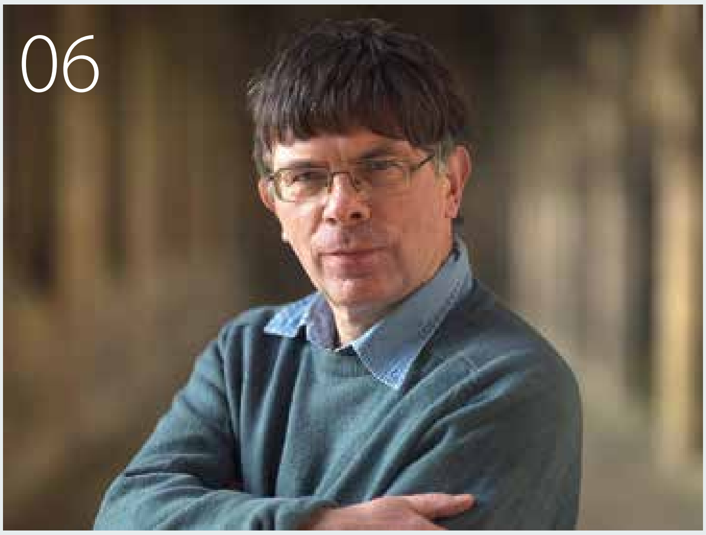
04

Congratulations to **Helen Williams** (Newnham 1994) and **Jerome Neufeld** who have both been promoted to Readerships.

05

Sanne Cottaar will deliver the 2019 Bullerwell lecture at the European Geosciences Union meeting in Vienna in April. The lecture is one of the principal events in the British Geophysical Association's calendar and its speaker is selected by competition. Awarded to an 'outstanding early-career' British geophysicist, the lecture has been presented each year since 1981.

Simon Conway Morris (Churchill 1972, St John's 1975), Chair of Evolutionary Palaeobiology, formally retired at the end of December. In the Department he gave the 1A palaeobiology lectures over a geological interval and shared the rain on various field-trips. Otherwise, Simon is principally known for three areas of enquiry. First are his contributions to our understanding of the Cambrian "explosion", notably through investigations into the canonical Burgess Shale and similar deposits. Some of this work summarized in *The Crucible of Creation*. This work included drinking fermented mare's milk in Mongolia, getting lost in Xinjiang and swigging whisky out of plastic film canisters in Greenland. Second is his enthusiasm for the role of convergence in evolutionary biology, explored in *Life's Solution* and more recently in *The Runes of Evolution* and touched on also in his forthcoming book. Finally, he is active in the realm of public outreach (including the 1996 Royal Institution Christmas Lectures), including the defence of evolution and the wider science/religion debates. Simon has every intention to continue with his research in the Department and to carry on enjoying the rain.
42evolution.org, mapoflife.org



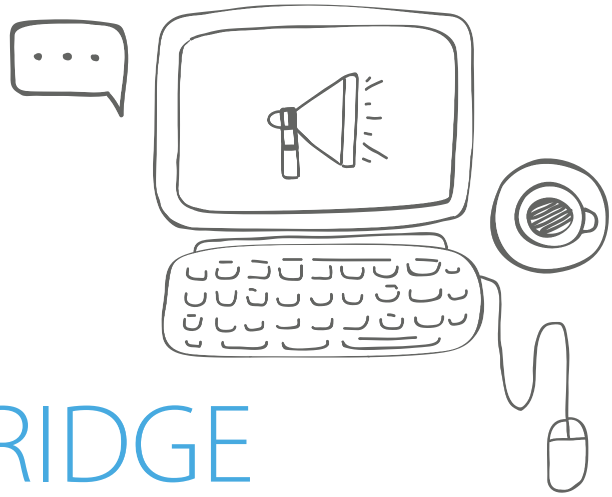
07

Congratulations to **Ian Farnan** who has been promoted to a Professorship. Ian's research interests are in understanding fundamental processes involved in the disposal of radioactive waste such as radiation damage and the aqueous corrosion of nuclear waste forms and natural analogues. Techniques and methods developed to tackle these problems are readily adapted in developing new nuclear materials for fuels and clads that may be deployed in future nuclear reactor systems.

Award winning

Marie Edmonds (Jesus 1994) has been named as the 2019 Thermo-Fisher Scientific VMSG (Volcanic and Magmatic Studies Group) award winner. The prize is awarded annually to a scientist who has made a significant contribution to our understanding of volcanic and magmatic processes. Marie delivered the VMSG keynote lecture in January.

Congratulations to **Emma Liu**, Leverhulme Research Fellow in Volcanology, who has been awarded a 2018 L'Oreal UNESCO for Women In Science fellowship to support her postdoctoral research. Emma's research focuses on constraining the magmatic processes that govern the magnitude and impact of emissions from volcanoes.



FOR ALL THE LATEST CAMBRIDGE EARTH SCIENCES BLOG POSTS VISIT BLOG.ESC.CAM.AC.UK

FROM THE CAMBRIDGE EARTH SCIENCES BLOG

DRAGON WATCHING: UNLOCKING MYSTERIES OF LIZARD MOVEMENT

Luke Grinham, PhD student

Evolutionary biomechanist and NERC DTP PhD student Luke Grinham's research focuses on the evolutionary transition from a quadrupedal style of movement to a bipedal one in reptiles.

The extant (living creature) side of my work, where I perform experiments to investigate animal movement, draws on expertise developed prior to joining the Earth Sciences Department. Most recently, I was working with *Chlamydosaurus kingii*, the frilled lizard, and observing its facultatively bipedal behaviour. Usually, this reptile climbs branches or walks around on four limbs, but under certain circumstances it will sprint on just its hind-limbs!

Using high speed video cameras and some fancy mathematics, I can record the lizards running in three dimensions, and reconstruct their movements. From these reconstructions, I can learn more about what their bodies are doing during this physically demanding behaviour. Data gathered from these experiments can be used to not only understand the motions of these living creatures, but can also be used to inform hypotheses about extinct animals.

Read more blog.esc.cam.ac.uk/?p=1149

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SCANNING EDIACARAN FOSSILS IN NEWFOUNDLAND

Sasha Dennis, Part II student

In September, I spent three weeks in Newfoundland, Canada working on world class Ediacaran fossil surfaces with Emily Mitchell, Charlotte Kenchington and Lucy Roberts. This fieldwork was the final field season of a three-year project to map all of the oldest deep-water Ediacaran fossil communities across Newfoundland, Canada and Charnwood Forest, UK. These fossil communities consist of thousands of immobile organisms preserved in-situ so that the fossil surfaces are a near-census of Ediacaran life. Therefore, the fossil positions encapsulate the life-history of the organisms: how they reproduced and interacted, with each other and their local environment.

The two main aims for this trip were high-resolution laser scanning and photomapping the surfaces. The sensitivity of the scanner meant we couldn't work in fog or rain - the main weather conditions on the Avalon peninsular. When the forecast was good, we worked dawn 'til dusk to maximise field time. We were up at 6am on day one, trekking out to the first surface with 150kg of kit by 8am.

Read more blog.esc.cam.ac.uk/?p=1209

Dispatches from Antarctica: **the WACSWAIN project**

The WACSWAIN (WArm Climate Stability of the West Antarctic ice sheet in the last INterglacial) project, led by Professor Eric Wolff, aims to understand what happened to the West Antarctic ice sheet during the last interglacial period, between 115,000 and 130,000 years ago.

Eric has been blogging since the start of the project, including from Antarctica where his team recently undertook three months of fieldwork to retrieve a new, 650m-deep ice core. Excerpts from a handful of Eric's posts follow; catch up on the full series at ***blog.esc.cam.ac.uk/?tag=wacswain.***

INTRODUCING THE WACSWAIN PROJECT

There is so far no clear evidence whether the West Antarctic ice sheet (WAIS) survived, retreated or disappeared during the last interglacial. Our team of scientists, engineers and field guides from the University of Cambridge and British Antarctic Survey will retrieve ice from the last interglacial at Skytrain Ice Rise, an ice dome adjacent to the main WAIS, allowing us to assess what really happened.

MAKING CAMP IN THE ANTARCTIC

Work for all of us has been about preparing for drilling, and making the camp more comfortable. The engineers have been spending time setting up the generator to power our ice drill, and building up the drill system itself. One time-consuming task is to keep warm and nourished. We sleep in two-person pyramid tents, and it takes a long time each evening to get the tent warm from a paraffin-fuelled Tilly lamp, hang clothes to dry in the top of the tent, and get into the sleeping bag.

ICE CORE DRILLING BEGINS

We are working in two teams of three, each working two four-hour shifts, so that we drill for 16 hours per day. At noon, I trudge through soft snow to the long, semi-cylindrical drilling tent, dressed in the warm overalls I need to spend four hours standing around at -15 degrees.

CHRISTMAS IN ANTARCTICA

A complete day off on Christmas Day was very welcome. We all received messages from our family and friends, and some of us made satellite phone calls, but of course we had to make our own entertainment. Our engineer Scott has kept the drill going, but turned his talents to making a tree out of wooden board material. Caspar produced frozen food (including chicken breasts and a cheeseboard) that he'd been keeping hidden. And we all joined in making imaginative use of our field food to create things approximating Christmas pudding and other traditional treats.

ICE CORE COMPLETE!

We know we have reached the bottom because the last metre of ice we drilled contained pebbles some millimetres across, and in the last few centimetres a yellow layer. The depth we have reached is 651.04 metres. This took us 42 days of drilling 16 hours per day, with just a break on Christmas Day and Saturday evenings.

Now I'm looking forward to returning from what is a beautiful but harsh field site, and to having my first shower and complete change of clothes for two months. But perhaps that is too much information …

Main image: The camp at Skytrain Ice Rise.

Removing the inner barrel from the drill to extract the next length of ice.

Eric Wolff (central in orange) with other University of Cambridge and BAS team members at the Rothera research station.

OBITUARIES

Roderic Long 1942–2018

The Museum and Department were very sad to hear of the death of former staff member Rod (Roderic) Long. Uncle Rod, as he was affectionately known, was to many people the face of the museum. Dave Norman writes his recollections of a man who will be remembered for his friendly, helpful and kind nature.

ROD LONG WAS, FOR AS LONG AS WE CAN REMEMBER, THE PALAEONTOLOGICAL ASSISTANT AND GALLERY WARDER IN THE SEDGWICK MUSEUM OF EARTH SCIENCES. HE WAS THE FRIENDLY AND WELCOMING FACE OF THE MUSEUM, AND RETAINED A STAGGERING KNOWLEDGE OF THE EXHIBITS WHICH HE DISPENSED IN ENDLESS SNIPPETS OF WISE AND GENUINELY HELPFUL ADVICE TO VISITORS.

Rod's long association with the museum meant that his knowledge of many of the academics (long-since departed) was as fresh and bright as if they were still working on the collections.

Rod was born and raised in Burnham Market and his early experience of the passage of aircraft from the many air-force bases in East Anglia during and immediately after the 2nd World War gave him a lifelong interest in aviation. In his early teens, Rod began working in a local garden nursery. By nature a rather self-contained, shy individual, he was content in his own company, quiet and yet surprisingly sociable. It was during this early part of his working life that the 'fly-paper' quality of his memory became evident: he quickly picked up the common names of the flowers and memorised all their Latin names.

At the age of fifteen Rod was appointed as an assistant at the Fitzwilliam Museum in Cambridge. He found himself surrounded by interesting and precious objects that he could care for and learn about. Museums probably attracted Rod because their air of quietness and contemplation rather suited his personality. While assisting with the collections Rod began to develop curatorial skills and, after a few years at the Fitzwilliam, was appointed to a similar position at the Sedgwick Museum of Geology.

Working under the fastidious eye of curator Albert 'Bertie" Brighton, Rod kept the museum 'ship-shape' and ready for business each day, as well as assisting with documenting the enormous collections. The study, sorting and organisation of this huge assortment of objects – rocks, minerals and fossils – was a daunting task, but Rod evidently relished the task.

In keeping with the foundation of the Sedgwick Museum (1904) and the public money that was donated in memory of Adam Sedgwick, the museum had generous opening times. Rod increasingly became the welcoming face of the Museum. He greeted visitors in his white lab-coat, introduced them to the collections, identified specimens that they brought in, and dispensed his comprehensive knowledge. It is largely due to Rod that the Sedgwick has been regarded as the 'friendly museum' – his ethos lives on to this day.

Although shy and retiring by nature, Rod paradoxically revelled in sharing his knowledge along with an endless supply of jokes when the occasion permitted. His passion remained aircraft, and the nearness of Duxford provided endless pleasure in his free time. High days and holidays would see him return to Norfolk to visit his family and his roots. After retirement Rod rarely came into the museum but retained his friendship with many employees.

A quiet, reserved, private, shy and yet happy bachelor, Rod's needs were simple. His life was simple and unadorned, and yet enriched by his gift of a quite extraordinary memory. Always ready with a smile, a laugh and a merry quip – especially against himself – and the kindest and most gentle of natures, Rod was a truly lovely man.

David Norman
Director of the Sedgwick Museum (1991–2011)

Rod pictured in the Museum in the 1970s with the Iguanodon skeleton.

Thank you to our donors 2017–2018

We wish to thank alumni and friends who have generously made donations to the Department over the last year. Every effort has been made to ensure the list is accurate; do contact us if you believe we have made an omission.

We would also like to thank all those who made a gift to the Department anonymously.

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The Department is extremely grateful to Alan Smith (1937–2017) who left a generous bequest in support of fieldwork connected with teaching and research.

If, after providing for your family, you are considering remembering the Department in your will, or want to learn more about the impact of a legacy, please contact:

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