GeoCam

EARTH SCIENCES ALUMNI MAGAZINE

ISSUE 17 | SPRING 2020

NEWS

Using AI to avert ‘environmental catastrophe’

FEATURE

In conversation with Liz Hide

RESEARCH

Earth’s deep carbon

UNIVERSITY OF CAMBRIDGE

Richard Harrison, Professor of Earth and Planetary Materials took over as Head of Department on 1 August 2019.

Richard was both an undergraduate and graduate student in the Department, returning in 2001 after spending nearly five years as a post-doctoral researcher at the Institut für Mineralogie in Münster, Germany. Richard's research applies nanoscale methods to study the magnetic properties of rocks, sediments and meteorites.

@NanoPaleoMagnetism

Welcome

It is my great pleasure to welcome you to the 2020 edition of *GeoCam*. As soon as my predecessor, Simon Redfern, announced his intention to depart for pastures new (page 18) I began to feel the finger of fate slowly and surely pointing in my direction. "Bookie's favourite, they're calling you," said one of the PhD students, "Morning boss", said the technical staff with a nudge and wink. "Don't be daft," I said, "why on Earth would they want me to be Head of Department?" Well six months later, and here I am – the chance to help shape the future of the finest Earth Science department on the planet, supported by our wonderful staff and students, was too good an opportunity to pass up!

This year we've welcomed two new university lecturers: Oscar Branson and Rachael Rhodes (page 18). Oscar studies biomineralisation, focusing on carbonate formation and dissolution, the ocean carbon cycle and carbon capture technology. Rachael is spearheading a strategic research partnership with the British Antarctic Survey, focusing on high-resolution records of atmospheric conditions over the past several million years contained in ice cores.

Something that sadly had to be placed on ice this year, was our ambition to unify the Downtown and Bullard sites in a new building in NW Cambridge. Our plans will hopefully begin to defrost once the financial outlook improves. However, as one door closes, another one opens, and we celebrate instead the opening of our fantastic new Collections Research Centre – the Colin Forbes Building (page 14). Liz Hide, Director of the Sedgwick Museum (page 12), will be delighted to give you a tour!

In terms of fundraising, our attention now turns to the life-blood of the Department: our undergraduate and graduate students. It's fantastic to see how our students embrace the opportunities that Cambridge has to offer thanks to the financial support of our alumni, whether it's taking their 4th year project to the Moon (page 15) or experiencing all that the Arran weather has to throw at them (page 22). I would like to take this opportunity to thank all our alumni who help us to provide these opportunities to students, and look forward to meeting many of you on our next Alumni Day and Dinner on the 9th May 2020.

Richard Harrison, Head of Department

IN THIS ISSUE

Cover Image: A view up the majestic Durung Drung glacier, which is located at an average altitude of 4,780 m in the Zanskar Himalayas of northwest India. At 23 km long, the glacier is thought to be the largest in the region. However, like many of the glaciers in the Himalayas, it is suffering the effects of climate change, with the abandoned terminal moraine bearing witness to the rapid retreat up the valley.

The Clean Labs

The isotopic signatures of geological samples – rocks, minerals and meteorites, shells, soils and even river and ocean waters – provide us with clues about their age, origins and the processes that shaped them.

Making these isotope measurements requires that samples are prepared in extremely clean specialist environments free from contamination, such as the Department's isotope geochemistry laboratories, aka the Clean Labs, nestled in the top floor of the South Wing of the Downing Site.

In these laboratories are facilities for handling samples in a multitude of ways for a spectrum of different isotope systems. Also present are plasma-source mass spectrometers, which use plasmas formed from argon gas (~6,000K, comparable to the temperature of the photosphere, or outer surface, of the sun) as an ionisation source. With these instruments, and the invaluable support of expert facility manager Dr. Marie-Laure Bagard, we can measure the isotope compositions of elements like iron, copper and magnesium at levels of precision that cannot be achieved by conventional mass spectrometers. These particular laboratories are used by a wide range of people in the Department, including staff members Helen Williams (pictured), Ed Tipper, Alex Piotrowski, Mike Bickle, Oscar Branson, Sasha Turchyn and a wide range of students, postdocs and research fellows working with them.

RESEARCH NEWS

FOR ALL THE LATEST EARTH SCIENCES RESEARCH NEWS, VISIT ESC.CAM.AC.UK/ABOUT-US/NEWS

MUSSELS COULD 'TOUGH OUT' CLIMATE CHANGE

Earth Sciences' Luca Telesca and colleagues have been testing the ability of the economically important Atlantic mussel species *Mytilus edulis* and *M. trossulus* to cope with climate change. The large-scale examination of natural variation in shell biomineralisation of these species demonstrates the mussels' ability to vary shell growth and resist the impact of climate change in their shallow marine habitat.

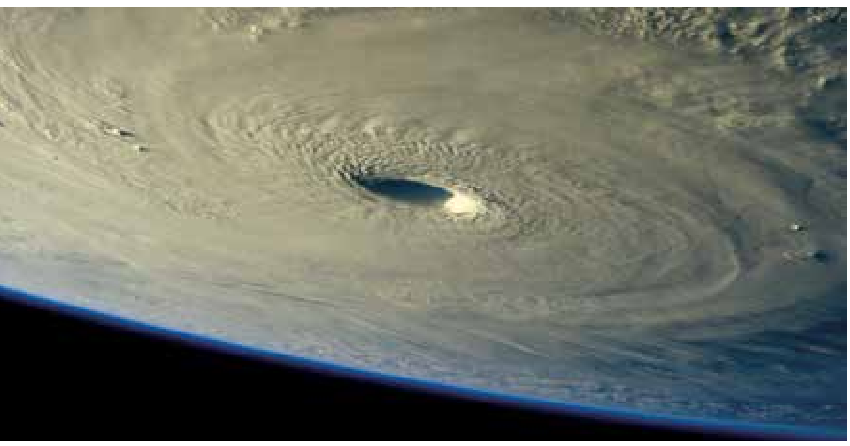
The research data shows a widespread variation in the mussels' response to different local conditions such as changes in seawater temperature, salinity and food availability. Luca Telesca and colleagues found that salinity is the best predictor of regional variation in the production of mussel shell mineral and organic composition.

The new measures of blue mussel adaptability indicate a compensatory mechanism, which can potentially provide a previously unexpected resilience in these species to global environmental change.

Read more tinyurl.com/wbr2ygl

USING AI TO AVERT 'ENVIRONMENTAL CATASTROPHE'

A new Centre at the University of Cambridge will develop AI techniques to help address some of the biggest threats facing the planet. Funded by UK Research and Innovation (UKRI), the Centre for Doctoral Training in Application of Artificial Intelligence to the study of Environmental Risks (AI4ER) is led by Dr Emily Shuckburgh. Simon Redfern, Head of the Department of Earth Sciences until August 2019, was instrumental in securing funding for the new Centre. The first cohort of 10 students arrived in October last year. Each cohort is based at the Bullard Laboratories in year one.



Climate risk, environmental change and environmental hazards pose some of the most significant threats we face in the 21st century. At the same time, we have increasingly larger datasets available to observe the planet, from the atomic scale all the way through to global satellite observations.

"These datasets represent a transformation in the way we can study and understand the Earth and environment, as we assess and find solutions to environmental risk," said Simon. "Such huge datasets pose their own challenges, however, and new methods need to be developed to tap their potential and to use this information to guide our path away from environmental catastrophe."

The new Centre brings computer scientists, mathematicians and engineers together with environmental and geoscientists to train the next generation of thought leaders in environmental data science. They will be equipped to apply AI to ever-increasing environmental data and understand and address the risks we face.

Read more tinyurl.com/ulxqk85

'CRYSTAL CLOCKS' USED TO TIME MAGMA STORAGE BEFORE VOLCANIC ERUPTIONS

The molten rock that feeds volcanoes can be stored in the Earth's crust for as long as a thousand years before rising to the surface in a matter of days. This result may help with volcanic hazard management.

Researchers from the Department, including lead author Euan Mutch and co-author John Maclennan, used volcanic minerals known as 'crystal clocks' to calculate how long magma can be stored in the deepest parts of volcanic systems. This is the first estimate of magma storage times near the boundary of the Earth's crust and the mantle – the Moho – and determined previously unknown timescale information from the deeper crust.

A second paper by the same team found that that there is a link between the rate of ascent of the magma and the release of CO_2, which has implications for volcano monitoring.

Read more tinyurl.com/uykr2ty

'MAGNETIC GRAPHENE' SWITCHES BETWEEN INSULATOR AND CONDUCTOR

A new study, with lead author Earth Sciences' Research Associate Seb Haines, has found that certain ultra-thin magnetic materials can switch from insulator to conductor under high pressure, a phenomenon that could be used in the development of next-generation electronics and memory storage devices. The results will aid in understanding the dynamic relationship between the electronic and structural properties of the material, sometimes referred to as 'magnetic graphene', and may represent a new way to produce two-dimensional materials.

For their study, the Cambridge researchers squashed layers of magnetic graphene, or iron trithiohypophosphate ($FePS_3$), together under high pressure and found that it switched between an insulator and conductor, a phenomenon known as a Mott transition. The conductivity could also be tuned by changing the pressure. The planes of the crystal structure are pressed together, pushing the system from two to three dimensions and from insulator to metal. The researchers found that even in two dimensions, the material retained its magnetism.

"We are continuing to study these materials in order to build a solid theoretical understanding of their properties," said Haines. "This understanding will eventually underpin the engineering of devices, but we need good experimental clues in order to give the theory a good starting point. Our work points to an exciting direction for producing two-dimensional materials with tuneable and conjoined electrical, magnetic and electronic properties."

Read more tinyurl.com/y8wqgoz5

FIRST STUDENTS ADMITTED FOR MASTER OF ADVANCED STUDY (MASt)

The Department welcomed its first students studying for an MASt in Earth Sciences at the beginning of the academic year. This is a taught master's level course where students work alongside 4th year undergraduate students (Part III). The course is aimed at those who hold an undergraduate degree in Earth Sciences and is intended for students who are planning a career, further training or research within the Geological Sciences. It is an intensive year which includes an independent

research project, where for the first time students are generating their own data, and critically assessing and integrating that of others.

Read more tinyurl.com/s8hokmn

CHUANCHUAN LÜ, RESEARCH FELLOW &
NICK RAWLINSON, BP-MCKENZIE CHAIR IN EARTH SCIENCES

Left: Tim Greenfield overhauls the ocean-bottom seismometer before the deployment.
Right: Part of the science party with the last seismometer to be deployed.

A DAY IN **THE FIELD:**

Imaging of North-Sulawesi subduction in the Celebes Sea

How does subduction start? The answer to this question remains enigmatic and controversial. The process of subduction, which drives global plate tectonics and helps to shape the Earth as we know it, began as early as 4.1 Ga, but how the first subduction zone initiated remains unknown.

Some have argued that the plate tectonic cycle was kick-started by spontaneous subduction at passive continental margins, yet such a phenomenon has thus far not been observed in a modern plate tectonic setting. Consequently, scientists have a very limited understanding of what mechanisms may initiate spontaneous subduction.

One area of the world which may hold fresh clues about how subduction may nucleate at a passive margin is Sulawesi in eastern Indonesia. This is far from the long subduction arcs that generate so-called megathrust earthquakes and potentially destructive tsunamis with some regularity. Instead, more unusual earthquakes tend to occur, which are also driven by subduction zone dynamics. For instance, the magnitude 7.5 earthquake which struck Palu in Sulawesi in September 2018, was caused by displacement along a transform fault that was controlled by a subduction zone in North Sulawesi. This earthquake was also unusual in generating a 6m tsunami, which does not normally happen for an earthquake that primarily results from horizontal displacement.

The North-Sulawesi subduction zone is part of a particularly complex system of deformation that involves the nearby Philippines to the east and Banda Arc to the south. The Celebes Sea, which is ~47 Myrs old, has been subducting southward underneath North-Sulawesi since 5 Ma. A long sinistral strike-slip fault (the Palu-Koro Fault), acts as a crucial moderator between east Sundaland (the southern limit of the Eurasian plate), the Celebes Sea, and Sulawesi. Intriguingly North-Sulawesi, which is part of the overriding plate, exhibits no volcanic activity and has a very limited accretionary prism (although in the east a volcanic chain is present that connects to the arc associated with westward

Right: The research vessel, 'GeoMarin III' with, from l to r: ChuanChuan Lü, Tim Greenfield, Nick Rawlinson and Simone Pilia.

Molucca Sea subduction). This unique tectonic setting makes it an ideal location to study subduction initiation on a recent passive margin. A group of scientists from Cambridge, Indonesia and China have come together to undertake an ambitious amphibious seismic experiment. This involves the deployment of 20 land stations in northern Sulawesi and 27 Ocean Bottom Seismometers (OBS) in the southern Celebes Sea and Makassar Strait, which also spans the region offshore of Palu, where the large earthquake occurred in 2018.

ORGANIZING A MARINE SURVEY IS SIMILAR TO CONDUCTING AN ORCHESTRA.

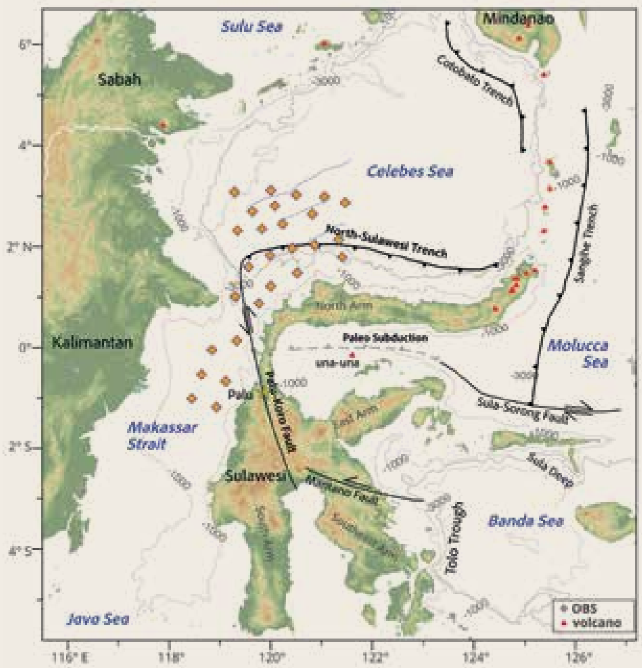
As well as gathering a large ensemble of instruments and personnel, you have to coordinate different sections to work in harmony. The research vessel "GEOMARIN III" from the Marine Geological Institute of Indonesia, the OBS units from the Chinese Academy of Sciences, the survey permission obtained with the support of the Institut Teknologi Bandung, all had to be carefully coordinated to ensure that the cruise to the Celebes Sea from Cirebon (near Jakarta), departed in mid-August.

Fieldwork at sea requires scientists to work in shifts and rotations. During the cruise, three Cambridge researchers (Chuan, Simone and Tim) worked in 8 hour shifts with science parties from the other institutes. Based on the timing of the work shifts, we named our teams after Indonesian birds which are active at similar periods during the day: team Hingkik (Owls) from 22:00 to 06:00, team Mynah (Bali starling) from 06:00 to 14:00 and team Sulawesi Woodcock from 14:00 to 22:00. During these shifts, the OBS units were prepared and then dropped into the ocean, where they autonomously descended to depths of up to 5km. There they are destined to remain for over ten months, recording ground motion due to earthquakes.

Before the vessel sails to the designated deployment position, the science team has to assemble an OBS unit, attach it to the metal ballast (which anchors it to the seafloor) and set up the recording system that is connected to the seismograph. It sounds simple enough, but is a different story when the sea is rough. For the first four days in the Java Sea, several people could barely move out of their bunk because of severe seasickness. Fortunately, for the remaining six days, a peaceful Celebes Sea allowed us to have a pleasant journey. Nevertheless, assembling and setting up the OBS unit for the deployment was stressful work since any mistake would result in £32,000 worth of OBS to be lost at the bottom of the tropical seas forever. After spending ten days at sea, from 16 to 25 August, we had deployed 27 OBS units that spanned a region from the Makassar Strait to the Celebes Sea. It is worth noting that team Woodcock beat the other two teams by a slight margin by releasing the largest number of OBSs (ten units) during their shift.

Earth imaging using seismic waves is one of the most effective methods for looking deep beneath the Earth's surface to find out what is there. By using earthquake signals recorded by the OBS units deployed around the North-Sulawesi subduction zone, scientists at Cambridge hope to create the very first 3-D image of this very young subduction zone, which may provide new insight into how spontaneous subduction zones nucleate.

The research region of the North-Sulawesi subduction survey. The diamonds are the locations of the ocean-bottom seismometers; the red triangles are the active volcanoes; the black solid lines with triangles mark the trench of the subduction zone; the black solid lines with arrows mark the strike-slip fault in the region and the blue dotted lines mark the sea-floor magnetic isochrons.



Earth's deep carbon

MARIE EDMONDS, PROFESSOR OF VOLCANOLOGY AND PETROLOGY

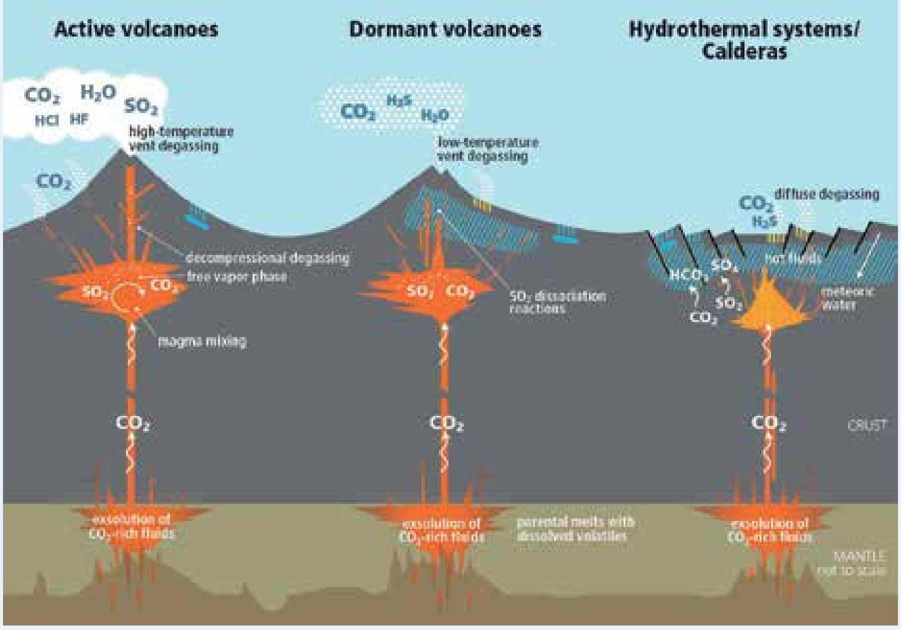
Carbon is fundamental: the backbone of life, component of super-strong materials for Society, the principal agent modulating our climate and the habitability of our planet's surface. Yet, the atmosphere and oceans contain much less than 1% of our planet's carbon. Where is the rest?

2019 marked the end of a decadal programme, the Deep Carbon Observatory (DCO), originally conceived by Dr Robert Hazen of the Carnegie Institution for Science, with seed funding from the Alfred P. Sloan Foundation. Over a decade, more than 1,000 scientists from 55 countries have engaged with the DCO, and have contributed much new knowledge and understanding of deep carbon, including as microbial life in the deep subsurface.

The Reservoirs and Fluxes community of the DCO (one of four communities, the others being Deep Energy, Deep Life and Extreme Physics and Chemistry) was charged with understanding the magnitude of the carbon reservoirs in the deep Earth, what form it takes and how it moves.

The carbon in our atmosphere and ocean is 'turned over', or replaced, on timescales of hundreds of thousands of years, by the processes of volcanic degassing (which supplies carbon) and burial of carbon in sediments and subduction (which removes carbon, back into Earth's interior). Over geological time these fluxes, though large, are thought to have largely balanced out, creating a stable planetary carbon envelope.

Mount Etna, Italy, one of the largest volcanic carbon emitters on our planet.



The new CO_2 flux data from volcanoes showed that dormant volcanoes as well as active volcanoes emit large fluxes of previously "unseen" CO_2, derived from the degassing of magma bodies in the crust below. These diffuse CO_2 fluxes make a large contribution to the total volcanic outgassing carbon flux. From DCO Decadal Report, 2019.

How to count volcanic carbon

But what is the volcanic carbon flux? And how does it compare to 'anthropogenic' fluxes of carbon into the atmosphere from the burning of fossil fuels? A subgroup of the Reservoirs and Fluxes community set out to try to estimate the global volcanic carbon flux. On the face of it, this would seem like an intractable problem. There are more than 10,000 volcanoes that have been active in the Holocene, and more than 700 volcanoes that might be considered 'active' at any one time.

A key characteristic of the global volcanic budget of sulfur dioxide, which is easy to measure using ultra-violet sensors on satellites, is that a few volcanoes emit extremely large fluxes of gas to the atmosphere. By quantifying the gas flux from the top 40 outgassers, it should be possible to account for almost 90% of the global volcanic gas flux.

New, improved sensors were developed (by researchers at the University of Palermo, Italy), to measure the ratio of carbon to sulfur in volcanic plumes which, when combined with SO_2 fluxes measured using UV spectroscopy, yielded a CO_2 flux. These instruments were installed at the crater rim, or flown through volcanic plumes using unmanned aerial vehicles. Results are summarised in a special issue of G-Cubed, on Volcanic Carbon Degassing, edited by Edmonds, Fischer and Aiuppa.

Carbon from volcanoes and volcanic regions adds up

Campaign measurements and installations of instruments revealed which volcanoes were emitting large fluxes of carbon. 'Big emitters' are the volcanoes Mount Etna (Italy) and Popocatepetl (Mexico), both of which emit between five and ten thousand tons of CO_2 every day. The carbon emissions from these volcanoes are supplemented by the assimilation of carbon-rich fluids derived from the heating up of carbonate sediments in the crust. Papua New Guinea and Vanuatu together hosts three big volcanic carbon producers – Ambrym, Aoba and Bagana volcanoes.

A surprising result is that it is not only active volcanoes that are sources of carbon; inactive calderas (such as Yellowstone, USA and Campi Flegrei, Italy) and continental rifts supply a large proportion of the global volcanic carbon budget. The East African Rift, for example, is thought to produce as much carbon as the entire submarine mid-ocean ridge system.

Overall, the global volcanic carbon budget is thought to sum between 280 and 360Tg (a Tg is a trillion grams, or one 'megaton') CO_2 per year. This amount is tiny (less than 1%) compared to the whopping 35,000Tg of CO_2 that is produced from the burning of fossil fuels and other human activities.

New ways of forecasting eruptions

The high temporal resolution records of CO_2 flux collected from active volcanoes all over the world yielded unexpected value for eruption forecasting. It was noticed that the CO_2 flux increased dramatically, by up to 80 times, a few days or weeks prior to explosive eruptions at basaltic volcanoes like Stromboli and Etna (Italy), Villarica (Chile) and Turrialba (Costa Rica). This finding raises the possibility of using gas data, in tandem with seismicity and geodesy, to forecast the timing of eruptions.

Catastrophic emissions of carbon

Though Earth is thought to have been in approximately 'steady state' with respect to the deep carbon budget over the Phanerozoic, there have been abrupt perturbations to the carbon cycle. These abrupt changes were due to asteroid impacts (which may have vapourised carbonates), large igneous province emplacement (which resulted in enhanced volcanic carbon emissions for up to a million years) and climate tipping points produced by the slow, inexorable movement of the continents. These ideas have been summarised in an open access issue of Elements in October 2019, edited by Suarez, Edmonds and Jones.

Marie is Co-Chair Reservoirs and Fluxes (with Prof. Bernard Marty, Université de Lorraine), Deep Carbon Observatory Chair Synthesis Group 2019, Deep Carbon Observatory.

www.deepcarbon.net

Further reading:

Special issue of G-Cubed, on Volcanic Carbon Degassing, edited by Edmonds, Fischer and Aiuppa: tinyurl.com/v25mjr4

Open access issue of Elements in October 2019, edited by Suarez, Edmonds and Jones: tinyurl.com/rsk52az

DANIEL FIELD, UNIVERSITY LECTURER

Untangling the origins of modern bird diversity

Daniel Field digging for small Jurassic vertebrates in Colorado, USA.

Modern birds comprise nearly 11,000 living species, inhabit virtually every corner of the modern world, and exhibit a mind-boggling variety of forms and lifestyles. But how has this awe-inspiring diversity arisen?

A pair of African Yellow White-eyes in Uganda. PhD student Lizzy Steell is studying the anatomy and evolution of passerine birds such as these, which altogether represent 6,000 living species.

Our lab uses evidence from the fossil record to piece together the evolutionary history of birds (and occasionally other vertebrates, like turtles, sharks, and mammals). We primarily focus on unravelling the origins of the spectacular diversity of living birds, and the step-by-step evolutionary process by which biologically modern birds evolved from their dinosaurian ancestors. This work is bringing us closer than ever to a more complete understanding of the origins of these fascinating creatures.

Our work is generally divided into projects aimed at clarifying How, Where, and When the spectacular diversity of living birds, their specialised features, and their extraordinary phenotypic variety have arisen. These studies draw on three-dimensional data from remarkable new fossils, cutting edge visualisation techniques, and a wealth of new phenotypic and genomic data from ongoing international collaborations.

The lab group boasts a vibrant, friendly mix of personalities from around the world. Third-year PhD student Albert Chen (Taiwan, USA) recently published a major component of his thesis research on the evolutionary history of hummingbirds and their relatives, drawing on data from fossils, comparative anatomy, and living bird genomes. Fellow third-year PhD student Juan Benito (Spain) is preparing to publish a comprehensive monograph on the 86-million-year-old fossil bird-relative *Ichthyornis* (it still retained teeth!), which will clarify the extent to which the sophisticated flight apparatus of modern birds was already in place during the Age of Dinosaurs. Albert and Juan are also both contributors to an exciting project, currently in review, reporting the discovery of one the oldest "modern" bird fossils ever discovered! Postdoc Junya Watanabe (Japan) is funded by a Newton International Fellowship and is investigating the independent evolutionary pathways that have given rise to wing-propelled diving birds like penguins and puffins.

In October, three new researchers joined our group: Lizzy Steell (PhD, UK), Klara Widrig (MPhil, USA), and Kit Baker (Part III MSc student, UK). Lizzy is focussing on unravelling the evolutionary history of passerines (aka "perching" birds), the most diverse group of living birds, comprising over 6,000 living species. Klara is using new visualisation techniques to digitally "dissect" the bones and muscles of living birds, in order to create a three-dimensional avian anatomical atlas. Kit is using similar digital techniques to reveal the skeletal morphology of an amazing early relative of birds, the feathered dinosaur *Confuciusornis*, which lived 120-million-years ago. In 2020, we look forward to welcoming Pei-Chen Kuo (Taiwan) and Armin Schmidt (Germany) as new PhD students, and Garance Robin (France) as a visiting Master's student.

Thanks to funding from a UK Research and Innovation Future Leaders Fellowship, our group plans to tackle the following major evolutionary topics over the coming years:

i) Tracing the origin of the modern avian skull, and sophisticated avian flight. Three dimensionally preserved fossils are extremely rare among the closest relatives of modern birds from the Age of Dinosaurs. Exquisite new fossils from this interval, uniquely, exhibit both three-dimensionally preserved skulls and skeletons. High-resolution CT scanning combined with 3-D mathematical analyses will elucidate the origin of the modern avian brain, and cutting-edge range-of-motion analyses will illuminate how the modern avian flight stroke evolved.

The Field Palaeobiology Research Group in October 2019. From l to r: Juan Benito, Kit Baker, Albert Chen, Lizzy Steell, Klara Widrig, Junya Watanabe, Daniel Field.

ii) The origin of modern avian geographic patterns, and the role of historical climate fluctuations in structuring avian distributions. We have previously shown that the geographic distributions of many groups of modern birds have fluctuated dramatically through their evolutionary history, but the causes of these inter-continental range shifts are unclear. By combining the latest palaeoclimate models with cutting-edge ecological modelling approaches, we will determine the extent to which climatic change over the last sixty-six million years has contributed to these patterns and predict future climate-driven geographic changes.

iii) Refining the timing of the modern avian radiation. By taking a three-pronged approach – developing new divergence time models, generating new sequence data from understudied species, and evaluating new fossil calibrations – we are poised to generate the first comprehensive and accurately time-scaled picture of the modern bird tree of life, a fundamental step toward discerning the patterns and processes that have generated Earth's modern bird biodiversity. This will also shed light on how major events in Earth history, like the mass extinction event that killed the giant dinosaurs, have shaped avian evolution.

This interdisciplinary work will have impacts on teaching, museum exhibition, and media, and will involve many early career scientists. We anticipate that data generated from these projects will facilitate myriad future studies on avian evolution, and combined with outreach efforts accompanying publications, will educate both young and old about evolution and palaeontology. We hope to incorporate visual data from this project into exhibits at the Sedgwick Museum, engaging the public and allowing museum-goers to manipulate both digital and physical specimens of key early bird fossils.

Daniel Field was a recipient of a Future Leaders Fellowship by UK Research and Innovation (UKRI), announced in September 2019: tinyurl.com/rr9yqmu

@daniel_j_field

danieljfield.com

IN CONVERSATION WITH
Liz Hide

Liz Hide (St John's 1988) became the first full-time female Director of the Museum in January 2019. Liz was a graduate student in the Department and has a long association with the Museum. Liz discussed her life and work with Research Fellow Charlotte Kenchington.

How do you feel about being the first female director of the Museum?

It's very cool. I'm hugely grateful for the work that Liz Harper and Sally Gibson did as interim directors before me. There are lots of women working in museums but, especially in science museums and collections, it's mostly men in directorial roles. So it's my hope that having a woman at the top of a world-leading museum will help others feel confident that they can lead as well.

How do you see the role of the Museum today?

Public visitors are the heart of the Sedgwick, but we're also a University Museum, embedded within the Department. One of the roles of the Museum is to help and encourage people to study Earth sciences, and to make it a subject where people, whatever their background, feel welcome. Many members of the public have stereotyped perceptions of what a geologist looks like, so I want to challenge that. Can everyone who visits the Museum come and see someone who looks like them? This is just one way we can show that the value, and potential, of the Museum goes beyond just the collections – it's a space where we can discuss and showcase ideas and where we can make people feel welcome.

So more than somewhere to go on a rainy Saturday and see the dinosaurs?

I'm delighted that people come to us for the dinosaurs, but I'm keen to show that we are about more than that. I see dinosaurs as a bit of a gateway drug – they get young people interested, and then I hope they find there's more to the Museum, and more to Earth sciences. I hope that we can have something to offer adults and young people as well as children.

How do you see the Museum attracting wider audiences?

University spaces like the Museum can be intimidating. I want to hear from the public what makes them feel welcome and interests them, and I want to go out into our communities and show people what we have to offer. We work with researchers, teachers and schools, and with members of the public, tailoring our programmes so that they work for them. We also work with groups of young carers, homeless people and people who may find it hard to otherwise visit, for example partially sighted people.

The Community Cabinet, one of our ongoing projects led by my colleague Rob Theodore, showcases collections made by members of the public. Our current display includes specimens which young people brought to our outreach events around the city over the summer, and then wrote labels telling us why these rocks and fossils are important to them.

Some of our projects are much larger scale. During February half-term we take part in the Cambridge-wide Twilight at the Museums, and might have 2000 people through the Museum on that day, many of whom are first-time visitors. If we make sure they have a positive interaction with the Museum, they'll come back. We've also got plans for some new programming over the coming year, such as volunteer-led LGBTQ+ tours of the museum as part of the Cambridge-wide Bridging Binaries initiative.

Your position is associated with both the Museum and the Department. How do you hope to strengthen the links between the two and what do you hope would result?

I was really heartened to hear new Head of Department Rich Harrison articulating very clearly that the Museum IS the Department. That's what I've always felt – for me, the Museum is an essential part of the Department, as much as the library or the coffee room. Even if fossils aren't your thing, the Museum is a really important interface with the public, more than 160,000 of them every year. I'm keen to make research more visible to our public audiences, for example by having researchers out in the gallery talking to the public about their research.

I think we need to be rebranding and rethinking how we present Earth sciences as a subject at the heart of a climate-sustainable future. At a time when experts and facts are being challenged, we can train people to present arguments and data and research around climate science and sustainable science. We've got the opportunity to create the debate, and root that debate in science.

FOR ME, THE MUSEUM IS AN ESSENTIAL PART OF THE DEPARTMENT, AS MUCH AS THE LIBRARY OR THE COFFEE ROOM. EVEN IF FOSSILS AREN'T YOUR THING, THE MUSEUM IS A REALLY IMPORTANT INTERFACE WITH THE PUBLIC, MORE THAN 160,000 OF THEM EVERY YEAR.

You've been Director for a year. What moments have stood out for you?

There have been some amazing moments this year: the Sedgwick was one of six museums shortlisted nationally for the Kids In Museums Family Friendly Museum of the Year; and our exhibit showcasing Emily Mitchell and colleagues' work was recognised with a Vice Chancellor's Award for Public Engagement with Research, reinforcing the message that museums are good for Impact. We also had a lot of fun flying rainbow flags for Cambridge Pride to show solidarity with LGBTQ+ people, and it was a really special moment to receive the keys to our new building in West Cambridge (more on page 14).

Perhaps the most important achievements have been behind the scenes. Over the last year, I've sat down with the Museum team and our partners to think hard about what, and who, the Museum is for. How do we support world-leading research, and also support families? The result is a new Strategic Mission for the Museum, which clearly articulates what we are, and where we want to be in the next five years. We're working to increase the research use of our collections, to support student learning and skills development, and to increase and diversify our public audiences by offering an exciting and stimulating public programme. We want to play a much greater role in the wider museums sector – as a world-leading museum that also supports smaller museums in our region.

What would you like people to know about the Museum, and your tenure as director?

I'm always interested in talking to people about what the Museum can do for them. We have truly unique and amazing collections, and an amazing Museum as well, but we are also all about the people and about working together. Come and have a chat, come and visit, come and volunteer – give me a shout!

Follow Liz at @TheMuseumofLiz
sedgwickmuseum.org

Collections Research Centre: THE COLIN FORBES BUILDING

The Sedgwick Museum received the keys to the brand new Colin Forbes Building in September and began the ambitious task of transferring our rock collections – weighing more than 150 tonnes – from a variety of locations across Cambridge. Bringing our collections together and creating a space to welcome research visitors is a big step towards the Museum's aim of creating a world-leading centre for Earth Sciences collections research.

Situated on Madingley Rise, adjacent to the Brighton Building store and conservation lab, the Forbes Building is a state-of-the-art collections centre. To minimise degradation of the rock and fossil collections, the internal environment is kept at a steady temperature and humidity; and includes a special cold store to house the Museum's archive and photographic collections, ensuring that these important materials continue to be available for researchers from across the world. The building's foundations have been specially designed to withstand the exceptional weight of the collection.

To date, the team have moved the Harland Collection, collected from Svalbard and comprising 1,800 drawers, 16 tonnes of specimens. In total, approximately 12,000 drawers containing approximately 300,000 rock specimens will be moved into the Forbes building. They include the Harker collection of igneous and metamorphic rock, rocks collected by Raymond Edward Priestly during the 1910 Terra Nova expedition and also the Dawson and Harte collection of samples from the Earth's deep interior.

The Museum welcomed a new member of the team, Catherine Craston, who has a key role in moving the collections into the store. Catherine is recruiting and training a team of volunteers to 'help us move a mountain'. Tasks will include helping to label, clean, photograph and digitise the drawers of rocks, and to move them into their new homes. If you are interested in being part of the volunteer team, information is available at **sedgwickmuseum.org/** and **ucm.volunteermakers.org/**.

Collections move team, from l to r: Simon Kelly, Sarah Wallace-Johnson, Charis Millet, Catherine Craston, Matt Riley.

MARY MURRAY, PART III STUDENT

Last summer, I had the opportunity to do research at the Earth, Atmospheric and Planetary Science Department in MIT, Cambridge, Massachusetts. I made new friends, gained experience in another Earth Sciences Department, explored a new country and – most excitingly – got my hands on some real moon rocks!

Mary in front of the Small Dome at MIT.

Summer in **"the other Cambridge"**

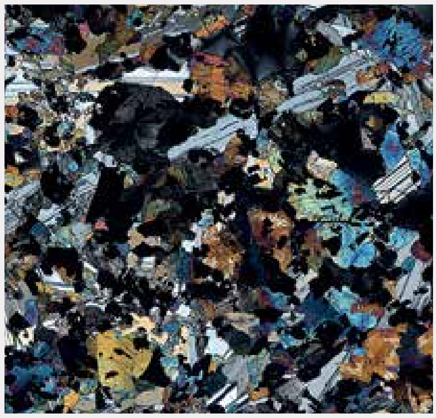
For my master's project, I am studying the early lunar magnetic field. I am using mare basalts brought back by the Apollo 17 astronauts, on loan from NASA to the Paleomagnetism Laboratory at MIT. I prepared subsamples and used the 2G SQUID Magnetometer to study their magnetic behaviour using alternating field demagnetisation. We are hoping to extract and characterise the primary magnetisation that was imparted when they formed 3.7 billion years ago on the lunar surface. While my data was hard to interpret, it is a step towards increased understanding of the moon's magnetic field over time. It is rewarding to be able to contribute to real science. My fantastic supervisor, Claire Nichols (Newnham, 2010), welcomed me to the friendly and impressive lab group. I enjoyed learning about aspects of Earth sciences, and especially planetary science, that are not a big focus at Cambridge, UK.

Some aspects were frustrating. My first sample proved to be one of the least reliable magnetic recorders seen by most of the lab, and the data from my second sample was also extremely noisy. Working with exotic lunar samples is challenging because the quantity of material is limited. You have to work with what you have, rather than what you would like to have.

This taught me a lot about extracting signals from limited data. Nothing is quite as clear as it is in a textbook!

It was gratifying to become part of the lab group and wider graduate community at MIT. I enjoyed learning about everyone else's research. I went to a colleague's impressive thesis defence. It was inspiring to see his finished research and fun to celebrate afterwards.

I also took the chance to explore. Like most keen geologists, I love the outdoors. I spent a weekend hiking and climbing in the White Mountains with the MIT Outing Club. As the President of the Cambridge University Hillwalking Club, I made sure to steal some ideas. It was fun to get to know a totally new crowd. My new foolproof technique for making friends is: turn up at the planning meeting and ask "So who wants to share a tent?". I also took a friend from the lab (a senior at MIT) on her first ever train ride to Salem, then we did another trip to the Boston Harbour islands. In the sweltering heat, I borrowed a bike and spent weekends cycling to different swimming spots. Thanks to some amiable "hackers", I got to explore some of the less accessible and more entertaining parts of the MIT campus.



Seen in thin section a basalt collected by Apollo 17 astronauts belies its origin 3.7 billion years ago.

Overall, I clocked over three hundred hours data collection on the 2G SQUID; made new friends; did science; lived in another country; learnt to code; swam in lakes, rivers, pools and the ocean; ate a lobster tail in the North End; and left with a squid memento knitted by a friend.

And finally, the question everyone asked me: which Cambridge do you prefer? Even with all the excitement and opportunities of Cambridge, MA, the original Cambridge is too special to be beaten so quickly. With all its beautiful buildings, the crazy quirks of our department, three years of memories and packed with people I love – **I know which Cambridge I choose**.

EMMA LIU, LEVERHULME RESEARCH FELLOW

Above & beyond

Volcanologist Emma Liu travels to some of the world's most active volcanoes to understand what makes them erupt. Her latest work is helping a Pacific community to monitor the restless mountain they live with.

Standing on the rim of the volcano with her colleague and a local guide, Emma listened to the low roar of the crater's belly and watched as it spewed incendiary gobbets of lava. A moment later, they launched their 'eye in the sky', a drone that can fly high above the volcano to collect gas chemistry data from directly inside the plume.

"Volcanoes are always going to erupt and so remote gas sensing – 'breathalysing' them, if you like – to assess hazard is an important defence to build resilience in communities that live nearby," explains Emma.

Worldwide, around half a billion people live in areas at risk from volcanic eruptions. Even a volcano a thousand miles away can bring chaos and disruption to many, as Iceland's Eyjafjallajökull taught us in 2010. Yet we still have much to learn about what makes volcanoes erupt and whether we can predict when. Drones offer an invaluable contribution to monitoring by making observations closer to volcanoes than ever before, irrespective of hazardous or inaccessible locations. In fact, some of the research team's flights are from a distance of 8 km away and to a height of 3 km.

"There are satellites that monitor volcanoes for gas release, but there's a lot of uncertainty and errors involved in that because you're looking from so far away at something quite small," Emma explains. "Drones are providing a real intermediary between direct sampling and remote measurements in that we can get these close-to-vent measurements but from a safe distance."

As well as providing access to the inaccessible, drones are also changing how the researchers monitor changes in the behaviour of a volcano.

"We now design sophisticated aerial experiments to test specific hypotheses, like how the chemical reactions that are happening in the volcanic plume mature as they move downwind and what this means in terms of forecasting," she adds.

Their drone carries lightweight sensors to measure gases, particulates, temperature and humidity, as well as cameras to take visual and thermal images of eruptions in real time.

Emma's recent work has been in Manam, Papua New Guinea, where she leads the Aerial-Based Observations of Volcanic Emissions (ABOVE) programme, funded by the Alfred P. Sloan Foundation as part of the Deep Carbon Observatory. Five major explosions have occurred here in the past year. In 2004, the whole island was evacuated, and islanders only started to return five years ago.

"We chose Papua New Guinea for many reasons," she explains. "We looked at our global dataset of carbon emissions around the world and identified gaps. Papua New Guinea really stood out because it has some of the most strongly degassing volcanoes as measured from satellites in space and yet almost entirely lacks ground-based measurements."

"Also, permanent relocation is seen as unacceptable to the islanders because the island is essential to their way of life. Instead they want to help themselves to live alongside the volcanic hazard."

ABOVE is the first time a global collaborative effort of scientists, aerospace engineers and pilots has been assembled to fill in some of the gaps in our understanding of what makes volcanoes

Above: Preparing to launch a fixed-wing drone to measure the volcanic gases at Manam volcano with the help of the local community.

Left: Dr Brendan McCormick Kilbride deploys a MultiGAS analyser to measure the chemical composition of volcanic gases.

erupt. In May 2019, the research team undertook an ambitious field deployment to Manam, and also Tavurvur (Rabaul), in Papua New Guinea. They brought with them fixed-wing and rotary drones fitted with tiny sensors and cameras to collect data from the volcanoes. Each group had a slightly different focus on what, where and how they sampled the volcanic flux.

One drone, for instance, measured carbon dioxide levels as it flew through the plume, feeding the information in real time back to the drone operator. When the gas level was high enough, the operator would trigger a pump to take a sample for analysis back on ground level, where the ratios of carbon dioxide and sulphur dioxide could be used to forecast volcanic unrest.

"Right from the beginning this project was all about jumping us into the next decade of deep carbon science," explains Emma.

"We collected data for the first time at a volcano where it's never been monitored before, we achieved engineering feats that a year ago we wouldn't have even entertained, and we can now start to fill in some of the gaps in our understanding of the signature 'breath' of a volcano and the critical role of volcanoes in the deep Earth carbon cycle."

Working with members of the Manam Volcanic Disaster Response Committee, Emma saw an opportunity to help a community-led resilience programme.

"Meeting the islanders was quite sobering – it helped us to understand the deeper social context of what an evacuation really means for the people involved," says Emma. "The generosity of the local tribe was unimaginable – we would leave equipment outside as permanent monitoring stations and within a few minutes the local people had constructed shelters above of wood, bamboo and woven leaves. None of this project would have been possible without them."

One of the biggest successes, she adds, is the collaboration the team set up with the local volcano observatory to continue the measurements. She and colleagues trained local scientists how to use the drones, funded through a Global Impact Acceleration Grant from the Engineering and Physical Sciences Research Council Global Challenges Research Fund.

"The islanders have been relying on visual monitoring up till now," she says. "They can now fly them over the volcano to do the same gas monitoring as we were. And when there is an eruption, it will be useful to get something in the air to see what and who is most at risk."

One representative from each of the provinces in Papua New Guinea came to their training workshop and as a result has since successfully lobbied provincial governments for additional funding to help them build the resilience programme.

Meanwhile, Liu will continue to collect data from the volcanoes themselves. "Field-based studies are crucial – these aren't processes we can recreate in the lab – and there's a buzz about being there. When I'm at the crater rim, with a line of volcanoes stretching before me... at times like this, I feel a little bit superhuman."

Louise Walsh

Main: A multi-rotor drone takes off to collect gas samples from inside the crater of Tavurvur, Papua New Guinea, piloted by Dr Ian Schipper.

A shorter version of this article first appeared in *Research Horizons*, Issue 39, and later on-line at cam.ac.uk/stories/activevolcano .

Dr Emma Liu was a Leverhulme Research Fellow in the Department of Earth Sciences as well as a Fellow of Lucy Cavendish College. Emma is now at UCL.

RECENT NEWS & AWARDS

The Geological Record

01

Ekhard Salje (Head of Department 1998–2008) received an Honorary Doctorate at the Julius-Maximilians-Universität Würzburg in October, awarded in recognition of his scientific achievements and committed work as a long-standing chair of their University Council.

02

Simon Redfern (Gonville and Caius 1982), Chair of Mineral Physics, stepped down as Head of Department at the end of the last academic year and left Cambridge to take up a new role as Dean of the College of Science at Nanyang Technological University, Singapore (NTU). Simon was the founding Chair of the NERC Cambridge DTP, a member of the Committee on Radioactive Waste Management and has previously served as a British Science Association Science Media Fellow at the BBC. Before leaving Simon secured funding for a new centre at the University of Cambridge that will develop AI techniques to help address some of the biggest threats facing the planet.

03

Congratulations to **Marie Edmonds** (Jesus 1994) who has been promoted to a Professorship. Marie is a volcanologist interested in understanding the impacts of volcanism on Earth's atmosphere, as well as how volatiles are cycled from the interior of the Earth to the atmosphere via volcanoes, and then back again through subduction. Marie was awarded the Daly Lecture of the Volcanology, Geochemistry and Petrology section of AGU in 2019 for 'outstanding contributions to volcanology, geochemistry, or petrology'.

04

We welcomed **Oscar Branson** (Jesus 2010) and **Rachael Rhodes** (Research Associate 2015–2018) back to the Department at the beginning of the academic year as University Lecturers. Oscar's research focuses on understanding the links between environmental conditions and the formation and geochemistry of carbonate biominerals (in shells and corals). Rachael's research uses polar ice cores to understand past changes in climate and biogeochemical cycles.

05

Congratulations to **Marian Holness, Nigel Woodcock** and **Brendan McCormick Kilbride** who each received awards on President's Day at the Geological Society of London last June. They were awarded, respectively: the Murchison Medal, the Dewey Medal and the William Smith Fund for 2019.

06

Congratulations to **Liz Harper** (Gonville and Caius, 1983) who has been appointed as Honorary Professor of Evolutionary Malacology. Liz is an internationally renowned palaeontologist with an expertise in bivalve molluscs and brachiopods both fossil and living. She is interested in biomineralization and predator-prey relationships. She is an Honorary Fellow of the British Antarctic Survey and has worked in marine laboratories around the world.

07

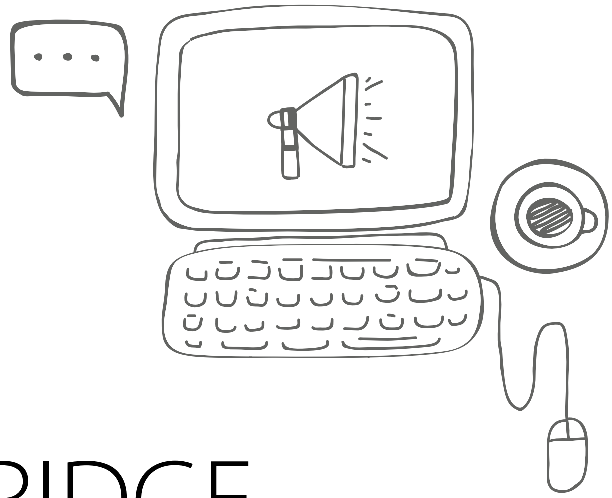
Congratulations to **Luke Skinner** (Clare Hall 1999) who has been promoted to a Readership.

Recently retired

David Norman came to Cambridge in 1991 as both a Lecturer and Director of the Sedgwick Museum, which he substantially redeveloped and professionalized. He taught in both Zoology and Earth Sciences, and on the Dorset and Sedbergh fieldtrips. David built a Vertebrate Palaeobiology research group, the alumni of which now occupy senior UK positions. His personal research covers descriptive morphology, dynamic and static functional mechanics, herbivory, the link between tectonics and evolution, taxonomy, systems and phylogenetic reconstruction. David has also written on Charles Darwin's geological researches and Richard Owen's palaeontology in Dorset.

Tim Holland, Professor of Metamorphic Petrology and Geochemistry, was one of the first to demonstrate, in 1979, that rocks found at the surface in the Alps had previously been buried at depths of over 70 kilometres. He is more widely known for the application of thermodynamics in describing phase equilibria and properties of minerals, fluids and melts, with particular emphasis on determining the evolution of metamorphic rocks. His dataset and associated software THERMOCALC, developed in collaboration with Roger Powell, have become essential tools for much petrological research. Tim was elected a Fellow of the Royal Society in 2014.

Keith Priestley, Professor of Seismology, came to Cambridge in 1991 as Assistant Director of Research from the University of Nevada where he was Professor of Seismology. In Cambridge he built a programme in observational seismology conducting numerous seismological field experiments with his students in various parts of the world. His former PhD students now occupy senior positions in Europe, Asia, and North and South America. He taught the Earth Sciences' geophysics course in the Physics Department. His personal research involves studies of the structure and mechanical behaviour of the Earth's crust and upper mantle and how these relate to the Earth's evolution and dynamics.



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

FROM THE CAMBRIDGE **EARTH SCIENCES BLOG**

SIFTING THROUGH THE SEDIMENT

Issy Baker, Part III student

While many of my friends spent their summer vacation swanning off to remote corners of the world for some well-deserved rest and relaxation, I decided that it would be fun to spend August doing some lab work in Cambridge – I was actually pleasantly surprised.

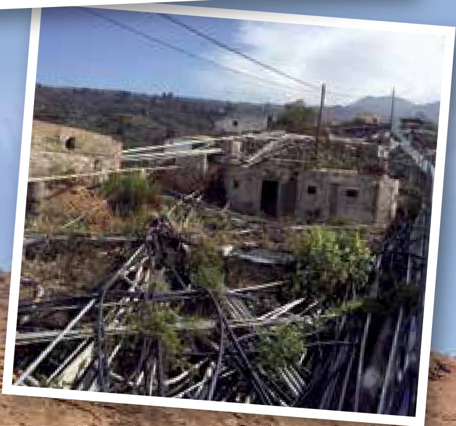
I was working for Nick Butterfield on some lake sediments from Idaho, which were deposited around 10 million years ago. These Miocene lakes would have contained pretty much all the life that you'd expect to find in a lake: fish, midges, their larvae and pupae, flies, crustaceans, plant matter, and of course, fungi. The sediments contain exceptionally well preserved fossils of all the organisms listed above, so my job was simple: to get the best fossils out of the rocks and mount them onto slides for examination.

Read more blog.esc.cam.ac.uk/?p=1530

Main image: What's this in my petri dish? Left inset: The carapace of a crustacean (2.5mm across).

Below: Group shot of GeoTenerife students with organisers from the Chemical Engineering Dept. and University of La Laguna.

Right: A water distribution point, little regulation leads to the chaos of pipes and regular leaks.



A 'WET' SUMMER: CAMBRIDGE AND TENERIFE

Nikki Sridhar, Part III student

This summer I was lucky enough to complete an internship in Environmental Consultancy with Mott MacDonald followed by a Hydrology Field Training Programme run by GeoTenerife. As a geologist, it can be hard to see how an Earth Sciences degree can be directly used outside of academia or the traditional field of oil and gas: the internship and training programme seemed a good way to explore alternative options.

For my first 6 weeks with Mott MacDonald in Cambridge, I joined the Contaminated Land team. Although this doesn't sound glamourous, it's an essential job on any construction project. The majority of my time was spent on a risk assessment for planned upgrades to the M27 which involved creating a cross section using both BGS maps available online, and a range of borehole logs.

After a short break, I flew out to Tenerife for the Hydrology Field Training Programme run by GeoTenerife which focused on the methods used to source and treat water. Tenerife is an interesting island to study this dynamic due to the scarcity of clean groundwater and the history of its cultivation.

Read more blog.esc.cam.ac.uk/?p=1496

Main image: Nikki and friends enjoying the amazing beaches.

The impact of a legacy

A generous bequest from Alan Smith (1937–2017) has helped ensure that all of our students have access to our extensive fieldwork programme throughout their undergraduate years.

The cost of our taught undergraduate field courses is considerable; £228k in the last financial year. We receive a contribution from the School of Physical Sciences together with donations from alumni and our Industrial Associates to help cover the costs. In order that costs are not significantly higher for our students than other NST options, students are asked to contribute only a nominal fee of between £95 and £155 per course, but for some students even this represents a considerable financial burden.

Alan Smith's bequest, together with other recent gifts, have started a capital fund that will provide a certainty of income to cover financial hardship cases when they arise, and will ensure that financial worries do not prevent students from taking part in our fieldwork programme.

Alan was an enthusiastic field teacher throughout his long Cambridge career. He taught in turn on most of the Department field courses and supervised generations of mapping project students, particularly for projects in Greece.

A legacy could open up a world of opportunity to future students, researchers and academics, helping to provide the environment and tools they need to achieve great things. A gift in a Will to support the Department of Earth Sciences can have significant tax advantages because the University's charitable status means that legacy gifts from UK taxpayers do not count towards the taxable value of your estate.

For further information about the impact of a legacy and guidance on how to leave a gift to the Department please do contact us:

Alison Holroyd, Alumni Coordinator
alumni@esc.cam.ac.uk

Josh Bowerman,
Senior Associate Director of Physical Sciences
josh.bowerman@admin.cam.ac.uk

Clockwise from above: 3rd year students in Skye, image C. Kenchington; 2nd year students at Millook Folds, Cornwall; 1st year student Emma Soh using her compass clino to take a selfie on the Arran fieldtrip.

Thank you to our donors 2018–2019

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.

CASP
Google Inc
Trinity College for their contribution towards the Sedgwick bicentennial celebration

1948
Alan Wells

1952
Brian Norford

1955
Graham Chinner
Philip Robinson
Alan Smith *(deceased)*

1956
Peter Warren

1957
Peter Simpson *(deceased)*

1960
Mark Moody-Stuart
Michael Seymour

1961
Jeff Bowen

1969
Barry Jefferies

1972
Paul Conyers
Alastair Graham

1973
Simon Mollett

1974
David Hanstock
Fiona Hanstock

1980
Marcus Flint

1982
Daniel Martin

1983
Rus Newton
Michael Percival

1987
Francisca Oboh-Ikuenobe

1993
Andrew Butler

1994
Jenny Brett

2000
Christopher Balmer
Corin Hughes
Helena Warrington

2001
Frances Barrigan
Kirsty Dodds
John Elliott
Joanna Ellis
Jon Farrant
Jacob Hall
Sarah Johnson
James Knibbs
Samantha Large
Laura Lawton
Ruth McKnight
Virginia Newton-Lewis
Louise Parker
Thomas Russon
Niall Sayers
Caroline Sindrey
Anna Watkins
Katie Whitbread

2002
Alistair Crosby
Eleanor Green

2004
Maria Andersson Bianchi
James Banton
Michael Coffin
Jillian Hegarty
Mairi Jeffery
Mark Logie
Ajay Mistry
Bob Myhill
Robert Pemberton

2006
Daniel Chapman
Rebecca George
Danielle Lopes
Hannah Mottram
Matthew Parsons
Natalie Read
Michael Turner
Owen Weller

Non Alumni
Bill Groves

Follow us online:

esc.cam.ac.uk

Latest news:
esc.cam.ac.uk/about-us/news

Cambridge Earth Sciences blog:
blog.esc.cam.ac.uk

ESC on Twitter:
@EarthSciCam

ESC on Instagram:
@cambridgeearthsciences

Moving home?

To keep in touch, make sure you update your contact details with us at:
alumni.cam.ac.uk/contact/update-your-details

Design and Print Management H2 Associates, Cambridge

Be part of the future with a gift in your Will

A gift to the Department in your Will could help the Department flourish far into the future. Such a gift can open up a world of opportunity for future students, researchers and academics. Many of our donors find that a gift in their Will is a good way to make a significant and lasting contribution.

For further information about the impact of a legacy and guidance on how to leave a gift to the Department of Earth Sciences please do contact us:

Alison Holroyd
Alumni Coordinator, Department of Earth Sciences
E: alumni@esc.cam.ac.uk

Josh Bowerman
Senior Associate Director of Physical Sciences
University of Cambridge Development and Alumni Relations
E: josh.bowerman@admin.cam.ac.uk

Dear World... Yours, Cambridge

The campaign for the University and Colleges of Cambridge