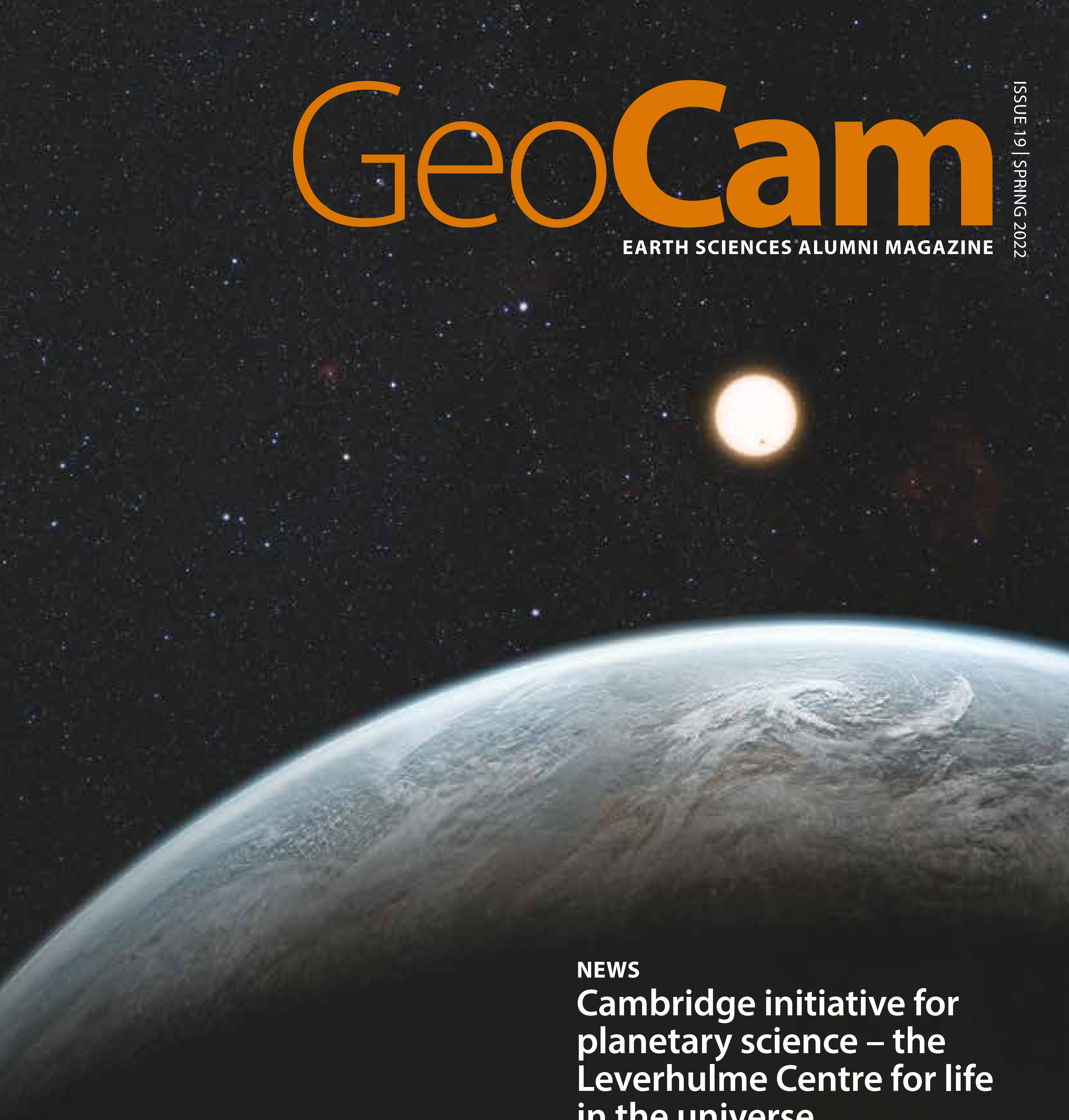


GeoCam

EARTH SCIENCES ALUMNI MAGAZINE

ISSUE 19 | SPRING 2022

NEWS

Cambridge initiative for planetary science – the Leverhulme Centre for life in the universe

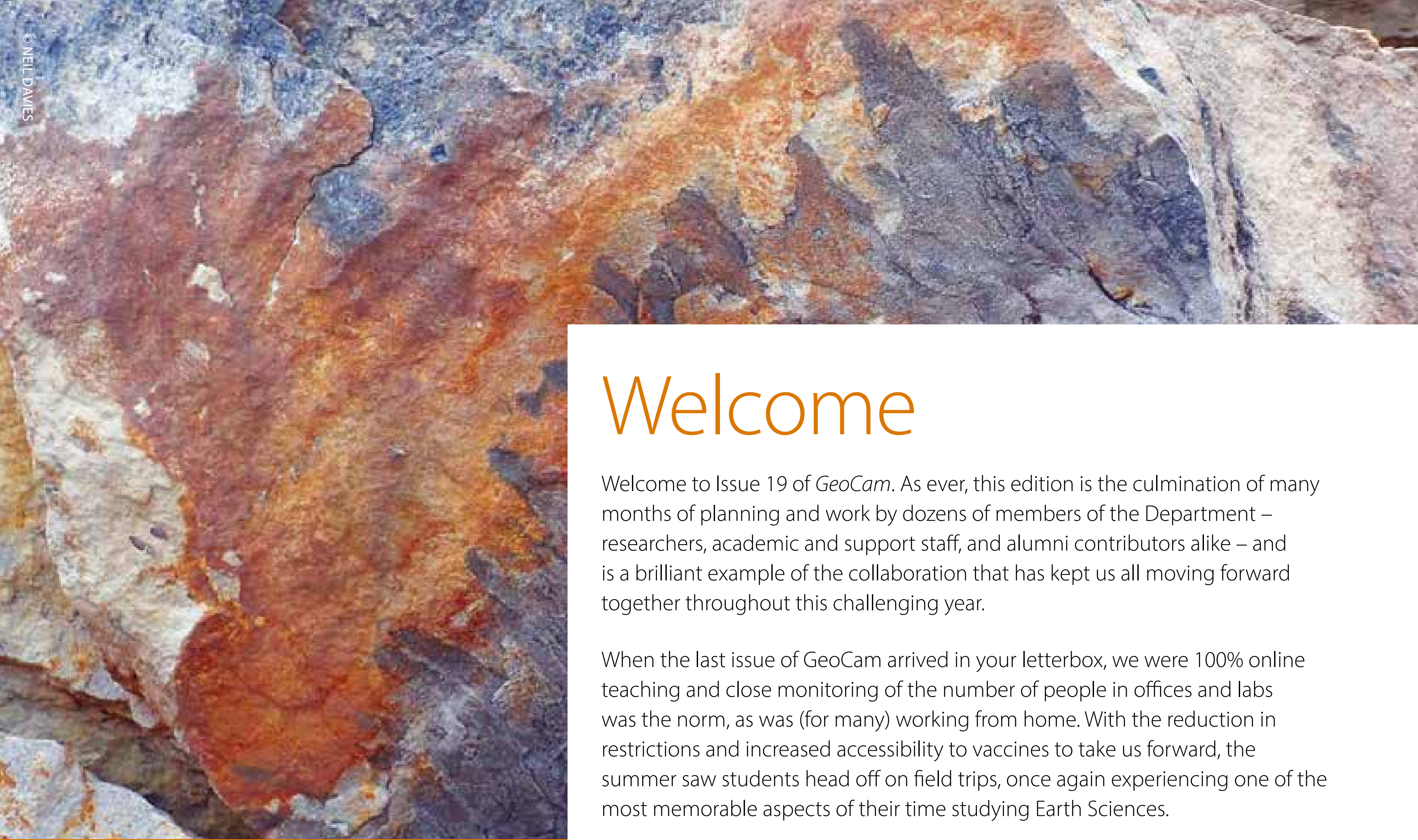
FEATURE

In conversation with Helen Williams

RESEARCH

Ancient landscapes shaped by plant evolution

UNIVERSITY OF CAMBRIDGE



Welcome

Welcome to Issue 19 of *GeoCam*. As ever, this edition is the culmination of many months of planning and work by dozens of members of the Department – researchers, academic and support staff, and alumni contributors alike – and is a brilliant example of the collaboration that has kept us all moving forward together throughout this challenging year.

When the last issue of GeoCam arrived in your letterbox, we were 100% online teaching and close monitoring of the number of people in offices and labs was the norm, as was (for many) working from home. With the reduction in restrictions and increased accessibility to vaccines to take us forward, the summer saw students head off on field trips, once again experiencing one of the most memorable aspects of their time studying Earth Sciences.

The start of the 21-22 academic year has been one filled with optimism. A full return to face-to-face teaching, labs, field trips, clubs, activities, and those much-missed student experiences has added to the positivity within the Department. The traditional 11.00 coffee time has returned, with an ever-growing gaggle of staff gathering each day to spark new ideas and trigger new collaborations. The end results of this daily 'work event' can be seen in the research stories within these very pages.

Research in the field, studying landscapes as seemingly diverse as the foothills of the Himalayas, the English Midlands and the Welsh Borders, provides potential for a greater understanding of how mountain belts work. Discover how an Earth Sciences degree can contribute to a varied career in the corporate (non-Earth Sciences) world – does it compare with your own professional journey? Learn how, armed with nothing more than the humble thin section (and a universal stage), it is possible to reveal the complex processes occurring underneath volcanoes. Peruse our news headlines and get a taste of one or two of our blog posts for an overview of all that we've been up to in the Department.

There is much to uncover within these pages, not least our gratitude for the support of our generous donors. With four funds in place to support field trips, students, the Sedgwick Museum, and a general fund that allows the Department to allocate funds where they are needed, donations are gratefully received. Your support helps us ensure an enriching experience and greater opportunities for everyone under the Department's care.

In a similar vein to the work that has gone into creating this magazine, a group of people, led by our Alumni Relations team, are working diligently on the Alumni Day and Dinner. It has been three years since we were able to host this event and we are all looking forward to welcoming you back this May.

I wish you a safe, healthy, and much more typical 2022. We hope to see you soon,

Richard Harrison, Head of Department

IN THIS ISSUE

Cover Image: Artist's impression of one of more than 50 new exoplanets found by HARPS

NIGEL WOODCOCK, EMERITUS READER

The Rock Crushing Rooms

Venture to the end of the corridor beyond reception, through a thick wall marking the western end of the Sedgwick Museum building, past two preparation labs, to a turret with a narrow spiral staircase. It requires some courage to venture onward and downward; at least, either courage or the urge to break and powder rocks for analysis.

Down in the basement are three rooms containing machines with attitude. It's as well that the basement has windows that dispel the impression of a dungeon filled with torture devices. Most fearsome are the rock splitter – with its large turn screw – and the jaw crusher – with its noisy antique belt-driven mechanism. There are also ball mills and a Wilfley table, which uses flowing water to separate out heavy minerals such as zircon.

Jason Day, who manages the crushing rooms, knows their history. "They and the ground-floor labs above started life as the residential Porter's Lodge for the Downing Site. The external ground floor doorway survives under the Downing Street arch, as does the bell push to summon the porter up the spiral stairs from his basement rooms," explains Jason.

Our modern user, following the ghost of the Porter back up the stairs, may be tempted to follow him further upwards in the turret. Where might that lead? Well that's another story …

IMAGES © NIGEL WOODCOCK

Main image: Descending the spiral stairs.
Right: Jason demonstrates the Wilfley table.

RESEARCH NEWS

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

The Deccan Traps.

© LOŸC VANDERKLUYSEN, DREXEL UNIVERSITY

SCIENTISTS ZERO IN ON THE ROLE OF VOLCANOES IN THE DEMISE OF DINOSAURS

Researchers have uncovered evidence suggesting that volcanic carbon emissions were not a major driver in Earth's most recent extinction event.

Earth has experienced five major extinction events over the last 500 million years, the fifth and most recent responsible for wiping out the dinosaurs 66 million years ago. Massive volcanic eruptions have been identified as a major driver in the environmental change which triggered at least three of these extinctions.

But what dealt the final blow to the dinosaurs – whether an enormous outpouring of lava from the Deccan Traps volcanic province in India or a large asteroid impact, or perhaps a combination of the two – has remained open to debate.

Now, a multi-institutional research team, led by scientists from The Graduate Center, CUNY, and involving the University of Cambridge, has, for the first time, accurately pinpointed the timing and amount of carbon released from Deccan Traps volcanic province. The new data means scientists can now assess the role of volcanism in climate shifts around the End-Cretaceous mass extinction.

Read more: https://bit.ly/31Txg6a

THE HIDDEN DANGERS OF VOLCANIC POLLUTION...

A team of volcanologists who observed the colossal 2018 eruption of Kīlauea, Hawai'i, have tracked how potentially toxic metals carried in its gas plumes were transported away from the volcano to be deposited on the landscape.

The research is the most extensive survey of metal release from any volcano to date – helping scientists understand the spread of metal-rich volcanic fumes and the exposure of communities to volcanic air pollution around Hawai'i.

Read more: https://bit.ly/3re5F87

Frank Trusdell (USGS) standing in front of slow moving lava flows just along from the Fissure 8 vent.

© EMILY MASON/USGS

THE LARGEST-EVER FOSSIL OF A GIANT MILLIPEDE FOUND IN THE NORTH OF ENGLAND

© NEIL DAVIES

The largest-ever fossil of a giant millipede – as big as a car – has been found on a beach in the north of England. The remains of a creature called Arthropleura dates from the Carboniferous Period, about 326 million years ago, over 100 million years before the Age of Dinosaurs. The fossil reveals that Arthropleura was the largest-known invertebrate animal of all time, larger than the ancient sea scorpions that were the previous record holders.

Read more: https://bit.ly/3FmtuzU

MUDDYING THE WATERS – WEATHERING MIGHT REMOVE LESS ATMOSPHERIC CARBON DIOXIDE THAN THOUGHT

The weathering of rocks at the Earth's surface may play less of a role in regulating our climate than previously thought, says new research from the University of Cambridge. The findings, published in PNAS, suggest Earth's natural mechanism for removing carbon dioxide (CO2) from the atmosphere via the weathering of rocks may in fact be weaker than scientists had thought – calling into question the exact role of rocks in alleviating warming over millions of years.

The research also suggests there may be a previously unknown sink drawing CO2 from the atmosphere and impacting climate changes over long timescales, which researchers now want to find.

Read more: https://bit.ly/3r7RT7f

© E. TIPPER

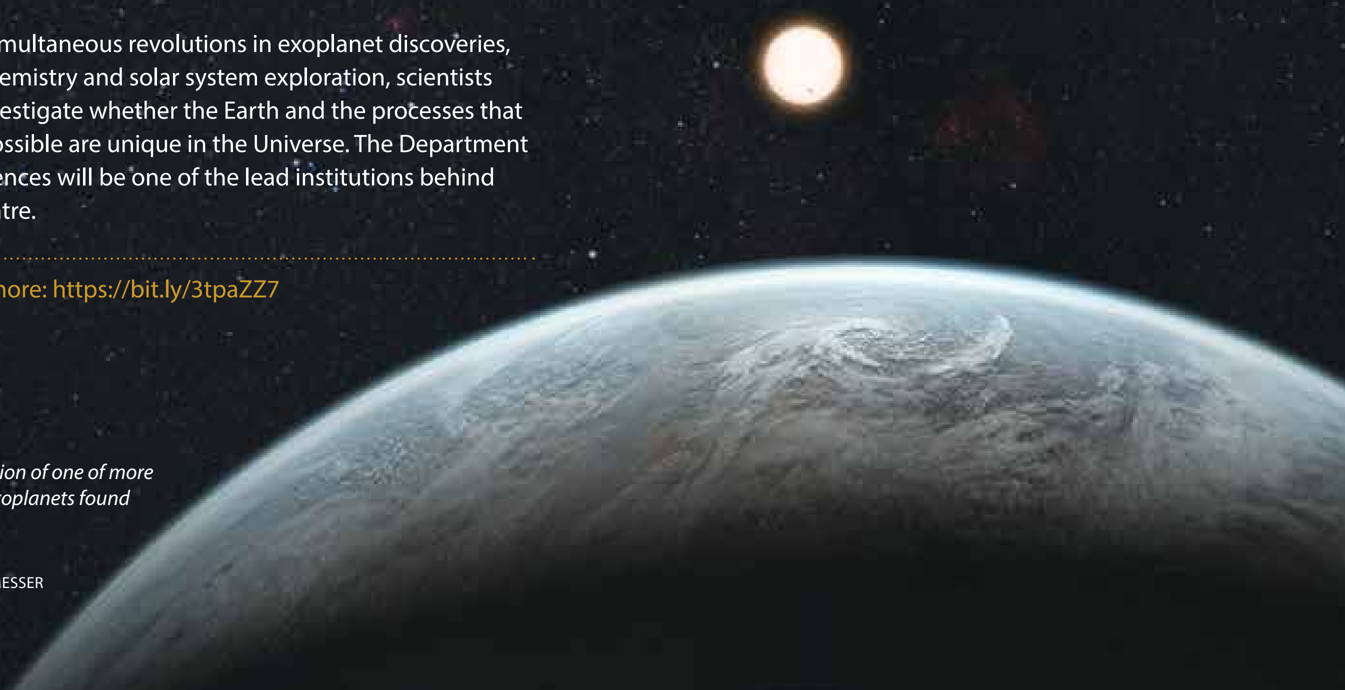
Pictured: Emily, Christina and Jotis sampling the Salween River.

DEPARTMENT OF EARTH SCIENCES TO PLAY KEY ROLE IN NEW LEVERHULME CENTRE FOR LIFE IN THE UNIVERSE

For the first time, addressing some of humanity's most fundamental questions on the origin and nature of life in the Universe is within the grasp of modern science. With a £10 million grant awarded by the Leverhulme Trust, the University of Cambridge is to establish a new interdisciplinary research centre dedicated to life in the Universe and led by 2019 Nobel Laureate Professor Didier Queloz.

Thanks to simultaneous revolutions in exoplanet discoveries, prebiotic chemistry and solar system exploration, scientists can now investigate whether the Earth and the processes that made life possible are unique in the Universe. The Department of Earth Sciences will be one of the lead institutions behind the new centre.

Read more: https://bit.ly/3tpaZZ7



Artist's impression of one of more than 50 new exoplanets found by HARPS.

© ESO/M. KORNMESSER

ALEX COPLEY, PROFESSOR OF TECTONICS

TWO DAYS **IN THE FIELD**

the surprising geological links between the Himalayas and the Welsh Borders

A day in the field has become a pretty different prospect compared to a couple of years ago. However, due to a surprising twist of science, our recent time meandering around South Wales and the English Midlands is the logical continuation of research into the active tectonics of the Himalayas.

My most recent overseas fieldwork was in India in November 2019. Along with Aisling O'Kane and James Jackson from Cambridge, and our Indian collaborators from IISER Kolkata and SMVDU Katra, we were examining the foothills of the Himalaya in NW India. In this region, the strong crust of the Indian plate is being thrust beneath the weaker rocks of the Himalayas and Tibetan Plateau. Along most of the length of the Himalayas, this motion is accommodated by big thrust faults that rupture in large earthquakes that form fault scarps. However, near the city of Jammu in NW India there are no such fault scarps, but instead a gigantic fold. We were examining the structure of the fold, and the recent uplift indicated by uplifted and abandoned river channels on the flanks of river valleys, to infer the geometry and rate of motion in the region. This turns out to be tricker than it sounds, when the fold is 100 km long and 30 km wide, and is only crossed by three roads. However, there are certainly worse things to be doing in late autumn, and we came back with lots of useful data, more vitamin D than is usual for Cambridge-based people in November, and no snake bites. Aisling has combined this data with results from analysing the seismic waves produced by earthquakes, and with models of the local ground-shaking produced by destructive earthquakes, into a new understanding of the causes and nature of the earthquake hazard in the region.

One of the main unsolved questions regarding the tectonics of the Himalayas, and mountain belts in general, is what controls how the strength of the rocks evolves during mountain-building, and how that strength affects the behaviour of mountain ranges. In other words, why is India strong and Tibet weak? Previous work in Cambridge has established that episodes of mountain-building in the geological past, resulting in heating and partial melting of rocks, can leave a mechanically strong residue after the melt is removed. In the rocks that now form India, such a

IMAGES © ALEX COPLEY

Sophie Miocevich and Owen Weller examining fragments of the deep crust, now exposed in the Malverns.

Inset: Aisling O'Kane pondering steeply-dipping rocks in the Himalayan foothills of NW India.

process is thought to have occurred when the Earth was young. However, we still need to understand whether this is the only way to create strong crust, and how its presence affects the behaviour of mountain belts.

Such questions, slightly unexpectedly, lead us to the English Midlands and Welsh Borders. Active mountain belts give us a wide range of observations and modelling opportunities, such as those used by Aisling, but to get to the bottom of mountain-building processes we also need to see the mineral-scale evolution of the crust involved. We therefore also need to examine some old and exhumed mountain belts. Anyone who has driven west from Cambridge (as I have regularly been doing this autumn with Sophie Miocevich and Owen Weller from the department) will have noticed how long it takes to reach hills, particularly if the perma-traffic-jam around Birmingham is in a bad phase. This monotony is because you are driving over the 'Midlands microcraton' – a lozenge of strong crust that underlies the flat interior of England. As you approach the Malverns, Welsh Borders, and Shropshire, the appearance of hills tips you off that you are reaching the softer rocks that were thrust over the edge of the craton after the Iapetus Ocean closed in the Palaeozoic. Much of the record of this process is now buried beneath more recent rocks, but Sophie has been performing some geological detective work to identify a series of fragments of old crust that give us a window into the middle of the crust during mountain-building events. An exotic array of outcrops, including a trench through some rocks argued over by luminaries of 19th century geology, a distinctly two-dimensional outcrop in a farm track, but also some glorious rocks on crisp autumnal days up on the hills have made us realise there is much more to this region than has previously been appreciated. When we've got the thin sections made, we'll be looking forward to piecing all the available information together into a view of how mountain belts work, uniting both the Himalaya and the Welsh Borders.

Figure 1: Fieldwork on the Skaergaard Intrusion in East Greenland.

IMAGES © MARIAN HOLNESS

MARIAN HOLNESS FRS, PROFESSOR OF PETROLOGY

THE POWER OF **PETROGRAPHY**

What goes on underneath volcanoes is a bit of a mystery, even though it exerts a fundamental control on eruptive behaviour – we can try to work out what is going on using indirect observations such as seismic signals, or by using clues in the erupted material.

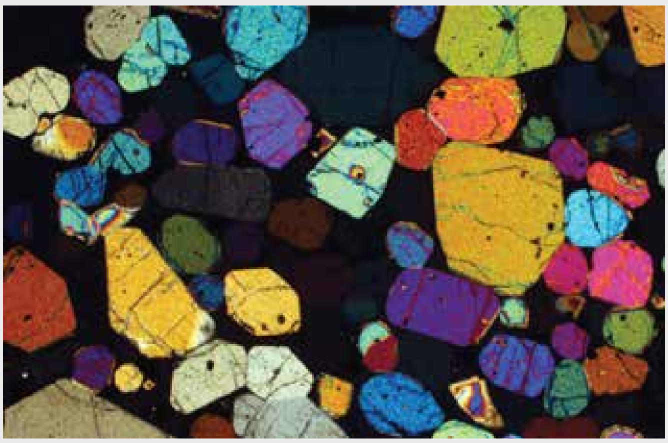
Figure 2. A Leitz universal stage mounted on an old teaching microscope.

We can, for example, look at the composition of the magma to see how much fractionation has happened (a process involving the separation of early-formed crystals from the remaining liquid), or see if its isotopic composition records evidence of assimilation of crustal material while the magma was stalled at depth before eruption. We can also take a look at any crystals swept up and entrained by the erupting magma – is there evidence of different magma batches mixing before eruption? If we are lucky, we might even get fragments of crystal mush ripped off from the margins of the magma chamber or, perhaps more likely, from the walls of any conduit the magma passed through before eruption (Figure 3). These clues can be very informative, but they can't ever provide us with any spatial information, as the magma is not *in situ*. The only way to work out the spatial arrangement and length-scales of processes occurring underneath volcanoes is to look at ancient examples of fully solidified intrusions now exposed at the surface (Figure 1).

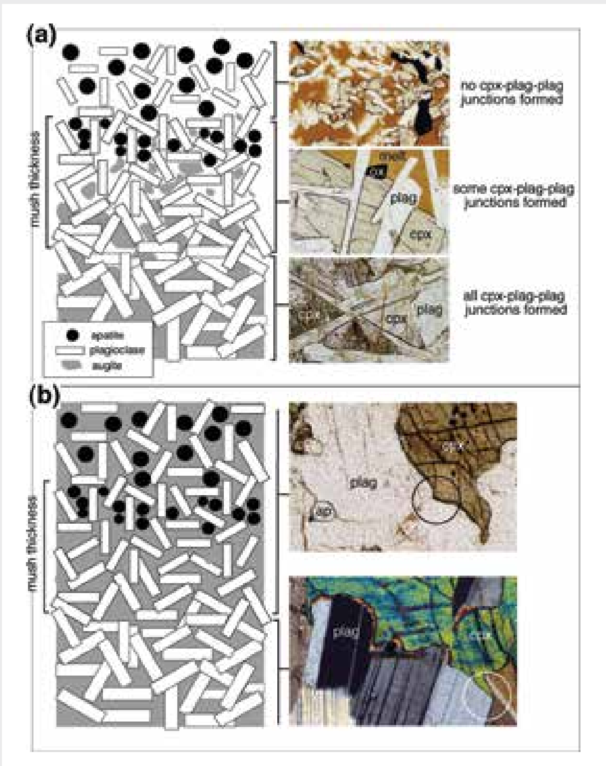
What is commonly done these days is to look at how the composition of these ancient bodies varies within them. Such geochemical work often involves reducing the rock to a powder to obtain the bulk composition. Reliance on bulk rock analyses may mean that the mass of information preserved in the way the individual grains in the rock fit together, their shape, size and orientation, is comparatively neglected. A close petrographic examination, following careful documentation in the field, used to be almost all there was available before the advent of geochemistry. These days, approaches like this take a back seat in many petrological research projects, despite the wealth of useful information that can be teased out from standard petrographic thin sections on a polarising microscope.

An example of what can be done using microscopes is the measurement of the thickness of partially solidified material that divides fully solidified rock on the edges of basaltic magma bodies from the mostly liquid centres. This mushy layer plays an important role in determining the rate at which the remaining liquid changes composition during fractionation, and can control the extent to which economically important elements may be concentrated in particular horizons in the progressively solidifying body. There used to be no way of being sure how thick it was – estimates ranged from a few metres, based on evidence of the depth to which layers are disrupted around fallen roof blocks or by gravitational slumping, to the many hundreds of metres required by some theoretical models of mass migration within the mush. This situation changed recently, when I noticed that the detailed geometry of junctions between two grains of plagioclase and one of a second phase (usually pyroxene) is dependent on the cooling rate during solidification. In intrusions undergoing fractionation, this geometry changes in a step-wise manner every time the bulk magma becomes saturated in a new solid phase, as the contribution of latent heat of crystallisation to the thermal budget causes a distinct slowing down of the cooling rate. This step-wise change is found below the layers hosting the first appearance of the new phase (Figure 4). The off-set tells us how thick the mush was, as the step-wise change in grain junction geometry marks the base of the mush, while the first appearance of the new phase marks the top. If we have drill core through this transition, we can tie down the mush thickness to within a few tens of cm!

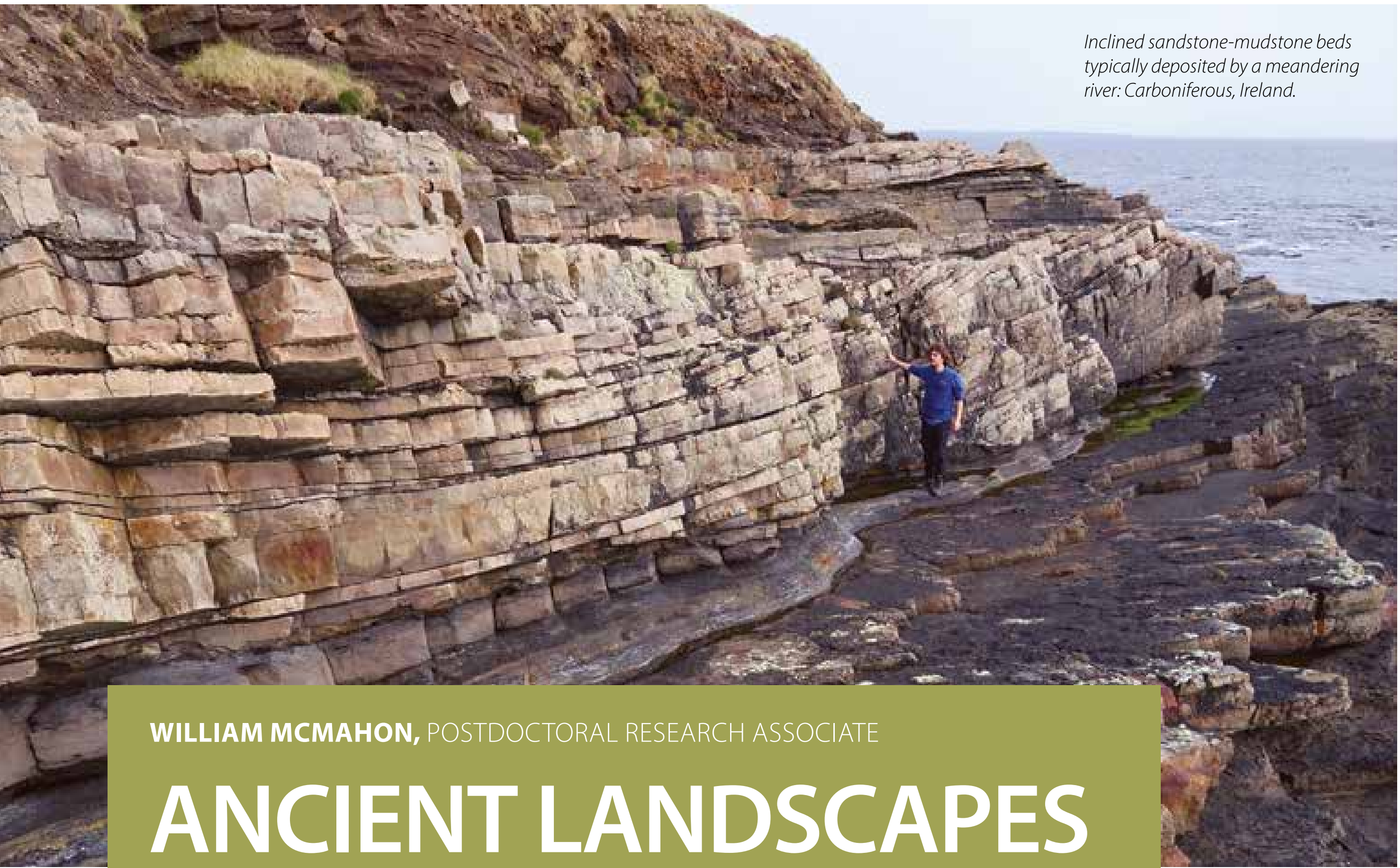
I get particular satisfaction from the fact that the accurate measurement of the geometry of three-grain junctions necessary to constrain mush thickness requires me to use a universal stage – these beautiful instruments (Figure 2) allow you to rotate thin sections in 3D and examine them from all angles. They used to be the go-to tool for determining mineral composition, using the variation in optical properties with crystal orientation, but once the electron microprobe was developed in the 1970's, they fell out of use and are no longer made. We are very lucky in Cambridge to have a cupboard full of universal stages (including some really old ones that belong in a museum!) plus the older-style microscopes that they fit onto, left over from the days before the Department of Mineralogy and Petrology was merged with Geology and Geophysics to form the Earth Sciences department as it is today. There is something very special about doing modern science using traditional methods and beautifully engineered instruments dating back almost a century.



Above: Figure 3 – A fragment of crystal mush entrained by a Hawaiian lava flow, viewed under crossed polarised light (image 4.5 mm across); a loose framework of rounded olivine grains with rapidly-quenched liquid (now glass) in the pores.



Right: Figure 4 – a) Microstructure from the fully solidified pluton margin (bottom) to the still-liquid pluton interior (top) as a new phase (apatite) starts to form. The number of fully-formed three-grain junctions decreases away from the margin. (b) The fully-solidified cumulates. The geometry of three-grain junctions (plag-plag-cpx) between plagioclase and augite shows a step-wise change from low angle (lower circle) to higher angle (upper circle). The three-grain junctions form in the last stages of solidification, so this change marks the base of the mushy layer at the moment the bulk liquid started to crystallise apatite (ap).



Inclined sandstone-mudstone beds typically deposited by a meandering river: Carboniferous, Ireland.

WILLIAM MCMAHON, POSTDOCTORAL RESEARCH ASSOCIATE

ANCIENT LANDSCAPES shaped by plant evolution

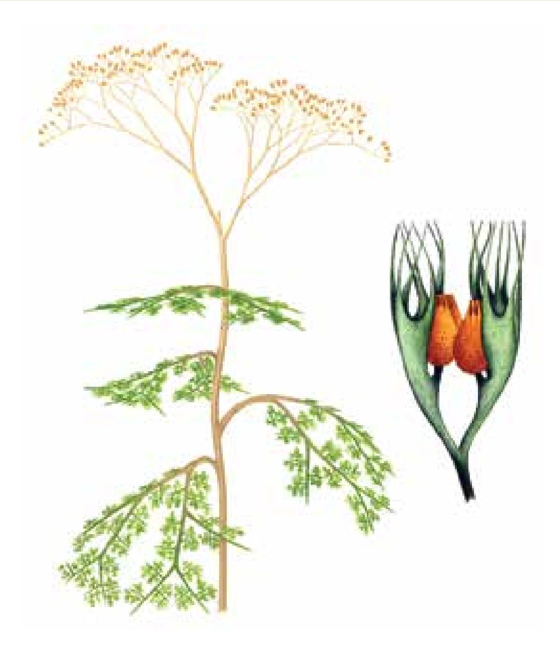
The Palaeozoic evolution of land plants drove some of the most significant environmental and geomorphological changes in Earth's history. Reduced atmospheric CO2, a Late Palaeozoic glaciation, a marine extinction, and the subsequent expansion of terrestrial fauna are just a few inferred global consequences of the newly greened continents.

Dr Neil Davies and I have focussed our research on an additional response: the sedimentological impact of the earliest land plants. At the present-day the impact of vegetation on sedimentological processes is well understood. Global warming is causing increases in the frequency of extreme rainfall events, with society's exposure to this hazard compounded by the removal of vegetation from floodplains as society continues to expand. It should therefore come as no surprise that Earth's ancient sedimentary record preserves a series of identifiable changes attributable to evolving vegetation types, spanning the 100-million-year period of Earth history that saw barren continents transform into densely vegetated biomes.

Exposed outcrops of sedimentary strata are the primary source of evidence. Every individual outcrop comprises geological materials formed at the interface of lithosphere and atmosphere at the planetary surface, the entire sedimentary record being contemporaneous with the evolution of almost all domains of life on Earth. Sedimentary rock outcrops therefore have immense value as a record of biologically driven changes of surface processes through time.

The record of meandering rivers is one such example. The snaking fluvial style made iconic through famous rivers such as the Amazon today was largely absent on Earth's surface for the first 90% of its history. Meandering deposition leaves a distinct calling card in the rock record: inclined beds of heterolithic strata that can be shown to have developed perpendicular to the prevailing flow. Such depositional patterns are exceedingly rare throughout the Precambrian, Cambrian and Ordovician, but become increasingly common from the Silurian onwards. For a river to meander it requires a certain amount of bank stability. While materials such as mud and ice can provide such stability, the advent of land plants (also broadly in the Silurian) introduced a new form of landscape stability at a previously unprecedented level. Roots mechanically reinforced floodplains, serving to decrease local erosion rates. The above-ground topography associated with the new vegetation types also interacted with river flows, decreasing flood velocity, and helping slow lateral migration. Together these below- and above-ground interactions successfully corralled fluvial flows into single-thread, sinuous channels, a process which has continually occurred ever since.

Mud matters! Palaeozoic plants are also now known to have left an indelible mark in the sedimentary record, this time with their signature written in mud. Mudrocks, fine-grained sedimentary rocks composed of silt- and clay-sized particles, are rare constituents of Precambrian and early Palaeozoic river deposits, but common constituents thereafter. Their rise, linked to the greening of the continents, somehow reflects changes in the routing of sediment by rivers associated with the evolution of plants. Plants serve to retain mud on the continents as root structures alter the mechanics of floodplain construction, in doing so heightening the chance of preserving these typically mud-rich areas in the deep time stratigraphic record. Perhaps more interestingly though, plants can also increase the total production of mud during erosion and weathering.



ARTIST: ANNETTE TOWNSEND ©AMGUEDDFA CYMRU-NATIONAL MUSEUM WALES

Reconstruction of Late Devonian Palaeophytic seed plants.

The production of mud through chemical weathering is fundamental to how Earth works as a planet. Chemical weathering links the continents and oceans, and in doing so provides the nutrients that sustain life on both the continents and within the oceans. Silicate weathering also provides the long-term sink for atmospheric CO2 that is degassed by the solid Earth. The mid-Palaeozoic upsurge in the amount of mudrock preserved on the continents is therefore fundamental to our understanding of the evolution of the Earth system.

Work in this department now aims to shed further light on this critical chapter in Earth history. If there was little mud preserved in rivers before the evolution of land plants, was more mud washed out into the oceans? Or was there simply less mud in the first place? To what extent did heightened chemical weathering play a role? Whatever the exact cause, the fact that these early plant ecosystems had such a profound, global sedimentary impact demonstrates that there is still much to discover about the coevolution of terrestrial ecosystems and the landscapes they call home.

EARTH'S ANCIENT SEDIMENTARY RECORD PRESERVES A SERIES OF IDENTIFIABLE CHANGES ATTRIBUTABLE TO EVOLVING VEGETATION TYPES, SPANNING THE 100-MILLION-YEAR PERIOD OF EARTH HISTORY THAT SAW BARREN CONTINENTS TRANSFORM INTO DENSELY VEGETATED BIOMES.

© WILLIAM MCMAHON

William in front of sandstone-dominant "pre-vegetation" deposits: Torridonian, about one billion years old, NW Scottish Highlands.

IN CONVERSATION WITH

Helen Williams

Prof. Helen Williams joined the Department of Earth Sciences in 2016 and is currently Professor of Geochemistry. She reflects on her life and work with Erin Martin-Jones.

Why are you interested in Earth's interior?

What really fascinates me is how the chemistry of Earth's interior has changed over time. The surface we live on is only a very tiny part of our planet: studying Earth's mantle is important to answer questions like why our planet hosts life, or indeed why other planets might not. The compositions of gases that come out of volcanoes, the movement of plates, our magnetic field, the heat in our planet: in my eyes everything links back to our planet's interior chemistry. My work focuses on this key theme, and I use isotopic evidence to unravel the processes going on.

What are you currently working on?

Last year, I had some work published in Science Advances, reporting some of the first evidence for crystal remnants from the Earth's early magma ocean in Greenland rocks. I'd had the thought when locating samples, 'If I don't find it here then I won't find it anywhere…' The moment I realised I'd finally found the evidence was amazing.

You are continuing your work on magma oceans?

I'm proud to say I've been awarded a European Research Council (ERC) Advanced Grant to expand this work, using sensitive isotopic tools to travel far back in time to Earth's first 500 million years. The question of how Earth's early magma oceans cooled and settled into the internal structure we have today is one of the most enduring questions in the geochemistry community.

IMAGES © SARAH HUMBERT

What first got you interested in Earth Sciences?

I started out at Cambridge as a biological natural scientist and have always found the broad science training offered by the Natural Sciences degree very useful. My transition to Earth Sciences really happened by chance – a second year earth scientist lent me her lecture notes in my first few days at Cambridge, and when I flipped through them I thought 'this seems pretty interesting…' Then, when I heard there would be a field trip to Arran I was sold. Soon I was hooked: I found I was devoting more and more time to my Earth Sciences classes and supervisions compared to my other subjects.

You organised a mapping expedition to Svalbard in your second year?

This was really the experience that made me think about research as a career. I wanted to get out there and prove something to myself. It wasn't easy – I remember when the flight was landing in Longyearbyen, I was so nervous I wanted to be sick. And yet I thought, 'I'm here now, I raised the money, I've got the logistics and the expedition sorted. There's no choice: it's going to have to work.'

When I was in the field I really appreciated the solitude: working by yourself to solve problems is really rewarding. You have to be comfortable with yourself, through thick and thin, and it was then that I started to think I might like a career involving research.

How did you get into mass spectrometry?

Through my PhD at the Open University – using the chemistry of volcanic rocks to infer processes operating under the Tibetan Plateau. At that time the OU took delivery of a new type of mass spectrometer, only the second of its kind in the UK. No one really knew how to use it: there was no community knowledge, so my contemporaries and I learnt through trial and error. This was a new frontier of new isotope systems and geochemistry and I knew at that point that I wanted to be part of it.

What drew you back to Cambridge?

After being a post-doc, both in the UK and abroad, and subsequently a NERC Fellow and a Reader at Durham University, I eventually decided to come back to Cambridge. The motivation was to challenge myself and keep learning. In Cambridge I get to work with and learn from experts from so many backgrounds, that's what really excited me about coming back…although at first it was strange – I remember getting these (very embarrassing!) flashbacks to what I was like as an undergrad.

What do you get up to outside research?

I'm a long distance, or ultra-runner (running fifty miles and up). What I like about these races is that they always involve problem solving: over such long distance you have to accept that things are going to go wrong. That might be navigation, food supplies, or difficult terrain, and you just have to solve those problems. Mentally these races can be really hard, so you have to constantly reach into yourself and find the confidence (or stubbornness!) to rise to the challenge.

Read the unabridged interview at **https://blog.esc.cam.ac.uk/?p=2301**

HUMPHREY COBBOLD

Life After Cambridge Geology

Humphrey Cobbold, great-great-nephew of noted early 20th century geologist E.S. Cobbold, shares his journey from Geology (1983–6) to PureGym.

I "discovered" geology at Cambridge in 1983 when I came up to read Natural Sciences having originally intended to 'major' in physics. I think I immediately loved the fact that the subject connected a range of sciences with the real world history of our planet and the universe. Quite frankly, it is a love I have never ever lost. I still love to read geology books and use what knowledge I can recall when I do my wild treks around the world – most recently in Patagonia, Morocco and South Africa – to try and interpret the landscape around me and what lies beneath.

Through a combination of good fortune and some hard work I have enjoyed a moderately successful business career. First, I joined McKinsey & Co (the management consulting firm) after Cambridge and became a Partner there. And then I went on to run rather than advise businesses, enjoying time in the newspaper industry, then running Wiggle – an online cycling goods retailer – and then building PureGym into the largest gym operator in the UK.

It has often struck me how well studying the science of geology prepared me for business. It is not the specifics that I note – although when I worked for McKinsey in South Africa I did work in the mining industry and being a Cambridge Geologist added quite a bit of credibility in the eyes of our clients!

No, the real value I see in business lies in a set of broader problem solving and data interpretation skills. In business it is important to be comfortable with incomplete data; to have a high tolerance for ambiguity; and one needs to hone the art of rapidly developing, testing and adapting hypotheses. These – and many others – are all skills and ways of working for which the study of geology is outstanding preparation. For example, no one expects complete or accurate data from the geological record, we cannot "see" into the centre of the earth (we have to make inferences from what little we can see) and geologists cannot run experiments over geological time periods.

There are also many inspiring examples of leaps of understanding from geologists. I particularly love the story of William "Strata" Smith's perseverance and courage in using an incomplete but growing fact set to completely reinterpret how we see the world in his map published in 1815. I have tried to focus my energies in business on changing views rather than preserving the status quo – it is much more fun. At Wiggle we changed the way people shop for cycling products. And at PureGym we have opened up access to fitness and activity by making a great gym product much more affordable than it was before.

I count myself as uncommonly fortunate to have discovered geology as a skill-based training for business, as a passion for my personal life exploring the great outdoors, and as a framework for thinking about the planet and universe at large.

Humphrey "jumping for joy" at nearly 5000m with the backdrop of a rather fine volcano in the Chilean Atacama.

Natalie and fellow students enjoying learning about uplifted delta sequences on a sunny day in December 2019, on the Greece field trip. L to R: Natasha Franklin, Peter Methley, Saffy Thorn, Natalie Forrest.

View from the Hosios Loukas Monastery, located to the north of the Gulf of Corinth, looking out at a landscape shaped by normal-faulting.

NATALIE FORREST, Cambridge Earth Sciences graduate now studying for a PhD in Leeds, shares

A tale of two earthquakes:

Characterising fault behaviour using satellite data

I was lucky to attend the Greece fieldtrip in December 2019, during which my year group and I studied the impact of active normal-faulting on the landscape. At the time, we had no idea that this would be our last Earth Sciences fieldtrip together. Nevertheless, we explored the wide-ranging geological evidence of active faulting in the region, including measuring the geometry of enormous fault scarps, and dating uplifted seashells now sitting many metres above sea level.

The Greece trip inspired me to do a Part III project with Dr Sam Wimpenny, studying the dynamics of the earthquake cycle: the process of elastic strain accumulation and release on faults. The magnitude 9 Tohoku-oki earthquake of March 2011 caused large deformation along the east coast of Japan, including on the inland Mochiyama Fault, which ruptured in a magnitude 6 earthquake. Intriguingly, a second equally intense earthquake occurred on the Mochiyama Fault just under six years later. This is the shortest repeat time ever recorded for two earthquakes with almost exactly the same slip on the same fault. The occurrence of moderate-sized earthquakes in Japan is nothing new. However, the normal assumption is that stresses accumulate slowly enough on faults that the repeat time of individual earthquakes is on the order of hundreds of years.

In my project, I used GPS data to measure the time-dependent deformation across the Mochiyama Fault, and to constrain simple quasi-static models of deformation caused by the stress changes in the initial 2011 earthquake. The nature of remote-sensing research meant that I could process data and run models on my laptop from anywhere; very beneficial when most of the project was done during lockdowns! My modelling showed that only half the original drop in shear stress in the 2011 earthquake had re-accumulated on the fault by the time of the 2016 Mochiyama earthquake. Therefore, I suggested the fault's frictional strength may have decreased by half to permit the second earthquake. As an analogy, consider the friction of two slabs of sandstone sliding past each other, in comparison to sandstone sliding along ice. The friction between the surfaces is lower with ice involved, meaning that a lower force is required to slide the sandstone block the same distance. For the Mochiyama Fault, one potential weakening mechanism is that hydrothermal minerals along the fault were shattered during the first earthquake, reducing the effective friction and allowing the second slip event despite the lower accumulated shear stress.

My Part III project taught me that recent improvements in satellite technology, such as GPS and InSAR, have vastly improved characterisation of how faults slip in the earthquake cycle. This data can contribute to seismic hazard assessment through improved monitoring of strain accumulation on faults, and characterisation of the geometry and material properties of global faults. Now, our research is being prepared for publication, and I have embarked on a PhD at the University of Leeds. There I will continue to study the earthquake deformation cycle using satellite data, supervised by Cambridge alumni Dr Tim Craig and Professor Tim Wright.

NICK TOSCA, PROFESSOR OF MINERALOGY & PETROLOGY AND **OLI SHORTTLE**, ASSISTANT PROFESSOR

Life in the universe

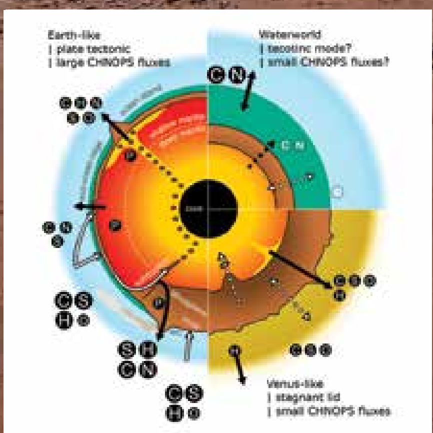
The year 2021 witnessed two defining moments for understanding the origins and distribution of life in the Universe: the Mars 2020 Perseverance Rover is now collecting samples that may preserve traces of ancient life and the James Webb Space Telescope has begun its mission to characterise the atmospheres of potentially habitable exoplanets. In parallel, a wave of discoveries has uncovered new pathways that could have generated the building blocks of life on Earth from simple molecules in ancient environments. There has never been a better time to ask: how did life emerge on Earth? Is the Universe full of life? What is the nature of life?

The Leverhulme Centre for Life in the Universe, funded through a £10 million grant from the Leverhulme Trust, will place Cambridge at the forefront in addressing these questions. The Centre aims to harness simultaneous breakthroughs in astrophysics, planetology, organic chemistry, and biology to develop a deeper understanding of life in the Universe. The new Centre makes it an exciting time to be an Earth scientist. By exploiting at least three interdisciplinary connections, Earth scientists are positioned to make fundamental discoveries that will re-shape the future of our discipline.

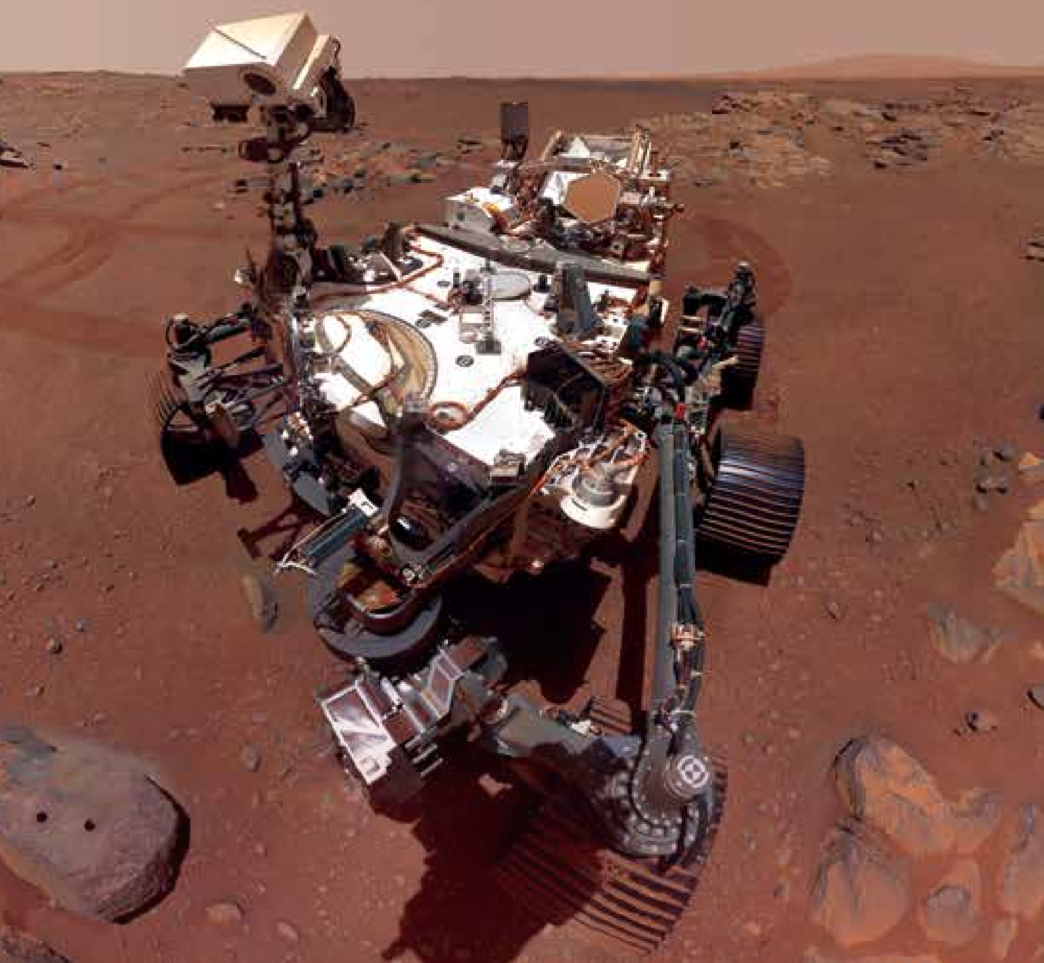
First, Earth scientists can collaborate with prebiotic chemists to understand how planetary environments facilitate or frustrate the chemical pathways to life. Second, we can work with astrophysicists to interpret potential biosignatures in exoplanetary atmospheres by relating the atmospheric and surface properties of exoplanets to their planetary scale evolution [Figure]. Third, we can use biology to understand how life impacts global planetary properties. Understanding the history of life on Earth provides crucial insight into the complex relationships between environments, life, and planetary properties.

If the time is perfect for this research, then so too is the place. Department of Earth Sciences researchers are driving this field forward: Prof. Nick Tosca is involved in Mars exploration missions and Mars sample return planning, Prof. Helen Williams is researching Earth's earliest magma ocean history, and Dr Oliver Shorttle – jointly with the Institute of Astronomy – is investigating planet formation and evolution in the solar system and beyond. Earth Sciences is also exploiting the wider Cambridge discoveries in prebiotic chemistry that will allow the Centre to adjust its research activities in response to new discoveries.

In ten years' time we hope that the Centre will have transformed what we mean by life in the Universe and how it emerged, and defined a new way in which such questions should be addressed. We hope to have cultivated a new generation of scholars who will re-shape interdisciplinary research in planetary science and life in the Universe into the long-term future.



Above: Figure of the planetary scale geological processes we are investigating that move life-essential elements carbon (C), hydrogen (H), nitrogen (N), sulphur (S), and oxygen (O) between planetary reservoirs on different types of worlds.



The Mars 2020 Perseverance rover on September 10, 2021 over the "Rochette" rock, out of which it has drilled two core samples. Future NASA/ESA (European Space Agency) missions will send spacecraft to Mars to collect these samples and return them to Earth for detailed analysis.

Transforming the visitor welcome at the Sedgwick

SARAH HAMMOND, SEDGWICK MUSEUM ADMINISTRATOR, INTERVIEWED BY CARA HANMAN

What is really important to me is the notion that the museum is a community space and so it should be welcoming, accessible, safe and enriching environment for all members of the community. This feeds into the work we've done over the last 3+ years looking at all aspects of visitor experience including signage, the front entrance welcome and maximising our facilities.

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© SARAH HAMMOND

Sarah Hammond

One of the areas we focused on was the Museum toilet as this provided an opportunity to provide support in the form of helpline numbers accessible in a private space, from Childline to the Samaritans. We have period supplies for anyone who might need them and this helps in a small way towards anyone experiencing period poverty. Baby changing supplies are also available. Recognising that families come in such a wide variety of shapes and sizes meant that we considered many different angles of what would support every member of a family.

In the museum, we added seating areas and, thanks to the generosity of the Friends, portable seating to make visiting more comfortable. We try to convey the message that this is not a hushed space, noise is expected and welcome. We improved our book reading area including a sensory bean bag.

As an old museum, we have a lot of old, detailed, hard-to-read labels. Rob Theodore, our exhibition coordinator, made new large-font labels with a friendly creature and bite-size facts for children to enjoy.

Then: along came COVID 19 and lockdown. Maintaining an enjoyable experience on reopening was important. The seating areas we could keep were repositioned to provide more space. We added accessible, easy-to-read, welcoming signage to get across the new covid-safety messaging. We created interactive packs people could take with them. We put a lot of at-home resources on the website too. We used the work we had already done to help inform our focus for this new twist. We had to work with a lot of new rules, including extra cleaning, hand sanitising, mask wearing, capacity limits, physical distancing and one-way systems.

Introducing ticketing to manage capacity in the museum brought an unexpected opportunity – the chance to revamp the front of house welcome. Traditionally, we've had a single staff member in the shop, available but a little removed. With ticketing active we needed more staff at the entrance. The whole team contributed to staffing front of house during this time and this has now continued, meaning every visitor gets a personal welcome on arrival. It has brought us closer to our audience and gives us the opportunity to engage with them face to face.

This new interaction noticeably puts people at ease in the Museum. Having to redirect our staffing to deal with all the covid safety guidance has really benefited the overall visitor experience so it's going to be a permanent change.

Read the unabridged interview at:
https://blog.esc.cam.ac.uk/?p=2316

RECENT NEWS & AWARDS

Obituaries

Dr Mike Bown

1928 – 2021

Alumni and friends of the Department will be sad to hear of the death of Mike Bown at the age of 93. For generations of students, going back to the days of the old Department of Mineralogy and Petrology, Mike will be remembered with great affection as a dedicated and enthusiastic teacher of crystallography and mineralogy. Those of us who had the good fortune to be on the staff with him will also remember his warmth and generosity as well as his sharp wit and invariable good humour.

Dr Graham Chinner

It is with great sadness that we share news of the death of Graham Chinner in December 2021. Graham joined the old department of Mineralogy and Petrology in 1955 as a graduate student, then spent his career teaching metamorphic geology in that department and then in Earth Sciences. Generations of students remember fondly Graham's entertaining teaching, such as his Shakespeare monologues on the Scottish Highlands field trip. Departmental memories of Graham are shared on the Alumni News pages of the website (details below) and memories from Trinity College appear at **https://www.trin.cam.ac.uk/news/tributes-paid-to-dr-graham-chinner/.**

We've shared notice of the passing of other alumni throughout the past year on the Alumni News pages of the website. You can see full obituaries at **www.esc.cam.ac.uk/alumni/alumni-news**

The Geological Record

Student Prizes

Aisling O'Kane won an 'Outstanding Student Presentation Award' at AGU 2020 for the poster: *The Controls on Earthquake Ground Motion in Foreland Basin Settings: The Effects of Basin and Source Geometry.*

Sophie Miocevich won the prize for the 'best student talk' at the Metamorphic Studies Group annual meeting in March 2021 with the talk: "How did the Archean crust evolve? Insights from the structure and petrology of the Lewisian of Scotland".

Debby Wehner won the prize for best talk at the PGRiP meeting run by the BGA in September 2021, Ben Conway -Jones presented the best runner-up talk which was a joint award.

Lucas Leung (Trinity) was awarded The Institute of Quarrying National Student Award 2020 as the best performing second year student.

Peter Methley (Selwyn) was awarded the David Johnstone Mapping Prize by the Tectonic Studies Group.

The Harkness Prize was awarded by the Part III Examiners to **Peter Methley** (Selwyn).

The British Geophysical Association undergraduate prize was awarded to **Cara James** (Jesus).

The Palaeontological Association Prize was awarded to **James Craig** (St Catharine's)

The Winifred Georgina Holgate-Pollard Memorial Prize was awarded by the Part II Examiners to **James Craig** (St Catharine's).

The Mineralogical Society prize was awarded to **Tom Metherell** (Fitzwilliam)

The Wiltshire Prize for the best 1B performance was awarded to **Rhiannon Ackland** (Selwyn)

Awards

Congratulations go to the following recipients of major awards:

1


2


3


4


5


Top to bottom: 1. Emilie Ringe, 2. Edward Tipper, 3. Marie Edmonds, 4. Sasha Turchyn and 5. Nick McCave.

New arrivals

The Chair of Geophysics: Welcome to Professor **Sergei Lebedev** who has taken up the Chair of Geophysics from 15 August 2021.

Cara Hanman joined the Department in June 2021 as our Alumni Coordinator.

Cara Hanman

Retirement

Martin Walker, Principle Technician and **Janet Walker**, cleaner, have retired after 30 and 10 years of service respectively.

Julie Blackwell, Senior Account Clerk, retired from the Department at the same time.

Emilie Ringe was given one of the three Journal of Physical Chemistry (JPC) and PHYS Division Lectureship Awards. Emilie was also named among the Chemical and Engineering News' Talented 12. (September 2021).

Edward Tipper is one of the two 2021 Pilkington Prize winners from the School of Physical Sciences.

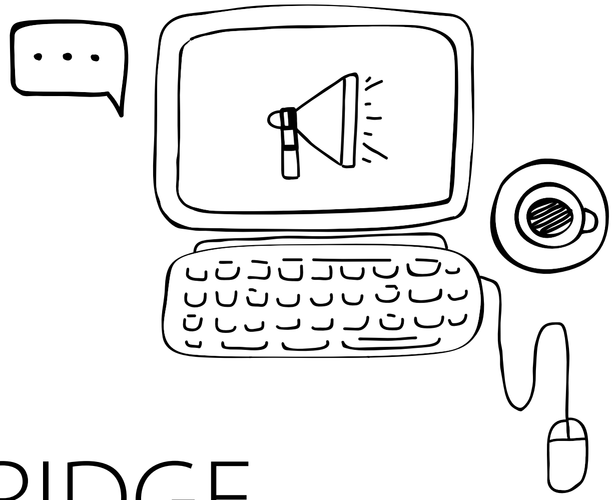
Marie Edmonds has been awarded the AGU Joanne Simpson Medal for mid-career scientists. Marie has also been awarded the title of Geochemistry Fellow by the Geochemical Society and the European Association of Geochemistry.

Sasha Turchyn is the recipient of the 2021 R. Berner Lectureship, presented at the Goldschmidt 2021 conference, for showing an 'exceptional ability to define globally important biogeochemical processes, develop new understanding, and significantly advance the corresponding area of research'.

Nick McCave has been elected as an AGU Fellow.

David Hodell has been elected as a Fellow of the American Association for the Advancement of Science (AAAS).

Nicky White and **Marie Edmonds** have been awarded the Lyell medal and Bigsby medal, respectively, of the Geological Society.



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

FROM THE CAMBRIDGE **EARTH SCIENCES BLOG**

INTERNING WITH THE ENVIRONMENTAL AUDIT COMMITTEE

Carrie Soderman, Research Student

From February to April this year, in the midst of lockdown and halfway through the third year of my PhD, I took 3 months away from geochemistry to work with the Environmental Audit Committee, a House of Commons Select Committee. Although not sure that I wanted to pursue a policy career, applying to the scheme seemed like a great opportunity to learn more about the career path and develop transferable skills.

I applied in the summer and, following an interview, I was offered a place as a POST (Parliamentary Office of Science and Technology) Fellow, and seconded to the Environmental Audit Committee (EAC) for my internship. Usually these policy internships would be based in London, but with home-working firmly in place, on 1st February I found myself logging onto a secured Parliamentary laptop, about to meet a Select Committee.

I was thrown straight in to work as a Committee Researcher. I would be heading up the planning for an April inquiry session on 'Community Energy', which was part of an overarching year-long 'Technological Innovations and Climate Change' inquiry. The committees are made up of cross-party groups of MPs, and each committee has a team of researchers (which now included me!), clerks and support staff who work behind-the-scenes to put together recommendations from the MPs to pass to the Government, who are then obligated to respond and either defend their position, or take on board any suggestions.

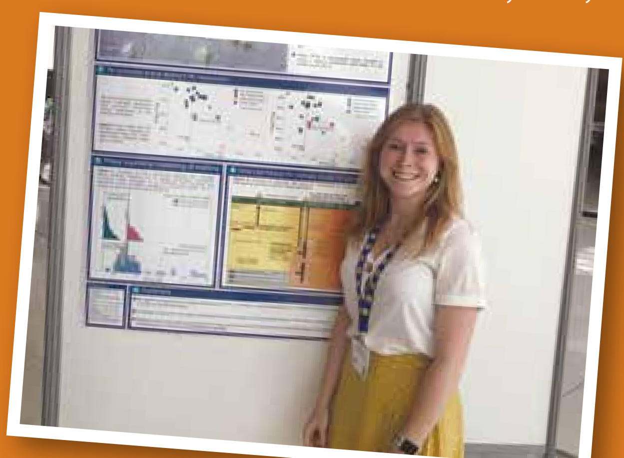
The inquiry's aim was to scrutinise the support for community energy in current UK policy, the role community energy could play in tackling climate change and emissions reduction, and any regulation or policy changes that could or should be implemented to boost the sector. I oversaw this inquiry from start to finish, and it was great to be given so much responsibility. This was a really interesting and topical inquiry to be involved in – it highlighted just how important community schemes are, not only for increasing support and use of renewable energy, but as a key way to change the mindset and energy behaviour of local populations.

I would highly recommend the internship scheme to other UKRI-funded PhD students. I'm now enjoying settling back into lab work again, but keeping an eye on what the EAC are up to. Their Twitter account is @CommonsEAC – look out for a Government response on community energy in the UK, due soon!

Read more https://blog.esc.cam.ac.uk/?p=2084

In the lab doing column chemistry pre-Covid, and with the mass spectrometer.

Presenting my research at Goldschmidt 2019 in Barcelona in the first year of my PhD.



IMAGES © CARRIE SODERMAN

CORALS ON CLIMATE, AND WHY THEY ARE EVEN COOLER THAN YOU ALREADY THINK

Madi East, PhD Student

Most structures we recognize as coral are actually home to hundreds to thousands of tiny creatures, called, 'polyps'. Related to anemones and jellyfish, these polyps secrete a hard external skeleton of calcium carbonate – this provides them with a home and gives rise to the branching, brainy or platy structures we see on a reef. It's this mineralized skeleton, and how coral polyps build it, that is the subject of my PhD research.

In the lab, and armed with a microscope and some coral skeletons for the first time, I was amazed by how intricate and varied the microscale architectures were. I came to learn that, at every scale, there are organized and repeatable units, such that the skeletal anatomy of an entire colony could be traced back to the organization of single crystals.

Using a very high powered microscope, known as a scanning electron microscope, I have seen lacy corallite cups arranged like the petals of a rose, tessellating snowflakes and even jagged rings like sharks teeth.

I was intrigued to learn that corals produce their own sunscreen, and may even coordinate skeletal growth with the cycle of the moon. And who knew that polyps could capture prey using harpoon stinging cells located on their tentacles?

From both the oldest corals in the sea, to those in the fossil record, corals help us put together pieces of the environmental puzzle of the past, from thousand to millions of years ago.

But like everything in science, things get a bit more complicated as you delve deeper! Sitting between the seawater and the growing crystal is a living, breathing, photosynthesizing organism. Such biological processes can influence the chemistry of the microenvironment. Many variables can influence the chemical makeup of the skeleton, potentially muddying the environmental record we hope to read.

Madi East

Corals are in a tough spot. Human driven impacts like warming oceans that lead to coral bleaching events, have the potential to wipe out reefs completely by the end of the century. I hope that in deepening our understanding of this incredible creature, and our knowledge of what climates it has survived in the past, I can help play some part in securing it a brighter future.

Read more: **https://blog.esc.cam.ac.uk/?p=2179**

Scanning electron microscope images showing a variety of coral form (note the scale at the bottom right).

Looking down the microscope at coral textures.

IMAGES © MADI EAST

Make a world of difference in Earth Sciences

Donations from our alumni are increasingly important in adding value to our students' experience of Earth Sciences, whether through teaching or through research as a Part II or III undergraduate or post grad.

There are four ways that you can allocate your gift:

- The **Earth Sciences Fieldwork Fund** helps maintain the Department's strong commitment to field teaching as a vital way of bringing lecture and practical material to life. Boosting fieldwork provision for all students who have missed field courses due to Covid restrictions will involve extra costs, which the fund can help with.

- The **Earth Sciences Student Support Fund** helps individual students struggling with the extra costs of doing an Earth Sciences degree. Our aim is for nobody to be disadvantaged because they can't afford a field course fee, or the cost of a laptop for remote learning for instance.

- The **Sedgwick Museum of Earth Sciences Fund** helps the Museum to care for and share its internationally important collections. The Museum has continued to provide access to its collections for researchers and students throughout the pandemic, while its targeted school and public programmes encourage the next generation of Earth Scientists.

- The **Earth Sciences General Fund** is unrestricted in its use. It can help to support all urgent or unexpected needs within the Department, which include topping up partially-funded postgraduate studentships, helping with travel to research labs, with new initiatives for lab equipment, and – most recently – adding cameras to microscopes to allow socially-distanced teaching.

You can donate online at **philanthropy.cam.ac.uk/give-to-cambridge/earth-sciences** or fill out the Donation Form inserted with this GeoCam.

For further information about donating to Earth Sciences or guidance on how to leave a gift, please do contact us.

Cara Hanman
alumni@esc.cam.ac.uk

Jasmine Aslan
Associate Director of Physical Sciences
jasmine.aslan@admin.cam.ac.uk

Dr Ed Tipper speaks to students during the Arran 2021 fieldtrip.

Thank you to our donors 2020–2021

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 this 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.

AWE Blacknest
Friends of the Sedgwick Museum
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Franca Oboh-Ikuenobe

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

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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:

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Yours, Cambridge

The campaign for the University and Colleges of Cambridge