GeoCam

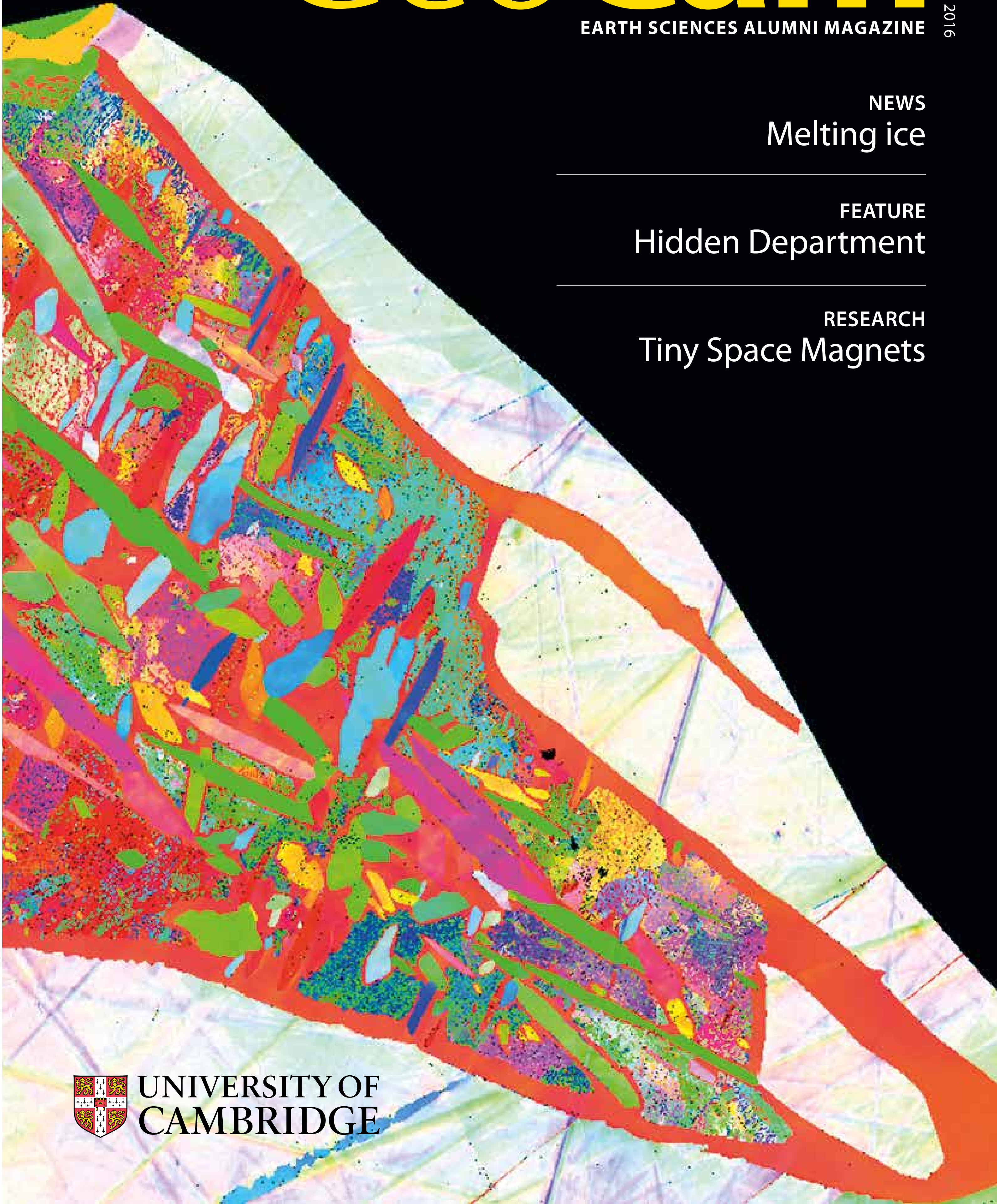
EARTH SCIENCES ALUMNI MAGAZINE

ISSUE 13 | SPRING 2016

NEWS
Melting ice

FEATURE
Hidden Department

RESEARCH
Tiny Space Magnets



UNIVERSITY OF CAMBRIDGE

RESEARCH NEWS

FOR ALL THE LATEST EARTH SCIENCES RESEARCH NEWS, VISIT WWW.CAM.AC.UK/AFFILIATIONS/DEPARTMENT-OF-EARTH-SCIENCES

Melting of massive ice 'lid' resulted in huge release of CO_2 at the end of the ice age

A new study reconstructing conditions at the end of the last ice age, authored by Earth Sciences' Jenny Roberts and Julia Gottschalk, suggests that as the Antarctic sea ice melted, massive amounts of carbon dioxide that had been trapped in the ocean were released into the atmosphere.

During the last ice age, it was thought that the deepest part of the ocean was made up of very salty, dense water, which was capable of trapping a lot of CO_2. Scientists believed that a decrease in the density of this deep water resulted in the release of CO_2 from the deep ocean to the atmosphere. However, the new findings suggest that although a decrease in the density of the deep ocean did occur, it happened much later than the rise in atmospheric CO_2, suggesting that other mechanisms must be responsible for the release of CO_2 from the oceans at the end of the last ice age.

READ MORE http://goo.gl/93BWOD

© E G MITCHELL

Earliest evidence of complex organism reproduction

A new study of 565 million-year-old fossils, authored by Emily Mitchell, has identified how some of the first complex organisms on Earth reproduced, revealing the origins of our modern marine environment. The study found that some organisms known as *Fractofusus*, which lived 565 million years ago, reproduced by taking a joint approach: they first sent out an 'advance party' of waterborne propagules to settle in a new area, followed by rapid colonisation of the new neighbourhood using stolon or runners to quickly produce clones, similarly to spider or strawberry plants.

READ MORE goo.gl/twAAD0

FRONT COVER IMAGE: *Electron back-scattered electron diffraction image of the Odessa IAB iron meteorite*
© CLAIRE NICHOLS, GERANT NORTHWOOD-SMITH, GIULIO LAMPRONTI

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Evolution website sets out to tackle great scientific unknowns

A team of scientists at Cambridge have created a new online resource dedicated to the subject of evolution. Named Forty Two (after Douglas Adams' famously cryptic solution to the meaning of life), the website includes video interviews in which researchers including Sir David Attenborough, Simon Conway Morris, Nicky Clayton, and Carenza Lewis offer their views on topics ranging from the nature of evolution itself, to the future of life as we know it.

Targeted at a general audience and, in particular, young people who are just starting to get into science, its aim is to provide an innovative and authoritative source of information about evolution on the web.

READ MORE goo.gl/G8zhDc
www.42evolution.org

New insights into the dynamics of past climate change

A new study of the relationship between ocean currents and climate change has found that they are tightly linked, and that changes in the polar-regions can affect the ocean and climate on the opposite side of the world within one to two hundred years, far more quickly than previously thought.

The study, by an international team of scientists including Earth Sciences' Julia Gottschalk, examined how changes in ocean currents in the Atlantic Ocean were related to climate conditions in the northern hemisphere during the last ice age, by examining data from ice cores and fossilised plankton shells.

READ MORE goo.gl/7DeM18

Spiky monsters: new species of 'super-armoured' worm discovered

A new species of 'super-armoured' worm, a bizarre, spike-covered creature which ate by filtering nutrients out of seawater with its feather-like front legs, has been identified by palaeontologists including Cambridge's Javier Ortega-Hernández. The creature, which lived about half a billion years ago, was one of the first animals on Earth to develop armour to protect itself from predators and to use such a specialised mode of feeding.

READ MORE goo.gl/NQLYan

© JIE YANG (YUNNAN UNIVERSITY)

Background image: Collinsium reconstruction,

© JAVIER ORTEGA-HERNÁNDEZ

ED TIPPER UNIVERSITY LECTURER

A Day in the Field

ASIDE FROM THE MAJOR HUMANITARIAN DISASTER OF THE NEPAL EARTHQUAKES IN APRIL LAST YEAR, ONE OF THE CONSEQUENCES FOR THE LANDSCAPE WAS A SERIES OF MAJOR LANDSLIDES, IN PARTICULAR TO THE NORTH EAST OF KATHMANDU ALONG THE MAIN ROAD INTO TIBET, A REGION WHERE I CONDUCTED MY PHD TEN YEARS PREVIOUSLY.

Recent research has indicated that co-seismic land-sliding is one of the key sources of sediment supply to rivers in major mountain belts. Six weeks after the Gorkha earthquake (see page 6), NERC funded an urgency grant to collect river sediments and waters to determine whether there was enhanced chemical weathering (an important natural carbon sequestration mechanism) associated with the major land-sliding that was triggered by the earthquake. Within two weeks of receiving the funding, research student Madeleine Bohlin and myself were on the ground in Kathmandu with 180kgs of sampling kit. Professor Mike Bickle joined us on a subsequent trip.

We spent our first day in Kathmandu acquiring a research "vessel" capable of taking us out on rivers with a four metres per second current. This turned out to be a cargo raft, more commonly used for transporting tourists' luggage on rafting holidays. After a visit to a sawmill we built a stable platform to hold our sampling rig made from scaffold. The rig is designed to lower a 50kg home-made sediment-sampling device to different depths in major rivers. These rivers are slightly more lively than the Cam: the current would take you downstream 16km in an hour with a discharge equivalent to four million litre bottles of mineral water per second. We determined this using something known as an acoustic doppler current profiler, traversed across the rivers using (amongst other methods) a rusty manually-operated cable car suspended 20-30 metres above the boiling river.

Our sediment-sampling strategy was to gather the suspended sediment mid channel in the rivers at different depths. Typically we collected five samples at the same place (within a few tens of metres), which, given the rapid current, meant we needed to get the raft back upstream (about 500-1000m) each time we collected a sample.

Unfortunately we had no motor on the boat, and we had to row, haul and push the raft back upstream in 35°C heat, sometimes up to our necks in the water. Once the samples are collected and the raft packed away the day isn't over. In the evenings the samples – each one is eight litres of water – have to be filtered to recover the sediment, a process taking several hours and conducted in field laboratories or "hotel" rooms. Titrations and other work for the day are also completed before packing all of the kit ready for the next day of travel.

Overall we collected 120 samples on two separate trips so far, with two more planned in 2016. Our first results are starting to emerge already, and within a few months we will be able to assess any increase in chemical weathering due to the landslides.

HIDDEN DEPARTMENT

SEDGWICK MUSEUM
Collections Store

© DUDLEY SIMONS

Drawer of rocks from the Terra Nova expedition, 1910–1913

© DUDLEY SIMONS

Sarah Finney, Sedgwick Museum Conservator at work in the Atlas Building

Much of the Museum's working geological collections, central to the research of many in the department and wider community, are currently housed in cramped and difficult conditions in the Atlas Building on the West Cambridge site. The newly proposed Geological Collections Store will adjoin the A.G. Brighton Building (the Sedgwick Museum's conservation unit) and vastly improve accessibility.

The current building houses the Museum's petrology collection. This world-renowned igneous and metamorphic rock collection is known as the 'Harker collection' after Alfred Harker who curated it. It includes rocks collected during the 1910 Terra Nova expedition and also the Dawson and Harte collections of mantle xenoliths, the world's largest collections of samples from the Earth's deep interior. Other treasures include a large number of sedimentary rocks curated by Harker and later by Maurice Black, many of which were collected by Adam Sedgwick and his predecessors. The collection of new specimens by our researchers underpins many recent publications.

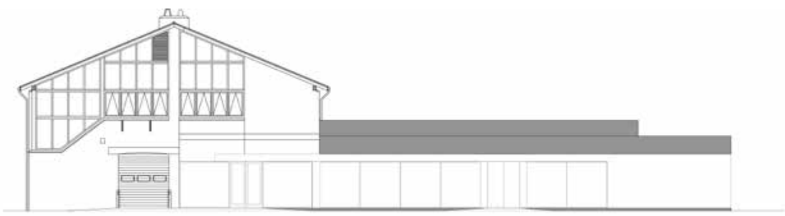
The continuing scientific value of the material is immense and much of it is irreplaceable, collected from remote regions, from mines which are long closed, quarries that have been backfilled, and from regions that are now inaccessible for political reasons. The cost of recollecting even a subset would run into millions of pounds.

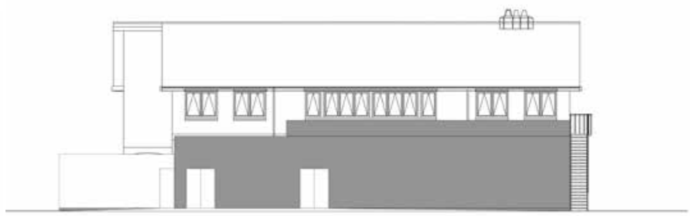
About 40% of the expected cost of the proposal, designed by Cowper Griffiths Architects, has been raised, with a substantial donation from CASP.

FOR FURTHER DETAILS, PLEASE VISIT:

http://www.esc.cam.ac.uk/alumni/support-the-department

@SedgwickMuseum





Proposed Geological Collections Store: West elevation (left), South elevation (right)

KEITH PRIESTLEY PROFESSOR OF GEOPHYSICS, GEODYNAMICS & TECTONICS

HIMALAYAN earthquakes

During 10–15 April 2015 Earth scientists from both Cambridge and Oxford met, as part of the Cambridge-led Earthquakes without Frontiers Partnership meeting (see page 13), in the Nepalese capital, Kathmandu, to raise awareness of the city's exposure to earthquake hazards.

Ten days later, on 25 April, the magnitude 7.8 Gorkha earthquake occurred on the Main Himalayan Thrust (MHT) close to Kathmandu. The earthquake caused more than 8,500 fatalities and 22,000 injuries, the full or partial destruction of almost 800,000 structures and numerous landslides and avalanches in the surrounding mountains. This was the first major earthquake in this vicinity since 1833 and the most devastating event in Nepal since 1934. A large earthquake in this area was anticipated, so modern geophysical instruments had been installed in the Himalayas.

Earthquakes result from the sudden release of stored elastic energy by rupture on faults. The stored elastic strain which caused the Gorkha earthquake had accumulated from the continuing collision of India with Asia which has uplifted the Himalayan Mountains. The supercontinent of Pangaea began disintegrating about 175 million years ago, ultimately sending India speeding northward at about 10cm per year, until it collided with southern Asia 40 to 50 million years ago. The northward motion of India then slowed, but it continued to underthrust the Himalayan Mountains, accumulating about two centimetres per year of elastic strain energy across the MHT.

The details of how earthquakes initiate, grow and terminate in relation to pre-seismically locked and creeping patches of faults are unclear. Professor Jean-Philippe Avouac has been monitoring the crustal deformation in Nepal with Global Positioning System (GPS) receivers for the past 20 years. His studies revealed that during that time, the portion of the MHT which ruptured in the Gorkha had remained locked and the pattern of locking is now well constrained (Figure 1).

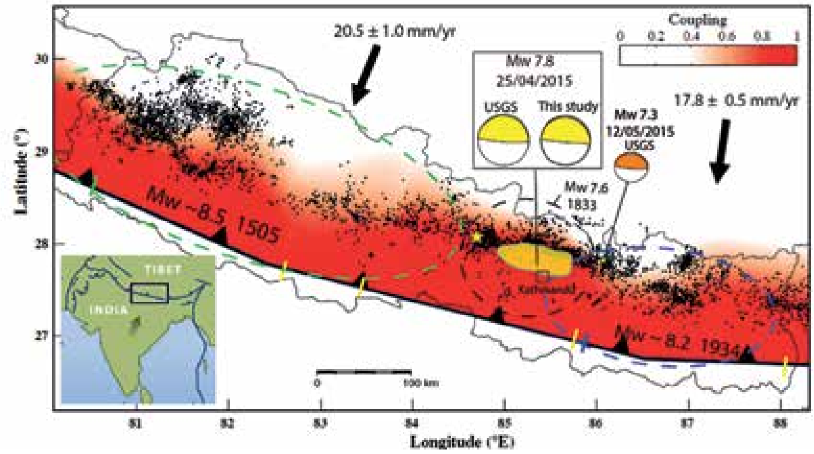
Using data from the GPS network, satellite synthetic aperture radar (SAR) and distant seismographs, Avouac and his colleagues determined that the

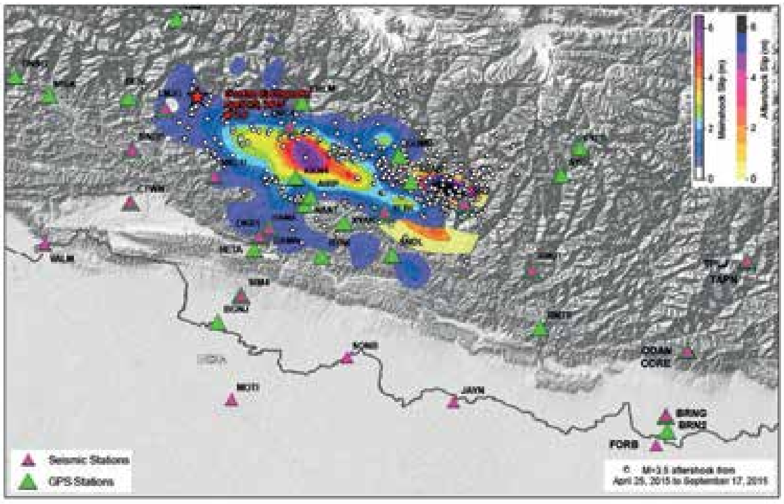
Gorkha earthquake nucleated about 80km northwest of Kathmandu. It then ruptured eastward for 140km, unzipping the lower part of the MHT at a depth of about 15km (Figure 2). The focal mechanism showed thrusting on a fault dipping about ten degrees to the north (Figure 1). High-frequency seismic waves radiated continuously as the slip pulse propagated from west to east at about 2.8km per second. SAR data show that the Kathmandu valley was uplifted as much 1.5m as a result of the earthquake, whereas the mountains north of Kathmandu subsided by about 20cm. The eastward unzipping of the fault resumed on 12 May with a magnitude 7.3 aftershock (Figure 3).

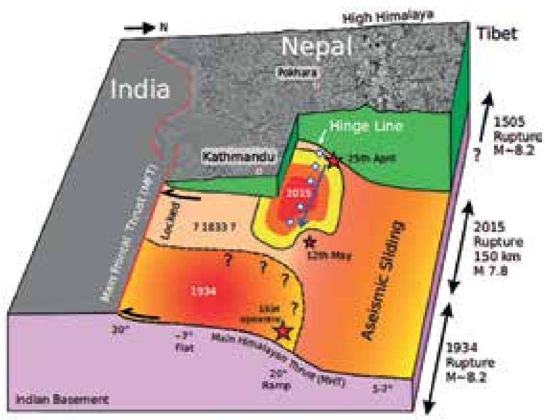
Our initial analysis suggested that the Gorkha earthquake had not ruptured all of the anticipated area of the fault. Only the lower portion of the MHT had ruptured, leaving the upper part locked (Figure 3). The earthquake was smaller than forecast, and had left half the expected fault surface unruptured. This was why there was less damage than anticipated in Kathmandu. There was good reason to believe that considerable slip potential remained, especially in the shallower part of the fault surface between Kathmandu and India. The threat to Kathmandu remained high.

The transfer of stress to neighbouring regions from the Gorkha earthquake could trigger future rupture in bordering areas of the MHT. Because of this, we immediately began installing seismographs south of Kathmandu in the region where the fault had not ruptured during the Gorkha event, but which had failed in an earlier event in 1833 (Figure 3). Those seismographs are now installed and we have turned our attention to the locked portion of the MHT west of the Gorkha earthquake, an 800km-long stretch between the 1833 and 2015 ruptures and the 1905 magnitude 7.8 Kangra India earthquake. This is a well-identified seismic gap with no large earthquake for over 500 years. The MHT is known to be locked there (Figure 1) and its slip deficit could exceed 10m. The last large earthquake occurred in 1505, and could have exceeded a magnitude of 8.5. This event produced significant damage in southern Tibet and ruptured the Himalayan foothills at the surface. Ominously, the Gorkha earthquake could have brought this portion of the MHT closer to failure.

One reason we deployed seismographs and GPS stations soon after the earthquake was because, in the threatened regions to the south and west of Kathmandu, the unruptured fault may have been slipping quietly and slowly in the period following the 25 April main-shock. This slip would relieve the built-up stress and reduce the hazard. Unfortunately, our GPS survey is showing that slow slip has not occurred. The fault segment remains locked and the potential for future earthquakes remains high. Our early conclusion, that the earthquake ruptured only the lower portion of the MHT in this region, has now been confirmed in numerous publications. Meanwhile, the up-dip portion of the MHT south of Kathmandu and its segment in the seismic gap west of Kathmandu is locked. These parts of the MHT will slip in a future earthquake, but we don't know when.







Top to bottom:
Figure 1: In red: locked zone of the MHT; black dots: locations of micro-earthquakes over past 20 years; yellow star: location of initial rupture for Gorkha earthquake whose main slip zone is indicated by yellow shading.
Figure 2: Summary of slip distribution for Gorkha earthquake sequence.
Figure 3: Cartoon of the faulting in the vicinity of Kathmandu

RICHARD J HARRISON READER, MINERAL SCIENCES

Tiny Space Magnets: Uncovering the magnetic secrets of the early solar system

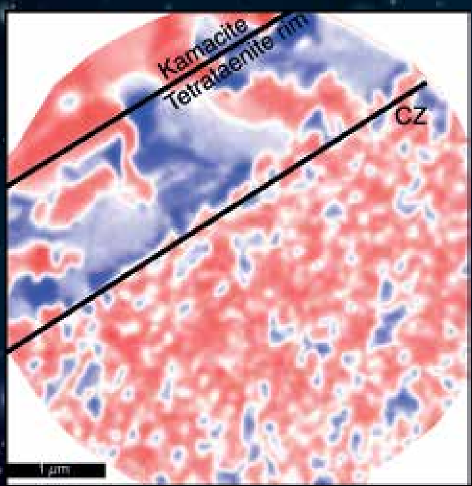
METEORITES ARE FRAGMENTS OF ASTEROIDS. THEY REPRESENT THE OLDEST AND MOST PRIMITIVE MATERIALS IN THE SOLAR SYSTEM – RUBBLE LEFT OVER AFTER THE PLANETS FORMED OVER FOUR AND HALF BILLION YEARS AGO.

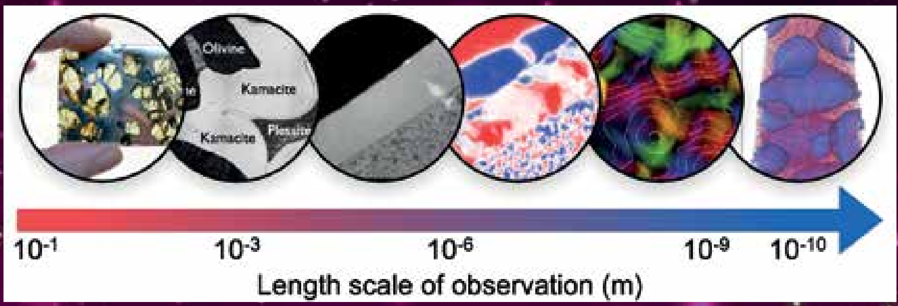
Information about the magnetic state of asteroids during the early solar system can, in principle, be recovered from meteorites. The critical question, however, is whether or not the magnetic minerals they contain have what it takes to retain a memory of such ancient magnetic fields?

The characteristic Widmanstätten pattern, familiar to anyone who has looked at a polished and etched section of an iron meteorite with the naked eye, hides a nanoscale complexity that is revealed only with high-resolution microscopy – a legacy of slow cooling (just a few degrees per million years) deep inside the parent asteroid. The paleomagnetic potential of meteoritic metal has been overlooked in the past, due to the fact that they are mostly comprised of kamacite (a soft magnet that makes a notoriously poor paleomagnetic recorder). Recent research, however, has uncovered regions buried within the Widmanstätten pattern that have just the right characteristics to capture reliable records of magnetic activity on asteroid bodies. This discovery, combined with the advent of high-resolution magnetic imaging methods, has allowed us to decipher the magnetic signals encoded within meteoritic metal for the very first time.

Much attention is focussed on the 'cloudy zone': a region just a few microns wide lying next to the kamacite lamellae that define the Widmanstätten pattern. The cloudy zone consists of a tightly packed array of nanoscale islands of tetrataenite, an ordered $Fe_{0.5}Ni_{0.5}$ phase that forms by the diffusive rearrangement of Fe and Ni atoms into alternating layers during slow cooling. Tetrataenite makes an excellent permanent magnet, and, if it could be synthesised in large quantities, could potentially be used as a low-cost replacement for rare-earth permanent magnets. Each island is ~100nm or less in diameter, and is uniformly magnetised in one of six crystallographically defined directions. The proportions of islands magnetised in each direction are biased by interaction

XPEEM magnetic image of the Imilac pallasite. The red bias of the cloudy zone (CZ) provides evidence of formation in the presence of a strong (~120 μT) magnetic field, generated by compositionally driven convection in the liquid iron core of the pallasite parent body.





Pallasites viewed from the cm to the atomic scale. From left to right: hand specimen of the Esquel pallasite; optical microscopy; XPEEM Ni map showing kamacite (top), tetrataenite (middle) and cloudy zone. XPEEM magnetic map showing multiple fine scale domains in the cloudy zone; electron holography of cloudy zone showing magnetic flux with nm resolution; an atom-by-atom 3D reconstruction of the cloudy zone obtained by atom probe tomography (Fe atoms are red dots, Ni atoms are blue dots, surfaces define the boundaries of tetrataenite islands).

IMAGE: WIKIPEDIA

Polished and etched sample of an Fe-Ni meteorite showing the familiar Widmanstätten pattern.

with the magnetic field of the asteroid. Measuring this bias forms the basis of our 'nanopaleomagnetic' method, but requires a rather unconventional probe to extract the necessary magnetic signal: polarised X-rays.

X-ray photo-emission electron microscopy (XPEEM) is a synchrotron X-ray magnetic imaging technique that yields maps of surface magnetisation with a spatial resolution down to ~30nm. The polished surface of the meteorite is exposed to an intense beam of X-rays tuned to the absorption energy of Fe. To detect the magnetism of the surface, the X-rays are given a 'twist' (circular polarisation) which makes the X-ray absorption process sensitive to the magnetisation direction of the sample. By detecting the difference in absorption for X-rays with an equal and opposite 'twist', the magnetic state of the sample is revealed.

We have recently applied this method to study the pallasites: stony-iron meteorites consisting of roughly equal proportions of olivine and Fe-Ni metal. The formation of the pallasites and the nature of their parent body have been the subject of intense debate over many years. The intimate mixture of olivine and metal leads naturally to the concept that the pallasites formed close to the core-mantle boundary of a differentiated asteroid. An alternative formation mechanism, suggesting a shallower impact origin for the pallasites, is now becoming more mainstream. In the context of this debate, paleomagnetism has emerged as powerful tool, providing robust discrimination between core-mantle boundary and impact theories.

Nanopaleomagnetic analysis of two pallasites, the Imilac and the Esquel, demonstrates that both were exposed to a strong magnetic field (roughly twice the strength of the present day magnetic field on Earth) as the cloudy zone formed below 400°C. This observation is consistent with an independent paleomagnetic study of iron inclusions within the olivine crystals, and effectively rules out a core-mantle boundary origin for the pallasites (generating such fields requires an active dynamo driven by convection of liquid iron in the asteroid core – by the time the core-mantle boundary reached 400°C, the core would have long since solidified). The timing of magnetisation coincides with the period of core solidification, suggesting that it was the ejection of light elements from the growing inner core that drove the convection needed to generate the dynamo – the same processes that operates in the Earth's core today.

The Sedgwick Museum holds one of the largest collections of meteorites in the UK, enabling us to explore the solar system from the comfort of our terrestrial laboratories. This fantastic resource is helping us to uncover new information about the processes that shaped the solar system – using asteroids as a natural laboratory to explore how planets large and small generate their magnetic fields.

FURTHER READING:

Bryson, J.F., Church, N.S., Kasama, T., Harrison, R., 2014a. Nanomagnetic intergrowths in Fe–Ni meteoritic metal: The potential for time-resolved records of planetesimal dynamo fields. Earth Planet. Sci. Lett. 388, 237–248.

Bryson, J.F., Herrero-Albillos, J., Kronast, F., Ghidini, M., Redfern, S.A., Laan, G., Harrison, R., 2014b. Nanopaleomagnetism of meteoritic Fe–Ni studied using X-ray photoemission electron microscopy. Earth Planet. Sci. Lett. 396, 125–133.

Bryson, J.F.J., Nichols, C.I.O., Herrero-albillos, J., Kronast, F., Kasama, T., Alimadadi, H., Laan, G. Van Der, Nimmo, F., Harrison, R.J., 2015. Long-lived magnetism from solidification-driven convection on the pallasite parent body. Nature 517, 472–475.

READ MORE

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NIGEL WOODCOCK UNIVERSITY READER AND TEACHING STAFF 1973 – PRESENT

GEOLOGY IN THE GREAT OUTDOORS

Field teaching in the 21st century

FIELD TRIPS HAVE BEEN PART OF CAMBRIDGE GEOLOGICAL TEACHING SINCE ADAM SEDGWICK'S DAY, AND BECAME A FORMAL COURSE COMPONENT WHEN BRIAN HARLAND SET UP THE ARRAN TRIP IN THE LATE 1940s.

By the 1960s, the independent mapping project had been added to a growing list of field activities, so that the Geology degree involved between 70 and 80 days in the field. This quota persists today, though spread more thinly over a four-year course.

Why do we and other UK universities place such a high value on field teaching? Why do the Geological Society require over 60 days of field work in their accredited geoscience degree? Why do employers of Earth scientists place a premium on field skills?

The main driver for field teaching is the chance to experience geology at scales not otherwise possible. Better microscopes and analytical tools mean that we can now image small volumes of rock in ever more detail. At a large scale, Earth observation satellites yield high-resolution images of regional geological features and associated geophysical and geochemical attributes. But features of intermediate size in the range 10cm to 100metres are still best observed by going in the field and seeing, feeling, and smelling the rocks.

Industry employers value field work because society interacts with rocks mostly at these scales: finding hydrocarbons or mineral deposits, digging foundations or tunnels, extracting water, or injecting fluid wastes. Geology professionals must have seen a wide range of field examples in order to ground truth their seismic interpretation, their rock-stability analysis or their hydrogeological model. Our fieldwork programme continues to supply graduates with the varied field experience needed for an increasingly complex society.

However, fieldwork trains students in far more than just geology. On a field course, or even more so on the independent mapping project, students quickly learn most of the "transferable skills" that other subjects have to teach explicitly. Organisational, communication and interpersonal skills are all learned naturally on field trips. First year students, typically inexperienced both in the outdoors and in unfamiliar cultures, grow in competence and confidence through four years of field work and move on with valuable life skills.



Above left to right: First years in Arran; Mapping cross-cutting dykes at Porthmeor; Nigel Woodcock, Sedbergh; DTP Newfoundland trip, all from 2015.

And then there is the social side of field trips … teaching and support staff, post-grads, post-docs and undergrads all live, eat and drink together, and share field conditions ranging from the hot aridity of southern Spain to westerly gale on the Isle of Arran. Remarkably, whatever the conditions, almost everyone enjoys themselves. In particular, students hugely appreciate the chance to talk informally to staff and post-grads about geology and about almost anything else. Field trips are a great social leveller, and the department is a friendlier and more productive place for it. You will find no other Cambridge department where students are already on first-name terms with the head of department in their first year.

We are keen to keep our excellent national reputation for field teaching. We appoint staff with the right skills and enthusiasm for the geology, and we give safety and first aid training to staff and students that make field trips as safe as possible. We face challenges in funding the fieldwork programme, which costs about £200k per year. Only about £130k of these costs is funded by the University from the student fee income: we have to find the remainder from donations and from charging students a course fee of between £80 and £150 per trip.

READ MORE:
www.esc.cam.ac.uk/escfieldwork

We are concerned that no student should be deterred from doing Earth Sciences because of fieldwork costs. So we have set up an Earth Sciences Fieldwork Fund to help them. If you would like to support field work in this way, go to **www.esc.cam.ac.uk/alumni/support-the-department.**

CAMBRIDGE FIELDWORK PROGRAMME

FIRST YEAR
- Ketton Quarry: half-day
- Isle of Arran: 7 days

SECOND YEAR
- Sedbergh, Cumbria: 8 days
- Dorset and Cornwall: 10 days
- Skye: 11 days
- Independent project: 28 days

THIRD YEAR
- Norfolk: 2 days
- Greece: 7 days

FOURTH YEAR
- Andalucia, Spain: 6 days


Arran field trip Easter 1950 as recorded by Dr Margaret Sudbury (née Walker, Girton 1949).

KEN MCNAMARA DIRECTOR, SEDGWICK MUSEUM

Displaying a Vanished World

Punting down the Cam 120,000 years ago may have been a rather more exciting experience than today, with more to trouble you than just a wayward tourist trying to steer their punt. Up ahead, as you drift gently along, some bubbles break the surface, quickly followed by an eye, and then a vast yawning maw crowded with huge, scimitar teeth as a hippo warily snuffs at your punt.

Gliding along the grass-lined river, giving way to meadows and further inland open woodland, it looks more like you're punting down the Zambezi than the Cam. There are lions and hyaenas ready to pounce on fallow and red deer that have come to the river for a drink; rhinos, bison and aurochs grazing on the meadows; and huge straight-tusked elephants, uprooting trees, helping to maintain a savannah-like habitat. And in the woods, bears and wolves stalk their prey. Not quite so exciting on Granchester Meadows these days.

Given the absence of an effective time machine, the Sedgwick Museum proposes to take visitors back to these times in a magnificent new display. Using the fossilised remains of these animals – collected, mainly from pits around Barrington, south of Cambridge, over the last hundred and fifty years – we will reconstruct what it was like to have lived around Cambridge 120,000 years ago.

This was a time when the climate was not too dissimilar to today, perhaps a little warmer. The display will also focus on the relatively dramatic change in climate that took place from then to the intense cold period of the last glacial phase 12-20,000 years ago, and illustrate how the fauna and flora responded to this.

It will also examine why these animals no longer inhabit this part of the world. Is it just because of climate change? What part was played by the most potent of predators and disturber of habitats, that also shared this landscape – *Homo sapiens?* Using bones from Burwell Fen and material dredged from the North Sea, especially tusks and teeth of mammoths, the display will show the fauna that returned as glaciers retreated northwards.

The museum already has a magnificent skeleton of an Ice Age Giant Deer, *Megaloceros* and a complete hippo skeleton on display. These will be joined by a fossilised menagerie from the museum's extensive collections to present a stunning visual display of a recent world before the overt influence of humans on the environment. We will also present information on how to read the current landscape and interpret the effects of the movement of ice sheets from the north over the region around Cambridge.

A generous pledge of funds from the Friends of the Sedgwick Museum has enabled this exciting display initiative to be undertaken.

READ MORE:

www.sedgwickmuseum.org

@SedgwickMuseum

PROFESSOR JAMES JACKSON, HEAD OF DEPARTMENT

DR SUPRIYO MITRA (ST JOHN'S 2000), INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH, KOLKATA, INDIA

EARTHQUAKES WITHOUT FRONTIERS

PROFESSOR JAMES JACKSON RETURNED FROM KATHMANDU, HAVING ATTENDED AN EARTHQUAKE WITHOUT FRONTIERS PARTNERSHIP MEETING, IN THE WEEK PRECEDING THE GORKHA (NEPAL) EARTHQUAKE ON THE 25 APRIL 2015.

The Alpine-Himalayan belt, stretching from the Mediterranean to the Pacific, is one of the world's most seismically active regions. Now, a combination of Earth science, social science and education is being used to help the region become more resilient to earthquakes, protecting lives and property.

The Ganges river basin is one of the most fertile and densely populated regions in the world. The Ganges flows through 29 cities with a population over 100,000, 23 cities with a population between 50,000 and 100,000, and close to 50 towns.

But someday – perhaps tomorrow or perhaps in 100 years – a massive earthquake will hit the region, and the consequences could be catastrophic: as many as a million lives in the Ganges river basin could be at risk, primarily because buildings have not been constructed to be earthquake resilient, despite the fact that the relevant building codes are in place.

Between 2 and 2.5 million people have died in earthquakes since 1900. Approximately two thirds of those deaths occurred in earthquakes in the continental interiors – places like northern India. Over that time, advances in the scientific understanding of earthquakes have been translated into impressive resilience in places where the hazard is well understood, mainly on the edges of the oceans. Comparable advances have not taken place in most parts of the continental interiors, where the hazard is still much less well understood.

"Earthquake science has progressed so that we're now much better at recognising the signals in the landscape that reveal the earthquake potential of active faults. We can't tell exactly when an earthquake is going to happen, but we can say it will happen, not least because it's happened before. What we can do, however, is to understand earthquakes better and use that knowledge to help make buildings safer." JAMES JACKSON

Four years ago, with funding from the Natural Environment Research Council (NERC), James and colleagues from other universities in the UK established Earthquakes Without Frontiers (EWF), an international partnership bringing together earthquake scientists from across the great earthquake belt of the Mediterranean and Asian in order to share expertise. It soon became clear that the project was about much more than earthquake science, and the real issue was how to translate science into effective policy, which requires an understanding of the social context in which people live.

With additional funding from the Economic and Social Research Council, EWF expanded to include social science and policy dimensions. The project, which runs until 2017, has three overarching objectives: to increase knowledge of earthquake hazards across the region; to establish greater resilience against these hazards; and to establish a well-networked interdisciplinary partnership to support local earthquake scientists. Within Asia, there are more than 50 national-level stakeholders who are working with EWF on earthquake risk reduction.

Across much of the earthquake belt, people live in large cities, mostly in poorly-built apartment blocks and buildings that have not been designed to withstand earthquakes. The problem that EWF faces is convincing the public and policy makers of the importance of making towns and cities more earthquake resilient. In these big cities, everyday life is difficult enough: there are huge problems with congestion and traffic, air quality, water quality, food supply and poverty. Quite understandably, the risk of an earthquake seems quite remote compared to daily worries.

Perhaps the most important change that can be made to increase earthquake resilience in these areas is the enforcement of building codes. The building codes in Los Angeles and Tehran are similar, but the difference is that in Los Angeles, most buildings are constructed according to those codes, while in Tehran most are not.

Enforcement comes not just from legal enforcement, but education. People are starting to realise that earthquake hazard is an important threat. Once you educate the public, it rises up the agenda and becomes prioritized because the public insists that it does. There are going to be around a billion new homes built across Asia over the next 10 years – let's ensure they are built so they are safe.

READ MORE

This is an edited version of an article that first appeared in Research Horizons, Issue 28: www.cam.ac.uk/research/features/earthquakes-without-frontiers

RECENT NEWS & AWARDS

The Geological Record

01 **Williams Smith's 1815 Map: Stripping the Earth Bare.** On 1 August 2015, exactly 200 years since its first publication, an original copy of Smith's map – rediscovered after more than a century in a museum box – went on public display at the Sedgwick Museum. One of the most significant pioneering geological maps of the UK ever made, William Smith's 1815 'Delineation of the Strata of England and Wales, with part of Scotland', mapped for the first time the distribution and succession of these strata across the region.

The culmination of years of almost single-handed investigation, the map had a huge influence on the science of geology, inspiring generations of amateur and professional geologists to establish the subject as a coherent, robust and important science.

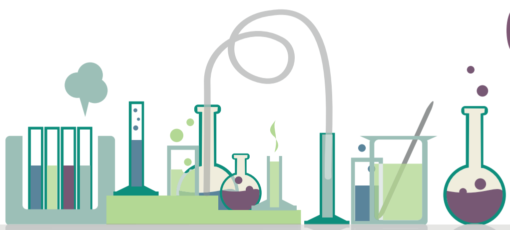
www.esc.cam.ac.uk/news/geological-mapping-stripping-the-land-bare

02 **Peter Friend** (Gonville and Caius 1954) was awarded the Polar Medal for Arctic research and leadership by the Queen. He joins a distinguished list of medal recipients. Peter taught in the department from 1958–2000 and remains an active, if retired, member whilst also acting as the Chair of the Trustees of the Friends of the Sedgwick Museum.

03 Congratulations to **James Jackson** who in June last year was awarded both a CBE for services to environmental science, in the Queen's Birthday Honours List, and received the Wollaston Medal, the most prestigious award of the Geological Society, at the Geological Society President's Day.

04

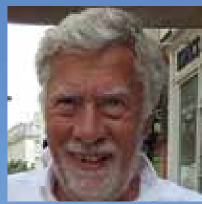
Simon Redfern (Gonville & Caius 1982), Professor of Mineral Physics and Fellow of Jesus College, will take over as Head of Department on 1 October 2016. Simon was both an undergraduate and graduate student in the Department before taking up a Lectureship in Geology and Chemistry at the University of Manchester, before returning to Cambridge in 1994. His research focuses on the relationship between the atomic scale structure of minerals and their physical and chemical properties across a wide range of conditions and throughout the Earth, from ocean to core. More recently, Simon took up the chance to work alongside science journalists at the BBC, as a British Science Association media fellow, and in his spare time he writes up science news for a wider audience
journalisted.com/simon-redfern-1
You can follow Simon on twitter @Sim0nRedfern



05 A generous donation from **Galson Sciences** along with a contribution from the School of Physical Sciences, has allowed us to extend and re-equip the IT teaching facilities on the Downing Site. The increased space will now be called the The Galson Sciences IT Lab.

06 **Geologists play a part in historic Women's Varsity Match.** The Light Blue women's rugby team defeated Oxford 52–0 in the Varsity Match in December – the first time the women's fixture has been played at Twickenham. Earth Sciences were well represented. Front row from left: Ayala Donegan (4th year u/g); Clare Donaldson (alumna and current PhD student); and on the far right: Heather Britton (3rd year u/g). All three played their part in the victory.

07 **Ekhard Salje**, Head of Department 1998–2008 and President of Clare Hall 2001–08, formally retired at the end of September. One of the world leaders in the field of mineralogy and mineral physics, Ekhard plans to continue with his research in the department.



Helen Williams (Newnham 1994) returns to the Department from Durham University as a University Lecturer and Fellow of Jesus College. Helen is currently working on a series of geochemistry projects; whose overarching aim is to understand the roles that plate tectonics and core formation have played in the development of the Earth as a habitable planet. Helen's research primarily focuses around transition metal stable isotopes, and she has applied these to a wide range of samples, including meteorites, mantle rocks and high-pressure experiments that simulate the conditions of terrestrial core formation.

09

Congratulations to **Tim Holland** who has been promoted to Professor of Metamorphic Petrology and GeoChemistry and to **Marie Edmonds** and **Sasha Turchyn** who have been promoted to Readerships.

Sanne Cottaar, recently appointed to a University Lectureship, was awarded the 2015 Keiiti Aki Young Scientist Award. The award recognises the scientific accomplishments of a young scientist who has made outstanding contributions to the advancement of seismology. Sanne studies the structure and dynamics of the deep Earth by using waves from strong earthquakes which are recorded across the globe.

11 **John Rudge** (Trinity 1999) has been awarded a prestigious Philip Leverhulme Prize in Earth Sciences. John's research has changed our understanding of how long it took the Earth to form and how quickly material is recycled by plate tectonics. His interests encompass a broad spread of geophysics and geochemistry, using techniques from continuum mechanics, numerical analysis and statistics to tackle a wide variety of problems in Earth Sciences.

www.trin.cam.ac.uk/news/decoding-earths-chemical-secrets-reaps-rewards

12

Stephen Sparks, University of Bristol, is the 2015 Vetlesen Laureate. Stephen taught in the department from 1978–89, publishing a series of influential papers with mathematician Herbert Huppert on the physics of magma chambers beneath volcanoes. Steve's research has improved the understanding of how volcanoes work and the ability to forecast deadly volcanic eruptions.

PROFESSOR JAMES JACKSON, HEAD OF DEPARTMENT

WEST SIDE STORY:
the move to Madingley Rise

Since the merger of the Departments of Geology, Geodesy & Geophysics, and Mineralogy & Petrology in 1980, the activities of the Department have remained physically split across several sites: the majority on the Downing Site in central Cambridge; with others to the west of the city centre at Madingley Rise, the Bullard Laboratories, the BP Institute (BPI), and the Sedgwick Museum's research and conservation unit, (with CASP, formerly the Cambridge Arctic Shelf Project, nearby). It takes constant attention, effort and commitment to maintain the dynamic of the Department across these dispersed sites, and to encourage cross-subject interaction: traditionally one of our strengths. With an expanding research programme, we have also outgrown many of our facilities, especially experimental laboratories, which are now crammed into unsuitable space.

We are therefore making plans to unify the Department in a single purpose-built facility at Madingley Rise, adjacent to the Bullard Labs and BPI. In addition to its tranquil and cherished garden, Madingley Rise benefits from close proximity to the expanding West Cambridge science and technology campus, and the North-West Cambridge development currently under construction to the North. Within the future plan for this part of Cambridge, Madingley Rise occupies a pivotal and extremely attractive, spacious location in semi-parkland, with easy access to surrounding facilities but away from the more densely built developments.

The new unified site will have a hugely positive effect on our students. With Physics and Materials Science close by, and Chemistry also planning to move there, physical Natural Science undergraduates will spend a substantial amount of their time in West and North-West Cambridge. They, and our visitors and industrial partners, will then also be able to experience the complete range of Earth Sciences activities in Cambridge for the first time. Our researchers will also benefit from proximity to colleagues in other departments, encouraging interaction across conventional disciplinary boundaries. The Sedgwick Museum will remain in its purpose-built location on the Downing Site, maintaining an Earth Sciences presence in the city centre.

Right: Conceptual site layout with Madingley Rise and the BP Institute in the foreground.
Below: Earth Sciences and related sites.

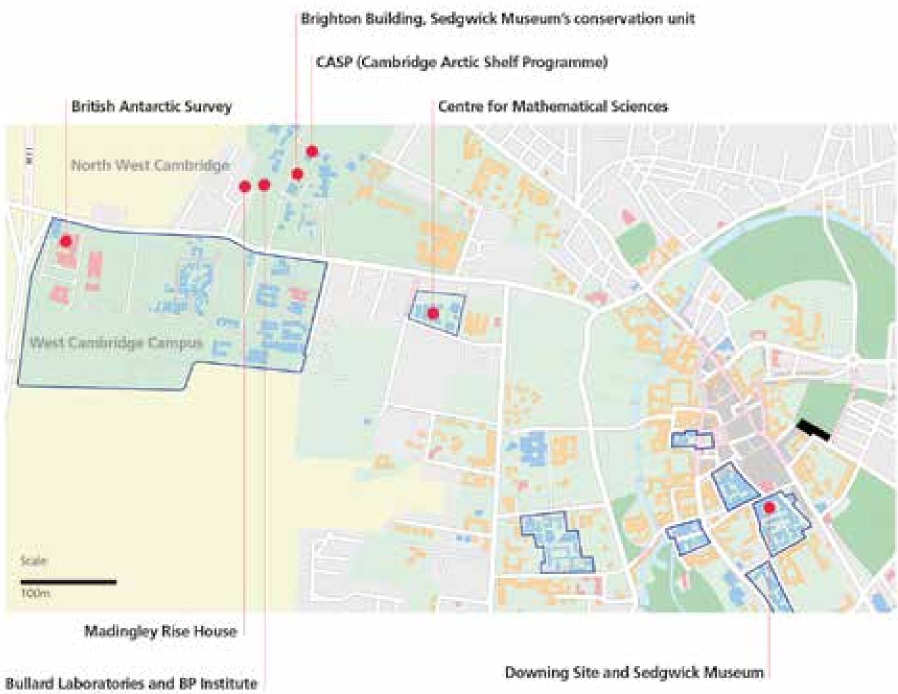
IT TAKES CONSTANT ATTENTION, EFFORT AND COMMITMENT TO MAINTAIN THE DYNAMIC OF THE DEPARTMENT ACROSS THESE DISPERSED SITES, AND TO ENCOURAGE CROSS-SUBJECT INTERACTION: TRADITIONALLY ONE OF OUR STRENGTHS.

Of course, many of us will miss the beautiful and convivial setting of the Common Room on the Downing Site, and have fond memories of the interactions and friendships made there. We are therefore very keen to ensure that the relaxed and friendly atmosphere currently enjoyed at both the Downing Site and Madingley Rise will be maintained in the new building. A key part of the planning brief is to incorporate an equally attractive and welcoming Common Room, acting as a hub that welcomes visitors and students into the new department, and forming an environment where everyone meets, interacts and socializes.

My hope is that alumni will support us in making this area of the department a vibrant, stimulating and inspiring place to be, so that future generations will have the same experience that we all had, and which in many cases, lured us into Earth Sciences and helped us form life-long friendships. For example, this might include exhibiting some of our museum treasures, many of which remain hidden in storage; but also in allowing some freedom in our budget to prepare the area adequately both in terms of the materials and finishes with which the space is created and the furniture that is placed within it.

I would be delighted to hear from you if you are interested in learning more about our plans.

In September 2016 I stand down as Head of Department, to be succeeded by Simon Redfern. I would like to take this opportunity to thank my colleagues who have strived selflessly to make the Department a place that is pleasant and supportive to be in, while continuing to enhance its reputation for excellence in research and teaching. I would particularly like to thank the support, assistant and administrative staff for their fine and energetic contribution to the well-being of the Department. It is easy for all of us, who are the beneficiaries of what they do, to be unaware of their dedication and commitment, and I am pleased to be able to acknowledge it properly.



READ MORE

www.philanthropy.cam.ac.uk/give-to-cambridge/earth-sciences

How you can contribute to the Department of Earth Sciences

Your donation will play a vital role in securing the future of the Department as a centre for excellence for study and research.

Online Giving

The University's Development and Alumni Relations Office has made it easier to make donations online to Earth Sciences. If you wish to make a donation to the department, please go to philanthropy.cam.ac.uk/give-to-cambridge/earth-sciences.

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Make a regular gift by Standing Order

Regular gifts by standing order allow the department to budget more accurately and to plan its spending more reliably. To give by standing order, please complete the form below.

A Gift in Your Will

One very effective way of contributing to the long-term development of the Department's programme is through the provision of a legacy in one's will. This has the beneficial effect that legacies to charities are exempt from tax and so reduce liability for inheritance tax. Further information about leaving a gift in your Will can be found at philanthropy.cam.ac.uk/how-to-give-to-cambridge.

Gift Aid

If you are a UK taxpayer you can Gift Aid your donation, currently adding an extra 25p for every pound that you give.

If you would like to discuss how you might contribute to the Department of Earth Sciences, please contact James Jackson, Head of Department (hod@esc.cam.ac.uk), or Glen Whitehead (Glen.Whitehead@admin.cam.ac.uk) who will be very pleased to talk to you confidentially.

Dear World...
Yours, Cambridge

Please allocate my gift to:

☐ Earth Sciences Unrestricted ☐ Earth Sciences Fieldwork Fund ☐ Earth Sciences Student Support Fund ☐ Sedgwick Museum of Earth Sciences

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Alumni events 2015

flickr.com/photos/earthscicam/albums

AD Alumni Day AP Alumni Panel Discussion

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

Contact us:

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E alumni@esc.cam.ac.uk
www.esc.cam.ac.uk

Alumni Events

Saturday 7 May 2016 Alumni Annual Day and Dinner

In response to feedback at our last Alumni Day in May 2015 we are moving from a biennial to an annual Alumni Day in Cambridge, alternating between the big all-day occasions – like May 2015 – to smaller half-day events with dinner held in a smaller College venue. We are holding the first of these alumni day-lites in 2016.

Highlights of the afternoon's events in the department include talks by Professor Simon Conway Morris (Churchill 1972, now a Fellow of St John's College) and Professor Marian Holness (Clare 1983, now a Fellow of Trinity College). A drinks reception will be held in the Sedgwick Museum followed by the Alumni Dinner in Clare College. We would like to particularly encourage those who graduated in 1956, 1966, 1976, 1986, 1996 and 2006 to join us.

Tuesday 22 November 2016 Alumni Panel Discussion at The Geological Society, London

Earth Sciences alumni are warmly invited to join us for our second annual panel discussion at The Geological Society, London. Our expert panellists will give short talks followed by questions from the floor. Afterwards there will be drinks and canapés in the Lower Library, and a chance to meet fellow alumni and the panel informally.

Climate Change: A view from the past

Climate change is one of the news topics of our time. Our knowledge about what will happen in the future is based on physics, but is grounded in observations of how and why climate has changed in the past.

The Department includes world-leading experts in extracting and interpreting records of climate change and carbon cycling from marine sediments, ice cores, rocks and other archives. They will convey their excitement about understanding the planet's climate mechanics, and discuss their plans for future work. They will be able to set future change in a context of those they observe in the geological record.

Among the topics they will consider are:

- How has Earth responded to, and recovered from, perturbations to the carbon cycle in the past? How does the scale and speed of the present manmade change compare to those past events?
- Did past climate change affect ancient civilisations?
- What happened to sea level when the polar regions were warmer than present?
- What has pushed the Earth into much warmer and much colder climates than present?
- What Earth Science research would best inform the debate about how to respond to future climate change?

Panellists include:

David Hodell, Woodwardian Professor of Geology, uses sediment cores collected from lake and ocean bottoms to reconstruct past changes in Earth's climate, oceans, and environment. He is engaged in research to understand the physical mechanisms responsible for the Great Ice Ages and has a longstanding interest in how ancient civilizations were affected by past climate change.

Eric Wolff, Royal Society Professor of Earth Sciences, whose main research interest is palaeoclimate from ice cores – collecting ice cores to analyse and draw conclusions about the mechanisms of climate change.

Alexandra (Sasha) Turchyn, University Reader in Biogeochemistry, uses the chemistry of sediments and fluids to understand how the carbon cycle works both now and over Earth's history.

Notifications for this event are sent by email only: do let Alison know, at **alumni@esc.cam.ac.uk**, if you would like to be added to the mailing list.