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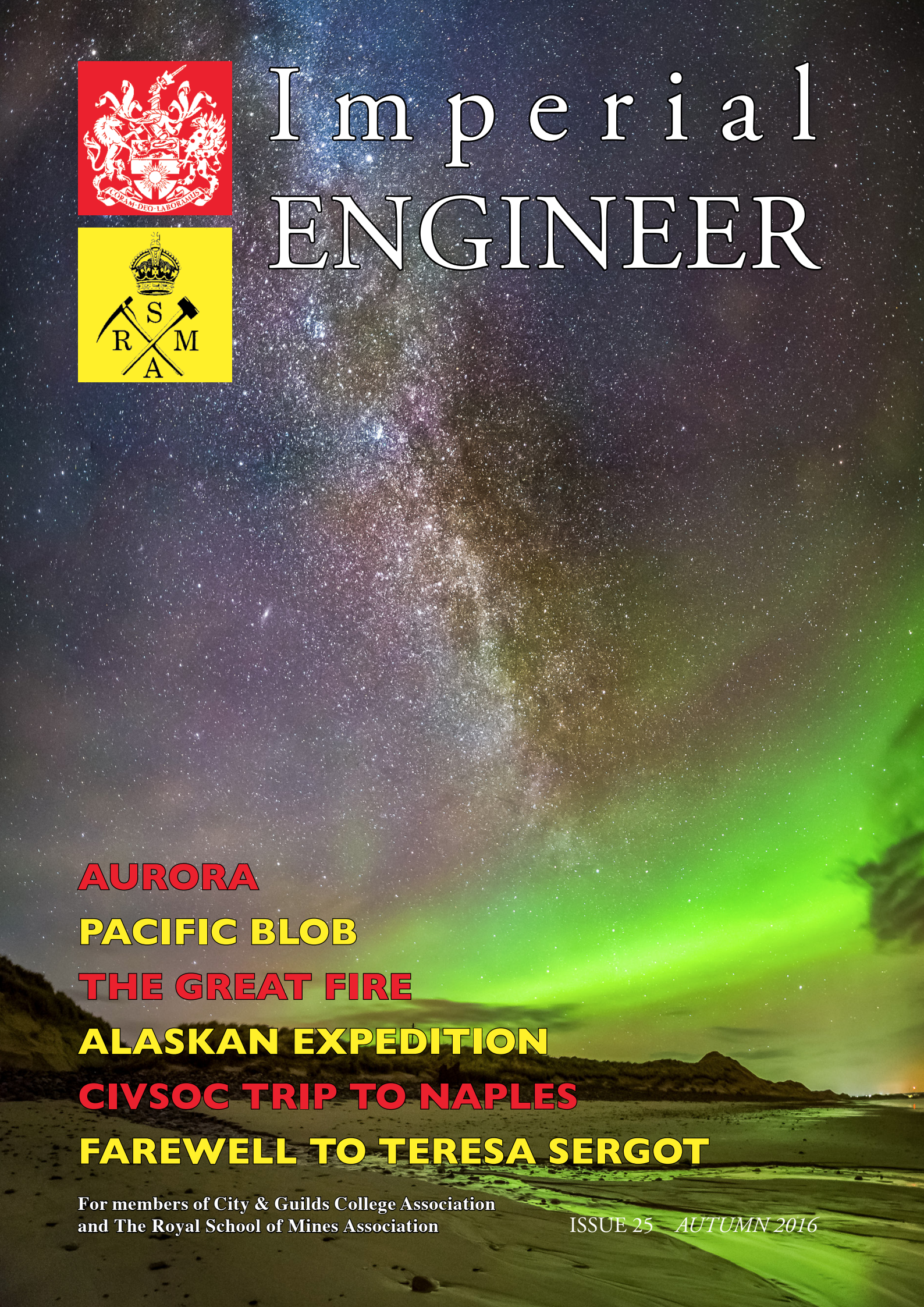

AURORA

PACIFIC BLOB

THE GREAT FIRE

ALASKAN EXPEDITION

CIVSOC TRIP TO NAPLES

FAREWELL TO TERESA SERGOT

For members of City & Guilds College Association
and The Royal School of Mines Association

ISSUE 25 *AUTUMN 2016*

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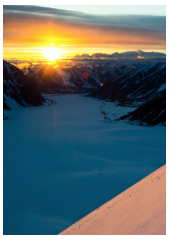

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Judith Hackitt

Welcome to the Autumn 2016 edition of Imperial ENGINEER and to this first letter from me as your CGCA President.

I want to start by formally thanking Roger Venables for all of his hard work as President over the last 2 years. Roger will of course continue to be actively involved in CGCA activities as past President.

Elsewhere in this issue you will find details of the strategic review we have carried out of CGCA where we have sought input from alumni and from current staff and students in the Engineering Faculty. We are now in the process of implementing a number of changes and adjustments to what we offer.

As the new academic year starts, we are looking to increase our level of engagement with individual departments significantly, as well as continuing to work with CGCU officers. We have established departmental contacts in all of the departments of the Faculty and will be talking to each of them about what they would like us to do with them that would be helpful and support the needs of current students in their department.

Our alumni told us that what they really want is to be able to make contact with their own former classmates and to arrange their own get-togethers. We are making changes to the way our information is organised to enable this to happen with ease and are pleased to say that the new CGCA Members' Forum is now live. This allows members to easily organise groups and events, but you will need to register so we can keep the forum private to CGCA Members. Go to http://cgca.freeforums.net to register, and please include your first name and surname in your username so we can confirm that you are a member.

When groups do hold get-togethers we would love you to take a photo and send us a few lines to tell us about who was there and what people are up to now, for us to include in future editions of IE or on our website (which we are going to be updating).

In the meantime, we are working to make our more formal events even better:

The decade reunion lunch has now become the 5 and 10 year reunion lunch and the first of these will take place on 26th November.

Our Annual Dinner next year will be at Saddlers Hall on March 3rd 2017 and I am delighted that Isobel Pollock-Hulf has agreed to be our Guest speaker. Isobel and I were contemporaries at Imperial back in the 70s and are still friends today. She is currently the first ever female Master of the Worshipful Company of Engineers. Please start ringing around your friends and get a group together to join us for what will be a splendid evening.

We are also planning to improve the offering for CGCA members at Imperial's Festival in May next year, but more of that later.

If there are things that you would like us to do to help you stay in contact with friends or there are things you would like to hear more about, do please get in touch. The committee of CGCA is here to make our Association work better for its members – and we can only do that if you tell us what you want.

In closing I would just like to add my personal thanks and best wishes to Teresa Sergot for all of her hard work over many years for CGCA. Happy retirement, Teresa.

PRESIDENTS REPORT

Tim Cotton

John handed me the baton of the Presidency in June and it has to be said that the efforts that he and the Committee have put in over the past three years have been exceptional. I believe we have a much better relationship with the College, a stronger funding model and continued enduring relationship with RSMU. Looking forward over the period of my tenure, the key challenges will be to further build the relationship with College, maintain the focus on funding and engage with the Materials students to maintain the relevancy of the RSMA as an Alumni association. The period between the spring and autumn issues of this publication is always a quiet one in terms of RSMA and RSMU activities. The 2016 Annual General Meeting of the Association was held on the 23rd June, followed by the final year Bar-B-Q, which was again well attended by the students plus a few stalwart alumni. Once again, Eddie Gadd donated generous quantities of his Ramsgate Brewery's finest ale which was much appreciated by one and all. The minutes of the AGM, including the President and Treasurer's report will be posted on the RSMA website in due course.

The RSMA was again represented at the IC alumni reunion day in May and this is a great opportunity for alumni to meet old friends and to see the Imperial of today and to absorb all the innovations and frontier developments in research and education, that warrant Imperial's position as one of the world's top academic institutions. RSMA had a small number of alumni visit the stand primarily due to a reunion of the 1966 Metallurgy class, although the stand was merely a meeting point before heading to the Queens Arms!

The 132nd annual dinner will be held on Friday 26th November at the Rembrandt Hotel in Knightsbridge. Last year was an excellent event with 127 guests and it is hoped that as many members as possible will attend this year. The dinner remains the most significant event in the Association's calendar. In this publication there is a flyer that contains the booking form and a group e-mail will also be sent out to all members, telling them how to book.

The student executives for this academic year are Noah Hawkins, President, and Evelyn Mason, Secretary. The Committee and I look forward to maintaining a strong and enjoyable relationship in our continuing support of the RSMU. We play Camborne at home this February and that always bodes well for more returning Alumni.

As many of you may know, Teresa Sergot retired from her role as Academic and Alumni Relations Manager in the Faculty of Engineering, at the end of September. Teresa has been an outstanding supporter of the RSMA and her assistance, leadership and advice in running the RSMA will be sorely missed. Over the last few months, there has been extensive dialogue with the College's Development Department in the Faculty of Engineering to establish how to fill the gaping hole left by Teresa. In short, whilst we will not have a 'new' Teresa we will have the appropriate level of support from the College via the Development and Alumni Relations teams. It is reassuring to note that College does recognise the importance of the role of the former constituent college associations and are willing to continue the support.

During his tenure, John O'Reilly and the Committee did an outstanding job in getting to grips with membership numbers, communication platforms such as LinkedIn and Facebook and fund raising. John initiated the 100 Club fund raising activity and this is continuing to grow, albeit at a slower pace than planned, so this will remain a key focus of my tenure. If you promised John to help out, then expect a call soon!!

CGCA AGM Presidential Speech

In her speech at this year's AGM in June, new CGCA President Dame Judith Hackitt DBE FREng FCGI outlined the results of the recent strategic review

It is hard for me to come to terms with the fact that I have been associated with CGCA (or the Old Centralians as it then was) for well over 40 years. I was the OC Rep on City and Guilds Exec in 1974-5 and continued as my year group rep for several years after we graduated. On the 8th June this year, I become the President of CGCA.

Whilst I was an undergraduate in Chem Eng I met my husband. We were in the same year group on the same course and we made many friends whom we have stayed in touch with over all of the intervening years. In fact, in 2015, our decade reunion brought together over 20 of us from Chem Eng 72-75 – almost 1/3 of the year group.

In the intervening years David and I have watched our own daughters grow up and go through University. Neither of them attended Imperial nor did they become Engineers, but that is not the point of this reference. What we learned from their University experience was that neither of them built quite the same attachment to their Universities as we did to Imperial, to City and Guilds and to Chem Eng. They have stayed in touch with a few people they made friends with, particularly those that they shared houses of flats with, but I don't see in either of them the same level of attachment/ affection to their alma maters that I feel to this place here in South Kensington. I suppose for me this was part of the process of realising that students and graduates of today see the world and relate to things differently from how it was "in my day".

My contacts with the College since I graduated have been many, various and sustained. I have been a graduate recruitment contact for my employer, I've given talks on careers, I am a member of the Chem Eng Dept Strategic Advisory Board and I was recently invited to become a member of the College's newly reformed Court. I am delighted to be the President of CGCA.

I am starting my Presidency with a case for change and modernisation of CGCA. Membership numbers are falling and the age profile of those in membership is increasingly skewed towards those of more senior years. This means that we are struggling to attract into membership those who are graduating now and who have graduated from the Engineering Faculty in the last 10-20 years.

Even among those who are active members, attendance at some events has been falling steadily. Attendance at last year's Christmas lunch and lecture is one example, but we have also been putting significant effort into arranging events for current students only to find that, on the day, attendance is very poor.

We've also seen a significant increase in the level of Alumni activity undertaken by the College itself. There is now a very well staffed development department and regular contact is made with Alumni often with an aim of securing funding or donations for College. Alumni events are now held around the world and the President of IC frequently attends these. The College also encourages alumni to come back and visit the campus, most notably through the Imperial Festival which now takes place in early May every year, but also to attend other noteworthy lectures and events.

This new level of Alumni activity within College is a good thing – it is not about competition but it is about adapting with the times and working in partnership. By working more effectively with others in College we can and must reposition CGCA as an integral and valuable part of the Alumni landscape – but to do this we must change our outlook and our activities.

Some of our soundings within College gave us some harsh feedback about our relevance – or lack of it. There is a balance to be struck between preserving the traditions and the history of where we have all come from and adapting to the new environment. Graduates today leave the Faculty of Engineering of Imperial College which is a University in its own right, no longer part of the University of London. The student population has always been international but that is even more true today than ever before. To get onto an Engineering course here today requires grades that many of us would have struggled to attain. Whether or not that is a function of changes in A level standards, what I do know from my engagement with current students is that they are under a lot of pressure, they work extremely hard and they work very long hours. They still socialise of course but it's different and it's rationed into the time they can make available.

There are new departments now which have no emotional affinity to the old C&G identity although we have been instrumental in ensuring that all of these courses, including the new Design Engineering course, continue to receive the award of ACGI at the end of the course. Departments are also much bigger – giving them a much more convenient and natural community which most students gravitate towards and this has resulted in a significant strengthening of Departmental society activity.

We conducted a membership survey which has shown us that our existing membership would also welcome some changes to how we operate and what we offer to them. Overseas members feel cut off and would like us to find ways to include them, members predominantly want to use CGCA to stay in touch with their own groups of friends rather than attend organised events which span several years and departments, but they do also want to stay in touch with what is happening at College and to have the opportunity to attend selected annual events.

The case for change seems to us to be clear whichever direction we look in. Our strategic review has given us some very valuable insights into the direction we need to take. The challenge is for us to provide that bridge between the past and the present for everyone – Alumni, wherever they are in the world, current students, and staff. It is not for us to dictate whether people gravitate to CGCA rather than IC or any other club they may have belonged to whilst they were here. We need to offer them a choice and we need to offer them flexibility to allow them to engage as they wish. CGCA has an important part to play in making this happen – provided we can embrace the changes we need to make.

We need to engage much more effectively with individual departments – with staff and with students – and we intend to seek input from each department within the Faculty to help ensure we have the right reps in place. In some of the newer departments we may invite members of staff to become CGCA dept reps. The key is to ensure that what we offer to each department is relevant and interesting to them – not what we think they need. This year we have already started that process by sponsoring (funding) a number of recent graduates to return and attend the final year dinner in two departments. This has been at the suggestion of the department and has been very well received. Being responsive is what will make our value proposition to those who have a choice to make about whether to join CGCA and stay in touch through us.

We must also develop a strong partnership with the College's Alumni team to ensure that we have a presence at their overseas events and also so that we can explore joint badging and sponsorship of high profile lectures and events. The College already has a very full programme of events which would be of interest to CGCA members who want to stay abreast of what is happening socially and academically, we don't need to create our own events, but open up those that already exist to our members.

We also need to modernise our communication methods. We have taken the first steps this year with the resolution of a data-sharing agreement with the College and a regular newsletter which now goes out via e-mail. But this is only the start. Members have told us very clearly that they want us to facilitate their contact with old friends not necessarily to be the organisers of formal get-togethers. We need to radically update and redesign our website and our presence in social media as well as continue to offer the printed form of publications like Imperial ENGINEER.

This is about evolution not revolution. Change is necessary but we also need to hold onto who we are and to our traditions. Events like the Annual Dinner will continue as will our decade reunions, although these will be moving to five rather than 10-yearly and we are also looking at whether we would attract higher attendance if these took place on the same weekend in May as the Imperial Festival.

Maintaining our traditions and our own identity is important. They link us to the history of Engineering at Imperial College, but we must also become an integral part of the broader Alumni family across Imperial College as it is today and will be into the future. CGCA's journey needs to be in sync with that of the College and the Engineering Faculty .

We will keep you all informed as we make changes to the CGCA offering, through Imperial ENGINEER and via our e-mail newsletters. But we also welcome your thoughts and ideas – especially if you didn't get the opportunity to participate in our survey. This is your association and your views matter.

Old Centralians' Trust

Annual roundup from Chris Lumb, Chair of the Trust

The Old Centralians' Trust has continued to support engineering students in undertaking activities which fall outside the definition of academic learning, based on the principle that it is the activities that are undertaken outside of the lecture room and laboratories which make the difference between a purely academic achievement and one which builds a much broader and rounded education. The Trust has also continued its readiness to fulfil its prime objective of relieving any student hardship which has arisen through no direct fault of the student concerned.

During the most recent financial accounting period – equating to the academic year 2014-15, the Old Centralians' Trust distributed over £44,000 across a wide range of student-targeted awards, bursaries and events.

One student came to the Trust in hardship when scholarship grants from the home country fell drastically in value due to currency exchange movements. Although the total gap in funding was much greater that the Trust could meet on its own, the eventual solution was to be able to provide the final £3,000 towards living costs, after the student's parents had taken extreme measures to raise a significant portion of the sum needed. This student went on to achieve excellent results at graduation.

Six key officers in the City & Guilds College Union were supported by the provision of John Elliott bursaries to assist with the inevitable costs of a frenetic lifestyle helping the Union to run smoothly and effectively.

Two Student Activity Awards, valued at £700 each, were provided in each of the nine departments running undergraduate courses. These awards are intended to help with the cost of an active lifestyle, whether this be in helping to run student societies, participation in sports, playing in orchestras, engaging in musical instrument lessons, volunteering to help others, or any other similar extra-curricular activity. In many cases the recipients are involved in several of these at the same time! All eligible students had been invited to apply during the Spring Term of the previous year, by providing a summary of the activities they had been undertaking, and were expecting to continue with. Final selection of the most worthy two in each department was made by the senior tutor in conjunction with departmental colleagues and, after approval by the Trust Board, the awards were distributed at the commencement of the Autumn Term.

Two significant awards were made to groups of students engaged in humanitarian projects - one to the College's Engineering without Borders group, who were concentrating on projects in the Philippines, and one to the Raincatcher group who spent much of the year planning and fund-raising in order to build rainwater storage facilities in Tanzania; these enable water from the rainy season to be stored for use during the long dry periods. These grants totalled just short of £3,000.

Support in the form of a grant of £1,540 was provided for a group of 69 Civil Engineering students, drawn from amongst all four years of the undergraduate courses, to travel to Naples in order to observe civil engineering projects in a different country, and to forge links with their undergraduate peers in Naples. At the University of Naples, the group was given presentations on research in structural aluminium, an area in which Naples University is a world leader, and on the use of virtual reality simulators for research into transport networks (see page 26).

An undergraduate student of Electrical and Electronic Engineering was awarded a Jessel Rosen Research Scholarship amounting to £600 in connection with a research project into 'walking drones', which was undertaken during the summer vacation.

In support of student sporting groups and engineering societies, £2,500 was awarded to the Imperial College Boat Club to assist with the cost of sending two crews to race at the Henley Royal Regatta in July 2015, whilst two separate awards were made to the Motor Club; firstly the sum of £650 towards the costs of taking the College's vintage motor car mascot Boanerges to Geneva for a Summer Tour, and secondly an award of £340 to fund the training of two student drivers in the skills and techniques necessary for towing Boanerges by trailer to participate in distant functions, where driving a vintage car the whole distance would not be a practical proposition.

Student adventure was supported by a grant of £200 to a student who undertook a walking tour across the Pyrenees mountains on the Franco-Spanish Border.

Engraved tankards and / or monetary awards were provided for four students under the headings of: the Holbein Memorial Award; Peter Moore Memorial Award; John and Frances Jones Award; and the Fellows of the City & Guilds of London Institute Centenary Award (the latter two of these are provided on behalf of the City & Guilds Association and the FCGI Witchell Fund respectively).

Each year a modest proportion of the available budget has been used to support postgraduate students in travelling to overseas conferences to present papers on their research, whether by way of a poster display or a podium presentation. During the year 2014-15, some fifteen students received assistance under this heading, with the total sum of £5,400 equating to an average travel grant of £360.

In addition to the awards described above, the Trust provided funding towards the annual Peter Lindsay Memorial Lecture, held each Spring in memory of Professor Peter Lindsay's most generous bequest, which greatly enhanced the assets held by the Trust in 2007 and enabled a significant increase in the scope of its work. The object of the Lindsay lectures is to provide an opportunity for engineering and other students at Imperial College to see and hear a leading academic speak about their work. The lectures are arranged by Peter's former academic department - that of Electrical and Electronic Engineering. In 2015, the eighth such lecture was given by Professor Paul Newman, FREng, BP Professor of Information Engineering at the University of Oxford and Head of the Mobile Robotics Group of the Department of Engineering Science at Oxford. The topic of his lecture was *Driven by Mobile Autonomy: an Enabling Technology of the Future* and this was delivered to a very full audience of students and staff.

Photo: Yuebi Yang

The Old Centralians' Trust is fortunate to have an excellent level of support from a number of academic and administrative staff within the Faculty of Engineering, without which its work would be much less easy to fulfil. Grateful thanks must be expressed to all of those staff members who are so generous with their time and advice, and in particular to Dr Teresa Sergot. Teresa will have retired at about the time this issue of Imperial Engineer is published, but she has given sterling support to the Trust throughout the past twelve years.

Generous Legacies for OC Trust

During the current academic year, the Old Centralians' Trust has received two generous legacies, and one gift in memory of a member who died early in 2016.

CGCA Life Member Rogers Knight (Mechanical Engineering, 1934-38), who died in March 2015 at the age of 99, was also a founder member of the OC Trust, and it is now known that Rogers has left a legacy which is expected to total £140,000 once the solicitors have completed their work. As a member of the Trust Board for a few months short of half a century, and having served as its Chair for a number of years, Rogers was intimately concerned with its work for the whole of that time and it is thus not surprising that he has been so generous upon his demise. He was also a member of the Links Club, and had expressed a wish that there might be an award that combines in some way the Links Club and the Department of Mechanical Engineering – the Trust will be working to see how this wish can be brought to fruition. At the same time, a major portion of the bequest will go to the General Fund of the Trust, so that the income arising on it can be spent in a more flexible manner and generally in line with existing objectives.

Michael St John Candy, whose death was announced in the Spring 2016 Issue of Imperial Engineer, left £2,000 to the OC Trust in his will, with no restriction as to how it should be used. The practice of the Trust is to spend income rather than capital, so it will be the income from this generous legacy that will be applied in support of the objectives of the Trust.

Finally, but by no means least, a most useful gift of £200 has been received from Mrs Caroline Fletcher, in memory of her husband Derek whose obituary was also published in the previous issue. This gift came with no specific conditions attached, so it will make a valuable increment to the General Fund.

Fellowship of City & Guilds of London Institute - FCGI

Barry Brooks FCGI (Past-President CGCA, 2004-06) is the Co-ordinator of the FCGI Annual Lecture-Lunch meeting held in June at 170 Queen's Gate. In introducing the talk given on 17 June 2016 by CGCA President, Dame Judith Hackitt FCGI, Barry has taken this opportunity to remind Guildsmen and Guildswomen about the Fellowship.

Fellowship of the City & Guilds of London Institute (FCGI) is the highest award that can be conferred by the Council of City & Guilds as authorised by its Royal Charter. It is awarded for outstanding personal and professional achievement. It denotes the ability to manage people, information and operations in complex professional or technical situations and to formulate and implement strategies at the highest levels of responsibility.

The first award of Fellowship was approved by Council in December 1892**.** Until 1990, the award was exclusive to holders of the Associateship (ACGI), namely engineering graduates from the City & Guilds College, one of the constituent colleges of Imperial College, now enlarged as the Faculty of Engineering. Since 1990, access to the Fellowship has been broadened to recognise those who have made outstanding achievements whatever their professional or industrial specialism.

Honorary Fellowship (Hon FCGI) was introduced in 1935 to mark the 50th Anniversary of the foundation of City & Guilds College. Its holders have been recognised for outstanding achievement closely linked to the affairs and philosophy of the Institute.

The Fellowship's Annual Meeting and Luncheon

The Fellowship's leather-covered minute book started in 1893. The first meeting of sixteen Fellows was called on 10 January 1934 and the record – taken from the Old Students' house journal, 'The Central', says:

"A meeting of outstanding interest was held at the Imperial College Union on Wednesday 10 January 1934 when, for the first time, all the Fellows of the Institute (FCGI) had the opportunity of assembling together as a body. The informal dinner afforded an excellent means of getting to know one another better, and of hearing news regarding the activities of members…… it was agreed that an Annual Meeting of Fellows be initiated and that the best time to convene it would be during the first 10 days of December."

Minutes of the second meeting, held in the Staff Common Room at the Union on 18 December 1934, recorded:

"The meeting expressed appreciation of the offer made by Professor Witchell of the City & Guilds College to act as Honorary Secretary to the Fellows and he will accordingly convene these Annual Meetings and it is hoped the social aspect will appeal to all Fellows."

These Annual meetings are now a key part of the Fellowship calendar and are designed to reinforce the links between Fellows (from all backgrounds), Imperial College and City & Guilds. The format combines a good meal at 170 Queen's Gate, networking with other FCGIs and their guests, updates about the College and City & Guilds, and a stimulating short talk by one or more senior members of the College and City & Guilds. For 2016, Dame Judith Hackitt covered all of these roles as a Trustee of City & Guilds, as a member of Imperial Council and as President of CGCA.

FCGI Centenary Award

From the early days of the Fellowship Luncheon, Professor Witchell built a modest surplus to subsidise any Fellows unable to afford the price. About 10 years ago, it was decided that a more appropriate use of the funds would be to provide a Fellows' prize to a student who had made a significant contribution to City & Guilds College Union. As the Centenary of Imperial College was in 2007, the Award was entitled the "**FCGI Centenary Award**" and comprises a cheque for £300 and an engraved tankard.

The funds are managed by the Old Centralians' Trust (the charitable arm of the City & Guilds College Association), and the winner is selected by the City & Guilds College Union President who attends the Annual Luncheon with the Award winner to read the citation.

Back to the Future – reinventing the UK's manufacturing industry

FCGI Speech 17th June 2016: Dame Judith Hackitt DBE FREng FCGI

First of all I should thank Barry for inviting me to speak today. Whether you thank him or not will depend on whether or not what I say over the next 15 minutes or so is interesting or in any way thought-provoking. When Barry first asked me to speak I was still Chair of the Health and Safety Executive so it would be fair to say that there was a wide range of options open to us in terms of what I might talk about today.

I stood down as Chair of HSE at the end of March after eight and a half years in the role and it felt right to me that I talked about my current interests rather than reflecting back on that most enjoyable but challenging period of my career. If you do want to ask me anything about that period I will be happy to do so later.

So, I decided to call this talk '*Back to the Future*'. That reflects my own personal journey but also in part relates to what I see going on in the world of manufacturing and how people acquire the skills to work in manufacturing.

I graduated from Imperial College in 1975 and went to work in industry – chemicals manufacturing in my case. I was the first person in my family ever to go to University. My father was a (mechanical) engineer but he had followed that route through an apprenticeship and night school to attain his HNC/HND qualifications. I loved working in manufacturing industry and I really got the whole concept of wealth creation and its importance to the economy. Not only the products of what we were making, but the value added we were creating, were vitally important to a thriving economy. Somehow I never ever bought into the notion that this country could be sustainable and economically viable built only on a service based economy.

To that end, as I have planned my transition from HSE, it is not surprising to see how much my commitment to manufacturing and to Engineering now features in the roles that I have. I am now the Chair of EEF, the organisation which represents more than 5,000 companies in the UK championing manufacturers and manufacturing. I am a Board member of the High Value Manufacturing Catapult which I will say more about in a few minutes, I am a council member and trustee of City and Guilds and I am involved with a variety of Universities in an advisory capacity – all associated with Engineering courses. I have spent the last two days here at Imperial College on the strategic advisory board in Chem Eng.

I am excited by the prospect of inspiring a new generation of engineers and technicians to become 21st century manufacturers here in GB.

We are at the beginning of the fourth industrial revolution. A new era that builds and extends the impact of digitisation in new and unanticipated ways. The challenge we face is to ensure that this revolution creates benefits for the many rather than the few and that the UK has a significant role to play in that revolution – by reinventing what we have always done exceptionally well in the UK, which is to manufacture and to generate wealth.

The first industrial revolution occurred when we shifted from our reliance on animals, human effort and biomass as primary sources of energy, to the use of fossil fuels and the mechanical power this enabled. The second industrial revolution occurred between the end of the 19th century and the first two decades of the 20th century and brought major breakthroughs in the form of electricity distribution, communications, synthetic chemical processes and new forms of power generation. The third industrial revolution began in the 1950s with the development of digital systems, rapid advances in computing power and communications which have enabled new ways of generating, processing and sharing information.

The third industrial revolution is not yet over but the fourth has already started and the two run in parallel. The fourth is about the advent of cyber physical systems which create entirely new opportunities for people and for machines. The capabilities build on the technologies of the third industrial revolution but this next 'wave' represents entirely new ways of embedding technology within societies, industry and even in our own bodies. Examples include genome editing, new forms of machine intelligence, and breakthrough materials, to name but a few. The combination of the third and fourth industrial revolutions is making possible products and services which increase the efficiency and enjoyability of our lives, while also reducing costs. Organising transport, booking restaurants, buying goods, making payments, listening to music, reading books

are all available to us all instantly – and there is much more to come, including for example personalised medicines and autonomous vehicles.

But what does all this mean for the world of manufacturing and for the skills we need in the engineers and technicians of today and in the future?

It is clear to me that this represents a fantastic opportunity for the UK to regain a prominent role in manufacturing and to grow significantly from the current level of ~10% of GDP. In fact much of it is already happening. It is the case that for many years our universities here in the UK have produced world class research, but it is often in the translation of that research into commercial business propositions where we fall short. The High Value Manufacturing Catapult works with business to bridge that gap between research and commercialisation, taking risk out by offering open access to world class industrial-scale equipment. HVMC is now well into its fourth year of operation and comprises seven centres around the UK, each with their own area of specialisation but also working collaboratively together to provide solutions. The areas of specialisation range from process innovations – biologics and printable electronics – metal forming, composite new materials, battery technologies, to nuclear advanced manufacturing. In four years the centres have worked with more than 3000 businesses – 50% of them being small and medium sized enterprises in the aeronautic, auto, medical, construction, oil and gas, and food and drink sectors. They are facilitating continuous improvement but also delivering step changes. The business model enables approximately 1/3 of public funding to support the work and to date, for every £1 of core public funding, the centres have been able to demonstrate delivery of £15 net economic benefit.

HVMC is one of several Catapults which have been set up by Government and it is the engine for delivering innovation in manufacturing enabling the UK to move towards digitally connected factories and supply chains.

There are of course a number of other fundamentals which we need to have in place if we are to deliver this renaissance in UK manufacturing. We need to know that we are going to have affordable and secure energy in both the medium and long term, we need significant investment in transport infrastructure, and we need the recently announced apprenticeship levy to be used well to deliver quality apprentices in areas where we are desperately short of skills – like manufacturing. In short, we need Government to commit to a strategy which will be supportive of industry for the future and for the long term.

The skills shortage is a particular area which needs to be addressed and here we still have much to do. The UK has fallen behind many other parts of the world in inspiring young people – especially girls - to study science in schools and go on to become scientists and engineers. The problem is well known and has been for some time and there is no shortage of activity to try to address it. In fact there are literally hundreds of different initiatives all trying to achieve the same thing but this disunited effort only succeeds in creating a cacophony of noise which confuses teachers, parents and students. Despite the fact that those of us who are parents know that children mature at different rates and that some will be better suited to an academic path, whilst others will be better following a vocational route; despite the fact that those of us who have worked in industry know that we all work together in multidisciplinary teams to deliver results in the real world; our own professional engineering institutions continue to make progression much more difficult for those who have not followed a conventional path and they continue to maintain silos around each discipline. This has to change and it has to change soon.

I am more hopeful about the number of young people I now see taking up apprenticeships. EEF has its own brand new apprentice training centre in Aston, Birmingham where we train people to work in manufacturing for our members and for others. In 2013, we had 97 new starts on our scheme. We are in the process of expanding into a second building as we speak and in September this year we will see no fewer than 330 new starts. That is but one example of the growth in interest and take up of apprenticeships in manufacturing. Our future plans in EEF include the establishment of a Manufacturing Academy and a manufacturing Leadership Institute.

I have tried here to cover a lot of ground in a short space of time but I hope I have given you an idea of some of the exciting things going on in manufacturing in the UK today and of some of the challenges which lie ahead. I do not know whether our decision in a week's time will be to stay in the EU or to leave. But one thing I am certain about is that whether we remain or choose to leave the EU, this country requires a strong, thriving manufacturing industry taking a key role in delivering the fourth industrial revolution for the future benefit of us all.

Thank you.

Our new RSMA President: Tim Cotton

Tim is an experienced and qualified mining engineer with 20 years of experience in operations, technical and commercial roles, working on mines around the world exploiting a range of metals and minerals. Most of his career has been spent working for one of the leading global mining and metals companies, Rio Tinto.

His career in the mining industry began in 1988, when Tim joined Goldfields of South Africa as a Learner Official on the gold mines of the West Witwatersrand, near Johannesburg. This was a working gap-year before studying Mining Engineering at the Royal School of Mines. Initially Tim was on a three year Bachelors course but, after getting caught up in the traditions and spirit of the Royal School of Mines, this became a four year Masters course! During his time as an undergraduate there were frequent interactions with the RSMA, and Tim remembers these fondly as they showed that there was a genuine pride in being a part of the RSM. Graduates came back from all years and were just as passionate as the current undergraduates about RSM. In addition, these returning graduates were able to show and describe life after university and it could be a very enjoyable and rewarding one too. In 1993, Tim graduated with a degree and Caren his long term girlfriend, who a short while later became his wife. He joined Rio Tinto. There then followed a series of operating, technical and management roles and opportunities that took Tim and his family to Zimbabwe, Australia, USA and Singapore before finally moving back to London in 2012.

Tim wanted a change in career and to stay based in the UK where his family were settled. He was intrigued by the idea of working as a risk engineer in the mining insurance industry, where his operational skills and experience would be invaluable. It appealed to him that through his work at International Mining Industry Underwriters (IMIU), his influence could make a difference at grass roots level in mining operations.

Tim also wanted to be able to become more involved with Imperial College, and the RSMA was the best way of providing that involvement. During the 20 years of working in and around the mining industry, Tim had always recognised that the brand of RSM was still strong. Where possible, Tim attended Annual Dinners and Final Year BBQs as a way of staying connected to RSM and using them as reunions with former classmates. At every event, it was generally noted that passion and pride shown by the current students in being part of RSM was as strong as ever. By joining the RSMA, Tim wanted to continue to support the spirit of the RSM and to encourage the current students to continue to grow the RSM tradition. Tim joined the committee in 2013 and now has the tremendous fortune to be the President. The industry is changing, the College is changing and the incoming students are changing but, regardless, the traditions that the RSM hold dear: comradeship, friendliness and generosity, still resonate as guiding principles that people want to belong to.

Tim is married to Caren and they have with two teenage daughters Bria and Annabel and all live near Newbury in West Berkshire. His passions are rugby and hill walking with his friends. He enjoys tackling the tough British highland terrain, absorbing the beautiful and bleak views, but ultimately is always glad to know that there is a nice B&B close by and a local pub with a roaring log fire where he can warm his toes.

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

We bid farewell to Teresa Sergot

Dr Teresa Sergot has been the heart and soul of the Engineering Chapter since it was formed in 2004. After 12 years she is retiring. On Wednesday 28th September, the Faculty held a reception in 170 Queens Gate to bid Teresa farewell. After speeches from Richard Martin (Faculty Operating Officer), Professor Peter Cheung (Faculty Vice-Dean for Education) and Peter Chase (CGCA Treasurer), to which Teresa gave a witty and warm response, Richard Martin presented Teresa with a framed print of an old engraving of Imperial College.

Many of Teresa's colleagues were present, along with representatives from both Alumni Associations, including past presidents, and some former colleagues who had come back to help Teresa celebrate. Among these was Rosie Tipples and, of course, Teresa's husband, Professor Marek Sergot from the Department of Computing. A few days earlier, we had talked to Teresa about her career, her time at Imperial, working with alumni, and her future plans.

Teresa at her retirement reception with by her husband Marek and former colleague Rosie Smith (née Tipples) who brought her daughter Ffion along.

You first came to Imperial in 1969 to do a Chemistry degree, so you are an ARCS?

I *am* an ARCS

Then you did a PhD, also in Chemistry finishing in 1975 and then went to work at the Science Research Council.

As it was known then, so that ages me.

Then the CBI, and British Gas. Then you came back to Imperial.

Yes, eventually.

And you've been here ever since?

I've been at Imperial since 1994. In the meantime I had four children. I had a career gap of about seven or eight years and then came back to run industrial liaison in the Department of Computing.

So you were perfectly qualified for that weren't you? The Imperial background, the industry background, perfect! Just in the right place at the right time, just the person they needed!

Yes. My problem was that by the time I finished my PhD I was ready for a change from the lab. I just wanted something different, but I didn't want to move out of the scientific background so the Science Research Council was just ideal… until they moved to Swindon. I think I may have stayed with the Science Research Council had they been in London. They were in Holborn, great location, and gave me a lot of responsibility for a relatively junior person.

What was it you were doing there?

I was running committees. The SRC funds research, so…

Looking at proposals and bids for funding?

Proposals, yes, studentships, you know all sorts of aspects. So I felt I fitted in.

Not long from being a student yourself.

Precisely, so I felt I could still relate! But then they moved to Swindon. At that stage I was about to get married, needed a job in London, commuted to Swindon for a year… It was alright, but still day-in day-out…

So, was Marek at Imperial by then? Before you got married?

I knew Marek from the age of sixteen, but we went to different universities so our paths sort of split, but then we met up again in London, quite by chance, and the rest is history.

We got married and he got a lectureship at Imperial in the Department of Computing, so I needed to be in London. And that's when I worked for the Confederation of British Industry. Not my favourite of jobs, but… it was fine, it was there, I got the job, but I didn't get an awful lot of satisfaction from it. It was very different from what I was used to.

Different environment?

Different environment, but at least they gave me a job when I needed to be in London and still vaguely related to my semi-skills.

It sounds like you had, unbeknown to you, chosen the right path to be what Imperial needed.

It's kind of… I don't know, it seems almost inevitable… You do this because of that, and I guess you do lots of things in life like that. I do remember thinking "I can't see this very long term" and that's when I started looking around again and got the job at British Gas, and I really liked working at British Gas. Then I had my first child. And it's kind of hard working and children and everything, and don't forget this was in the 80s.

It was hard?

It was hard, but with Marek having an academic post, it made it slightly easier because his time was a little more flexible, that is until number two came along.

It was a very different environment, wasn't it?

It was a *very* different environment then. But there was another girl working with me in the Research and Development section of British Gas. I'd just had my second child and she'd just had another child. There was a job that was perfect for job-sharing, so I could start it and she could finish it, so we thought, "Ideal!" But we couldn't get it through British Gas because we were two heads, we counted as two heads and back then HR wasn't what it is now, your rights weren't what they are now.

So were you working back in the lab?

No, I was doing industrial liaison then. I was going to universities selling British Gas as funders. They used to give lots of studentships. And also I had colleagues in the SRC, and life is always about connections and contacts, so that helped me with that. But then when British Gas were unable to agree to the job share, I very briefly got a part-time job in the Department of Computing, but then my third child came along. And actually I thought, "no I can't do this". And also at that stage, I felt I needed to be with the children. And then we went on to have our fourth child.

I imagine it'd be a lot more straightforward now, more sympathetic.

Oh now, it'd be totally different. But on the other hand I'm glad it was harder, I have no regrets. I mean, what does 'career' mean? You know? It doesn't matter. And who knows if I'd have made a career if I'd carried on working, you never know what level you're going to reach. So you do what you need to do at the time. And I loved those early years. I was in the PTA, I'd made lots of friends with mothers at the school gates, and it was a lovely seven-eight years of my life. But then when my youngest was six, I thought… "I need to do something" and that's when I came back to Imperial, and now 22 years on I'm retiring.

So, twelve years ago, you took over as the lifeline for the Alumni Associations for Engineering – was that through choice?

No, I'll tell you how that came about. It was the time that Richard Sykes set up Faculties, and it was the time the Office of Alumni and Development was being restructured to fulfil these plans. Faculties are essential in my opinion because you can't govern a university… lots of departments, lots of heads of departments… without a much more formal structure. So Faculties were formed in 2004, and up until then I had had very little contact with alumni. When the Faculties were formed, the Faculty of Engineering was made up of City and Guilds plus the Royal School of Mines – with its two alumni associations CGCA and RSMA – so what they decided to do was to form a Chapter, which was a partnership of the two, plus a partnership with the Faculty. Students of course would be graduating from the Faculty of Engineering, although there's always an association with either Guilds or RSM. Some students don't relate to either, or are disinterested, and I guess they're true Imperial alumni with

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

probably best allegiance to their department. That's where a lot of people's main allegiance lies.

So was that a difficult time for you?

Well at the time I was working in Computing, I was doing various things, but I thought "I really do need a change now". And this was advertised as 'Chapter Manager', a very interesting title. I read about it, and I thought, "This sounds quite interesting". So I thought, "Well I'll apply", so I did, and I was fortunate enough to get it. I was interviewed by the Faculty, but also by Barry Brooks who was then Vice President CGCA and Bernie Pryor who had just ended his term of office as President RSMA. So I got the job, and then started the quite difficult early days of trying to marry two very long-standing associations who were suspicious of each other but actually had the same aims and aspirations. It took a while, but we got there and actually they work brilliantly together. And the first challenge was *Imperial ENGINEER*. Guilds had their journal, *Imperial College Engineer*, and RSM had their newsletter *RSMA Update*. And they merged them into what has become a really good publication. It's absolutely hit the right levels. And now we're up to issue 25. And it's going from strength to strength, it's tremendous.

Then in 2007, my time as Chapter Manager changed when my role in the Faculty was expanded to include Faculty coordination of education, something very much needed given there are now ten departments. I was quite keen to do this, to have a different sort of experience – not just alumni. As this was a big role, it was agreed that Rosie Tipples, whom many of the alumni will remember, helped me support the Associations so I could devote more time to looking after the Faculty's education matters via the Faculty's Teaching Committee, which was then chaired by David Nethercot who later became President of CGCA. So, one way or another, I've worked with David for several years.

And that set-up worked well did it?

It worked very well until Rosie got married and moved away! But then she was never replaced in that role, so my job was really to make the associations more and more self-sufficient. Which they've become! However, even now that I'm off, there's still a level of support that they do need from the Faculty. They'll definitely get that and that's where Nic Katona comes in.

So it's twelve years you've been doing that?

Yes, twelve years!

Have you enjoyed those twelve years?

Yes, I really have. I mean there are frustrating moments, but on the whole it's been great. Really, really, enjoyable. Possibly because I've met so many interesting people. And it's nice to be appreciated, as well.

I think you're definitely appreciated.

Well no, no, but there are some – particularly the elder alumni – who are just lovely.

So who are the most enjoyable people to work with, the students, the staff or the alumni.

Oh good question, the alumni of course! It's the alumni definitely. I enjoy working with students, but they're kind of transient and then they become alumni. But the alumni are there for the long haul.

So those are the most enjoyable, but who are the hardest to work with?

I don't think any of them have been particularly hard to work with.

Have there been any stand-out moments in those twelve years? Good or bad, highlights or lowlights?

A ride in Bo with Rogers Knight.

Oh I think we might even have a photo of that!

Teresa rides in Bo on the occasion of Rogers Knight's 90th birthday in 2005

Yes, on his 90th, which we organised for him. And I think the greatest achievement during my time has been the way that the associations have worked together to create and produce *Imperial ENGINEER*.

Okay. So, you're about to retire – are you going to miss it?

Yes, definitely. I'll miss the people, but I won't miss the commute. I travel at a time when tubes are like packed sardines, so I won't miss that. But I will, I'll miss it. I guess I'm heading for another career. So it's not as though I'll be at home twiddling my thumbs. I mean the fact is that when I went part time, it was the best thing I could've done because I realised that I'm so busy when I'm not at work.

There is a life out there.

There is a life, definitely!

So, have you got more things that you're planning on doing? Unfulfilled ambitions you want to achieve?

Yes actually I do! I want to travel, because that's something that I've always loved. And for various reasons you can't go, because it's term time, or the children are too little, etc, etc. And our house is falling apart, and needs a lot of TLC so I need time to be around to see that through, and of course all the grandchildren now!

I was going to say! Now that you're a grandmother you've got a new generation to start worrying about!

Yes, exactly! I'll miss my colleagues, I'll miss the alumni, but I'll still have enough interest to keep an ear and eye open as to what's happening, and I hope not to lose touch completely.

Should be the best of both worlds hopefully, keep the social side of it…

Yes, exactly.

That'll be good!

Really good.

Have things changed in the time you've been doing this?

Yes, in all the time – from being a student myself to seeing current students is a massive difference. Also within the College, there are far more women than when I came to College. There was me, 12 girls in chemistry undergraduate first year…

That's impressive.

…and a hundred blokes!

So did you have quite a pressured academic atmosphere? I get the impression now that students are working a lot harder, they're much more focused.

Absolutely, it is. It's all focused on getting jobs at the end of it, there's little time to sit back and enjoy the whole experience. And now, as they're paying fees, instead of enjoying summer holidays trekking off with a group of friends, they're looking for placements. I mean at least leave that till second or third year. But the pressure's on them from all sides – if you don't get a placement it'll look bad on your CV, and companies look at this…

It's much more pressured.

It is.

We were very lucky.

And it was free for us.

That's right. When I was here most of the foreign students were being paid for by their governments. So they had a lot of pressure to get a first, and go back and… you hardly ever saw them outside lectures.

Sadly it still is like that to a certain extent.

If you were to sum up what Imperial can mean to today's students, to perhaps encourage them to become active in the alumni life of Imperial, what would you say to them?

Imperial means an excellent education, exposure to world-class research, which can lead to exciting careers, opportunity for many extra-curricula activities and access to alumni scattered all over the world, some in very high-powered positions.

Now, some final quick-fire questions like they do in trendy magazines.

Okay, Mac or PC?

PC.

Grape or grain?

Grape.

Favourite composer?

Chopin.

Favourite author?

Oh, tricky one, I have several. Lee Child currently.

Oh, now that was unexpected. Favourite TV show? If you watch TV.

I do sometimes! Favourite… Oh, I used to love the Pride and Prejudice series.

Okay, favourite radio station?

Only listen to the radio in the car and given Marek usually drives, we often have Radio 5 on!

Well that's our questions done. Thank you very much.

Oh, thank you!

Is there anything you wanted to say?

I'd just like to thank everybody in the associations for all the help, all the support they've given me over the years, and for putting up with me for so long.

I think it's the exact opposite! They'd reciprocate.

I've really had a ball, I've really enjoyed it. And I will have such fond memories.

Well that's a good way to end. Thank you.

Teresa is to be awarded Honorary life membership of both CGCA and RSMA. Her IE role will be largely taken on by Nic Katona.

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

Imperial engineer develops imaging tool as part of the Human Connectome Project

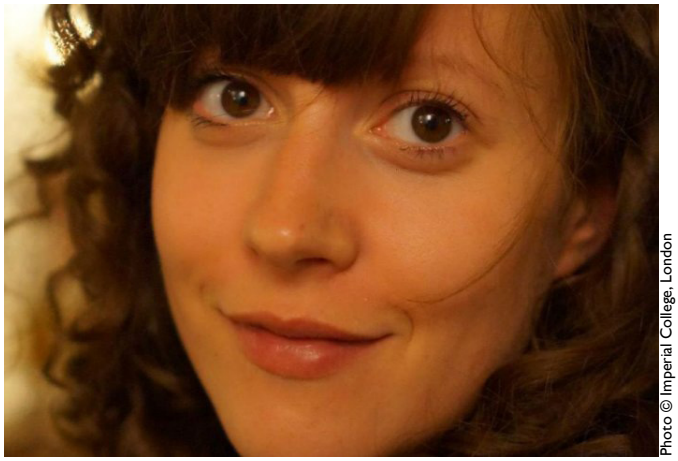


Photo © Imperial College, London

In a brief interview on the Imperial News website, **Dr Emma Robinson** from Department of Computing explains how her imaging tool is helping neuroscientists understand the functioning of the brain.

A connectome is a comprehensive map of neural connections in the brain. You could think of it as a wiring diagram for the brain. At a simple level, the brain can be seen as a relatively small number of regions that are interconnected together via neural connections. A connectome is a comprehensive map of the regions and their connections. Dr Robinson's research focusses on brain imaging, looking at ways of mapping brain activity and structure in people, using magnetic resonance imaging techniques. This is incredibly challenging as the human brain consists of approximately 100 billion neurons, and over 100 trillion pathways that connect them. At the moment, nobody knows how many regions there are in the brain or what form the regions take.

The *Human Connectome Project* (HCP) involves collecting the biggest and best quality set of brain imaging data to date. Using the data and state of the art visualisation and analysis tools, the researchers aim to better understand the brain at the millimetre scale. Researchers working on the HCP are gathering information and developing a 3D model that will enable them to navigate their way through the brain. By doing this and comparing it with genetic and behavioural data, such as gender and IQ, they hope to unlock information about how a living human brain works.

They have published a paper that is by far the most comprehensive and accurate mapping of brain regions that there has ever been. It describes 180 regions in total of which 97 have never been described before. It represents a culmination of the entire HCP project and would not be possible without the significant advances in image processing and analysis that were developed along the way. Dr Robinson's tool represents one of those advances.

The tool she has developed is called Multimodal Surface Matching (MSM). It has been vital for the HCP study because it enabled the researchers to compare and contrast brain activity across all the people who took part. This allows researchers to more confidently identify regions by seeing that each region has the same pattern of activity in each person's brain. In more general imaging studies, her tool might allow clinicians, for instance, to compare brain activity between healthy people and patients with dementia to better understand the effect that these diseases have on brain function. The tool will soon be available as part of the Oxford imaging software library, FSL.

The next steps are really exciting. She is already working on methods to improve on these results by looking more closely at how brain structure varies across different people. She is also collaborating with researchers from Kings College London and Oxford University further, on the *developing Human Connectome Project* (dHCP). They hope to replicate the success by imaging newborns and foetuses in the womb with the goal of generating a connectome. This would give new insights into the brain at a very early stage in its development.

For more information about the Human Connectome Project visit their website:

www.humanconnectomeproject.org

bit.ly/IE25-Robinson

Imperial researcher wins Royal Society award

Photo © Imperial College, London

Professor Neil Alford, Associate Provost (Academic Planning), has been recognised by the Royal Society, with the Armourers and Brasiers Company Prize. It was awarded for his outstanding contributions to materials research with benefit to society, especially the development of a type of technology that delivers a concentrated beam of microwaves, known as maser technology.

Masers amplify weak magnetic signals. First developed in the 1950s they had the potential to be used in a range of fields, including communications. However, masers were inconvenient to use – only functioning in high magnetic fields, a vacuum and freezing conditions at temperatures close to absolute zero (-273°C). They were superseded by lasers, which were more portable, cheaper and easier to use.

In 2012, Professor Alford demonstrated that masers could work under normal conditions, using less energy, without the need for a vacuum or frigid space-like conditions. His work paved the way for an improved version of maser technology to be used more widely in areas as diverse as exploring the galaxy, extremely sensitive detectors and possibly quantum computing, which could theoretically perform calculations based on the behaviour of particles at the sub-atomic level.

Professor Alford, who was previously head of the Department of Materials, said: "It has been a very exciting journey bringing maser technology out of the cold and into the 21st Century. I am absolutely delighted and honoured to receive this award. It's a reflection of the importance of materials science and it's also a tribute to the extraordinary people that I have worked with over the years."

bit.ly/IE25-Alford

Imperial renews Athena SWAN silver status

Imperial has renewed its Athena SWAN silver status, in recognition of its ongoing support for women in science. The institution-wide award, originally granted in April 2012, recognises Imperial's successful development of employment practices that further and support the careers of women in science, technology, engineering, maths and medicine.

In renewing its status, Imperial was required to demonstrate evidence that it had delivered on promises made in the original submission as well as developing new plans and initiatives.

Imperial is the first university to renew its Silver status under new criteria, which now includes gender equality in arts, humanities, social sciences, business and law departments (AHSSBL).

Imperial's Provost, Professor James Stirling, paid tribute to College staff across all departments and in the Human Resources Division who worked hard on the renewal submission. He said: "At Imperial, we know that attracting, developing, promoting and retaining the very best female staff is key to our remaining one of the world's great universities. This is why we are committed to removing barriers and ensuring gender equality at all levels across the College. Athena SWAN plays an important part in this."

Professor Dorothy Griffiths, the Provost's Envoy for Gender Equality and former Dean of Imperial's Business School, played an instrumental role in both the original submission and the latest renewal. She said: "I am delighted that the College has been recognised for all the work it is doing to support its female staff. We are among a small group of UK Universities who have achieved Silver status.

"I hope this shows the world that Imperial is a good and supportive place for women to work."

bit.ly/IE25-Athena

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

Three new Imperial Fellows announced by the Royal Academy of Engineering

Imperial is celebrating the election of three more researchers to the Fellowship of the Royal Academy of Engineering.

Professors Ahmed Elghazouli, Ron Hui, and William Jones, were formally elected in September. Becoming a Fellow is one of the highest honours that an engineer can receive in the UK, and Fellowship is awarded in recognition of outstanding and continuing contributions to the profession. The new elections take the number of Imperial Fellows of the Royal Academy of Engineering to 84.

Professor Jeff Magee, Dean of the Faculty of Engineering, said: "Whether they are making iconic buildings structurally sound, developing more sustainable electrical systems or making combustion engines more efficient, today's new Imperial Fellows deserve our congratulations. Being made a Fellow is an impressive achievement. Well done to Ahmed, Ron and Bill for their hard work and dedication. This acknowledgement is thoroughly deserved."

Photos © Imperial College, London

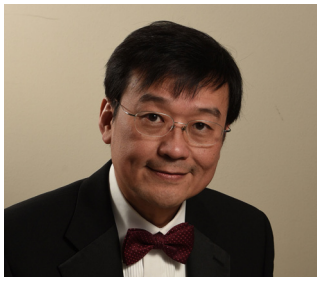
Professor Ahmed Elghazouli

Professor Elghazouli, in the Department of Civil and Environmental Engineering, is internationally renowned for his outstanding contributions to research, education and practice in structural earthquake engineering and developing buildings that can handle extreme loads. Not only has his research underpinned key improvements in design practice, but he has also been a leading design expert on notable engineering projects worldwide.

He has provided specialist seismic design expertise for iconic structures including skyscrapers, heritage centres and key infrastructure in Europe, China, the US and the Middle East. He has also advised on projects by visionary architects such as Norman Foster and the late Zaha Hadid.

Professor Elghazouli said: "This honour is coveted and acknowledges an engineer's outstanding and sustained contributions to engineering. I am absolutely delighted that I was even considered for such an honour, let alone being made Fellow.

"As an engineer, I have always been passionate about enhancing links between academia and industry. Becoming a Fellow should now offer me new opportunities to formulate strategies for further enmeshing academic and industrial interactions. I also hope to work with other Fellows on developing new policies to promote engineering nationally and around the world."



Professor Ron Hui

Professor Hui, Department of Electrical and Electronic Engineering, focuses his research on the field of power electronics, which is the process of switching between electronic circuits in order to control the flow of electrical energy. Most of Professor Hui's research focuses on new forms of sustainable lighting, technologies that transfer energy wirelessly and new sustainable energy systems. All of his work shares the common theme of 'sustainability,' with an emphasis on the reduction of greenhouse gases and cutting down the waste generated when electronics become obsolete.

Dr Hui said: "I was told about my election to the Fellowship in May this year. The glow and immense sense of satisfaction lasted many days after I heard the good news. At present, I am focusing on developing new types of renewable energy generation systems that could help to reduce greenhouse gas emissions. So, for me, the best way to think about such a great honour is to use it as a tool to mentally spur me on to do more research that could help our planet."

Professor William Jones

Professor Jones, Department of Mechanical Engineering, played a leading role in developing models that enabled engineers to evaluate airflow and the combustion process in huge industrial engines. In particular, he is internationally renowned for his innovative methods in modelling the combustion process in gas turbines, which are used to power aircraft and generate energy in power stations. Over many years, he has contributed to the industry's ability to calculate important features such as emission levels and the temperature of turbines when in operation, which is important for making them run efficiently. Among Professor Jones' many achievements, his modelling work has been used by two large manufacturers to improve their gas turbine designs.

Professor Jones, said becoming a Fellow is the icing on the cake of a long and fruitful career.

"I was a PhD student at Imperial before I began my career here in 1977. I remember the head of the Department wearing a bowler hat, dressing in a pinstriped suit and driving a Rolls Royce to work each day. I don't think you'd see many heads of departments these days coming to work in such a get-up!

"Working at Imperial for such a long time gives me a different perspective on academic life. One thing I've noticed is how hard it is now for early career academics to establish themselves. Now, there is such an emphasis on getting research funding. However, there are limited funds out there, making it harder for young academics to establish themselves. Being elevated to the Fellowship gives me an opportunity to shine a light on the good work of Imperial's younger academics who have it much harder than I did when I initially started."

bit.ly/IE25-RAEng-Fellows

Imperial engineer awarded Young Engineer of the Year

Photo © Imperial College, London

Dr Ben Britton, from the Department of Materials at Imperial, was one of only five researchers in the UK to receive the Engineers Trust Young Engineer of the Year in June. It was awarded by the Royal Academy of Engineering with support from the Worshipful Company of Engineers at the Royal Academy of Engineering Awards Dinner, at the Tower of London on Thursday 23 June. Dr Britton and the other winners each receive a prize of £3,000 for their outstanding achievements.

Dr Britton completed a DPhil at the University of Oxford in 2010 researching titanium for aerospace applications. In 2012, he joined the Department of Materials at Imperial as a Nuclear Metallurgy Fellow. Dr Britton's work on the engineering and materials science of commercially important alloys is vital to the aero-engine, nuclear and energy industries in the UK and overseas.

In 2014, he won the Silver Medal for 'Outstanding contribution to materials science from the Institute of Materials, Minerals and Mining, by an individual under 30'. Last year, he was awarded a Royal Academy of Engineering Research Fellowship and was also appointed a lecturer at Imperial.

Dr Britton said: "Recognition by the Royal Academy of Engineering through my fellowship has opened many doors and given me the confidence to embark on major research projects with an international reach. With this award, I hope to reach further and deliver new insights into the behaviour of materials in ever more challenging environments."

In addition to his research, Dr Britton directs the MSc course in Advanced Nuclear Engineering, as well as teaching two undergraduate courses and supervising and advising graduate students. He also contributes to the College's public engagement schemes through events, festivals and school visits.

Professor Peter Haynes, Head of the Department of Materials, said: "I am delighted that Ben's outstanding achievements have been recognised by this award. In addition to being a rising star in metallurgy, Ben is a terrific colleague with a passion for sharing the excitement and importance of materials with young people."

bit.ly/IE25-RAEng-Young

Mixing science with adventure

At Imperial Festival this year we were lucky enough to attend a lecture about aurorae given by Imperial Alumna Dr Melanie Windridge. Her talk was fascinating, combining the science behind the aurora with her obvious love of such a beautiful phenomenon (and the travel required to observe it!). She has written an equally fascinating book, *Aurora: In Search of the Northern Lights*, in which she also examines the cultural aspects of aurorae. We asked her to give IE's readers a taste of her enthusiasm.

I heard the roar of engines and saw the smoke, watched the bright glow grow at the base of the rocket as it lifted off into air. I watched it piercing into the clear blue sky, getting smaller and smaller. It was extraordinary to realise that at that very minute that rocket was leaving the Earth and going into space. The otherworldliness of it all thrilled me.

It was August 2000 and I was a summer student at the Rutherford Appleton Laboratory. In the lecture theatre I watched the launch of the rocket that took the second pair of satellites from the Cluster II mission up into orbit. The four identical satellites are still flying in formation now, collecting three-dimensional data on near-Earth space and the conditions that cause the aurora. The experiences of that summer stayed with me, imprinting on my mind a latent fascination with our connection with the Sun.

I went on to do a PhD in plasma physics at Imperial College, focussing on fusion energy. I was – and still am – attracted by the practicality of this research, but by the end of my PhD I wanted to see the aurora, the most spectacular natural plasma phenomenon on the planet. I also have a visceral attraction to mountains, ice and snow, and had become interested in the Arctic and polar exploration. In the aurora my passions converged. The plasma physics danced above the boundless snowy land that held me in thrall.

My fascination with the northern lights grew gradually to a point where I didn't just want to see it; I wanted to know it. I knew the basic science behind the aurora – that it is an event caused by charged particles that are channelled down magnetic field lines and interact with our atmosphere. But there had to be so much more to it than that. What caused the differences in colour, or the various shapes and patterns in the aurora? Why did we sometimes see pillars of light stretching skyward, sometimes twists and ribbons? Why is it sometimes calm and sometimes wild? Why does it sometimes move further south? It seemed I still had so many questions.

The science behind the aurora is fascinating and varied. It combines astronomy, geology, magnetism, atomic physics and more.

My first view of the northern lights was in Kiruna, Sweden, on an Arctic Science course. At the top of a ski slope, turning my back to the town and the brightly-lit mine to which the town owed its existence, I looked north, where a very quiet aurora was beginning to appear as a green, arcing haze. Over time it grew in colour and clarity, the arch becoming more defined, then breaking and twisting.

Later, my journey took me to northern Norway to learn about folklore, history, early auroral science and the beginning of our movement from myth to the possibility of knowledge. I trekked the Laugavegur route in Iceland, highlighting the geological structure of the Earth and how it furnishes us with a protective magnetic shield, without which life as we know it wouldn't exist.

The flawed paradigm

It surprised me at first that the explanation of the aurora that we hear most typically is in fact deeply flawed – that basic idea that particles from the Sun are channelled to Earth by our magnetic field. This alone cannot explain the bright night displays. Solar particles – predominantly electrons – simply do not have enough energy to cause the vibrant colourful lights, so they must be *accelerated* somehow. Besides, if electrons are captured by the magnetic field and funnelled directly to Earth they would hit Earth on the side facing the Sun – in other words, during daylight. It is impossible to see the aurora in broad daylight. The auroral light is too weak and diffuse to compete favourably against light pollution from cities, let alone against strong sunlight.

It would be more accurate to say that *"the aurora is caused by charged particles from the sun interacting with the earth's magnetic environment to accelerate electrons into the earth's atmosphere."*

It's a small but vital difference. To simply talk about particles being funnelled to Earth is a misrepresentation of the facts. It also implies that we have a full understanding of the mechanisms of the aurora, many of which are still under debate. Importantly, it focuses attention on the particles themselves rather than the bigger question of where the energy comes from to generate these awe-inspiring light displays.

Eric Donovan, Professor at the University of Calgary, is astonished that when people talk about the aurora they need to know where the electrons come from. When we flick a light switch, causing a stream of electrons to flow through a circuit and transform their energy into light in a bulb, we don't ask where the electrons came from because it is irrelevant to the mechanism of the transfer of energy. "The solar wind matters for the aurora because it's where the energy comes from," says Eric. "It's how the energy of the solar wind becomes the aurora – that's the interesting bit."

But then how, you might be wondering, do charged particles get around to the night side of the Earth and create the northern lights there? And how are they accelerated to the higher energies required for those more vivid, colourful displays? That is the magic and mystery of the true aurora, which I explore in detail in my book. Here is a summary.

Auroral origins

The origins of the aurora are right back at the Sun. The Sun is always throwing out charged particles – a moving plasma that we call the solar wind. On top of this, sometimes the Sun releases more matter into the solar system as the twisted magnetic field lines of

Photo: Catherine Bateson

Aurora in Kiruna

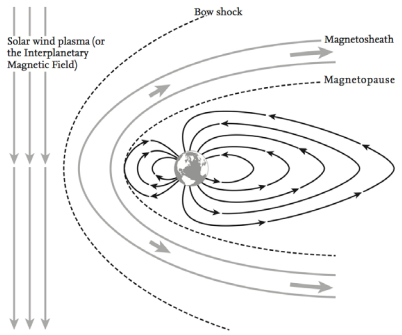


Figure 1. As the solar wind hits the magnetic field of Earth it is deflected around the outside, flowing in a layer called the magnetosheath. The Earth's magnetic field is stretched out behind. The cavity of the Earth in the solar wind is the magnetosphere and its boundary is the magnetopause.

– tales of an aurora hunter

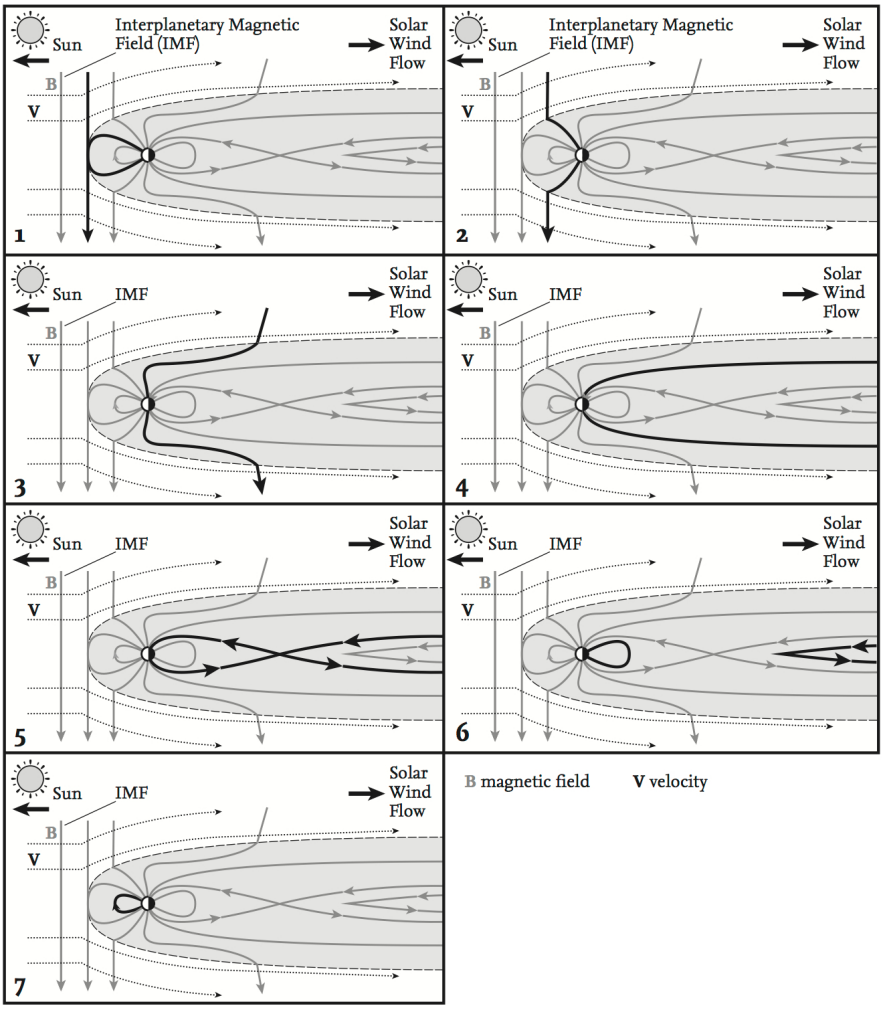


Figure 2. The Dungey Cycle. Magnetic field lines are opened up on the Sun side of Earth, dragged (with their plasma) over the poles and laid down on the tail side. Here they push down until reconnection closes the field lines once more and they migrate sideways back to the Sun side of the Earth. This cycle can continue as long as the magnetic field of the solar wind is pointing southwards.

the Sun break in a solar eruption or even a giant *coronal mass ejection (CME).* A coronal mass ejection is enormous! The Sun throws out billions of tonnes of matter into the solar system travelling at millions of miles per hour. We and all the other planets in the solar system sit in this turbulent sea of plasma.

This solar wind is constantly buffeting the Earth, sometimes weakly, sometimes strongly. All these fast charged particles would be dangerous to life, but the Earth has a magnetic field, which forms a protective magnetic shield called the magnetosphere, see Figure 1.

The Dungey Cycle

The solar wind is deflected around the magnetosphere when it hits Earth, but it also transmits some of its energy to the magnetosphere – it's like it pumps it up, or sets it ringing like a bell. This effect is particularly strong when the solar wind magnetic field direction is southwards.

The magnetic field topology of the magnetosphere is changed during the process, see Figure 2. Field lines from the front of the Earth are broken apart and dragged over to the back, where the "tail" of the magnetosphere is squashed so much that magnetic fields break explosively again – in a process called reconnection – and catapult electrons from within the system to Earth.

These explosive bursts of reconnection in the tail fire particles down towards Earth on the night side, which is why the best and brightest aurorae are seen on the back side of the Earth. These explosive events are called substorms.

This re-configuration of the Earth's magnetic field during a substorm is called the Dungey Cycle, after Imperial College physicist Jim Dungey who originally proposed the idea in the early 1960s. It is the cycle of the field lines, and of all the plasma within the magnetosphere constrained to follow them. Steve Milan from the University of Leicester once described the field line pattern of the Dungey Cycle to me as the magnetosphere performing Tai Chi: open; over; close; around; repeat.

Looking down on the Earth from above, if we could see the field lines we would see a central hole of open field lines stretching out into space around the poles. It is at the boundary where open field lines reconnect into closed ones that we see the aurora, like the footprint at the end of the field line. Seen from space, this footprint takes the shape of an oval of light around the pole – the auroral oval.

Reconnection is triggered through a sequence of events that has been the subject of study for at least forty years and that no one really understands properly yet. The Dungey Cycle offers a good global picture, but the actual onset of reconnection has to do with the microphysics that is going on in the reconnection regions. Currents are also involved because they exist due to the movements of charged particles and at the boundaries of plasmas, such as around the edge of the magnetosphere or bisecting the tail. The whole system is interconnected. Around reconnection events the tail current becomes disrupted and some current flows along the field lines into the ionosphere. No one knows yet whether the disrupted currents trigger the reconnection or whether the reconnection triggers the currents. This is one of the biggest open questions in the field and is known as the 'substorm problem'.

Arctic Adventures

Travelling in Canada, visiting small

Photo: Chris Sinclair

Melanie watching the aurora in Scotland

observatories shut down for Summer, I learned how images of the aurora can tell us about what is going on beyond our globe, about the intricate interplay of the solar wind and the Earth's magnetic field described above. I explored how early twentieth century technological advances in photography and spectroscopy helped understand the heights and colours of the aurora. And I learned how, with our ever-advancing communication and space technologies, we found out that there is a darker side to the northern lights. The same solar events that cause incredible aurora displays can knock out power grids, damage satellites and scramble our communications. 'Space weather' is becoming an increasingly important research topic.

Finally my travels took me to Svalbard in February, where I skied out from Longyearbyen towards the frozen East Coast – just me and a guide – so I could see the aurora in a true wilderness environment, as the old polar explorers would have done. The Sun was not yet risen from the Arctic winter; we skied through a milky-blue twilight. The trip was more intense – more brutal – than I could have imagined. I realised then that out there everything becomes about survival and nothing else matters.

The first two days were simply white. The light was flat and the sky a barely-there grey. No sun, no colour, no contrast. Low mountains rose up on either side – white with high, grey rock bands. The land was windswept ice.

In the afternoon of the second day we emerged into the vast and beautiful Reindalen – a wide, long expanse edged by flattened mountains that looked like a giant line of piled white sugar subsiding into the valley. We were skiing mostly on icy crust, so pulling the sleds was relatively easy, but we were accompanied always by the loud scraping sound of skis over uneven, frosty ice. It was too loud to talk. We progressed in our own individual worlds.

Every hour or so we would stop for a very quick break, putting on a down jacket immediately. I would sit on my sled and drink some water from my thermos flask, eating a few nuts or a biscuit, always swapping my hands in my mitts between each action that required the dexterity of free fingers – it was the only way to prevent the fingers becoming painful from cold. Despite my best efforts they would hurt anyway, and it was always a relief to start skiing again and for the pain in my fingers to gradually diminish.

Day three was in colour. It was clear and the sky showed a tinge of blue. When the Sun rose, although we didn't see it, it licked the top of the mountains and painted them a pinkish hue. The whole sky near the horizon turned an orangey-mauve, like watercolour blood orange. We made our way quickly down the flat, lavender-tinted valley, travelling at what felt like a fast walking, or slow jogging, pace. It got colder. Temperatures dropped to almost -40.

That third evening we saw the northern lights. We looked out at around eleven o'clock and there they were – a faint greenish white, stretched out east–west across the whole sky, reaching up in places like towers to the heavens. From where we were camped we had a wide view and it was beautiful to see the lights over the full horizon.

Photo: Svante Strand

Skiing in Svalbard

An incredible ending/Solar Eclipse

A month later the Sun was back (I had missed it) and I watched the total solar eclipse in Svalbard – one of only a few thousand people. Wrapped up in down clothing and standing in a wide, frozen valley, I stood and stared at a black disc in the sky and its wispy silver halo. I smiled in awe and disbelief that I had been able to witness such a rare sight in such an incredible place.

Looking up at the corona and seeing the solar wind streaming away from the Sun, I was able to reflect on how intimately connected we are with the Sun on so many levels. I thought back over my journey and about all I had learned: from my first taste of the Arctic two years previously, to standing there in the snow on Spitsbergen seeing one of the most incredible sights on the planet.

I was at the end of a journey of discovery. It had been an incredible time. Beyond the science of the aurora, I had learnt about the landscapes and cultures, the histories of people who devote their lives to the pursuit of an idea or a goal. I learnt about the strength of the human spirit, our capacity for pain, endurance, loss and renewal.

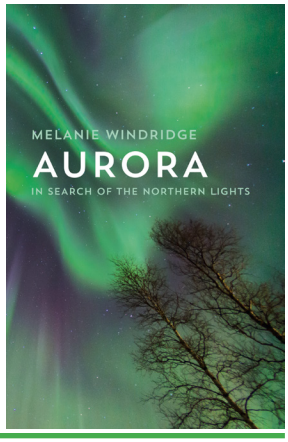
The aurora is our connection with the Sun. It is how our little planet protects itself from the streaming charged particles of the 'solar wind', absorbing the energy in its magnetic field and dissipating it as an incredibly beautiful light show. But it's more than that too. It's the people, the places the landscapes and the stories – this is what brings the aurora to life. Plasma physics has never been so beautiful.

Photo: Ivar Marthinusen

Eclipse in Svalbard

Dr Melanie Windridge is a plasma physicist, speaker, writer… with a taste for adventure. Her book *Aurora: In Search of the Northern Lights* was released in February 2016. Melanie has a PhD in fusion energy and is Business Development Manager for fusion start-up Tokamak Energy, as well as working in education with the Ogden Trust, Anturus and Your Life. Melanie loves the mountains and believes science and exploration go hand in hand. Find Melanie at www.melaniewindridge.co.uk and on Twitter, Facebook and Instagram.

Aurora: In Search of the Northern Lights is available on Amazon and in all good bookshops.



Explanation for the northern Pacific Blob

The Blob, the name given to a large mass of surficial warm water about 2.5˚C higher than normal in the northern Pacific Ocean, was first detected in late 2013. It has continued to spread and persisted until early 2016. This abnormal oceanic condition has an important role in the abnormal weather conditions experienced in the Pacific Coast. Its cause has remained a mystery until now.

Submarine volcanic eruptions are an important natural means for the switching on of hot seawater in oceans. In this report, the timing of such an event is used to explain the Blob appearing in the northern Pacific Ocean from autumn 2013 persisting into 2016.

Wikipedia has provided an account on the Blob. http://bit.ly/IE25-Blob

Nicholas Bond of the Joint Institute for the Study of the Atmosphere and Ocean, University of Washington first detected the circular body of abnormally warm seawater in the northern Pacific Ocean for which he coined the term "The Blob".

Initially the Blob was reported as being 800 km wide and 91 m deep. It expanded and reached the size 1600 km wide, 1600 km long and 91 m deep during June 2014 when the term "The Blob" was coined. In February 2014, the temperature of the Blob was about 2.5˚C warmer than what was usual for the time of the year.

Wikipedia has provided another account on the Nishino-shima volcano located 940 km south of Tokyo with details of the 2013 to 2015 eruption. http://bit.ly/IE25-Eruption

In November 2013, an eruption created a new island south-southeast off the shore of Nishino-shima Island. By December 2013, the island rose 20 to 25 m above sea level, with an area of 5.6 km^2. By December 20, 2013, the island had grown fast enough for experts to predict that it would probably join up with Nishino-shima before the end of 2013, and cease to be a separate island. On December 26, 2013, the Japanese Coast Guard confirmed that the two islands had joined.

During July and August 2014, lava flow increased, causing the island to expand rapidly to the east. Between September and December, the lava flow increased further and headed north, almost completely overrunning the pre-existing island. On December 27, 2014, Japanese authorities said the island had reached nearly 2.3 km^2 in diameter, was estimated to rise to about 110 m above the sea level and was still active.

Eruption continued throughout the first half of 2015, and the island continued to expand. By August, the volcano ceased to erupt smoke and ash, but continued to emit lava. As of September 16, 2015, the total area of the island had decreased slightly, but the fumarolic zone had expanded as "vigorous volcanic activity continued without significant change".

The Blob was created by natural submarine volcanic activity. Three blobs of warm water seen off the North American coast, ranging from Alaska to Mexico dated September 1, 2014 can be explained by pulses of eruption activity transporting the warmer surficial waters to these locations.

Because of the existence of warmer surficial seawater in the northern hemisphere, cooler waters from the southern hemisphere were drawn northwards. This may help to account for the observed contraction of Arctic Ocean sea ice and the expansion of Antarctic Ocean sea ice.

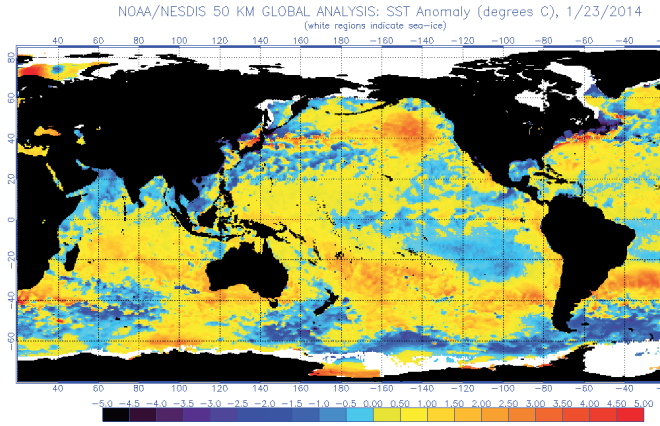
The timing of the volcanic eruption and the Blob is therefore close to perfect.

In conclusion, the warm sea-surface temperature observed in the Blob was initially caused by the submarine eruption of the Nishino-shima volcano. The patterns of regional temperature changes observed in the northern Pacific Ocean was merely nature's way of returning temperature in equilibrium back to normal through ocean circulation. Variation in atmospheric carbon dioxide cannot be a solution to such localized changes. Furthermore, a possible role for the Blob in the development of the exceptionally strong El Niño year experienced during 2015 cannot be ruled out.

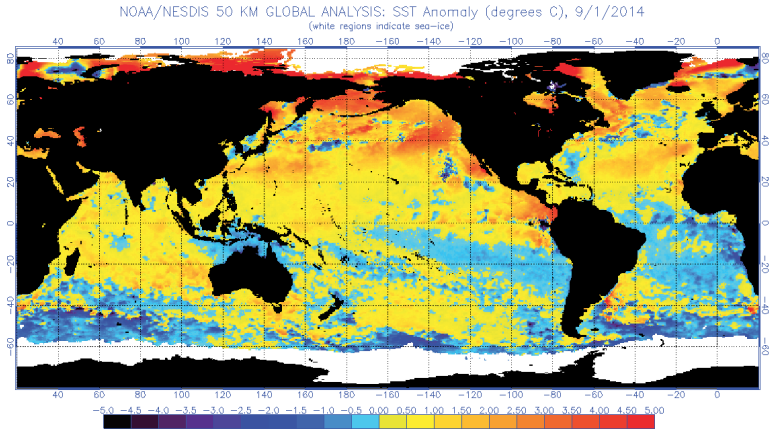
Thanks are due to Wikipedia for providing the information needed for this study.

Photo: Japan Coast Guard

Submarine eruption off Nishino-shima volcano with the new volcano rising above sea level on November 21, 2013



Global map of sea-surface temperature anomalies showing the Blob in the northern Pacific Ocean on January 23, 2014 (northern hemisphere winter)



Global map of sea-surface temperature anomalies showing the Blob sub-divided into three parts in northeastern Pacific Ocean on September 1, 2014

Professor Wyss Yim DSc PhD DIC FGS was at Imperial College in the Department of Geology from 1971-1974. After that he spent 35 years until retirement at the University of Hong Kong where he taught civil engineering, geosciences and environmental management students, and, helped found the Department of Earth Sciences. He was awarded the DSc by the University of London in 1997. Wyss served as the Deputy Chairman of the Climate Change Science Implementation Team of UNESCO's International Year of Planet Earth 2007-2009.

Alaskan Expedition

We often receive reports from student expeditions, especially if they've been supported by CGCA or RSMA (or their Trusts), that make interesting reading, so we try to include them as articles here in IE. For some reason this report didn't make it to the editorial team until this year, but their report was too good to ignore and so many of their photographs were stunning that we are including it now, somewhat belatedly (for which we apologise).

In September 2011, a team of four Imperial students, aged between 20 and 25 years, post-graduates and undergraduates from different scientific disciplines, started organising an expedition. All had notable mountaineering experience and were members of the Imperial College Outdoor Club (ICOC). The team comprised: Sara Arbós Torrent, Team Leader; Boris Korzh, Equipment and Finance Officer; Sam Thompson, Logistics and Medical Officer; and Arnaud Sors, Photography and Communications Officer.

Arnaud, Sam, Boris, Sara

Their aim was to combine good skiing with good alpine climbing. Thus, the team was looking for an area that was remote with potential to attain first ascents, relatively easy access in order to maximise their time on the glacier, with peaks that could be summited in a single day, and in a region that was 'in season' in June due to exam constraints. These conditions determined Alaska as the final destination for the expedition, and weather was the primary factor taken into account in deciding the final region within Alaska.

The team planned to live for a month, unsupported, on the ice and rock of the rarely explored territories of the Saint Elias Range; more specifically, the Jefferies and Fraser Glaciers. None of the members had been to Alaska before. The expedition provided a great opportunity for them to learn how to adapt to the conditions there. Their general objectives before departure were to:

- Return home safely having enjoyed the challenges and unique environment of Alaska.
- Explore rarely visited territories of the Wrangell – St Elias National Park and Preserve.
- Attain first ascents of previously unclimbed peaks using both ski-mountaineering and alpine climbing techniques.
- Identify other potential objectives in the area for future expeditions.
- Obtain relevant aerial photographic material both of the objectives and the glaciers.
- Inspire other members of Imperial, as well as the wider mountaineering community, to explore Alaska.
- Extend the ski mountaineering, alpine and expedition experience of all members.

Returning from the expedition, the team considered that all these objectives had been met, except for the kite aerial photography.

Planning and Preparation

The expedition dates – June to July, 2012 – were chosen in order to maximise the probability of reasonably stable weather conditions (long days, good snow quality, minimal precipitation). Extensive research was carried out in order to be able to determine, as accurately as possible, the previously climbed mountains in the region of interest. Information about the logistics used for this type of expedition was also sought. The team organised the travel arrangements, planning and gathering of the equipment required, procuring the cooking stoves, gas and fuel, as well as the buying and sorting of all the food, themselves.

With few roads, often in poor condition, the region visited can only be reached by flying with Ultima Thule. Ultima Thule is, in fact, a luxury lodge – one of the very few private properties in the heart of the Alaskan National Park – hundreds of miles away from any road; hence, it can only be reached by plane. The lodge is run by Paul Claus and his family. Paul is an excellent pilot and, as an avid climber, has claimed most of the first ascents of the climbed mountains in the area. As a side business, he runs charter flights to and from remote areas for climbers.

Whenever the team operated in pairs, each pair carried a large range radio which allowed inter-team communication. This system was implemented to ensure that help could be provided should something happen to any of the party members. Communications to the outside world were made via a satellite phone. Coverage was sometimes low and sparse although they always managed to establish connection. The team made a special effort to keep frequent communication with the outside world and daily satellite messages were sent to a previously set up twitter account. Daily weather reports were sent to the satellite phone thanks to the invaluable help of Jonathan Phillips.

The team brought three cameras, in order to make sure there would be at least one per team of two climbers, even if one broke down or ran out of battery. They used two compact cameras

Photos by Arnaud Sors

Unloading Paul Claus' Otter plane

and one Nikon D3100 DSLR, with a versatile 18-105mm stabilised lens. In addition, the team also had three Go-pro Hero2 cameras. These were used to record some ski descents as well as to capture slow processes such as the igloo building progress, where a picture was taken every minute. Finally, these cameras were also used when trying to implement Kite Aerial Photography.

Eager to experiment with Kite Aerial Photography, KAP, whilst on the glacier, the team brought a moderately big (about 1m2), one-line lifting kite. Such kites cannot be guided; they simply inflate and keep a stable position in the direction of the relative wind. Underneath the kite, they attached a Go-Pro camera. The angle of the kite line relative to the ground varies depending on the strength of the wind.

They were not able to perform static pictures because of the general absence of stable wind. Most of the time there was no wind at all, or not enough to sustain the camera and its loading, even though the system had very good lifting capabilities. On rare occasions they witnessed stronger but irregular winds which did not provide good flying conditions for the kite. So they sought an alternative method in order to generate the required apparent wind; flying the kite behind them whilst skiing. Towards the end of their stay, they were just below the summit of Whale peak. This provided a non-stop ski descent to the base camp with an altitude height difference of 700m. They managed to film the whole descent which resulted in a 5 minute-long skiing aerial video.

Expedition Journal

Day 1 - 1st June

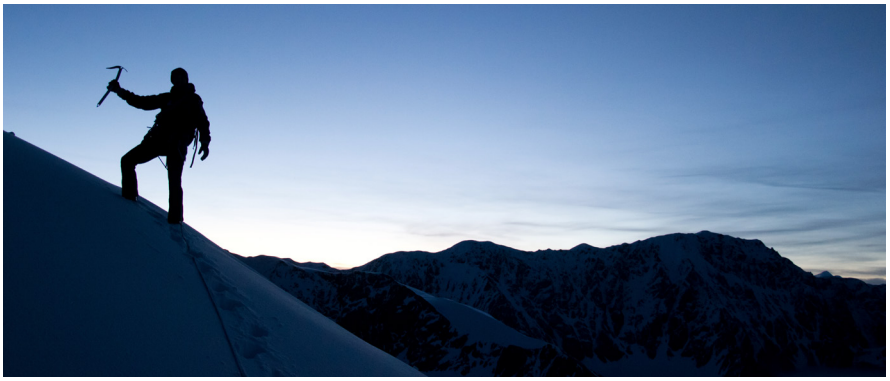
Sara and Sam left for Alaska from Heathrow airport. They arrived in Anchorage just before midnight and took a taxi to the hostel.

Day 2

After a hearty breakfast, they started to sort out all of the equipment, including the kite and the GoPro cameras which had been posted there.

Day 3

Today was dedicated to food shopping. It was



possible to take Coleman fuel from the hostel, since many people leave their unused fuel there before flying home.

Day 4

Having remained in the UK for a few more days, due to exams which they had to complete, Arnaud and Boris left London at 9:30am and arrived in Anchorage at 7pm, leaving just enough time to do all of their packing.

Day 5

The team was picked up at 5am by Paul Claus' parents. The weather was perfect for flying, so as soon as the team arrived at the Chitina airstrip, they loaded up the single Otter aeroplane. After a stern briefing from Paul Claus, they took off and flew to the head of the Jefferies Glacier, with the base camp being set up directly at the landing spot. This meant that Arnaud and Boris had transferred from London to the glacier in under 36 hours! As soon as the tents were set up, the team started to construct an igloo in order to have a communal area.

Building an igloo

Day 6

There was hope for a ski tour today, but cloud and snow set in, so the team remained at base camp and completed the igloo. An inventory of the food was carried out to check that everything was in order.

Day 7

The weather cleared and the whole team set off on their first ski tour/climb. A 10,213 ft peak near base camp was targeted, and the name of Alopecia Peak was suggested due to the patchy snow on the rocky slopes. At the summit a white-out had set in, but would occasionally break, allowing Arnaud to carry out a full ski descent of the same route used for the ascent. Everyone was happy to reach the first summit so early on and celebrations with a little whiskey were in order.

Day 8

Bad weather returned and the team relaxed, starting the first of many books that would be read throughout the expedition. The temperature warmed up significantly, causing the igloo to start dripping inside.

Day 9

Clear skies and the absence of any wind in the morning, allowed a ski ascent of Whale Peak (10,730 ft). The view at the top was outstanding: all of the surrounding peaks, and Mount St Elias visible in the distance. While there, the team reccied several routes on the neighbouring Ocean Peak. Then an immaculate ski descent all the way back down to base camp.

Day 10

Following two different routes, Sara and Arnaud (S&A) climbed together, starting at about 3am, whilst Sam and Boris (S&B) started at 7am, summiting Ocean Peak just after the first team, to perfectly clear skies. S&B took their skis to the summit, and after a traverse across the summit ridge could complete the same ski descent undertaken the previous day.

Day 11

The team decided that it was time to start moving around to explore other areas before returning to base camp one week before the planned pick-up date but, with heavy snowfall all day and 30cm of fresh snow settling, the day was spent resting and packing.

Day 12

The heavy snow continued, so the team remained at base camp for another day.

Day 13

Finally, the opportunity to move. The team relocated to the head of the Fraser Glacier, a journey of over 8 hours with the last half being completed in a full white-out. However, using GPS, this did not present too much of a problem.

Day 14

It was decided to move the camp slightly further down the glacier to avoid the large crevasses and to be in a better position for returning from climbs. The tents were loaded erect on top of the pulks (sledges) for the move, saving significant effort. The weather was still poor, so nothing else was done.

Day 15

S&A went out for a ski tour to a col at the top of the glacier, even though there was a complete white-out and progress was only made with a map, compass and GPS. A few hours after their return, at 7pm, the skies miraculously cleared and the team had a full view of the area for the first time. Extremely excited, S&A decided to ski tour Baldtop peak via its west face. S&B had their sights set on the north face of Mount Short (11,003 ft) which stood directly above the camp. However, before making an attempt on the route, they needed to reccie the descent route down the east side of the mountain. After successfully spotting a possible descent route, they returned to sleep before setting off in the morning.

Day 16

S&A summited Baldtop peak just after midnight and were rewarded by an outstanding sunset, they then proceeded to ski down the same face, which was the skiing highlight up to this point. S&B started climbing at 7am and summited Mount Short at 2pm. The full team united back at base camp, before S&A set off again on another short mission to reach a point at about 9,600 ft. Once back for the night, everyone celebrated with a quick whiskey.

Day 17

To take full advantage of the good weather, the full team did not rest and summited another peak, Eleanor Peak (10,153 ft). From here they traversed to the top of Baldtop peak to complete the exquisite descent of its west face.

Day 18

A few other peaks interested the team in this

The view from Flying Peak

area, although everyone was ready to move down the glacier to the next location. In order to maximise the number of climbed peaks, the team split up once again. S&A went for a high peak, which they subsequently named Cantaloupe Island Peak and managed to complete half of the descent on skis. S&B focussed on two smaller peaks, linked by a ridge, which they traversed. Clear weather all day.

Day 19

With a large number of peaks summited in the vicinity of the camp, the team was happy to move to the next location, further down the Fraser Glacier, which would give access to the highest peaks in the area. On the way down, they hoped that Siri Peak would come into view, but it stayed hidden further up a subsidiary glacier. Instead, the north face of Mount Hope provided plenty to look at.

Day 20

Bad weather, right on cue, meant the team had time to rest up.

Day 21

It was time to get to know the area better. S&A enjoyed a quick ski part way up an east face, opposite camp, followed by a skin up halfway up the two main subsidiary glaciers to get a better view of the available routes. S&B had their sights set on Siri Peak. It wasn't practical to attempt the climb starting from this camp, so they packed equipment into the pulks and skied up to the base of the mountain, to enable an early start directly on the route.

As they approached the mountain, it became obvious what route they would take the next day, a magnificent wide gully striking a direct line to the summit.

Day 22

A very eventful day.

S&B set off at 5am, their route consisting of perfectly hard and sticky neve. Progress was exceptionally quick with the pair topping out at 7.40am. The view was magnificent, dominated by Mount Logan, which now seemed very close. It was decided that the route name would be 'Imperial Gully' as an acknowledgement of the expedition's main supporter and the grandeur of the route.

In the meantime, S&A climbed Flying Peak. They reached the summit but, unfortunately, the descent via the north-west ridge turned out to be quite substantially more serious and technical than expected. After digging through a cornice from the summit, to set foot on the underlying slopes, they progressed along the top of the ridge and came upon another wind-sculptured snow accumulation that included a cornice-like overhanging ledge. After digging through it again, they down-climbed 10 metres of ice and reached easier terrain which led to the south col. At that point it was almost 2pm and the snow on all surrounding slopes had fallen down in superficial but wide avalanches in all of the south-facing gullies. Given that their supplies of water and food were very limited at that point, S&A decided that the best option was to go down anyway, trying to be as fast as possible. They unroped because the slope was not very steep, but at some point Sara lost control and slid along the slope. Unfortunately an ice screw caught her leg and injured her. They managed to descend safely to base camp but it was decided that it would be better for Sara to be evacuated.

Day 23

Paul Claus arrived early, to pick up Sara and take her to the hospital. The remaining members of the team decided to stay for the rest of the expedition.

Day 24

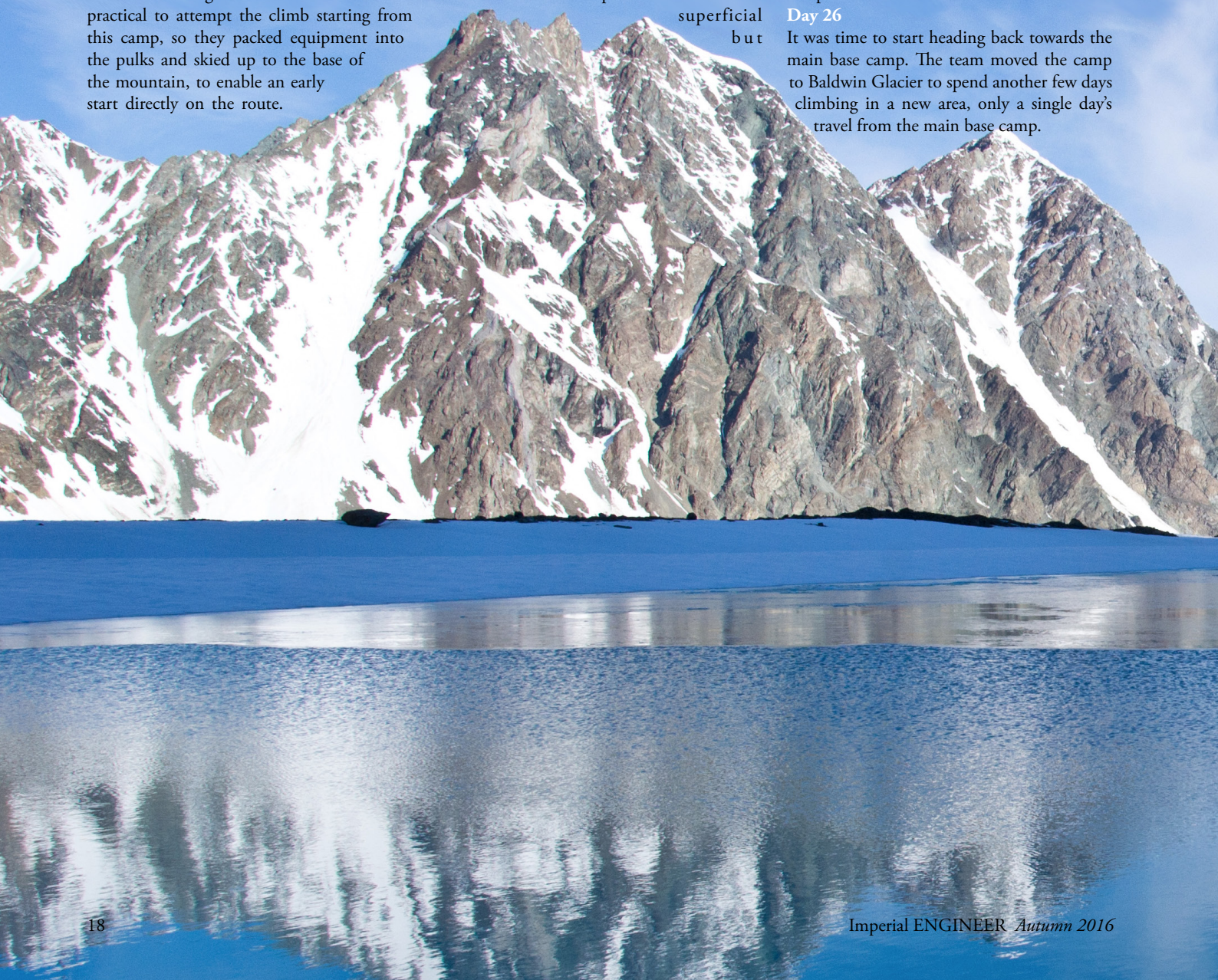
The team ski-toured further down the Fraser glacier to reach another subsidiary glacier to its east. From here, an ascent of the east face of Mount Crystal was made. On the way to the mountain, the team came across a glacier lake and undertook some water skiing.

Days 25

The team wanted to make an ascent of a previously unclimbed M85, in the vicinity of the camp. However, the weather conditions started to become very unstable, so a day at camp was forced.

Day 26

It was time to start heading back towards the main base camp. The team moved the camp to Baldwin Glacier to spend another few days climbing in a new area, only a single day's travel from the main base camp.



Days 27 to 29
All plans of climbing or skiing were thwarted by shocking weather conditions.

Days 30 and 31
With the dehydrated meals almost finished, the team gave up hopes of climbing near the Baldwin Glacier and moved back to base camp. The change of diet was much appreciated by everyone, the most popular ingredients being the smoked salmon and maple syrup. The weather remained bad.

Days 32 and 33
Finally, at 9pm, the skies miraculously cleared. Not willing to waste the opportunity, preparations were made to set off for a night climb. Even during the darkest time of the night, there was enough light to climb without a head-torch. The summit of Forgotten Peak was reached at 2am, followed by an excellent ski descent of the main glacier back to base camp at dawn. Climbing in the early hours of the morning in the Alaskan twilight was a surreal and magical experience.

Day 33
With acceptable visibility and the kite aerial photography kit in hand, the group ski toured once more to the head of the Jefferies Glacier. A successful video shoot was pulled off with a GoPro camera attached to a trailing kite during the ski descent.

Day 34
Time to prepare for departure. The pilot was contacted to inform him of the current weather conditions. To kill time, two of the team did some ice climbing in a crevasse, by lowering in and climbing back out on top rope.

Day 35
In the morning, the slightly changeable, but hopeful, conditions were sent to the pilot once again. Instructions were received to start packing up and we waited patiently, occupying the time with some video making. To the team's disbelief, just as they heard the plane approaching, cloud suddenly came in and they heard the plane departing. As despair began to set in, and not for the first time during the expedition, a miracle happened; Paul Claus came flying in, under the cloud, a gap of probably just 50m! Needless to say all the equipment was quickly stacked inside the single Otter aircraft and the team flew back to the Ultima Thule Lodge. There they experienced a wonderful Alaska sauna, followed by a somewhat uplifting debrief with Paul. After another short flight to Chitina, they were back in Anchorage the same day.

Days 36 to Day 40
Contingency days were spent in Anchorage, with multiple visits to gear shops, bars and the supermarket.

Flights back to London and San Francisco (two of the members headed straight to Yosemite after the expedition) were caught on the 10th and 11th July.

Summary

We encountered some granite but generally the rock was of poor quality and loose. We therefore picked our routes based on the quality of ice and snow on a particular line and avoided any long sections of rock (apart from ridges). There were a number of north faces that were in good condition. These offered the most technical climbing in the safest way. The grade of climbing ranged from *facile* to *difficile*, D. The majority of routes climbed were around *assez-difficile*, AD.

We identified a number of unclimbed faces and peaks that could form part of a future expedition to the area.

Climbing in such a remote and wild location was an amazing experience. The routes were not especially long but often had technical sections and could be descended by alternative routes. Half of the time spent on the glacier (fifteen out of thirty days) was spent climbing or ski-mountaineering.

We climbed a total of thirteen peaks, the majority of which were previously unclimbed: Alopecia Peak; Ocean Peak; Mount Short; Sam Peak; Boris Peak; Eleanor Peak; Cantaloupe Island Peak; Flying Peak; Mount Crystal; Forgotten Peak. We also established new routes on some of the peaks that had already been climbed, via interesting unclimbed lines which offered great technical climbing. One such line we named Imperial Couloir.

Navigation
Navigation was not a problem most of the time. We took two GPS devices and accurate maps. We also used snow wands to mark out each camp in case of a white-out. We rarely ventured out when the weather was in white-out conditions, however, we were sometimes caught in one. The GPS devices were very good and made accurate waypoints.

Weather
The weather was extremely mixed over the course of the 31 days we spent on the glacier. This was mainly due to the maritime weather system that operates in the area. Half of the days we spent on glacier had high pressure and clear skies, the other half were poor, with snow and high winds. We had updates on fronts approaching via satellite communications and could generally plan accordingly. We had occasional 20 cm dumps of snow overnight. When followed by a warm spell this made certain slopes highly avalanche-prone and we heard several naturally triggered avalanches. The maximum wind speed we experienced was around 50 mph. In general, aside from on the ridges, the wind did not pose a problem.

Communications
As mentioned earlier, we had two-way radios for communication between the climbing pairs, and a satellite phone to communicate with the outside world. The satellite phone also had its own solar panel, but to provide flexible charging options a Power Monkey battery was used as a back up charging source, during night time or overcast periods, which could be charged using a dedicated solar panel. The Power Monkey was also used to charge personal mp3 devices.

For emergency purposes, an EPIRB (emergency position-indicating radio beacon) was taken to assist evacuation in extreme situations. The EPIRB, satellite phone and solar panel were borrowed from the Imperial College Exploration Board.

Environmental Considerations
We tried to be as environmentally conscious as possible, taking all our litter and waste out with us, burning it at Paul Claus' lodge.

Whilst at base camp we also created a lavatory that could be removed on leaving the glacier. All our

human waste at base camp was taken out with us and disposed of at Paul Claus' lodge.

Medicine

All team members had Expedition First Aid Qualifications, covering all the basics as well as some more complex scenarios of lifesaving in remote and mountainous environments. A comprehensive first aid kit was taken, which included a main base camp kit and two smaller climbing packs.

In the accident that occurred on the evening of the 22nd of June, Sara took a fall and suffered lacerations on her leg, caused by an ice-screw cut. No bleeding was present at the time of injury and she was able to safely return to base camp on her own account. First aid treatment was performed upon arrival at base camp. Although the injuries were not life-threatening, evacuation was considered necessary in order to avoid infection and provide better stitching. Emergency protocol was followed and evacuation took place on the following morning, with hospital treatment being received in Anchorage. The emergency and contingency plans showed good performance when implemented and no other medical problems occurred.

The team would like to thank the Exploration Board, with a very special mention for Dr. Lorraine Craig, for their help and support during the evacuation process. We would also like to specially thank Martin Boniek, the pilot from Wrangall Air who, in his own spare time, took Sara to Providence Hospital, waited while the treatment was taking place and then kindly helped Sara find a suitable place to sleep. There are no words that can describe the kindness and generosity he showed.

Skiing

As pioneers in the Alps have stated, ski touring is the best way to travel the mountain in winter. We encountered almost exclusively snow terrain, and skis proved to be a huge asset during travel on the glaciers: to move camp, access routes, and to make rapid descents from mountains. On soft or crusty snow that would break under the pressure of a bare shoe, skis allowed much faster access to all summits and generally saved a lot of time on the way down. Thanks to the skis, the fact that glaciers were enormous did not cause any problems.

Terrain and Snow conditions

The area of the Wrangell mountains that we explored is mainly composed of large glaciers which are not very steep. Mid-sized mountains emerge alongside the glaciers, most of which are generally steeper than those one is used to in the European Alps. Snow conditions were often similar to those encountered in the Alps at the beginning of spring except that, most of the time, the snow layer was much thicker. Bad weather was quite frequent, and over the duration of our stay it snowed between eight to ten times. However, most of the time, the quantities of fresh snow were quite small.

Future potential

The potential for skiing in the Wrangells for good skiers is infinite. Some of the summits, such as Baldtop peak or Flightpath peak are a 'frequent' destination suggested by Paul Claus for his clients, but virtually everything else, especially if it is technical, has never been done before. Even around the four base camps we operated from, there are a number of steep couloirs that have not been skied yet, especially on west sides that also offer the advantage of not heating up too much in the morning.

Pulling a heavy pulk

Acknowledgements

The Team would like to thank the Imperial College Exploration Board for their invaluable help, support and advice, especially Dr. Lorraine Craig. We would also like to thank the financial support given to us by the Gino Watkins Memorial Fund, the Old Centralians Trust, the Mount Everest Foundation, the Alpine Club, the Andrew Croft Memorial Fund, the British Mountaineering Council, The Eagle Ski Club, the Photonics Academy of Wales and the Augustine Courtland trust.

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We would like to thank the IC Obra Vally, IC Reru Vally and IC Svalbard expeditions for their help and advice while planning this adventure. Thanks to David Swinburne and Stuart Howard for their advice on Anchorage hostels and general information on how to plan an expedition to Alaska. We are also indebted to Steve Gruhn for the invaluable information about the climbed and unclimbed mountains in the area visited.

Also we would like to send a very warm thank you to Paul Claus, the Kenicott Rangers and specially Martin Boniek for their help in Sara's evacuation.

Finally, and most importantly, a very especial thank you to Jonathan Phillips, without whose invaluable help, advice and expertise as well as his daily weather reports, this expedition would never have happened.

Hydraulic Fracturing in Hydrocarbon Reservoirs and Induced Seismicity in Cogdell Oil Field, West Texas

Third year Geology student Sharinia Kanagandran entered this for the RSMA Essay competition. Being a report rather than an essay rendered it ineligible. However the judges felt that such a topical subject would be of great interest to the readers of IE.

Introduction

What is hydraulic fracturing?

Hydraulic fracturing is a controversial subject, with its negative portrayal in the media stemming from a movie called 'Gasland'. The pseudo-documentary claimed that the process contaminates underground aquifers and causes earthquakes. Hydraulic fracturing has been employed for hydrocarbon extraction since 1949, with over 2.5 million fracture treatments performed world wide (Montgomery & Smith 2010). Initially most reservoirs did not require any fracturing, however, as hydrocarbons were extracted from most 'cheap and easy' reservoirs, the industry moved towards more challenging and unconventional resources.

Unconventional hydrocarbon resources, such as shale gas, are often stored in sedimentary rocks with low permeability. As pore spaces lack the connectivity required to flow from reservoir rock to the well, the reservoir needs to be stimulated to generate fracture connectivity which allows for hydrocarbons to reach the well. The technique which creates this stimulation is hydraulic fracturing – fluid is pumped into the well to increase pressure and creates fractures (Davies et. al 2013).

Fracture stimulation is necessary as it increases production rate, making extraction economic.

How does it induce seismicity?

While hydraulic fracturing allows for profitable extraction of hydrocarbons, there is a risk of adverse effects – one of which is induced seismicity. A nearby fault in a near-failure state of stress can experience seismicity, as increasing fluid pressure can reactivate the fault plane and generate an earthquake (Clark et. al 2012). This could occur both during the process of hydraulic fracturing and soon after (Davies et. al 2013). Davies et. al proposes that it could occur via three methods; fracturing fluid could enter the fault, a fluid pressure pulse could be transmitted to the fault through a direct connection with fractures, and deformation of the rock due to hydraulic fracturing could increase fluid pressure in the fault or in proximal fractures (Fig. 1).

This report will examine the triggers of induced seismicity by studying an earthquake at Cogdell Oil Field in West Texas. This will be used as a case study to provide approaches to reduce risk, subsequently, an assessment of hydraulic fracturing will be produced to evaluate its benefits relative to the risk.

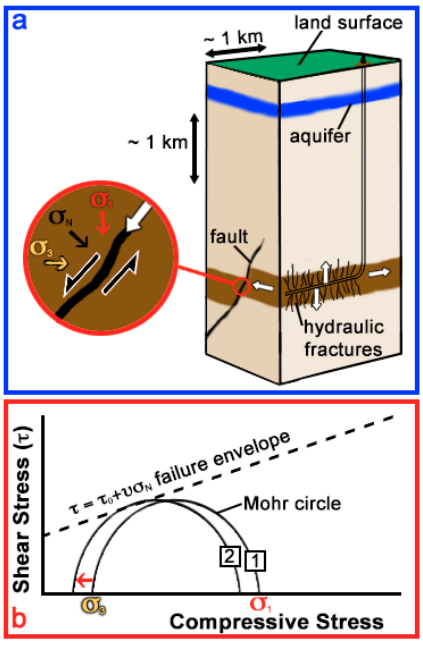

Figure 1: a) A well with hydraulic fracturing. Fluid can be transmitted to a nearby, critically stressed fault (white arrows). b) Mohr stress diagram of the fault plane; Mohr circle 1 depicts the fault plane prior to hydraulic fracturing, Mohr circle 2 depicts the fault plane post hydraulic fracturing. The fluid pressure in the fault zone could increase and cause a decrease in compressive stress (σ_1 and σ_3). So the Mohr circle moves to the left, crosses the failure envelope and shear failure occurs (after Davies et. al 2013).

Discussion

Mechanics of induced seismicity and size of earthquakes

Seismicity is induced when the mechanical state of seismogenic crust is distressed enough to cause a fault to fail (McGarr et. al 2002). When there is an increase in pore pressure, normal stress along pre-existing fractures is reduced, triggering shear slip – a dominant source for inducing seismicity (Fig. 1) (Rutledge & Phillips 2003). Furthermore, seismicity can be induced at the ends of generated fractures as large shear stresses from fracture opening can cause slip (Sneddon 1946). However, it is not restricted to fractures as microseismic events could travel further into the rock (Evans et. al 1999).

An important factor of induced seismicity is size of the earthquakes generated. In most cases, hydraulic fracturing can induce microearthquakes which cannot be felt, however there have been cases where hydraulic fracturing has led to felt earthquakes. The largest were magnitude 7.0 earthquakes at Gazli, Uzbekistan in 1976 and 1984 (Davies 2013). The area had been aseismic until fracturing began (Davies 2013). Due to cases like these, managing induced earthquakes is extremely important and factors which affect their size need to be well understood.

There are numerous factors which affect the size of earthquakes, and it depends on both the process of creating fractures and the area fractures are generated in. The temperature and volume of injection fluid, its type, phase, injection rate, pressure and depth below surface significantly affect the size of induced seismicity (Davies et. al 2013). Furthermore, if hydraulic fracturing is carried out in an area with pre-existing stress, such as a fault, it would increase the size of the earthquake (Ellsworth 2013).

Cogdell oil field, West Texas – induced seismicity

The Cogdell oil field (Fig. 2) is part of Horsehoe atoll, a Paleozoic chain of reef limestone mounds in which there are 2.7 billion barrels of recoverable oil stored in 70 reservoirs (Dutton et. al 2004). In December 1949 the Cogdell field was discovered, and secondary recovery was initiated in April 1956 due to few vertical open joints as most were calcite-filled (Burnside et. al 1954). The field is located in the Midland Basin of West Texas, United States and is 20km away from Snyder (Fig. 2), the largest town in the vicinity.

Between the period of 1974 and 1982, there was a sequence of induced seismic events related to the Cogdell oil field (Davis & Pennington 1989). The most significant of these seismic events occurred on 16 June 1978 and had a magnitude of 5.3, M_L = 5.3 (Davis & Pennington 1989). According to Davis et. al, the total felt area was estimated at 130,000km^2 (1989), with residents close to the epicenter reporting cracked windows (Davis & Pennington 1989). The fault was a normal fault with an estimated seismic moment of 6.5 x 10^{22} dyne-cm and a focal depth of 3km (Voss & Hermann 1980). As the epicentral region of the earthquake was determined to be approximately 33° N, 100.8° W, it was established to be within the boundaries of the Cogdell oil field and likely to be related to it (Davies et. al 1989).

After the earthquake, a two-year study conducted by the USGS uncovered 20 epicenters in the vicinity of Cogdell oil field (Harding et. al, 1978). The mean depth for microseismicity in the area was 1.9km, shallow and relatively close to the injection depth of 2.1km (Davis & Pennington 1989). Due to there having been no previous seismicity in the vicinity of Cogdell oil field, it was suggested by Harding et. al (1978) that the earthquake was induced by injection of hydraulic fluids.

Causes of seismicity at the Cogdell oil field

The likely mechanism for induced seismicity at

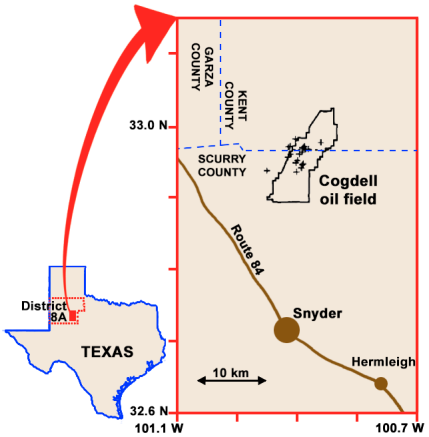

Figure 2: Location of the Cogdell Oil Field in West Texas. Microearthquake epicentres (+) determined by Harding (1981) between 1979 and 1981 are superimposed.

Cogdell oil field is an increase in fluid pressure. An increase in pore pressure would lead to a decrease in effective strength of faults, leading to the fault crossing the Mohr-Coulomb failure envelope (Fig. 1) and initiating slip (Hubbert & Ruby 1959).

Even though injection fluid pressures at Cogdell oil field are high and at shallow depths, even the most conservative stress estimates indicate that at least 16 other fields in District 8A (Fig. 2) should be in failure (Davis et. al 1989). Contrary to this, Cogdell is the only seismically active field. This might be due to shear failure occurring at the other fields as aseismic creep or microseismicity (Davis & Pennington 1989).

Another factor which could have influenced induced seismicity in Cogdell rather than fields in the same district is the net volume of injected fluid. The Cogdell oil field had a net volume of 37 million m^3 injected into the reservoir, which is abnormally high for the region, with only 2 projects surpassing Cogdell in net volume injected (Davis & Pennington 1989). However, this does not explain the lack of induced seismicity in fields with a greater net volume injected and similar reservoir fluid pressures.

A possible explanation for this is injection geometry; Cogdell is operated as a single injection project with a perimeter injection pattern (Davis & Pennington 1989). Stress loading decreases with the cube of the distance and due to this, it is difficult to generate high shear stress increases in large areas (Davis & Pennington 1989). However, the perimeter injection pattern leads to the development of large, isolated barriers surrounded by regions of aseismic deformation, creating optimum conditions for seismic failure (Davis & Pennington 1989). This is a plausible explanation for lack of induced seismicity in other fields as most other large injection projects use spot injection or line drive injection pattern (Davis & Pennington 1989).

Improving hydraulic fracturing – reducing risk of seismicity and regulation

The Cogdell oil field is a perfect case study to demonstrate that hydraulic fracturing is not completely risk free and can be further improved. Due to an increase in fluid pressure being one of the main causes of induced seismicity, lowering fluid pressure can strengthen faults and increase their resistance to deformation. However, this has to be done from the very beginning of the fracturing process rather than during production, as this could generate asperities (Pennington et. al 1986). Moreover, as seen in Cogdell, injection geometry can strongly influence induced seismicity – therefore, the perimeter injection pattern should be avoided in large fields. Companies planning future injection projects should account for injection geometry to avoid induced seismicity. Moreover, as injection geometry is not a well understood factor, further research should be carried out regarding its effects on seismicity.

The risk of generating fault slip on nearby faults should also be reduced during hydraulic fracturing and this can be accomplished by running 3D seismic studies or similar mapping methods which can locate faults with a throw of 50 to 100+ feet (King 2012). This data would allow for the selection of well locations a sufficient distance away from major faults, so as not to risk triggering them. If a fracture enters a fault, injection might need to be stopped as continued injection could activate the fault if it is of a significant size (King 2012). However, continued fracturing of a small fault may not induce seismicity and might hold significant hydrocarbon reserves (King 2012). Due to factors like these, a detailed study of local geology should always be performed prior to hydraulic fracturing. In Cogdell oil field, a number of faults might not have been identified as early studies on regional geology lacked the technology to accurately identify subsurface faults (Burnside 1959).

There is little federal regulation on the practice of hydraulic fracturing in the United States (Rahm 2011). Due to recent controversy with hydraulic fracturing and the contamination of drinking water resources, it has been investigated by the EPA and some states have been regulating the chemicals used in the process (Coglianese & Nash 2001). However, regarding induced seismicity, there have been no regulations implemented.

Is hydraulic fracturing worth the risk?

Although hydraulic fracturing can lead to induced seismicity, the likelihood of a felt earthquake being triggered is incredibly low. Since 1956, there have been 45 induced felt earthquakes (greater than magnitude 2.0), with a low average magnitude of 3.9, caused by the fracturing of hydrocarbon reservoirs (Davies et. al 2013; Montgomery & Smith 2010). In contrast to the 2.5 million fracture treatments performed worldwide, this is insignificant, just a 0.0018% chance of inducing seismicity (Gallegos & Varela 2015). Hydraulic fracturing most commonly induces micro seismicity and sometimes even though the pore pressure increases sufficiently to cause a fault to fail, aseismic deformation occurs.

In spite of an extremely low chance of inducing a felt earthquake, regulations should be implemented to limit the risk of induced seismicity. Primarily, an adequate site characterisation to identify and avoid faults by using 3D seismic studies should be carried out in all hydrocarbon reservoirs. Then the fluid pressure should not be too high because if significant pressurisation of faults are avoided, fault reactivations can be avoided altogether (Rutqvist et. al 2013). Furthermore, hydrocarbon companies should conduct in-depth research into injection geometry to understand geometries which increase the likelihood of induced seismicity. The introduction of new regulations and restrictions would reduce the risk of induced seismicity, leading to an improved trust from the public in hydraulic fracturing.

References:

Adams, J. & Rowe, C., 2013. Differentiating Applications of Hydraulic Fracturing. *Effective and Sustainable Hydraulic Fracturing*.

Atkinson, G.M. & Wald, D.J. 2007. "Did You Feel It?" Intensity Data: A Surprisingly Good Measure of Earthquake Ground Motion. *Seismological Research Letters*, 78, 362–368.

Burnside, R.J. 1959. *Geology Of Part of the Horseshoe Atoll in Borden and Howard Counties, Texas*. Washington, DC, United States Department of the Interior.

Burnside, R.J., Stafford, P.T. & Myers, D.A. 1954. Geological Survey Investigations of the Scurry Reef and "Horseshoe Atoll" in Western Texas. *Science*. 119 (3096), 617–618.

Byerlee, J.D. & Brace, W.F. 1972. Fault stability and pore pressure. *Bulletin of Seismological Society of America*. 62 (2), 657–660.

Clark, C.E., Burnham, A.J., Harto, C.B. & Horner, R.M. 2012. INTRODUCTION: The Technology and Policy of Hydraulic Fracturing and Potential Environmental Impacts of Shale Gas Development. *Env Prac Environmental Practice*. 14 (04), 249–261.

Coglianese, C. & Nash, J. 2001. *Regulating From the inside: Can Environmental Management Systems Achieve Policy Goals?* Washington, DC, Resources for the Future.

Davies, R., Foulger, G., Bindley, A. & Styles, P. 2013. Induced seismicity and hydraulic fracturing for the recovery of hydrocarbons. *Marine and Petroleum Geology*. 45171–185.

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Davis, S.D. & Pennington, W.D., 1989. Induced seismic deformation in the Cogdell Oilfield of West Texas. *Bulletin of the Seismological Society of America*. 79 (5).

Davis, S.D., Pennington, W.D. and Carlson, S.M., 1989. A compendium of earthquake activity in Texas: The University of Texas at Austin. *Bureau of Economic Geology Geological Circular*, pp.89-3.

Dutton, S.P., Kim, E.M., Broadhead, R.F., Breton, C.L., et al. 2004. *Play Analysis and Digital Portfolio of Major Oil Reservoirs in the Permian Basin: Application and Transfer of Advanced Geological and Engineering Technologies for Incremental Production Opportunities*, Bureau of Economic Geology, The University of Texas at Austin.

Ellsworth, W.L. 2013. Injection-Induced Earthquakes. *Science*, 341, 1225942–1225942.

Gallegos, T.J. & Varela, B. 2015. Trends in hydraulic fracturing distributions and treatment fluids, additives, proppants, and water volumes applied to wells drilled in the United States from 1947 through 2010: data analysis and comparison to the literature. *Scientific Investigations Report*.

Harding, S.T. n.d. *Induced Seismic Cogdell Canyon Reef Oil Field*. United States Geological Survey.

Harding, S.T., Carver, D., Henries, R.F. & Langer, C.J. 1978. The Scurry County, Texas, earthquake series of 1977-1978, induced seismicity? *Fiftieth annual meeting of the Eastern Section of the Seismological Society of America*. 49 (3), 14–15.

Hubbert, M.K. & Rubey, W.W. 1961. Role Of Fluid Pressure In Mechanics Of Overthrust Faulting, I. Mechanics Of Fluid-Filled Porous Solids And Its Application To Overthrust Faulting: Reply To Discussion By Francis Birch. *Geol Soc America Bull Geological Society of America Bulletin*. 72 (9), 1445.

King, G.E. 2012. Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor, and Engineer Should Know About Hydraulic Fracturing Risk. *Journal of Petroleum Technology*, 64, 34–42.

McGarr, A., Simpson, D. & Seeber, L. 2002. 40 Case histories of induced and triggered seismicity. *International Geophysics International Handbook of Earthquake and Engineering Seismology*. 647–661.

Montgomery, C.T. & Smith, M.B. 2010. Hydraulic Fracturing: History Of An Enduring Technology. *Journal of Petroleum Technology*, 62, 26–40.

Pennington, W.D., Davis, S.D., Carlson, S.M., Durpee, J., et al. 1986. The evolution of seismic barriers and asperities caused by the depressuring of fault planes in oil and gas fields of South Texas. *Bulletin of Seismological Society of America*. 76 (4), 939–948.

Rahm, D. 2011. Regulating hydraulic fracturing in shale gas plays: The case of Texas. *Energy Policy*, 39, 2974–2981.

Rutledge, J.T. & Phillips, W.S. 2003. Hydraulic stimulation of natural fractures as revealed by induced microearthquakes, Carthage Cotton Valley gas field, east Texas. *Geophysics*. 68 (2), 441–452.

Rutqvist, J., Rinaldi, A.P., Cappa, F. & Moridis, G.J. 2013. Modeling of fault reactivation and induced seismicity during hydraulic fracturing of shale-gas reservoirs. *Journal of Petroleum Science and Engineering*, 107, 31–44.

Sneddon, I.N. 1946. The Distribution of Stress in the Neighbourhood of a Crack in an Elastic Solid. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*. 187 (1009), 229–260.

Voss, J.A. & Herrmann, R.B. 1980. A Surface Wave Study of the June 16, 1978 Texas Earthquake. *Seismological Research Letters*. 51 (1), 1–14.

Should a Materials Science graduate interested in Environmental Sustainability join the field of Nanotechnology? A critical view

This essay by Iacopo Russo won the RSMA Essay competition.

When one thinks or reads about the environmental sustainability of human activities, there are two major concerns one is very likely to encounter: on the one hand, human activities cause the release of harmful substances to the environment, and on the other hand they are responsible for the depletion of the Earth's finite resources. Within the former concern fall issues related to smog in urban areas, acid rain, toxic releases in air, water and soil, and, more broadly, the greenhouse gas emissions that lead to global warming. Within the latter concern, one could include issues to do with the availability of fresh water and fertile land, the reduction of biodiversity and the finite supply of mineral stocks.

If one looks more closely at this diverse range of issues, one will find that many are fundamentally related to one precious resource our society makes extensive use of: energy. As an example, if we had enough energy, we could desalinate water and reduce the stress on fresh water supplies; we could extract minerals from less concentrated sources; we could neutralise or reduce the emissions of toxic releases to air, water and soil. Therefore, it could be argued that many of the concerns about the environmental sustainability of human activities can be reduced to concerns about the sustainability of harnessing, storing, delivering and using energy. As of today, most of the energy in the world is generated by burning of the (in)famous trio of fossil fuels, i.e. coal, oil and natural gas. Reserves of these fuels, which have accumulated through millions of years in the Earth's crust, have literally fuelled the growth of the world population and economy for the past 150 years. Although some people may disagree, it now appears that we are not really short of fossil fuels and that we would not have too much difficulty in expanding our future supply of energy. However, their burning causes the release of greenhouse gases leading to global warming and climate change, which are now considered to be the number one threat for the world economy by experts interviewed, for example, by the World Economic Forum. Therefore, it seems like concern about the environmental sustainability of human activities during the next years should be focused primarily on global warming.

Given the outlined scenario, as I approach the end of my undergraduate degree in materials science and engineering, an apparently simple question takes shape in my mind: how can I make the best use of what I learnt in the past four years to improve the sustainability of energy generation and use so as to avoid dangerous global warming? Looking back at the history of innovation, it is difficult to underestimate the role that advances in materials science have had on the improvement of the energy system. The design of new materials and improvements in the way they are made have led to great technological change in this field. For example, advances in the understanding of quantum mechanics, solid state physics and semiconductor materials have led to the design of photovoltaic cells for the direct conversion of solar energy into electricity. The same advances have led to the development of light-emitting diodes (LEDs), which have proved to be way more energy efficient lighting and display devices than the ones previously available. In other areas of materials science, metal alloys and composite materials have been developed that are much lighter than steel but have the same strength and stiffness, allowing the development of lightweight and less fuel-thirsty vehicles in the transportation industry. It is easy to see how materials play a role at all levels of the energy life cycle; they have potential for the sustainable production of energy, for its efficient storage and for its effective use. The available knowledge on materials is increasingly recognised by academia and industry worldwide as a (if not **the**) key limiting factor for the development of new technologies.

In particular, there is one sub-discipline that, above all others, has recently attracted attention, funding and talent in the materials science community: nanoscience and nanotechnology. Nowadays, it is hard to find an academic institution in the world whose physics, chemistry and materials science departments do not advertise extensive and ambitious research programs on nanomaterials and nanodevices. Many research institutes and collaborative initiatives dedicated to nanotechnology have also started making their appearance, interfacing with industry in order to develop scalable manufacturing techniques. The scientific journals focussed on nanotechnology, such as Nature

Nanotechnology, ACS Nano and Nano Today have some of the highest impact factors among the physical sciences journals, indicating that more and more scientists are entering the field. So, could the study of nanomaterials be the key enabler of the major discoveries for making energy harnessing, storage and use more sustainable? Is our increasing control on the design of materials at really small scales going to allow us to profoundly innovate the way we generate and use energy? I found that these were key questions, whose answers would immensely help me decide whether entering the field of nanotechnology would be the best way to put my skills and knowledge to work.

Nanotechnology could be defined as the study and manipulation of matter at the nanometre (a billionth of a metre) scale. Trust in the potential of nanotechnology is fundamentally fuelled by the assumption that even if incremental improvements in existing technologies will continue to play important roles in addressing some of the challenges of environmental sustainability, they will not be sufficient; instead, it will be necessary to develop revolutionary, disruptive new technologies. Nanotechnology is thought to qualify for the job because the transition between the macroscopic properties of materials which we are all used to and the surprising, weird properties of the molecular and quantum world happens in that size range. Therefore, control over materials at that scale opens up a whole world of possibilities, with materials that have new functionalities, unexpected properties and potential for a revolution. A few examples may make this point clearer. Many nanomaterials are characterised by an extremely high surface-to-volume ratio. In many applications, such as in catalysis and in battery electrodes, it is the surface of materials that plays the key role in determining the device performance. The use of nanomaterials could dramatically reduce the weight of these devices and improve their functionality. Quantum dots, which are nanocrystals of semiconductor materials, have tunable optical properties and a very high photoluminescence, which make them ideal for displays with high brightness and low energy consumption. More recently, a material that has attracted huge amounts of attention is graphene. This is a one-atom thick, single layer of carbon atoms arranged in a honeycomb structure and, due to these characteristics, has often been termed a '2D material'. Another of its nicknames is 'wonder material', which it earned after early experiments showed that it is one hundred times stronger than the strongest steel and much more conductive than the purest copper, in addition to a whole host of other extraordinary properties. These are just three examples of a whole range of new exciting material systems, which have made nanoscience by far the hottest topic in the materials research community.

As with anything that suddenly captures so much attention and popularity, however, I found that the rise of nanotechnology research had some downsides too. To begin with, fundamental limits to innovation are underestimated by scientists for fear of disappointing and curtailing the opportunity of additional funding. No researcher, if put on the spot, could deny that there are fundamental problems affecting our control of nanomaterials and the improvement of nanomaterials-based energy devices, but few in the field like to talk about it. One such problem is related to the already discussed high surface-to-volume ratio. Because of their huge surfaces, nanomaterials are extremely reactive and, in some cases, they have been shown to be toxic to living creatures. Controlling their reactivity is extremely difficult and this is due to fundamental physical principles. If looked at from the perspective of energy minimisation, nanomaterials are, put simply, not meant to exist. All materials have in fact a natural tendency to minimise their surface-to-volume ratio. This is also part of the reason why fabricating nanomaterials on a large scale has proved to be so difficult. Another fundamental problem is that the sudden burst of interest and expectations from nanotechnology has caused researchers to elaborate devices from nanomaterials before more fundamental aspects have been properly investigated. The increasing pressure put on researchers to deliver results, due to these big expectations, has led them to attempt to apply nanomaterials where there is not such a strong case for their use. Overexcited by the feel of novelty and aware that the prefix 'nano' currently attracts more attention than any other buzzword in the physical sciences, some researchers have sacrificed more reasonable scientific interests for the pursuit of misguided nanomaterials investigations. A specific example of this is the use of quantum dots in solar cells. Although quantum dots have high photoluminescence properties, they are not such amazing absorbers of light. And this is why, notwithstanding years and years of research, the efficiency of solar cells employing quantum dots can hardly achieve 10%. On the other hand, if only materials scientists could find a way to successfully deposit more traditional semiconductor thin films over common substrates, we could achieve efficiencies higher than the current commercial silicon cells. In the case of graphene, the material has been proposed for all the applications imaginable: solar cells, batteries, flexible displays, transistors, sensors. But the truth is that no one in the world can yet produce even a metre square of graphene reliably and at a reasonable cost.

Perhaps, rather than focusing insistently on finding new, revolutionary solutions with an optimism that appears unreasonable given the trade-offs intrinsic to some technologies, it could be beneficial to take another approach. Human society's high environmental impact is not only due to inadequate energy supply technologies, but it is also due to the ever increasing demand for resources. Could we possibly find ways to guarantee the same human wellbeing while reducing the amount of energy and resources we require? Could materials scientists – could I – help find these ways? One possibility that appears reasonable is to go back to the traditional, bulk materials we use in great quantity and explore ways to reduce the environmental impact of their production. Perhaps the great innovations in materials science for sustainable development will come from very banal materials like steel, cement or paper. These are not the materials that currently attract the young and talented materials engineers and yet they are the most used worldwide, whose production is responsible for a big proportion of industry's carbon emissions.

What I have tried to argue is that a more careful and rational assessment of the potential of nanotechnology for the improvement of the energy system should be carried out by the materials science community, even if this is set to challenge strong existing interests. New, talented individuals who aspire to have an impact on important societal issues should not be led astray by the disproportionate popularity of nanotechnology and should realise that there are many uncaptured opportunities for innovation in fields such as materials recycling and primary material demand reduction. This is obviously not to underestimate the importance that nanotechnology will play in the transition to a cleaner energy future. Clearly, pursuing a PhD in nanomaterials is better than working to improve the corrosion resistance of oil steel pipes. After all, what is important is to continue to be fascinated by the extraordinary properties and the immense socio-cultural relevance materials have for us and our society, and to retain a strong passion for improving the relationship between us and the fragile Earth that supports our civilisation.

Iacopo Russo, 23, has recently completed his MEng in Materials Science & Engineering at Imperial College, graduating with First Class Honours. In Autumn 2015 he seized a fantastic opportunity to spend a semester in exchange at MIT, where he started the laboratory work for his final year research project. On returning to Imperial, he completed his thesis on the investigation of quantum dots for applications in solar cells, and realised that joining the field of nanotechnology was not his ideal path.

After months of reflection and applications, he accepted an offer to start his PhD in October 2016 in "The Use Less Group" led by Prof Julian Allwood at the University of Cambridge, where he will investigate resource-efficient low-carbon metals processing techniques.

The opportunity for Hydro-electric power generation in China

Jolyon Nove recently wrote to say that he had just returned from China and had no doubt that there is an obvious opportunity to develop clean energy hydro-electric power generation upstream of the Three Gorges Dam. An opportunity he sees for Imperial and its alumni. We asked him to expand…

The Paris Agreement is an agreement within the framework of the United Nations Framework Convention on Climate Change dealing with greenhouse gas emissions mitigation, adaptation and finance starting in the year 2020. An agreement on the language of the treaty was negotiated by representatives of 195 countries in Paris and adopted by consensus on 12 December 2015.

This is an opportunity for British, Australian and Chinese Engineers to be of service to China. As a society, we have to balance many issues in considering Climate Change. The Paris Agreement is a world first and can be taken as global recognition of man's impact on our environment.

Photos: Jolyon Nove

What we do is for the sake of our children.

China is part of the Climate Change agreement. The upstream tributaries of the many rivers, including the Yangzi River, provide the opportunity for run-of-the river hydro-electric power stations to be located. After the consideration of all the factors, sites could be selected at the best locations in China.

China's system of Government is supportive of long range implementation of plans. The Three Gorges Dam is the largest dam in the world and was built to meet China's need for flood control and sustainable electricity supply.

Nothing is perfect. The issues for and against dams including The Three Gorges Dam are discussed elsewhere. In truth we could always have done better. In fact we can still do better.

The Three Gorges Dam

Initial investigations may be needed to the left and right river flows of the main river just upstream of The Three Gorges Dam. An apparent advantage of such investigations is the ease of construction access and electrical distribution to the existing electrical grid. Sustainable mass produced medium head hydro-electrical energy generation and transformer units can be produced economically. The energy produced could be connected to the nearby national electrical grid at the Three Georges Dam.

This is an opportunity for British, Australian and Chinese Engineers to form a consortium and be of benefit to humanity. Britain started hydro-electric power generation. Australia designed the Snowy Mountains Scheme. Recently China has developed this knowledge into the massive and innovative Three Gorges Dam for flood mitigation and hydro-electric power generation.

British, Australian and Chinese civil engineers have a long tradition of building massive projects in China from the Great Wall of China to the Three Gorges Dam, and modern highways and railways.

Now we must all look to co-operating in the future in dealing with climate change for the sake of our children.

City and Guilds, British, Australian and Chinese Engineering and Financial Institutions could provide multi-service assistance to modern China and the world beyond.

Massive engineering projects from The Great Wall of China to modern highways.

Jolyon Nove was born in London in 1936. He went to Scaitcliffe School and Oundle. He served in the Royal Engineers as a commissioned Officer on active service in anti-terrorist activities in Cyprus. He landed with the First Battalion Paratroops' Regiment on the Suez landings. He served in Libya.

Jolyon gained an honours degree in civil engineering from City and Guilds College in 1960 and was President of the C&G Students Union. He permanently came to reside in Australia in 1962.

Jolyon served the Snowy Mountains Hydro-electric Authority designing power stations and dams. With the permission of the Commissioner, Jolyon lead a team of 40 that had their International Competition design purchased by The Danish Public Works Department. He joined the Electric Commission of NSW to be of service in working on the design of a major dam built on fly-ash. He also designed thermal power stations and their environmental and security systems.

After retiring from the Electricity Commission, Jolyon studied and made presentations on sustainability issues and has been granted Patents relating to sustainable designs. The latest Australian Patent granted to Jolyon is Australian Patent No. 2013202511 "Method of growing an organic product".

CivSoc Tour 2016 – Naples

Day 1

At 8.30am on the 29th March 2016, almost 70 Civil Engineers, across four years, from the Department of Civil and Environmental Engineering at Imperial College assembled for the annual CivSoc International Tour. This year's tour to Naples, which was one of the most anticipated events with most places available filled in a matter of seconds, began with the students being issued their tour LIVIC and hoodie.

Following the journey from Imperial College Union to Naples, the students were welcomed at the airport by a team from University of Naples Federico II who accompanied the group to the La Controra Hostel on prearranged coaches. The team were available for the remainder of the evening answering any queries the students had about Naples and providing recommendations for activities that could be undertaken on the free days.

The hostel was modern, affordable and cosy as well as being located within walking distance of the city centre. The friendly staff were always available for advice. There was a large courtyard which allowed the students to socialise in the mornings and in the evenings after the day's activities. The group was divided across rooms of varying sizes such that most contained students from multiple year groups in order to provide opportunities for intermixing and socialising together. A breakfast buffet of toast, cereal, tea and coffee was provided by the hostel for the group every morning.

After the group had settled into their rooms, the evening was spent getting accustomed to the area and beginning to explore some of culinary delights unique to Naples. For most, this was their first taste of Napoli pizza.

Day 2

The original plan was for the tour to arrive in Naples on the 30th March. However, due to the airline cancelling the group's outbound flight, a decision was made by CivSoc to arrive a day earlier. As this year's tour was after the Easter weekend, a number of the students had already made arrangements to travel from their family to home to Naples on the Wednesday, which would have originally been the first day of the tour. These students were able to successfully make their way to the Hostel to join the tour.

Overall, this resulted in an additional free

day in the Tour timetable which the students were successfully able to use explore Naples and the surrounding region. Collectively, the students were able to visit the island of Capri, explore the nearby town of Sorrento, climb up to a 14th century monastery for a coffee overlooking the city, as well as partake in a walking tour of Naples that had been recommended by the hostel.

Day 3

Day three of the tour began with a wake-up call at 8.30am. Coaches were arranged to take the group from the hostel to Pompeii, an ancient Roman city that was destroyed and buried by a volcanic eruption in AD 79. Upon entry to Pompeii, the students had almost five hours to explore the ruins that had been carefully excavated over the last 40 years. A number of the students opted to hire a guide to provide themselves with a deeper insight and understanding into Pompeii.

Much of the city was constructed in stone which meant that, unlike organic materials such as wood, a significant proportion of the city remained preserved due to the lack of air and moisture in the ash that buried the city. This therefore provided an incredible insight into life over two millennia ago, including being able to easily identify the purpose of many of the buildings that had existed. Within many of larger houses where the wealthy would have lived, the murals, artwork and mosaics that depicted the beliefs of the Romans who occupied the city remained intact.

Walking down the streets, it was easy to identify the Roman equivalent of the 'High Street'. Shops were easily identifiable by their large front openings and tracks within the stone where shutters would have sat. The most intriguing of these were the restaurant or fast food shop where hot food would have been readily available as well as the laundrette that used a sequence of baths ranging from dirty water at low level to clean water at higher levels.

Although the organic material had decayed, grains were found buried within the ash providing an insight into the crops that were grown around the city. In many of these places, conservationists have replanted their modern equivalents. The result of this has been the restoration of the courtyards facing Vesuvius that existed throughout the city.

Pompeii, for a city pre-dating the first century, was incredibly sophisticated. A water network within the city had supplied homes and businesses, public baths as well as the public fountains, through lead pipes. Not only this, a number of the buildings had arches at low level formed within their walls to increase their strength and provide a degree of resistance to earthquakes. Although the upper floors of the buildings were destroyed by the weight of the ash that fell on them, the height of the buildings that had existed was clear from the columns that remained. At the time, many of these would have had multiple storeys with many of structures being more than 10m high.

Overall, the visit to Pompeii provided an incredibly fascinating insight into the life and culture of a city from 2000 years ago. The students were amazed at the lifestyle that some had lived as well as the technologies that had supported the city.

Day 4

After an even earlier wake-up call of 7.30am, the group departed the hostel at 8.30am to walk to University of Naples Federico II located a 30-minute walk away near the city centre. Day four of the tour encompassed a visit to the university in the morning and visits to multiple completed metro station sites as well as another still under construction in the afternoon.

On arrival, the group were welcomed by Prof. Raffaele Landolfo and Dr Lucrezia Cascini from the Department of Structures for Engineering and Architecture. The talks commenced with a welcome on behalf of the rector and an introduction to the university, the courses on offer for the 110,000 students who attend, as well as the opportunities available to those from abroad. The group was introduced to some of the key research going on within the Department of Structures for Engineering and Architecture by the head, Prof. Landolfo, and within the Department of Civil, Building and Environmental by its head, Prof. Maurizio Guigni.

The topics of the talks then progressed to

Photos courtesy of CivSoc

the technical aspect of the ongoing Metro Line 1 project. The first lecturer, who was the director of the Metro system, gave a brief history of the Metro and the future plans for the system. Over three billion euros are being invested to extend the system and a key aspect of the development has been to reinvigorate the areas surrounding the stations through the introduction of art. As this is an ongoing project, the Metro is currently significantly underused. It is expected that this will be the case until the loop in the system, similar to that of the Circle Line in London, has been completed.

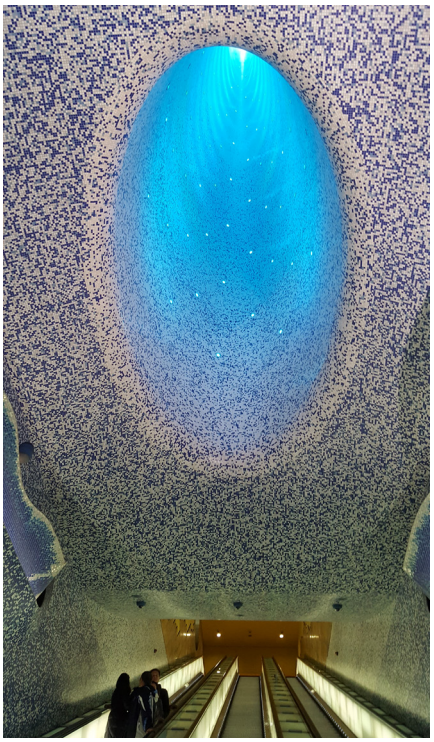
The second lecturer, the Design Director for the project, explained the utilisation of finite modelling techniques. This was a significant aspect of the project given that a number of the deep stations and tunnels were to be built under a dense urban environment. The modelling allowed the designers to ensure the effects on the surface were minimised to prevent any damage occurring. These challenges linked in with the third lecturer's topics. Due to the geography of Naples, the network has a gradient of 5.5% which is significantly higher than metro systems of other regions. Despite this, the stations toward the top of the system are more than 50m below the surface. A number of the stations under construction are below the water table thereby making the tunnelling works more challenging. In order to resolve this, a combination of injecting grout and using liquid nitrogen to freeze the ground is used to increase the workability of the soil.

The Operations and Maintenance Manager then took the stage to explain the use of the network and the works that are undergone daily to ensure the system remains clean. The technical lectures were then concluded by a talk from the Artworks Manager, Dr Maria Corbi, who is responsible for the art that has been introduced into the Art Stations of the Naples Metro. She introduced some of the artworks that were commissioned for these stations which are aimed at making the stations beautiful to look at and more interesting to travel through. The talks were closed by CivSoc's Chair, Fiona Walport, who spoke on behalf of CivSoc and Imperial to thank them for their overwhelming welcome and incredible support in organising the visit to make the tour possible.

The students were provided with a delicious two-course buffet lunch that gave them the opportunity to meet the lecturers as well as some of Italian students from the university. This allowed them to discuss the differences in their courses as well as to receive suggestions on places to visit whilst in Naples. After the site visits concluded later in the afternoon, the Italian students led a number of the group to what was one of the best gelato places in the city.

After a photo with all the students and lecturers involved, the group was led by the Metro Director and Arts Director on a tour of three completed Metro stations, Università, Municipio and Toledo. Over 200 works of art were commissioned for the stations across the network with each signifying a range of different themes. For example, Università's was that of connectivity. Both the floors and ceilings had a series of lines connected by nodes to represent the flow of information between places. In addition to this, the columns within the stations were shaped in a way that makes it possible to see the profile of two connected faces symbolising the communication between people.

Toledo was themed around water and light since it was one of the few stations below the water table. When travelling down the escalators towards the platforms, there is a distinct change in colour from yellow to blue to signify ground water level. At platform level there is a shaft that rises to surface level with LEDs providing a light show along its length.



The final station, Municipio, was designed in a more contemporary manner with neutral colours. This station is currently being extended to serve a second Metro line and the group was taken onto the site to see the ongoing construction works. The students were shown the station box, retained by props, that been formed to support the excavation down to platform level. Once the works at platform level are completed, the excavation will be filled and developed into an open public space.

Day 5

Day five was the second of the two free days timetabled into the tour schedule. The group used this opportunity to further explore Naples and the surrounding area. Many used the advice of the Italian students and hostel staff to plan their activities. Some used the day to successfully reach the summit of Mount Vesuvius, others visited the nearby island of Ischia, whilst a third group hired a boat to sail along the Amalfi coast.

The students regrouped in the evening for the end of tour dinner organised by CivSoc. This was held at a family run Italian restaurant who were highly accommodating to the group. The students thoroughly enjoyed the pizza and pasta available and used the opportunity to reflect on the week's experiences whilst enjoying some of Naples' culinary delights for one last time.

Day 6

Sadly, the final day of the Tour was an incredibly short one. At 5.00am, prearranged coaches collected the students from the Hostel and transported the group to the airport for the bittersweet moment of returning to London. The CivSoc International Tour 2016 was incredibly successful and achieved well beyond the goals set out by the committee. No issues occurred during the tour and everything went according to the plan and budget that had been set.

The tour provided the students with an experience that had the perfect balance of being an educational and relaxing experience. Not only did the tour achieve it's main goal of experiencing Civil Engineering in a foreign country, the students were also given the educational experience of history, culture and technical knowledge. Their thirst for adventure also ensured the students made the most of their time in Naples to explore the region and enjoy the local culinary delights. In addition, the social aspect of the tour allowed the students of all four years to intermix and forge new friendships. The feedback received from the participants was extremely positive and the great success has already begun to build the excitement and enthusiasm for CivSoc International Tour 2017, wherever that may be.

Thank You

CivSoc's 2016 Tour to Naples would not have been possible without the generous support of our partners. At this point I would like to thank IC Union, the OC Trust (CGCA), CCC, Vinci Construction, Robert Bird Group, Teach First and the Civil Engineering Department of Imperial College London. Thank you so much on behalf of all the students and I hope we can continue this collaboration in the future!

Jayneil Master International Tour Officer CivSoc Committee 2015-2016

From Great Conflagration to Modern Regulation

We caught up with Tim Munday, CGCU President 2014-15, to see what he's been doing since graduating last year. It proved to be very timely as the approaching anniversary of the Great Fire of London – an event that not only reshaped the City but also building regulations – was very much on his mind and relevant to his current work.

Photo: Antoine Buchet/shutterstock.com

On Sunday September 4th 2016, to commemorate the 350th anniversary of the Great Fire, a 120 metre long replica of the 1666 City skyline was set alight on the Thames.

350 years ago on the morning of 2nd September, a Sunday, a fire broke out at a Bakery on Pudding Lane, the rest as they say is history. The Great Fire raged until the following Wednesday having ripped through the dense wooden buildings. It destroyed 80% of the City, some 13000 homes. The conflagration, the only word considered suitably descriptive by contemporary sources, burnt so hot that it exploded the stones of old St Pauls and melted not just the lead from church roofs but also the locks of the city gates.

This singular event is often considered to be the genesis of the modern Building Regulations. After all within days Charles II had issued a proclamation concerning the rebuilding; in weeks grandiose plans for the classical rebuilding had emerged (including one from Christopher Wren). And by February 1667 a comprehensive Act was passed by parliament, which issued restrictive rules governing what could be built and where. It also empowered the City Corporation to appoint surveyors to control all the work within their boundary, a forerunner to the present day District Surveyor. The Act also created a mechanism for paying for the reconstruction of public buildings, the Coal Tax, which, with little irony, ensured that a tax on fires within the City paid for the damage of the Great Fire.

The new regulations intended to create a less flammable city. It defined only four types of buildings that could be built which depended on the type of street the site fronted. Building materials were restricted to brick and stone and wood was almost entirely banned from the exterior of buildings. Compared with those of today the regulations were draconian, insisting on a prescriptive uniformity that clashed with what had existed before and has come since.

It is surprising then the speed at which the city was rebuilt, particularly considering that it had recently experienced both war and plague and the amount of work it entailed. Despite this the majority of work was completed by the early 1670s with only really the work to restore public buildings remaining. It is apparent that such restrictive regulation did little to hinder the progress of construction.

However I believe it would be wrong to claim the 1667 Act at the first building regulations. Legalisation pre-dating the fire had already banned thatched roofs and insisted on building in brick and stone. The risk of fire was well known before 1666 and steps had already been taken to reduce its impact. What can be said is that the Great Fire was a wakeup call and the first large scale adoption of regulated building work. That the fire of 1666 remains the Great Fire is testament to the fact that the Building Regulations work have adapted to the changing use of the City and advances in construction.

Subsequent London and National Building Acts have developed the regulations with the aim to ensure the complete safety of people in and about buildings. The changes have often come progressively, but some have been introduced retroactively after other unfortunate events. In this way the aftermath of the fire continues today. The City still appoints a District Surveyor to control work within its boundary and they lead an experienced, multi-disciplinary team in doing this.

Tim Munday graduated from the department of Civil Engineering in 2015 and has since that time worked in the District Surveyor's Office at the City of London Corporation. In his job as a Building Control Officer he implements the Building Regulations in the South of the Square Mile, including Pudding Lane, where the Great Fire started.

Estonia Fastpacking expedition

Catherine Spurin is a 4th year Geophysicist, currently doing a MSci project in hydrogeology. Tom Raven is a 4th year Geologist, currently doing a MSci project in dinosaur palaeontology. They started running together 2 years ago having done little running before, and completed their first marathon in September 2015. They decided as they both loved running and the outdoors to do something different, so this September they ran the length of Estonia, with a little help from the RSMA Trust and the Imperial College Exploration Board.

Photos: Catherine Spurin

This September, Tom and I fastpacked a 380km North to South traverse of Estonia self-supported. In order to carry out the expedition self-supported, we arrived in Tallinn 2 days prior to the start date of our challenge in order to organise 6 food drops along the route which we could pick up at later dates, keeping the weight of our bags to under 7.5kg with water. A day's food consisted of 6 protein bars and a freeze dried curry. The expedition lasted 16 days, including 4 rest days.

Our expedition was to fastpack the length of Estonia using the RMK route that extends from Oandu in the North to Ikla in the South. The RMK hiking route is approximately 375km.

Day 0, we got the bus to Altja and ran to the sea, approximately 1.6km away, before going to Oandu so that the expedition ran coast to coast. This was a short day and we had lots of energy so ran the majority of the route. The first night in the tent was very noisy because of the crickets and although we were the only ones at the campsite, we both still managed to worry about the axe for firewood near the campsite…

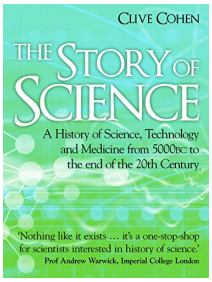
The next day marked the start of the RMK hiking route and the start of our 375km journey across the bog lands and through the forests of Estonia. We were super excited to start the day, and were very happy to be able to get the day's water from a nearby well instead of the river which was pretty fast flowing. On day 2, however, we did have to get our water from a river near the campsite. We were both pretty upset about how brown the river water was and ended up putting a lot of chlorine tablets in our reservoirs just to be safe. For the rest of the trip, whenever we could buy water from shops or from wells, we didn't hesitate, and came back to the UK with a lot of the chlorine tablets we took out.

Day 4 was the only wet day of the expedition. Unfortunately, the rain was torrential and we were crossing a large bog that day. The boardwalks for the bog were completely flooded meaning we practically had to wade through a river. We ended the day with purple, shrivelled feet and wet socks. Day 5 was our 1st rest day of the expedition, and wet and slightly defeated, we checked into a B&B and used the heaters to dry our clothes.

Day 8 – the worst day of the trip by a long way. The food drop in Lelle was not delivered by the courier company (for reasons still unknown to us) and the plan had to be changed so that we would arrive at the next food drop location in the next 2 days instead of the planned 3. We had to buy supplies for the next 2 days from a local store. Side note, the food drop was meant to be delivered to the local store, but when we called, the store owner could not speak any English so we got a friend who could speak Estonian to ask if we could send a food parcel there. However, she decided that our food parcel was definitely a bomb and refused to take the parcel meaning we had to send it to the post office, which in a town of 300 people, was open for 2 hours a day. When we arrived in Lelle on day 7 of the expedition, we were too late to collect the parcel and had to camp on a football field in the town (this probably scared the store owner half to death). Anyway, with only snickers bars to power us, day 8 began. The day was long as it was mostly boardwalks which were too narrow to run on. Then that evening when we were sleeping, someone decided to open our tent and shine a light in. Thankfully, me screaming the house down scared the intruder away but left us both visibly shaken and suddenly hating the evenings. We were initially meant to be doing the route over 18 days but after the late night scare, we reduced the number of days by increasing mileage every day and starting the days at sunrise.

The amount we ran varied drastically day to day. Some days we ran a lot but other times we struggled with the weight of our bags. The route was really well marked out so minimal navigation was required. We mostly camped along the route in our 500g tent that looked like a plastic bag, but also stayed in 1 forest hut along the way which was much warmer than our tent but had mice. Overall, it was one of the toughest things we've ever had to do but it was a crazy experience and it was a lot of fun (at times). We're glad we completed the expedition but next time we will favour daily showers and clean clothes!

BOOK REVIEW



An epic accomplishment. Clive (Chem. Eng. 1960-66) spent the last 15 years of his professional and academic life on this masterwork (gaining a second Ph.D. in the process). So far I have only been able to skim the first parts of this book but have already been well rewarded. All IE readers need to be aware of its availability so we can begin to share in Clive's voyage of exploration. This review is just an introduction.

He traces the beginnings of the process through the ancients' gradual mastery of the elements of astronomy and mathematics, pointing out that until these were achieved (together with written language) it was not possible to record and codify observations and to begin to build a codex of accumulated knowledge. The early developments were expanded by the Babylonians and Egyptians to facilitate agriculture and commerce. Meanwhile, basic technologies (for building, metallurgy, water systems etc.) evolved on an empirical basis.

Things changed radically with the invention (initially by the Greeks) of phonetic alphabets to replace hieroglyphs and symbols. This allowed a permanent record of precise thoughts and observations. This transition did not occur in China, that other great cradle of science and technology. Together with a lack of permanent records, this renders a reconstruction of developments there more difficult. These inventions paved the way for the Greeks to embark on geometry and philosophy; hence most famously Aristotle's 'natural philosophy'.

Further developments occurred following the expansion of Greek knowledge throughout the Roman world. Technology, however, evolved independently and science & technology only came together much later, arguably as late as the 18th century.

Then followed a millennium of innovational decline in the West. The division of the Roman Empire into East (Greek) and West (Latin) and its subsequent collapse in the West isolated scholars there from Greek learning for almost a thousand years, a process fomented by the emergent Christian church and its practice of control through belief. The Islamic world in its vigorous first flowering became the means of preserving classical learning to be passed back as the West awoke to the Renaissance.

Modern science began with the Renaissance and the Protestant reformation. Galileo and Copernicus in astronomy and then the giants of mathematics with Newton and Leibnitz at their head paved the way for a fusion of human knowledge and innovation that started and continues at extraordinary speed. IE readers will be more familiar with this part of the story, so this review concludes with a renewed recommendation to buy the book and enjoy Clive in his own words!

W.J. McAuley (Chem. Eng. 60-65)

Clive's book is available on Amazon Kindle or in 3 paperback volumes.

bit.ly/IE25-StoryOfScience

Mech. Eng. alumnus raises £3.2M investment to bring engineering to kids

After graduating, Joachim Horn (Mech. Eng. 2009-13) set up SAM Labs with a team of designers from the Royal College of Art and other engineers from Imperial.

SAM makes construction kits that turn playtime into educational fun. Their kits are focused on STEM learning in education and encourage kids (of all ages) to learn the basics of programming and engineering. Highly interactive, with "cute wireless electronic blocks, an app so friendly you could hug it, and quirky wondrous projects to complete", there's nothing to stop open-ended play and creativity. Last year's Christmas partnership with the London Science Museum resulted in the best selling 'SAM Inventor Kit'. Dubbed the 'LEGO® of the Internet generation', SAM is a collection of clever little blocks and an app to build awesome inventions. Each SAM Block has its own unique skill: a light, a motor, a button and more. SAM

blocks are wirelessly connected together in the SAM Space app to program and customise projects.

For an initial Kickstarter campaign to turn the original vision into a product, Joachim wrote "I'm a mechanical engineer, and was always scared of the dark magic of electrical engineering. Stuff never works, there's always a bug, and you can't duct tape it into correctness. I wanted to find a way to make it fun for people to learn circuitry and coding. A human-centered model that would be easy to use and which taught you while you worked with it. This gave birth to SAM, the idea of giving designers and creative people the powers of engineers. We hope to be the start of a democratic revolution for the Internet of Things so that children can learn, and impactful, highly technologically innovative projects can be undertaken by designers who do not necessarily have the luxury of having been technically trained as engineers." The campaign was hugely successful, reaching their funding goal in less than three days. Since then they have been developing the product and the company and in April this year announced that they had raised £3.2M in venture capital, led by Imperial Innovations, which will allow them to build the business. "I'm humbled and very appreciative that Imperial Innovations plc has played such a supportive and exciting role along this journey" said Joachim.

At the end of September, SAM Labs launched a new kit: Curious, an immersive out-of-the-box inventing experience, allowing users to build and program their own cars and games. Equipped with five paper-fold car bodies, a car base, and remote control, kids can build and program their own vehicles with SAM, whilst gaining 21st century skills. A step-by-step tutorial booklet, and the informative SAM app, both filled with detailed instructions, will guide them through an array of other smart projects and hacks.

You can find out more about SAM Labs on their website **http://samlabs.com/** You can view Joachim giving a TED talk in London in June 2015 at **bit.ly/IE25-SAM-Ted**

Tea party in BC

The RSM 'brand' remains strong out here.

At a June 11th IC alumni 'tea' in British Columbia, 20% of the attendees had RSM connections and of those that sent regrets (including Harry Burgess in Toronto) it was 25% RSM. Attendees 15 alumni and partners etc plus 12 'regrets', makes 27 from BC – then with Harry from Toronto it was 28 – without his inclusion the BC RSM regret percentage was still a strong 16.67%.

The RSM attendees besides me were Sam Henry (Metallurgy 69-72), full colours and half colours and Mary Farhang (RCS 81 and RSM 82).

Also, I wish to send my personal thanks to Teresa Sergot for keeping in touch these past years. And my very best wishes for the future.

Nigel Fitzpatrick.

Both Sam and Nigel made one of these in the RSM foundry

Elec. Eng. 1978-81 class reunion

On Saturday 10th September 2016, the Electrical Engineering 1978 to 1981 class held their annual reunion with a drink in Beit Quadrangle followed by a dinner at the Moti Mahal restaurant in South Kensington. 13 former classmates attended, from left to right in the photo below are: Krishna Thakrar, Ajit Amin, Roger Edwards, Freddie Barros, Mike Casey, Simon Milner, Henry Szyszko, Yogesh Joshi, Ian Tyes, Trevor Hall, Shahid Raja, Alan Higginson, Arthur Jordan. Not only was this a milestone event, being 35 years since the class graduated, but times were telling since 2 of those attending had now retired.

Anyone wanting to contact the group should email:

alan.r.higginson@btinternet.com

1964 City & Guilds Epic Film

While trying to engage with classes of 1964/5 recently, Imperial's development team unearthed a short film. It was originally shot in Super 8mm in 1964 by David (Yogi) Bishop but was digitised in 2003 and uploaded to YouTube to share with the world! Many of the cast are (or have been) members of CGCA, and David Bishop (Elec Eng 1961-4, Mech Eng 1964-5) is the CGCA's rep in Melbourne.

bit.ly/IE25-CGCA-1964Film

DIARY

Tues, 1 Nov, 19:00
Friends of Imperial
Lecture – The Future of AI
bit.ly/IE25-Friends-AI

Thurs, 3 Nov 17:00-20:00
Imperial Fringe
Criminal Investigations
bit.ly/IE25-Fringe-Crime

Wed, 9 Nov 17:30
Nuclear Security & Non-Proliferations – ISST 2016 Vincent Briscoe Lecture
bit.ly/IE25-ISST-Briscoe

Tues, 15 Nov 10:00-19:00
Centre for Blast Injury Studies 2016 Networking Event
bit.ly/IE25-CBIS-Networking

Thurs, 17 Nov 17:30-19:00
DSI Lecture – On Human-Agent Collectives
bit.ly/IE25-DSI-HACs

Tues, 22 Nov 19:00-21:00
Friends of Imperial
Lecture – Synthetic Biology: Addressing Global Challenges
bit.ly/IE25-Friends-Synthetic

Fri, 25th Nov 19:00
RSMA
132nd RSMA Annual Dinner
Rembrandt Hotel

Sat, 26th Nov 12:30
CGCA
5&10 Year Reunion Lunch
bit.ly/IE25-CGCA-Decade

Thurs, 1 Dec 18:00-19:00
Dyson School of Design Engineering Talk – The Cradle to Cradle Design
bit.ly/IE25-Dyson-Cradle2Cradle

Thurs, 8 Dec 17:00-20:00
Imperial Fringe
All Around the World
bit.ly/IE25-Fringe-World

Wed, 15th Feb 2017
CGCA
Peter Lindsay Memorial Lecture
bit.ly/IE25-CGCA-Lindsay

Sat, 18th Feb 2017
RSMA
115th Bottle Match
Harlington Sports Ground

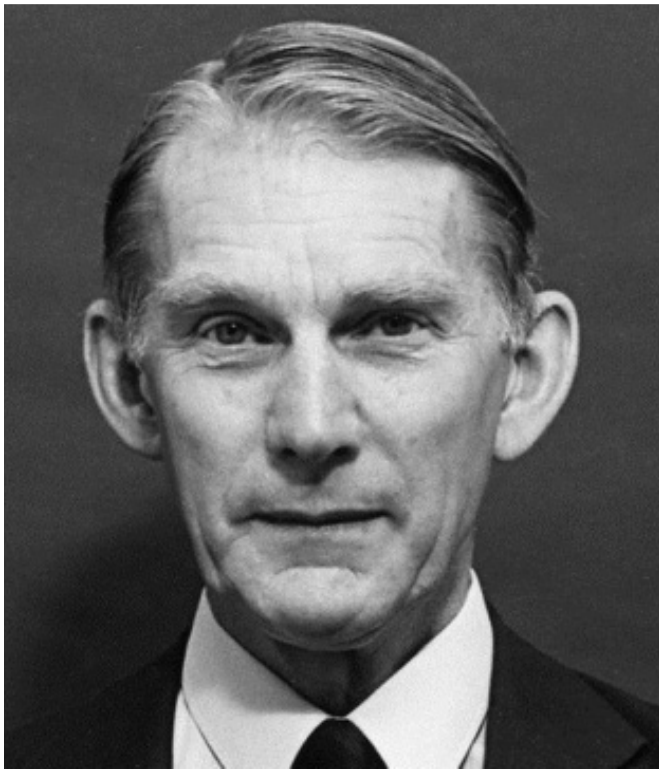
Fri, 3rd Mar 2017 18:45
CGCA
Annual Dinner at Saddlers' Hall
bit.ly/IE25-CGCA-Dinner

Sat-Sun, 6-7 May 2017
Imperial Festival

Wed, 14th Jun 2017
CGCA
AGM and President's Evening BBQ (Details available soon)

Thurs, 29th Jun 2017
RSMA
Final Year BBQ

For details follow links, or see page 2 for contact details



Engineer, academic & sportsman

Prof BERNARD G NEAL (Staff 1961-82)

The Department of Civil Engineering would like to offer its condolences to the family and friends of Professor Bernard Neal, Head of this Department from 1976 until 1982.

Bernard took his degree in Cambridge and, after the interruption of the war, took his PhD in 1948. At Cambridge, he became one of the originators of the static and kinematic methods of performing Plastic Limit Analysis or collapse load analysis of framed structures, and he made many subsequent contributions to this field of research.

He remained in Cambridge on the teaching staff until 1954 and was elected a Fellow of Trinity Hall, leaving to take up a Chair of Civil Engineering at University College Swansea. In 1956, he published 'The Plastic Methods of Structural Analysis', a book which has become a classic and been translated into several languages, including Russian.

In 1961, Bernard took up the Chair of Applied Science with Special Application to Engineering, at Imperial College, based in the Department of Mechanical Engineering. Here, he was responsible for the Common Course, the undergraduate preliminary programme which, until 1971, had to be taken by first year undergraduates of all engineering departments at the College. He was also Dean of the City & Guilds College from 1964-67, and published 'Structural Theorems and their Applications' in 1964.

Bernard has a special place in the history of the Old Centralians' Trust; he was a signatory to the original Trust Deed, and served as a Trustee throughout the remainder of his term as Dean of City & Guilds.

In 1973, he became Chair and Head of Structural Engineering and then, in 1976, when Sir Alec Skempton retired as Head of Department, Bernard was selected to replace him. He continued in this role until 1982, whilst also remaining Head of the Engineering Structures Section until 1981. Bernard was a firm leader, respected by his colleagues in all Sections of the Department. He kept the undergraduate course in Civil Engineering in very high esteem. and the Department in good order, through his ability to find funding from unexpected sources and very careful housekeeping, until his retirement in 1982.

His was elected a Fellow of The Royal Academy of Engineering in 1980.

Bernard was also an accomplished sportsman captaining Cambridge at tennis and excelling at croquet, playing for Great Britain and winning the All England Club's men's singles title 38 times. Later, as a valued member of the Links Club, his sporting prowess earned him the nom-de-plume of "Ball Boy"

A Life member of CGCA, Professor Neal passed away on 26 March, 2016, just short of his 94th birthday.

Intelligent, feisty & caring

PAULINE ROWE (nee GARMIRIAN) (Civil Eng 1946-49)

Pauline was born on 5 August 1929 in London, the only daughter of a Turkish Armenian trader, Gregory Garmirian. She grew up in Hendon and excelled at school with 14 passes of Oxford school certificates, 9 of them at Grade A. She completed her A levels in 1946 with Grade A success in both pure maths and applied maths and a B grade in physics.

She then moved on to Imperial where she graduated as a civil engineer in 1952, aged 23.

In 1952, she married Peter Rowe, a fellow CGCA Member, later Professor of Chemical Engineering and Head of Department at UCL.

Pauline's own career started in 1947 as a trainee at Sandford Fawcett Wilton and Bell. She also worked over the years for Watchams in Caversham, and Hawker Siddeley in London and Loughborough.

Apart from her life as a civil engineer, her passion was the St Johns Ambulance service where she served with distinction and achieved the rank of officer sister with 8 bars on her service medal.

She was a loyal and supportive wife to Peter; they were married for 63 years, until Peter passed away in 2014, aged 94.

Pauline's life can be characterised as that of a sharp, intelligent woman. She was frugal and feisty, but hers was also a lifetime given to caring for others during wartime, through her service for St Johns, and caring for disabled people in the community.

Pauline died on 4 March, 2016, and is sadly missed by her two sons, Tim & Andy, 7 grandchildren and 5 great grandchildren.

Greatly missed

TIMOTHY STACEY GARE (Civil Eng 1960-63)

Timothy was born on 10 January, 1941. He obtained a Bachelor's Degree in Civil Engineering from Imperial College and continued his studies thereafter, receiving an MSc from the London Business School.

He was working for SG Warburg in 1973, and later for Savix Limited, before moving to Switzerland, where he practised as an investment consultant in Geneva, latterly through his own company TSG Investment Management SA.

Timothy was intelligent, kind and, for years, a very successful man.

He sadly passed away from leukaemia, on 18 December 2015, at the age of 74. He will be greatly missed by his wife Noëlle.

A gentleman and a very good leader

GROSVENOR REX DAVIS (Staff 1966-82)

Rex, as he was generally known, was born on 16 September, 1922, in Walmer, Cape Province, South Africa.

He studied geology at Rhodes University, graduating with a BSc in Geology in 1942, Honours in 1948 and a PhD in 1951.

Between 1942 and 1966, Rex was involved in mineral exploration and production in Northern and Southern Rhodesia (Now Zambia and Zimbabwe) and Uganda.

Like most geologists who survive beyond 30, he had many adventures while engaged in field work. On one occasion, he climbed out of a dry river bed and peering over the bank found himself looking into the face of an astonished lion. Fortunately the lion, more astonished than Rex, did a quick back flip and headed off fast into the bush.

When Rex was a student, the prevailing view on the origin of mineral deposits, apart from alluvial placers, was that they were principally sourced by hydrothermal fluids of deep crustal origin. Thus mining geologists were experts in 'hard' rocks of igneous and metamorphic origin, rather than the 'soft' sedimentary rocks.

Rex's own observations of the Zambian Copper Belt confirmed the then heretical views of Bernard, Garlick, Fleischer and Wolf, that some mineral deposits result from sedimentary processes of mineral concentration and precipitation. In the Copper Belt, there was a clear correlation between the ore minerals and the depositional environment of the host sediments.

In 1966, Rex was appointed Professor of Mining Geology at the Royal School of Mines, Imperial College, after 24 years of practical experience as a mining geologist. His Inaugural Lecture 'Mining Geology in Prospect' was delivered in June 1967 and makes interesting reading half a century later. It is a masterly global overview of mineral economics, exploration and extraction technology (including the use of nuclear explosives), education and research.

Rex came to Imperial College with two big ideas. One, based on his experience in Africa, was his appreciation that sedimentary processes had as much to contribute to mineral exploration as did hydrothermal ones. He required mining geology students to take a new course in sedimentary environments. This did not go down at all well with the macho students of the Royal School of Mines. Rex required a newly appointed young lecturer to deliver the course. The member of staff responsible for drawing up the timetable had a wicked sense of humour and scheduled the lectures for 2.00pm on Friday afternoons, a time when mining students were in training for the weekend in the union bar.

Rex's second big idea was to use the expertise of the Royal School of Mines to win research contracts with outside bodies to train post-graduate students, maintain industry links and generate income for the department. In this he was fulfilling the words of the Imperial College Charter but, unfortunately, the Rector of the day thought that Rex's idea of setting up a sort of 'RSM Ltd.' was 'like taking in dirty washing'.

One morning, while commuting to college, Rex chanced upon an IC alumnus who was then working in North Sea petroleum exploration. They discussed the common association of mineral deposits and petroleum. The next year the alumnus happened to join the staff of the IC petroleum group. A successful conference 'Forum on Oil & Ore in Sediments' was organised and the proceedings published in 1977. This was the catalyst that resulted in Rex applying to Saudi Arabia for a research contract to survey its mineral resources.

The application was successful and the 'Cover Rock Project', as it was called, ran for several years in the late 1970s and early 1980s.

In 1974, Rex took over from Professor John Sutton as Head of the Geology Department. He had the great misfortune to succeed Sutton just as the money supply declined.

Within the first term of his Headship, a 10% cut on expenditure was imposed across the College.

Rex's spell as Head of Department was not a happy time for him. His experience in the hierarchical mining industry made it hard for him to adjust to the new consensual form of university government wherein heads of departments were restrained by committees.

Rex crossed swords with the Rector again when the Professor of Petroleum Geology retired in 1977. By then, the North Sea was established as a major petroleum producing province.

The Rector, who had a low opinion of geology anyway, saw no need for a replacement in petroleum geology and therefore no need to fill the post. Rex tendered his resignation. Fortunately the Rector blinked first. A new professor was appointed and the department has since developed as a major global leader in petroleum geoscience.

Rex left Imperial in 1982 at the age of 60, somewhat bruised by his 16 years in academe.

He rapidly established himself as an international consultant in mineral exploration, based in Dorking in the summers, and South Africa in the UK's winter months.

Rex received various honours and awards. He was President, an Honorary Member and a Gold Medallist of the Institute of Mining and Metallurgy. He was elected FREng in 1983.

Rex was also a Freeman of the City of London and of the Worshipful Company of Engineers.

Like many geologists, the word 'retire' was not in Rex's vocabulary. He was an enthusiastic member of the Mole Valley Geological Society, the local group of the Geologists' Association close to his home in Dorking.

Rex was still writing peer-reviewed articles at the age of 73, continuing to give ad hoc lectures here and there, and playing bowls regularly until his death.

In 2000, Rex and his wife Elizabeth moved from Dorking to Ditchling.

Elizabeth died in 2014, and Rex died on the 60th anniversary of their wedding, shortly before his 94th birthday, on 9 July, 2016.

He leaves a son and a daughter, five grandchildren and admirers around the world.

Prof. Dick Selley

Some tributes to Rex from former colleagues:

I was sad to hear about Rex. He was my first boss after I graduated as a wet-behind-the-ears mining geologist in 1958.

In those days it wasn't difficult getting a job with zero postgrad experience, if you were prepared to travel. I wrote only one letter - to Frobisher Ltd in Bulawayo - on the advice of John Webb at RSM, and by return air mail I received an air ticket.

After a couple of days of flying, starting from Heathrow to Salisbury thence to Bulawayo, I arrived at Frobisher's office and met the Chief Geologist: Rex. He packed me off by train northwards across the Zambezi to Livingstone, and from there I spent the next year in the bush, doing geochemical drainage sampling for copper.

Rex's visits to our field camps were always a delight to look forward to for his guidance and humour. After twelve months in Northern Rhodesia, I received the order to drive south to join the company's small gold exploration team in Southern Rhodesia. We pegged eight abandoned mining properties in the Turk Mine district north of Bulawayo, dewatered and surveyed three of them, and finally brought one of them back into production after refurbishing the old cyanide extraction mill. Rex's sense of humour remained intact, even after one underground inspection when he emerged back on surface exhibiting a distinct greenish complexion. We suspect carbon dioxide might have had something to do with it.

After Frobisher Ltd., I remember an underground tour of Mufulira in the early 1960's where I was working, by then, as a mine geologist and I had the pleasure of showing Rex around as one of the visitors.

Geoffrey Hammond

I knew Rex at RSM 1966-71 and attended his exploration management course in Adelaide.

He was a gentleman.

His views on the 'soft rocks' having something to do with ore accumulations led me to have numerous heated discussions with many mature age Australian geologists in Mt Isa, Broken Hill and even on the Goldfields.

John Noakes

Prof Rex Davis was a gentleman and a very good leader. He worked very closely with my father for years at the RSM.

Bernie Pryor

A life of dignity, clarity and authority

KAREL PETER LABBERTE (RSM 1991)

From an obituary compiled by Marcel Damen:

Karel Labberte was born on 16 July, 1967, in Wageningen.

I have had the privilege to have known Karel since our time at the Technical University of Delft, some 30 years ago, and he has been one of my very dearest friends ever since.

Karel was part of the first generation of students from Delft to complete their final stage of the Delft Curriculum at the Royal School of Mines.

Apart from being a superb academic, Karel also excelled on the social level and was invited to join the Chaps Club, played in the RSM rugby team and won the Bottle Match against Camborne that year.

After his graduation, Karel left for South Africa and built up a successful career in the mining and steel industry, settling in Cape Town.

Just in June 2015, after he had initially recovered from his illness, Karel joined the Chaps Derby Day celebrations, which he was still speaking of a week before he passed away.

That same week we also spoke of his life and the times ahead and Karel told me he was at peace and was pleased that he had been able to live a life of dignity, authority and clarity; this was his life's legacy.

Karel died, in Cape Town, on 26 April, 2016, leaving his wife, Janet, and sons, Ryan and Mitchell.

In his memory, the Chaps Club will inaugurate a memorial pot, which will be called the 'Karel Labberte Overseas Ambassadors Pot'.

Glück Auf, Karel!

Some of the tributes received from Chaps commemorating those days:

Very sad news indeed. That Bottle Match was the 1991 '4-3 thriller' at Harlington from memory... far too young to be leaving us… Glück Auf.....You will be missed.

Lloydy

Karel…lived and breathed the spirit of what a Mines Man should be. He was a key part in creating a great partnership with Delft and RSM that has generated some truly memorable friendships.

Tim Cotton

Karel was truly larger than life and will be missed by all. I had the pleasure of playing in the same Bottle Match with Karel. He was a naturally gifted sportsman, who took to rugby with his usual passion, skill and determination during his year at RSM. He also led the way for the RSM-Delft exchanges, which enriched both universities.

Henry Longden

We shall always remember Karel as the trailblazer for us Delft 'lot' who had the invaluable opportunity to become part of the RSM and Chaps community.

Rob Peters

Karel had a massive and warm grin, and very loud stirring voice. RIP Karel and love to your family. You will be truly missed.

Kurt Budge

I have very fond memories of Karel…He truly was a larger than life character. A force of nature in everything he did. I will miss him.

Rob Rowe

Consultant engineer

PETER CLARK (Met 1945-48)

Peter attended the Royal School of Mines at Imperial College from 1945-48 and was an ARSM.

He worked for many years in the oil industry and as a corrosion engineer and as a consultant.

He continued to consult after retirement, working, even as recently as the last few years, in relation to a pipeline at the Hong Kong International Airport.

Peter passed away quietly in Wyong Hospital, New South Wales, Australia, in the afternoon of 8 July 2016.

He was 88 years old and had outlived two wives.

He is survived by his brother, three sons, one granddaughter and three grandsons.

'A very privileged life'

CLIFFORD DOUGLAS WILLIAMS (Met 1948-51)

Cliff was born on 3 December 1928 in Port Pirie, South Australia, where his metallurgist father, Dr G. K. Williams, was, at the time, the works manager at the BHAS lead smelter.

In 1946, Cliff began his metallurgical engineering degree at the University of Adelaide and had two years to complete the course when his father accepted a post as a consultant to the National Smelting Corporation, Avonmouth in Bristol, and the whole family travelled to England.

On arrival, Cliff enrolled at the Royal School of Mines. He thoroughly enjoyed his time there and made lifelong friends. His English friends called him "Digger" to acknowledge his being an Australian.

In 1952, after graduating, Cliff found work in New York, at Swigmaster and Brier, as a graduate metallurgist. During this time, he applied to mining companies in Australia for work and was offered a job in the copper smelter of the Mount Isa Mines, Queensland, which he happily accepted, arriving back in Australia in February 1953.

By 1955, Cliff had become Assistant Superintendent, and the Head Smelter Superintendent in 1957. He married an Adelaide girl, Dorothy Proudman, in March 1959 and they had two daughters.

He became Metallurgical Development Manager in 1962 and Chief Metallurgist of the development group in 1966.

In 1973, he transferred to MIM's Brisbane head office as Research Manager and he and his family settled in St Lucia in Brisbane. He was made the MIM representative on both the Australian Mineral and Industrial Research Association (AMIRA) Board and the Australian Mineral Development (AMD) Board.

In 1979, he became a member of the International Lead Zinc Research Organisation (ILZRO), attending his first meeting in Paris, in 1979, and remaining a member until 1981.

In 1981, Cliff was appointed General Manager of research in MIM Holdings where he remained for the next ten years.

He had a long association with the Mining School at Queensland University and its research centre, serving on its board.

In 1991, after 38 years with the Mount Isa group, Cliff retired, established Williams Business Enterprises and began consulting. He remained happily in consulting until he retired, in 2000.

Cliff had always been involved in charities. In Mount Isa, he ran school fetes and, when he was Chairman of the Kindergarten Association, he and his Committee were asked by MIM to build a Kindergarten in Mount Isa in memory of Eileen Fisher, the Chairman's wife who had died in a plane crash.

When he came to Brisbane, Cliff ran the Red Cross Door Knock for his area and was President of the National Association for training the Disabled in Office Work (NADOW)

Cliff was also president of the St Lucia Community Association and, when he retired, he supported Meals on Wheels, delivering meals until he was 85 and could no longer manage some of the stairs to people's flats.

Golf had always been Cliff's main recreation. He played twice a week. His main claim to fame was that his golf never got any better but he carried on playing with his old friends – they were all in their 80's. He didn't give up until seven weeks before he died, at the age of 87, giving up driving and golf on the same day.

Cliff lived a very full life. He was never one for sitting about. One daughter and her family lived in Toowoomba and one in Maleny, about an hour and a half away. Every month, Cliff would drive up to lunch with each one in their lunch hour, to have his own time with them because he said he never got a word in when all the women were together.

He had a close and loving relationship with his wife of 57 years, who survives him. He always felt that he had had a very privileged life.

Cliff died on 14 April, 2016.

Open, honest, pragmatic... Inspirational

DAVID CLARENCE OSBORNE, (Mech Eng 1971-74)

From an obituary compiled by David's older brother, Noel Osborne, (Mech Eng 70-73)

David Osborne , better known as 'Dave', was born on 18 March, 1953, son of an RAF Officer who had left his native Trinidad to fight in the 2nd World War. David was the youngest of 3 boys.

Their early years were spent moving frequently with their father; places like Stafford, Bracknell, Rheindalen in Germany, Bicester, Andover and finally Uxbridge.

At 13, David and his older brother, Noel, were sent to a boarding school in Brockenhurst, in the New Forest. It was here that Dave developed his passion for mischievousness, hard work, sport (playing rugby at the local New Milton Rugby Club), and eventually beer.

By the time Dave reached the lower 6th, he was already the school first team basketball Captain and Noel remembered being humbled by his younger brother's superior prowess. The Sports Day results of 1970, will remain indelibly etched in Noel's mind; for the 100m, 200m and the Triple Jump:

Second place - Osborne,N
First Place - Osborne,D

In 1971, Dave went to Imperial College where he studied Mechanical Engineering, played lots of rugby and drank the odd pint of beer.

Dave was in the IC First Team, and also played for the combined London University's team. He was also engaged with the Imperial College City & Guilds Union, spending one year as the mascot bearer (of Spanner and Bolt) and, during his last year, David was President of the City & Guilds College Union.

Dave in Boanerges, before setting off for the London to Brighton run, ca 1973.
Photo from David Willey (also Mech Eng 1971-74)

During the university holidays, Dave worked for ALCAN, working with Information Technology. It was here that he got his first job after gaining his degree, later moving to ISTEL.

His career spanned several decades, reaching senior positions in large businesses such as NTL (now Virgin Media) and SITA where he was a Senior Director.

In his CV, Dave summed himself up as: *A professional Director/General Manager; a strategist who clarifies and influences both the pace and direction of change as well as delivering what was agreed.*

This may sound a bit like corporate 'speak', but to his brother, Noel, it describes Dave as a person who was open and honest, a pragmatist, a good leader, someone who would get the job done.

Noel recalled that, whenever they discussed problems or uncertainties, Dave would always bring these attributes to the discussion. His was a no-nonsense approach, but very soon the answer always became obvious.

Away from work, Dave's passion was rugby. He played at a high level for Newport and then Northampton Saints, before settling down at his local club at Stratford-on-Avon, where he played for several years, becoming the Club Captain.

He spent several years coaching the younger players, one of them wrote of him:

'*A true Legend and Gentleman. Fearsome on the Pitch. An honour to have played alongside Dave. Inspirational to so many of us younger players.*'

In 2006, Dave was diagnosed with bowel cancer, and he fought hard, to make it through the first round. It was far from easy with several complications, and it seemed to go on for ever. Gail and the family, were not only helping him through a tough time, but they too were on a difficult journey.

Dave never complained, just understood the problem and did what had to be done. Soon, he was back at work, getting fit, and it was business as usual.

Sadly, towards the end of 2014, things took a turn for the worse.

Before he went back to the doctors, Dave continued with a planned family holiday to Canada and the journey of a lifetime across the Rockies.

For the last 18 months or so, it was a hard a fight, but fight he did, with his wife, Gail, by his side.

Unfortunately, there was not going to be a last minute score to win this final match. Dave died peacefully at home on 29 May, 2016, with his family by his side.

He leaves behind his wife, Gail, children Ben and Kate, and brothers Lawrence and Noel.

Engineering entrepreneur

PETER LESLIE ASHCROFT (Mineral Technology 1966-69)

Peter was born in Liverpool in 1946.

He arrived at the Royal School of Mines in September 1966, to be one of nine undergraduates on the Mineral Technology course.

With a distinct Liverpudlian accent he was well known. He participated in college life; principally the RSM Motor Club and Imperial Entertainments Committee; as well as propping up the Union Bar as much as any other Minesman of his day.

Graduating in 1969, Peter married Pauline, his school sweetheart, and they went to the Zambian Copper Belt, Peter working at the Mufulira concentrator of Roan Selection Trust.

In the mid-70s, Peter got a position with Fraser & Chalmers, based in South Africa, and spent some years selling and installing mineral processing equipment into the SA mines. He also worked for Greenings screens in a similar capacity.

But Peter was always an entrepreneur, and he saw a good opportunity to get into the fibreglass manufacturing industry.

Working for others at first, he eventually set up his own company and widened the scope of his interests.

Go to Sun City and see the large animals and other fabulous decor adorning the hotel and complex, which were made by Peter's firm. In Johannesburg, the mobile phone masts are hidden in palm trees – fibreglass ones also made by Peter's firm. He used his technical expertise to create fibreglass domes that looked like genuine copper.

Peter enjoyed his work and lived life to the full.

He suffered medical problems in the mid-2000s and had to give up his work, his son Christian took over running the firm.

Peter's lifestyle changed dramatically and although his brain was still active and needed stimulation, he became physically dependent on others. Pauline also suffered with bouts of cancer at the same time.

When Pauline died unexpectedly in April, 2015, Peter's daughter Corrin and husband, Stash, took over his care.

Peter was around to see Christian married to Jan and a grandchild on the way for Corrin and Stash.

Peter was still very much himself and recognised his friends and family to the end. He passed away calmly in hospital on the 17 April, 2016.

Highly innovative teacher

NORMAN LOCH (Mech Eng 1959-60)

Norman was born on 13 July, 1936 and educated at Boroughmuir School, Edinburgh. At the age of 16, he joined Ferranti as a student apprentice mechanical engineer, completing his Ordinary National Certificate at evening classes. His high grades led to his being invited to undertake a full-time Associateship in Mechanical Engineering at Heriot-Watt College, which he completed in 1958.

He then returned to Ferranti as a design engineer, working on airborne radar systems for the English Electric Lightning and Blackburn Buccaneer aircraft. In 1959, he was sponsored by Ferranti to study for a post-graduate Diploma at Imperial College in London, from which he graduated with flying colours, his diploma project being the study of viscoelastic materials. He was a member of CGCA.

In September 1965, he became a Senior Stress Engineer at Rolls Royce in Derby, undertaking design work on nuclear submarine systems. His main role was to design and analyse pressurised water reactors for Royal Navy nuclear submarines, using analogue and digital computing techniques, and specifically investigating the elasto-plastic material and mechanical vibration behaviour of these structures.

He returned to Heriot-Watt University in September 1969, as a Lecturer in Engineering Design.

He was very popular with staff and students, his major academic strength lying in his ability to transfer his extensive knowledge and experience of design and dynamics in a clear and comprehensible way. He was highly innovative in his teaching methods and projects, and was much sought after for advice and guidance from students and staff.

After retiring from full-time work in December 2000, he was re-engaged on a part-time basis and continued to contribute to mechanical engineering teaching until November 2003. On leaving, he was subsequently invited to assist part time with Engineering Design teaching at the University of Edinburgh for a few years.

Norman's life revolved round his family, his students, his friends and golf. He died in January, 2015.

A life lived to the full

CLAYTON RAYNER WILFRED (STEVE) STEPHENS (Civil Eng 1951-54)

Steve was born in South London on 16 November, 1932. Sadly his mother died when he was born, so he was initially cared for by his maternal grandparents, of whom he was very fond but, after his father re-married, Steve lived with his father and new family.

In 1951 at the age of 18, he won a County Major Scholarship to study Civil Engineering at City & Guilds.

On graduation, Steve joined Tarmac and worked on Shoreham Power Station, Brighton, followed by spells around the UK, before becoming based in Tarmac's office in Park Lane, where he met his wife-to-be, Gillian.

After their marriage in 1962, and the births of their daughters Hilary and Holly, Steve became agent for the construction of Fawley Power Station. In 1972, the family moved to Forestside Gardens in Ringwood, their home from thereafter.

From 1982, Steve worked in London, for the 1981 'Schal/Tarmac' joint venture between Tarmac and the American construction management specialists Schal. The business grew through the '80s with the majority of work being commercial office buildings, many of which included complex engineering and logistics. Steve remained with Schal until retirement in 1992, and worked on a number of their major projects, which meant spending a great deal of time away from home. Many of the jobs were technically challenging, and Steve enjoyed overcoming construction problems by devising innovative solutions.

He believed that his greatest achievement was in demonstrating that the new offices over Charing Cross Station could be built without disruption to train services or to the general public; a treasured possession was a letter from the architect, Terry Farrell, thanking him for making the project possible!

In retirement, Steve became heavily involved in local educational and sporting affairs, and became a governor of Ringwood School.

In addition, he was an active member of the Fordingbridge Bowls Club, becoming treasurer and then working on plans to construct the new clubhouse, which now stands proudly in his memory. More recently, he joined the Greyfriars Men's Club, meeting regularly, enjoying the company and taking a full part in the discussions.

Being diagnosed with prostate cancer in 2001 did not deter Steve from living life to the full, enjoying his family, friends and grandchildren.

He died on 27 August, 2014, at the age of 81 and is sadly missed by his family and by many friends.

'I like to think I glimpsed the obvious occasionally'

DUDLEY DENNINGTON (Civil Eng 1944-47)

Dudley, who has died aged 89, was one of a number of highly regarded civil engineers who could turn their hand to any problem.

Born on 21 April, 1927, he graduated in 1947, and after National Service in the Royal Engineers, joined Sandford Fawcett & Partners, working on water-related projects.

Following experience with contractors Demolition & Construction, and Wm Press, supervising oil refinery construction, he joined George Wimpey & Company in 1952. In 1965, in charge of Wimpey's structural design department, he was offered the post of assistant chief highway engineer for highway construction at the fledgling Greater London Council (GLC), working under the energetic Peter Stott, director of the new department of highways and transportation. County Hall was a challenge from day one, and required the linking of engineers from the defunct London County Council and Middlesex County Council into one highways team, while fielding tough queries from, and negotiating with, politicians in committees.

By 1970, Dudley was traffic commissioner and director of development, in charge of all the GLC's planning, traffic and highway projects, and co-chairman of the Greater London Traffic Executive. He was also founder chairman of the Greater London Road Safety Unit. Under his guidance, the computerisation of London's traffic signals was completed. He delivered the Council's bus lane programme, and spearheaded the banning of cars in Oxford Street, increasing the average speed of traffic flow, and improving road safety across the capital. London's radical approaches of this time were studied and copied around the world. He did not minimise the difficulties in such large scale infrastructural planning, but said: "I like to think I glimpsed the obvious occasionally".

Leaving the GLC in 1972 he became a partner in consulting engineers Bullen and Partners, with responsibilities including major highway projects in the UK, and work in the Middle East and Hong Kong. A senior partner, by 1989, he stayed on as a consultant following retirement in 1992.

He was a fellow of the Institution of Civil Engineers, served twice on its council and, in 1990, was its Vice-President for engineering. He was a member of the Marshall Committee, a visiting professor of civil engineering at King's College London 1979-1982, and an active member of several professional bodies including the Engineering Council. He was also a long-standing member of the Blythe Sappers, the club of ex-Royal Engineers, and of the City & Guilds College Association. In his spare time, he was a keen watercolourist, and a contributor to the Enigma brain tester feature in the New Scientist.

Dudley Dennington, BSc (Eng), FREng, FCGI, FICE, FIStrucE, FIHT, died on 12 May, 2016.

He leaves a wife and two daughters.