Sealab 2005: Spotlight on Chris German

In June, *Angelina Souren* had a long conversation with *Chris German* at his office at the National Oceanography Centre, Southampton (NOCS) – which prior to May used to be called the Southampton Oceanography Centre (SOC) – in the UK.

Chris German is a marine geochemist and an expert on hydrothermal vents. For the past five years, he headed the fluid flow group within NERC's Challenger Division for Seafloor Processes. He was also an Honorary Visiting Professor at the University of Southampton linked to the Graduate School of SOC and the School of Ocean and Earth Science – a position he still retains. Both are part of the NOCS, which currently houses some 450 research scientists, lecturing and support staff as well over 600 undergraduate and post-graduate students. Over the summer of 2005, however, Chris, his wife Romey, son Jamie and their two dogs and a cat have all relocated to Woods Hole. Chris' impending departure was a good opportunity to interview him for the Geochemical News. He had already sold his house and was staying at a campsite as his visa for the States – of course – was taking longer than expected.

Chris has always been highly driven. He likes what he does for a living, and it shows. It gets noticed. He received an MBE (Members of the Order of the British Empire) – for services to Marine Research – from Buckingham Palace in 2002. Two years earlier, Chris and Dr. David Vaughan of the British Antarctic Survey were selected by the Royal Institution as Scientists for the New Century.

How it all began

How did you end up in science? Are any of your relatives in science as well?

My older brother was the first of our family to show an aptitude as a chemist and went straight into teaching the subject, following university. But as he progressed through the education system, he became first a Headmaster of an inner city school in the west Midlands and has since progressed to helping run the Local Education Authority. My father was an engineer and my mother a school teacher specialising in special needs teaching. Adding in my sister and sister-in-law, that makes four past or present school teachers in my family – so I guess I was pretty sure I wanted to do something different from that.

Of course, the other major influence I had, growing up, was that one of my grandfathers was in the Navy in the early 20th century and both of my grandfathers, my own dad and both my uncles. So every male in my family for two preceding generations spent at least some time working at Chatham dockyard, three to four miles from where I grew up.

I read somewhere that you initially did not want to have anything to do with the sea. How did you end up at sea anyway?

I am still not quite sure myself. From a very early age, I enjoyed chemistry. It was something I was interested in and had an ability to do. However, I was also pretty good at languages and for a long time, I quite fancied the idea of becoming a diplomat. Certainly some of the teachers at my school were quite keen to steer me to the arts.

But somewhere around age 15, 16, it became clear that science was where I was headed. In the UK system, you specialize quite strongly from age 16 on. I studied Maths, Physics and Chemistry to the exclusion of all else and when I got accepted to Cambridge to read Natural Sciences, Plan A was to end up as a chemical engineer working in the petrochemical industry.

The trouble was, at Cambridge the Natural Sciences course (Tripos) required that you take up an additional 4th subject in Year 1. I chose geology– and to make a long story short, that is how I ended up in geochemistry. Several people were particularly instrumental in my transition from a chemist to a marine geochemist during the next 3 years.

First of all, both my mum and my brother had an interest in geology when I was a very young teenager. But where we grew up, in North Kent, that meant that my full exposure to geology pre-university had been wandering at low tide through the mud-flats of the Thames estuary, looking for fossilized tree ferns. Not the sexiest pastime for a teenager! My entire 1st year at Cambridge compounded many of these prejudices, being tutored by a man who had devoted his life to Thames Valley gravel!

But then, around Christmas of my 2nd year a new tutor arrived from Australia, Steve Sparks (now a professor at the University of Bristol). By that time, I had turned away from ideas of pursuing chemical engineering and had enjoyed some parts of 1st-year geology enough to be studying a hard-rock petrology/geochemistry course in Year 2. The first term had been pretty dry - lots of crystallography and mineralogy, but after Christmas we started doing more petrology and it was at the same time that this new tutor arrived. He was a very bright young guy and arranged all sorts of things for us. I was lucky enough to be one of the few to have him as an undergraduate tutor as well as having him oversee my transition at the end of that year, from being a chemist with a minor in geology to becoming a geologist. He helped support that and present it to the head of the department, who had to oversee the transition. That was Ron Oxburgh, now Lord Oxburgh, who has more recently been Rector of Imperial College in London and, in the past year CEO of Shell. But back then, they were just the grown-ups who came out to see me during my honours mapping project.

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Two years earlier, Chris and Dr. David Vaughan of the British Antarctic Survey were selected by the Royal Institution as Scientists for the New Century.

That brings me to the next person responsible for helping drag me into the earth sciences: Jon Blundy who is also now at Bristol. I got to spend three months in the Italian Alps to do my mapping with him. He had just finished top of his undergraduate degree class in Oxford and was starting a PhD with Steve in the Adamello Massif – also one of Ron's favourite stomping grounds at that time. It was his first field season where he showed remarkable tolerance of my profound ignorance and also drove me around a lot. By combining their considerable talents, I would say that those three successfully helped me transform from a competent chemist to an okay but fairly average geologist.

Not the stuff he expected

In my final year as an undergraduate, I had to be pretty careful which courses I chose, given that I hadn't taken a lot of conventional geological courses in Year 2 (little things like sedimentology, paleontology that the majority consider quite important). Instead, the plan was that I stick to what I knew and concentrated on courses in petrology with a view that

Previous page: The research submersible Alvin (photo credit NOAA)

my grades would be held up by an expected high grade in my particular forte - geochemistry. In those days, geochemistry was taught almost entirely by Keith O'Nions (now at Oxford) with some extra lessons on instrumental analysis and design by Jim Long, a specialist in hand-built ion probes.

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"I was not actually allowed to sweep on the streets straightaway. For the first week, I was only allowed to work in back alleys..."

But disaster nearly struck – and now I am close to answering your question: over the summer between my second and third years, the department in Cambridge recruited a new member of staff who took on 50% of the geochemistry course. The person concerned – and ultimately responsible for just about all that followed was Harry Elderfield, who – for those who do not know - is very much a marine geochemist. That was not the stuff I thought I was going to be studying!

So, suddenly, 50% of the geochemistry course was marine-based, with lots of discussion of weathering and related 'soft-rock' stuff. This was exactly the stuff I had avoided in Year 2 so the message was clear – to come out with a decent degree at the end of the year I was going to have to work pretty hard. Again, however, I was fortunate that it was part of the Cambridge system that I had weekly tutorials, with Harry Elderfield and a fellow student, Libby, who was also cox for the University Boat Club. Every Wednesday, Libby would skip out of our tutorial early and head to the river. Harry and I then sometimes used to carry on for one or two hours. He was really generous with his time. I was very lucky as it was his first year that he was doing tutorials. I'm pretty sure he got wiser later on! Indeed, when I became his PhD student, suddenly I found that I was doing most of the tutorials for later generations of undergraduates. Hope I measured up!

Released on police bail

Another thing I remember from those days – and that not many readers other than Steve Sparks would know about – was that I had to be bailed out of jail during an undergraduate field trip that last year – guilty of over-enthusiastic souvenir-collecting!

That was in Bangor, North Wales. The first activity of the final year of the degree course was for everybody to meet up in North Wales for a one-week field course. On the first night, before we had even started, I went into town with a couple of friends and on the way home we ended up collecting various road signs. Our excuse was that they had been standing in bad spots where we bumped into them and we removed them for the sake of safety. I suppose an equally valid hypothesis could have had something to do with how we were walking, but I digress…

We had actually walked past the local police station, carrying these signs, but it was about two miles further up the hill when a police car stopped us. The officer took us down to the police station and put us in a cell. Another two hours later, they got Steve Sparks out of bed and it was about 2 in the morning, I think, by the time we got back to where we were staying. We were released on police bail, for the duration of the field course, and on the last evening, we had to report back. That's when they told us there wouldn't be any charges and thus we avoided a criminal record.

Working as a road sweeper

The rest of the year passed quite uneventfully. I managed to graduate with a strong 2.1, put in a late application for a PhD with Harry Elderfield and went home to wait for 2 to 3 months to hear whether that had been approved. In the meantime, I had graduated at Cambridge on a Saturday, got home on the Sunday and started working at 6am Monday morning as a road sweeper. I spent twelve weeks working on that job. I knew it wasn't forever, but I wanted to prove to myself, before I went any further in life, that I could do whatever kind of job it took to get by, in the future.

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In fact, I only started as an apprentice road sweeper: I was not actually allowed to sweep on the streets straightaway. For the first week, I was only allowed to work in back allies, but once I had proved myself fit to be seen by the tax-paying public, I was even allowed to sweep in front of the local town hall, which had to be done twice a day. And pretty soon I got to play with some fun toys…

I never realized how much fun you could have with one of those machines that suck the drains dry. Quite often, you would have to rescue car keys for people who had accidentally dropped them down a drain. The most glorious was the week I spent on the refuse vans. Those vans had a driver and only two people loading the bins. As luck would have it, I was replacing someone on a team who routinely ran marathons. One of these two extremely fit men had gone on vacation. The other guy was twice as fast as me; they had to go much slower than usual.

After two months, with one month still to go, I got a call saying that my PhD had been approved. So after three months, I went back to Cambridge to start being a student all over again.

Boiling seawater dry

My PhD was studying trace metals in the Indian Ocean. The initial plan was to spend six months to a year preparing the project and then in the summer of 1985 go to the Indian Ocean.

Within about a month of starting my PhD, we found out that the whole cruise programme had been delayed by one year. So I actually had to wait two years before I could go out to sea and get the samples for my PhD.

My supervisor, Harry Elderfield, sat me down and explained that it was not really a problem at all as he had plenty of samples sitting on shelves, from Saanich Inlet. And he had a new post-doc arriving from Woods Hole, Hein de Baar (now at the Royal NIOZ in The Netherlands) who also had some interesting samples from the Cariaco Trench. So for my first year, I worked alongside Hein de Baar

on the Cariaco Trench samples before he left and moved to The Netherlands. In my second year, I worked on the Saanich Inlet samples from Vancouver Island before I ever got to go to sea. In the summer of 1985, when everybody else in the lab was working on other topics, I ended up explaining to my geology friends that my project was about boiling seawater dry.

Of course, it was a lot more sophisticated than that, but in a nutshell, if you wanted to explain what you were doing when you wanted to determine dissolved Rare Earth Element concentrations (to an audience of geophysicists)... You start off with a litre of seawater and you end up with a very small precipitate, often a near-invisible amount, of something that you then measure on a mass spectrometer.

Black smokers

Someone who was also working at Cambridge in those days was Gary Klinkhammer. Gary was working on samples he had collected from the Mid Atlantic Ridge (MAR) in 1984, which provided the first evidence for hydrothermal activity anywhere in the Atlantic (Klinkhammer et al., Nature, 1985). In the summer of 1985, at the end of my first year as a PhD student, Gary, Harry Elderfield and Marvyn Greaves went on a second cruise and came back with the first discovery of black smokers on the Mid Atlantic Ridge.

So that is how I became interested in hydrothermal activity very early in my career. I spent two years not going to sea and, indeed, I was pretty sure I was not going to like going to sea so my PhD in marine geochemistry still looked pretty unhealthy to me. But I enjoyed what I was doing and when the chance finally came, I actually booked up for three months of ship time within a five-month window, in 1986. The plan was that when I finally went to sea that June, I was going to learn whether this really was the life for me – or not!

The real cruises for my PhD were actually from August to September and from October to November in the Indian Ocean, studying redox cycling and rare earth element geochemistry, in particular in the Arabian Sea. The first cruise, however, was to do studies at a brand-new hydrothermal site called TAG on the Mid-Atlantic Ridge. We arrived there about three to five days after the first Alvin dives to visit the site at the seafloor.

Have someone fly over and drop off a few spare parts, please

That first cruise, I volunteered for some responsibility on watches. Just about everything broke down and we could not figure out what we were going to do next. One of the major problems was that our Principal Scientist, Bill Simpson, then at the Institute of Oceanographic Sciences in the UK, had built a very large and complicated pumping system 'FIDO' (Filtration in the Deep Ocean), which was about twice the size of an ordinary CTD system, and just too heavy to be run from the ship's mid-ships winch. So eventually the winch overheated and broke down. We spent one entire night where we had the instrument deployed 3,500 metres below the ship within the Mid-Atlantic Ridge rift valley with cliffs that came up to 2000 metres within five miles either side of us. This was still in the very early days of GPS.

We had four hours per day when we actually knew where we were, and 20 hours a day when we were running on 'intelligent guesswork'. So, making sure we didn't crash into the cliffs was the first priority all that night

That, it transpired, was ***my*** job! I then learned something that I had never realized before: you can actually tack with a large research ship, using the ship's superstructure like a sail. So we were sailing up and down with a heading pointing towards the north. We had a ten-mile wide valley to work with, but we also knew our 'dead reckoning' might have us two or three miles out of position. So we drew a little five-mile corridor inside our map of the rift valley and tacked that ship north within our five-mile corridor, as slowly as possible, waiting for sun to come up the next morning.

On that cruise, we used to joke about whether we could call up Radio Shack or their equivalent and have them fly over and drop off a few spare electrical parts. But in truth, we ended up with nothing but a thin steel cable - the hydrowire – to deploy equipment from for the rest of the cruise – and only what was on-board ship to build our equipment with. Astoundingly, 48 hours later, and programmed with a very early Hewlett Packard calculator, we were ready to deploy a completely new system, built from scratch at sea. What is most impressive is the derivative of this system – the 'Stand Alone Pump' rapidly became a mainstay of, for example, the JGOFS Marine Geochemistry program and is still in frequent use in oceanography today.

On the longer term, this was not a particularly successful cruise. But on the short term, it gave me experience of being at sea and as far as that went, it was a fantastic experience. I got to see the whole process of how you have to reinvent your science programmes at sea, more often than people realize. What you end up doing is often not very close to what you had planned to do.

The second thing it taught me is how much a marine scientist relies upon the engineers they work with. That is what makes the difference. These are often the people who – when something goes wrong – determine if you are going to be able to get something

successful out of your cruise anyway or if you really are just dead in the water.

I am happy to say that I took to going to sea pretty well. I routinely do get seasick for the first one to two days away from port, but once I get my sea legs it really is no problem and I start wondering why I stayed ashore so long.

I went off and did my other two cruises that summer, which were pretty much pre-programmed in that at certain coordinates, we were going to collect water samples from certain depths. There wasn't a great deal of spontaneity involved because, to address the questions posed, you first had to collect the appropriate data set which meant certain key samples had to be collected in exactly the right way from a certain pre-ordained number of locations.

What I really liked about the hydrothermal research that I just had a taste of, by contrast, was that you would go out and start to collect data and then have to start making value judgements on the fly, at sea, and continuously reinterpret your data as each day passes to see if yesterday's assumptions and conclusions remain valid. Maybe that is true of all research cruises but in hydrothermal work in particular, you often didn't know at all what (if anything) was going to be down there. There was a lot more potential, it seemed, for making real discoveries while you were actually out to sea.

My PhD was going well. I seemed to be enjoying the research and I seemed to be quite good at it. I was enjoying the analytical chemistry and I was particularly impressed, as we began to make very precise measurements of rare earth concentrations, how the very first data that I was generating appeared to help nature make scientific sense! For the Cariaco basin, we had an oxygen profile and we knew theoretically that there should be higher rare earth element concentrations below the oxic/anoxic interface than above it. But when we collected the data for the first six samples right across that interface, and I saw them all stacked up in a straight line, that was the first time when I realized that this was actually what research was about: I knew from undergraduate study that people had great ideas that they wrote about in the literature. But actually finding out that when you measure real-world samples, something as complex as the natural environment, actually obeyed proper chemical principles, seemed really pretty cute. That is what brought it home to me: that it was just ordinary people like me that actually went out and did this kind of work.

That was a fundamental breakthrough, between being taught geochemistry, and having spent years reading articles with polished plots in journals like GCA and then actually getting hands-on and generating a data set that you hope will end up in a paper like that.

One of the other memories I have of that time was something Gary Klinkhammer explained to me then and still influences a lot of the work I do now. We were a small geochemistry group in Cambridge in those days, at the Bullard Labs that were devoted almost entirely to marine geophysics – so much so that all the other PhDs in my year were geophysicists. The big difference was that they all went out to sea for a month in their first year, collected a data set and then spent the whole of the rest of their three years analyzing those data. In my case I spent a lot of time at sea and then took samples back to the lab where I had to process them for detailed geochemical analysis. You end up with six months of working on the interpretation of your data. I discussed that with Gary Klinkhammer and he said: 'Geochemistry won't ever really make the transition until the day when we are able to go out to sea, come home with the data and have as much time to think about the results as geophysicists have now.' Two decades later, as we are moving towards having in situ chemical sensors online, we are finally getting close to that ideal. It rang very true in 1984, 1985 and even now, it is still constantly at the back of my mind. One day soon we'll get there and the future of seafloor observatories will take off.

To MIT via WHOI

Towards the end of my PhD, I decided that I wanted to do post-doctoral research and I wanted to work on hydrothermal systems. It seemed that the obvious person on the planet to go work with was John Edmond who was a professor at MIT (sadly, passed away in 2001). He had been involved in the original discoveries of hydrothermal vents and his PhD student Karen von Damm (now at the University of New Hampshire) had just finished working up the first samples from the East Pacific Rise, surrounded (at least in my imagination) by tube worms, giant clams and all that stuff. Gary Klinkhammer who had been at Cambridge with me, had already left in 1986 and moved across to MIT as well. So I applied for a NATO post-doc grant and followed in his footsteps.

Along the way, however, I had also spent a lot of time with Mike Bacon, from WHOI, at a Royal Society meeting in London in 1987 and discussed some ideas with him about deep-ocean scavenging processes and how they might relate to hydrothermal systems. So I called Mike Bacon up and asked if I could still come along and do some of this stuff, if I could get the right samples. That summer I won a 'Travelling Student' award from the Royal Society and used it to go to sea twice. The first cruise contained my first Alvin dive. A big thrill. The second cruise was going back to the Mid Atlantic Ridge with Harry Elderfield as part of a larger UK-US collaboration. My particular role was to make first use of the UK's new 'Stand-Alone Pumps', the direct descendants of what I had seen built at sea two years earlier.

"NASA have always spent about 10% of their research budget on explaining their scientific activities to the public. Few other programmes that I know of – or science colleagues I work with – would relish spending such a large slice of their 'science' budget this way. But when you look at the continuing support for NASA after several decades, you realise that this scale of outreach helps to bring back sufficient scientific investment to make sure you still get to do a thorough scientific job as well."

By the time I arrived at MIT in 1988 as a post-doc, it didn't seem like it would take long to learn just about all there was to know about hydrothermal activity. (I was very young, remember!) We knew that there were slow ridges like the Mid-Atlantic Ridge and fast ridges like the East Pacific Rise and we knew about one vent site on each for which the fluid compositions were actually very similar to one another. Analytically, two new things happened when I got to the US. First, there was the new technique that Mike Bacon's lab had just pioneered, using thorium and protactinium fractionation to study dissolved-particle interactions in the oceans. Also, just as I got to MIT, John Edmond and Ed Boyle took delivery of North America's first ICP-MS, a VG Plasmaquad. It was a very happy coincidence that suddenly there was this new machine. Before that I had only had about two days' worth of experience running some samples on a demonstrator machine at the VG factory in Cheshire, but in 1988 that turned out to be quite a head start on the majority! At MIT, I took a crash course in radiochemistry to learn radiochemical techniques.

Faster than I could get settled at MIT, however, Mike Bacon contacted me from WHOI. I was still welcome to come down and work with him that winter, and be the first person to study Th-Pa fractionation in a hydrothermal system. However, the North Atlantic Spring Bloom Experiment that was part of the initial JGOFS (Joint Global Ocean Flux Study) program meant that I had to be out of his lab by 1 May 1989 because that is when the first JGOFS samples would start coming ashore. I still hate to remember how many hours I worked processing samples that season, but I'm told you don't miss much in winter in Woods Hole – ask me again next summer!

Up close and personal

In my second year at MIT, I got back to TAG with John Edmond. During that cruise I got to see a black smoker up close and personal for the first time, which was fantastic. I only had one dive on the cruise, but it was quite a daytrip! We sampled the black smokers and the white smokers – our primary objective. Then, since we were ahead of schedule, we also got to drive around collecting high-quality video footage at some of the key locations on the mound. With 20:20 hindsight, I realise that this was actually my first exposure to outreach and improving the public understanding of science. To be honest, however, at the time it was such a pleasure for me that I had a hard time convincing myself that it was perfectly okay to be a bit of a tourist. I went along with one of the most experienced pilots that Alvin has had, Dudley Foster. We got some great samples and also had a really good day out, basically.

During that same cruise, I received a fateful telex. I had been up late analyzing samples for vent fluid chemistry because when those samples come on board they are chemically unstable and you need to get a whole series of key parameters (alkalinity, pH, H_2S

concentration) measured as soon as possible. That was my primary responsibility for the whole cruise which meant I had to stay with it for as long as it took each night. One morning after finishing one of those groups of samples I slept in, and woke up for lunch to find a telex cellotaped to the outside of my cabin door, offering me a job back in the UK, at the IOS. Again, this was before the days of e-mail communication. So I tracked down the radio operator and through a flurry of exchanged telexes I persuaded the UK government that it was both in my and their interest that I finished my fellowship at MIT before moving back to the UK, although they had initially wanted me to head back immediately.

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When I first arrived at MIT, I was quite proud that I was self-funded on a NATO research fellowship, but when I attended my first AGU conference, people assumed I was a PhD student because of my age. I had just turned 25 that summer and I probably looked younger than that. Indeed, Erik Brown, now at the Large Lakes Observatory in Duluth even annotated our wall chart of the geological timescale at MIT with 'younger than Chris German' – but only because he was one of the few who was! This highlighted a notable contrast between the demands of the UK and US PhD systems and compounded the fact that to be a PI at MIT then, maybe still, you had to have earned a tenured position. So with my age and status against me, I decided that if I wanted to start my own research initiatives, the best thing to do at the end of my NATO post-doc was to head back to the UK where the advantage of my job at the IOS was that I could develop my own ideas and have my own say about what I was going to do.

24 bottles of seawater and 22 bottles of champagne

I met my wife Romey the last summer before I went to America, after eight years in Cambridge. Actually, I met her children first. I was sharing a rented house with, among others, her ex-husband. Their children Martin and Helen used to come and stay over on weekends. I sometimes ended up babysitting them and so their mother made it her business to find out who this strange person who was babysitting her children was. I think the earliest such occasion was Helen's fifth birthday party and we just hit it off from the word go. But I was just about to finish my PhD and to go to America so it was also about the worst possible timing you can imagine for starting a serious relationship! Especially as I then spent two of our first three and a half months after meeting each other at sea. Still, nothing worth doing comes easy, allegedly!

At the end of that summer, we agreed to see how things were after a year. It probably would have been a good test for our relationship, if we'd kept to it. The original deal was that Romey would come out the following summer and drive me from coast to coast on a rented

Harley. Maybe there was something about her driving that scared me…

Within about a month of arriving, we found we were calling each pretty regularly. I was not settling in brilliantly in the US; the work was going very well, but at a price: I was not getting out much and meeting anybody where I worked and things weren't so great for her as a single parent in Margaret Thatcher's Britain either. So at some point, when I couldn't see any other way of improving life generally, I took a gamble and said 'Well, you could always just marry me and we'd both be happy,' Romey paused for a while – seemed like quite a long while – without saying anything and then just replied 'Alright.' This may all sound rather scarily precipitous and, indeed, I think we often do look pretty spontaneous to people who don't know us. But the sad truth is that it's an optical illusion. What actually happens is that Romey and I do a lot of talking, thinking and planning about multiple possible futures. That means that when great opportunities come up, we often find we have already thought things through pretty thoroughly and rationalised quite a lot in advance. So then it just becomes obvious what we should do. Romey was working at a school in Cambridge at the time so had to wait to take a week's holiday before she could come over to America. It was the week of Thanksgiving.

The following December I went back to the UK. I was flying Pan Am the day after the Lockerbie bombing, with two suitcases, one with my luggage and the other with 24 1-litre bottles of trace-metal clean Black Sea seawater. As far as the bomb disposal experts at Logan Airport were concerned, however, they were just 24 canisters of what could just as easily have been plastic explosives! Fortunately, I had a letter from MIT explaining that I was taking the samples to Cambridge to do rare earth analyses. Equally fortunately, nobody spotted that I had a helpful colleague at MIT who thought ahead and prepared the letter for me for just this eventuality. During that trip, I visited my parents, Romey and the children where we broke the news we were planning to get married. Romey came back in March of that year and we got engaged in the Public Garden in Boston.

I flew back to the UK in May of that year and we were married in Cambridge. It was a pretty amazing week. We got married one Saturday, I had my birthday in the middle of that week, and the following Saturday was the graduation ceremony for my PhD.

We weren't shipping anything to the US, so we had told everybody that we didn't want any wedding gifts that we couldn't drink before we sold up and moved out. So we ended up getting 23 bottles of champagne. The rarest of the lot was a bottle of Russian (Crimean) champagne from the shores of the Black Sea (this was ***before*** the fall of the iron curtain), smuggled out by Kelly Kennison-Faulkner, now at Oregon State University. Along with all the booze, a particularly nice touch was that we also got an antique ice bucket from my old research group in Cambridge and we still have that. But none of the champagne.

By the time we moved back to the UK again in 1990, Romey was seven months pregnant, expecting Jamie. He was due on the Thursday that would have been Thanksgiving in the US (how cute), but instead he arrived a day late and the Newspaper Headlines from the day of his birth read 'Thatcher Resigns!' That's my boy!

Public outreach

How do you explain the public's fascination with the deep sea? It seems to me that there are two scientific topics that the general public is very interested in. One is the deep sea and the other is astronomy.

What connects the two is weird biology. Another thing they may have in common is the explorational aspect, which may be a bit of a dirty word in science. Nowadays, you can't often get someone to fund you if you just say 'I wonder what happens there.' Instead, you have to rethink your question and present it as 'I wonder if such and such a thing happens there.' If you just have raw curiosity, you can choose to go anywhere, but if you want to do it at the tax payers' expense, it seems reasonable that you should have to try a bit harder than that and explain ***why*** it is important to explore somewhere nobody has been to before.

Space exploration strikes me as the modern-day equivalent of building cathedrals: the people who make the plans and have enough influence to get a major program funded are not likely to be young enough to stick around and still be actively involved in working up the results of all their plans. Research cruises are not quite that bad. It takes about two years after submitting a proposal until you can get to sea and collect the data, and then another two to three years when you need to work on the results. You are looking at a cycle of three to five years for any expedition that you plan to the deep-sea environment. Perhaps that is also part of why the public likes both fields: the scale of the science is outside most people's daily lives.

To me, it looks like you are willing to communicate with the general public, more so than some of your colleagues.

I seem to have an ability to communicate in a way people understand. You have to be very careful, though. One of my first experiences was in the very early 1990s. I had a call from somebody from the Sunday Times who was running an article and who needed some extra quotes. One question was 'What about the story of the origins of life from hydrothermal vents? What do you have to say about

that?' My exact quote was 'Well, it would be a lovely story if it was true, but I think the best you can really say about it is that at least all the ingredients are there.' The following Sunday, the back page of the main section of the Sunday Times said 'Chris German believes life originated at hydrothermal vents. 'All the ingredients are there.' he said.' It was at that point that I realized that you really have to be very careful and you really can't afford to relax and enjoy yourself too much when talking to the press. But I still do and I still get into trouble.

The other thing that I have become very aware of – and much more impressed by – is that outreach is rather like science in that, unless you throw enough money at a problem in the first place, to take it seriously and do things properly, you really can't get things done.

NASA have always spent about 10% of their research budget on explaining their scientific activities to the public. Few other programmes that I know of – or science colleagues I work with – would relish spending such a large slice of their 'science' budget this way. But when you look at the continuing support for NASA after several decades, you realise that this scale of outreach helps to bring back sufficient scientific investment to make sure you still get to do a thorough scientific job as well.

What struck me is that there is a lot more interest in science here in the UK than in Holland (where I am from). You can actually buy New Scientist at many supermarkets here. To me, that is pretty amazing.

I think that all probably comes down to the BBC, their natural history series and people like Sir David Attenborough. But there has been some very interesting new research I have learned of this year, in the US, on how to achieve effective outreach. This new study has identified that if you want to manage effective outreach with school-age children you really have only a couple of 'optimum' years to target. There is no point aiming outreach at school children who are too young because they won't have learned enough basic science to grasp the concepts. Certainly before age 10, they're not ready. By the time they become mid-to-late teenagers, however, it's just not cool anymore to be interested in anything scholarly anyway – even marine geochemistry. So one of the leading arguments now, which rings true to me, is that 12 to 14 is the age to aim for. Then working out how to get involved in outreach to school children suddenly becomes a lot clearer, because you only have one or two school years that you aim at and so you can really focus your efforts.

My son has just passed through that age group. He is 14 now, but last year he was studying plate tectonics in his geography lessons. He got a real buzz out of it. And what brought it home to him that here was a real 'happening' science was that his notebooks and mine from the same school year showed a lot of overlap up to the point when his teacher started teaching him about the eruption of Mount St Helen's. I was already at university when that erupted. We had a lot of fun working up a school project on Montserrat together last spring.

Future plans

What's next?

During the 1990s, I spent a lot of time – through InterRidge – examining the geologic controls of hydrothermal activity on the seafloor. One of the goals we set ourselves was to test whether there was any limit to how slow a ridge could be spreading and still host hydrothermal activity. Over five years or so we established that there is no ridge, no matter how slow it is spreading, that does not have hydrothermal activity. In fact, there isn't just some activity, there is plenty! But the exploration is not finished yet, because in the multi-disciplinary world that geochemistry lends itself so well to, you often need to study both geologically and biologically… And what still remains unanswered is how very geologically similar hydrothermal settings in different ocean basins can host quite huge differences in their biological communities.

This is the focus of a major new programme I am now involved in as Co-Chair. It is the Census of Marine Life program 'ChEss' – investigating the biogeography and biodiversity of chemosynthetic ecosystems. That may sound as if I am a marine biologist, but I am really still working on redox processes in the sea and their effect on geochemical cycles – near enough the exact same title as my original PhD thesis!

One of the next big programmes within this project is going to be to investigate what happens when a mid-ocean ridge and a subduction zone collide. From a biogeochemical perspective the Chile triple junction is probably the one place on earth where you can have every kind of low-oxygen marine environment together. We expect to be able to find cold seeps along the Chile margin and hydrothermal vents close by on the intersecting ridge. What's more, we can also expect to get thermal destabilisation of gas hydrates (already identified by seismics) as hot young lithosphere is thrust beneath the margin close to the triple junction. In addition, the whole of the Chile margin is also a whale migration zone. You may know that there are well established migration routes for Gray Whales, for example, between the Guyamas Basin and Alaska. But there is an equivalent migration in the southern hemisphere, off the coast of the Andes all the way down to the Southern Ocean with one of the Southern Hemisphere's most significant Blue Whale nursing and

feeding grounds just 200 km from the Chile triple junction itself. Why is this relevant? Whale falls to the seafloor set up sufficiently reducing conditions, locally, that these too can provide chemosynthetic 'oases' on the seafloor, similar to those provided by cold seeps and hydrothermal vents.

Biologically, there are some really interesting things to go and do there. If you look at all these different systems, there is no guarantee that any one species would be common to all of these different chemically reducing environments. They may, instead, be specially adapted for high temperatures or pressure. That is what we want to find out and right now, the only place you can get that information on this planet is at the Chile triple junction.

By the time we moved back to the UK again in 1990, Romey was seven months pregnant, expecting Jamie. He was due on the Thursday that would have been Thanksgiving in the US (how cute), but instead he arrived a day late and the Newspaper Headlines from the day of his birth read 'Thatcher Resigns!' That's my boy!

Of course, the SE Pacific is a very remote place if you are starting from here. Not so long ago, an initial response from a programme manager might have been 'That is a long way to go. Your ideas would be wonderful if where you wanted to work was somewhere close to the coast of Europe, for example, or just off Martha's Vineyard.' But it isn't. It's in the SE Pacific. The flip side of that is that you can make a virtue out of it.

It is a fascinating place. There is no reason why you can't organise programmes to go there. If the science is important enough then, in terms of value-for-money for the tax payer, it is not necessarily more expensive to go there. Rather, if you are going to go there, you want to make sure that you (on the collective international scientific scale) stay there for a while and make the most of the opportunity.

Which brings me to my second major ambition for the years ahead. It has been known for more than 20 years, from He-3 enrichments in the deep-water column, that there is a major hydrothermal plume dispersing west across the Pacific Ocean away from the southern East Pacific Rise. One of the major results of the WOCE expedition (thank you, physical oceanography!) has been to demonstrate that there is no other hydrothermal input to the oceans that is nearly so significant along any other part of the global mid-ocean ridge.

So, as part of the new GEOTRACES programme being pioneered by Bob Anderson at Lamont in the US and Gideon Henderson at Oxford in the UK, my own priority is going to be helping to develop a process study that examines what really goes on within that hydrothermal plume. We know that gross hydrothermal fluxes to the ocean are large (on a scale similar to rivers). We also know that processes in hydrothermal plumes strongly modify those gross fluxes from the seafloor and that hydrothermal plumes interact with the entire volume of the ocean, on average, on timescales that are not much longer than that for thermohaline circulation.

So hydrothermal plumes might buffer ocean chemistry at some scale, for at least some tracers. A complication arises in that key processes in hydrothermal plumes – such as Fe oxidation – vary from one ocean basin to another. But we now know where most of the gross flux comes from so if we want to really get to grips with what the net impact might be of hydrothermal venting, there is one obvious place left to go.

Again, it is inconvenient for the average programme manager that the most important place on earth to work is not also convenient to a Scripps, a Woods Hole, an IFREMER or an SOC/NOC. But we shouldn't apologise that the world is such an interesting place. We just have to get ourselves organised and start presenting the compelling scientific arguments.

With the advent of MC-ICP-MS, we now have the ability to measure almost the entire periodic table then compared to the original GEOSECS program (and of course, back then, a complete ocean chemistry program was constructed blissfully oblivious to the importance of submarine hydrothermal activity!). Now we have a wealth of experts committed to GEOTRACES so that you can really aim to conduct one ambitious and really detailed study. Everyone contribute their own specialist measurements and by pulling all of that together, in conjunction with some dedicated dives for fluid-sampling at the source Southern East Pacific Rise vent-fields, we'll end up with a fairly complete hydrothermal/geochemical budget.

What are you going to do in Woods Hole?

I basically have six months to settle in when I first get to Woods Hole. I am going to be joining the Geology and Geophysics Department where I already held an adjunct position, although I do already enjoy quite a lot of overlap with other departments. During those six months I get to settle in and join the department, learn to find my way around and submit a few proposals to get my own research up and running. Then on the first of January, I will take over as the new Chief Scientist for Deep Submergence.

The Chief Scientist for Deep Submergence's job is to be a go-between the national deep Submergence Facility and the users themselves, the US research groups.

I will find out in practice what this actually entails. Crudely, the idea is that I make sure that the US research community gets good value for money, that the taxpayers' money is well spent, ensuring best use of the facility.

Since 1998, I have been heavily involved in getting the first ROV set up for research in the UK. One of the big reasons why I wanted to get an ROV in the UK was to have the ability to go beyond our former limitations which allowed us to go from making a map of the seafloor along a 200-km section of mid-ocean ridge and get to within less than 200 m of a new vent site and then have to stop. It is frustrating in a way that is hard to communicate to end up knowing exactly where a brand new site of hydrothermal activity is – probably inhabited by completely new species previously unknown to science – and then have to hand that information to somebody else in a completely different research group (and in the case of UK research, not even in the same country as you) who can then go down, land straight on the site, take photographs and actually get to see what is there. It makes a big difference, when you're that close, to be able to drop a submersible, manned or otherwise, over the side of the ship and finish the job properly.

What is your theory about why some people have their favourite elements?

Sometimes it is what you start with and the techniques you know. There can be a huge activation energy involved. I happened to get experience with TIMS early on in my career, and then I moved on to radiochemical techniques at Woods Hole and was also in on ICP-MS technologies from the start. So I haven't ever really been tied down to one analytical technique. Instead, I suspect people think that I just keep banging on mindlessly about hydrothermal systems and reveal any latent narrow-mindedness that way. Of course, that still puts me in a quite distinctive minority of people working in areas of ocean chemistry that do not have any obvious direct link to global warming, climate change and those things that are often easier to explain to the tax payer as being important.

I do think that it is probably right, that 90% of our population probably should be using the taxpayers' money to work on immediate problems. But there are other things out there. It is important that somebody keeps that 'extra 10%' alive in the oceans because whenever we come up with new tracers and we want to start using them for understanding ocean budgets, and particularly when using them within a climate change perspective, somebody somewhere has to understand the complete (and not just a part of) the marine cycle of whatever that new tracer is. Somebody somewhere has to be able to at least check that the hydrothermal contribution (for example) is not important.

With iron, for example, there is a reasonable chance that perhaps 50% of the dissolved iron in the deep ocean is hydrothermally sourced. It would not be very difficult for this to be true – you could precipitate 98 to 99.5% of the dissolved Fe estimated to be released from hydrothermal vents and the remaining 0.5 to 2% would still make the mass balance work. So what if hydrothermally sourced Fe was important as a productivity-limiting micro-nutrient once it is upwelled to the surface? This is probably pushing the limits and wouldn't take long to disprove, but it is still untested and probably worth investigation.

I have about 20 years of sampling left, and I see things in five-year chunks. There are two questions I have always been interested in, in my hydrothermal research. One is 'where does it occur and why?' which is a very geological question, but you use chemistry to

answer those questions. The second question is 'Is it important?' Right now it strikes me that if I could get these next two big programmes – the Southern EPR and Chile Triple Junction projects – completed then I might, finally, think I have begun to get a pretty good overview of what's going on. So that's what I want to get done in the next five – or perhaps it'll take ten – years. But you know how it is, things sometimes change in six months.

Personal preferences

I read somewhere that you are a vegetarian.

Yes, that came in 1986 or thereabouts. I had been thinking about it for a while and in 1986, I found myself at sea during that first research cruise with a like-minded fellow PhD student, Phil Newton. I think we were both a bit overawed by just how much meat we were being served up at sea (in those days fresh salad lasted no more than a fortnight at sea and after that it was coleslaw, potato or rice salad for the next three weeks) and that it couldn't possibly be healthy. Since my father had had two major heart attacks in the preceding years, interspersed with major bypass surgery, it also seemed timely to do something preventive. The cumulative effect of this was that I became a vegetarian and have been ever since.

How does that work at sea, when they serve you so much meat?

On UK ships, it is not a problem at all. American ships vary from one to another. I remember my first trip on an American ship when I was served the main course, with roast beef and gravy. When I explained that I was a vegetarian, the steward said 'no problem'. He took my plate away briefly, then brought it back with a hole in the congealing gravy where the meat used to be. Life has progressed a lot since then. On most ships now, it's self-service and there is a lot more variety available. Of course, there are also vegetarian members of ships' crews who have also confided that there is nothing quite like having the Chief Scientist be a vegetarian to help inspire the cooks to try that bit harder, too.

But one of the most interesting experiences I've actually had was on a Japanese research cruise aboard the RV Yokosuka. It turned out – I think as much to their surprise as to anyone else's – that so much of the food that they served was in fact vegetarian – and pretty interesting too! Perhaps the French ships are most difficult, nowadays. There, I think asking for vegetarian food comes pretty close to an insult to the national pride. But the compensation for that is that they do serve excellent red wines with their meals!

What kind of music do you like?

Good question! The first band I saw live (and still rate) were The Jam. But I have one particular band that seem to have grown old with me at exactly the right pace – and that's The Cure. Must be my naturally sunny disposition, I suppose. Some people argue that my sudden relocation to Woods Hole this year is all part of a thinly disguised midlife crisis, but I actually had that when I turned forty and Romey bought me a bass guitar. When I was a kid, my parents did their best to coerce me into a classical musical education so I was in the school choir and I played violin. I also used to play viola in the local youth orchestra. But I always half-joked, at university, that if ever I was going to get back into playing an instrument then one day I was going to get a bass guitar (4 strings good, 6 strings too many).

The turn of the century was a pretty rewarding time for me. I had received 'early career' honours for my Chemical Oceanography and Marine Geochemistry work from the Challenger Society in the UK and from the International Lithosphere Panel in the same year that I was selected for the award from the Royal Institution and then not much more than a year later I was in the New Year's Honours list (the MBE). Instead of feeling pretty smug, I found myself worrying that I might have peaked too early – 'too much too young!'

But I shouldn't have worried, I soon found out that Robert Smith has already got there about a year ahead of me and written it down in the aptly titled '39'. I guess I must have obsessed a little too obviously about just ***how*** great the bass-line is in that track because when we went up to Oxford to meet up with our older kids on my 40th birthday, a year after the MBE, I also became the proud owner of a Fender Jazz Bass.

Now, armed with that and a 40W amp, any time life seems a bit too serious and the latest reviewer hasn't quite seen the road to enlightenment that was spelled out so clearly for them in my near-faultless(!) proposal I find I have a very healthy way to unwind. Both my sons also play guitar and Jamie is also pretty good on keyboard and drums, so between us we can cover a lot of ground. In recent years the boys have introduced me to Radiohead – who we got to see live in Oxford – and Muse – at their homecoming in Bournemouth. I've tried but pretty much failed to get them into Placebo and Interpol recently – but in times of crisis I always revert to the Cure, and that's still the music I write my best papers and proposals to.

And what books?

Something I picked up on somewhere – also gleaned from Harry Elderfield, I expect – was that the more quality literature you read, the greater the chance that it will impact on your own use of words. I have always been aware that when I was younger I studiously avoided reading more than the required minimum of the 'classics.' Now, I'm afraid that I routinely spend large amounts of cash on books before each time that I go to sea. Research cruises can be very intense experiences and sometime you just need a way to get away from the world when you are out at sea. And one easy way to do that is to just go and sit quietly and read a book somewhere. That way you can create a little bit of quality 'breathing-space' time and effectively just step off the ship for an hour of so. It can be a very helpful thing to do.

Nowadays you can actually go and buy many of the past classics for a pound each, as there is no copyright on them anymore. There are all kinds of books that I should have read in my teens, but I was too young to appreciate their importance. Now I am catching up. Last November, I read Hard Times by Charles Dickens while cruising between Fiji and Tonga! This year, sailing from the Cape Verdes, I read Robinson Crusoe for the first time. It was a bit daunting to read that the island he washed up on was en route back from South America to the Cape Verdes – especially as our final port was also on that route – in Ascension. On average, I aim to take at least one solid novel for every week at sea. The best exception to that rule was in 2001 when I spent 3 months at sea in the Indian Ocean. I started reading War and Peace at Heathrow on the outbound flight and finished it somewhere between Paris and Southampton airports on the final leg home. Of modern novelists I still haven't quite outgrown John le Carré but my particular favourite is probably Ian Banks (dour grim-reality Scotsman) with or without the middle 'M' he uses when writing science fiction.

One of my next ambitions when I get to the US is to learn Spanish. That is what my son is going to start learning at high school there, based on the fact that English, Spanish and Chinese are probably going to be the three key international languages of the coming decades. I suspect that I am already too old to make a success of Chinese, but I've done a bit of Latin in my time – enough to get by in Italian on a good day – so I am hoping to pick up enough Spanish that it will come in handy when I go to the Chile triple junction.

But I do also need to keep up with the Italian as well because, lest anybody thinks we're making another snap decision, Romey and I have already been thinking ahead and latest news is that is where we're going to retire: Northern Italy.

For more information, see these recent examples and references therein:

C.L.Van Dover, C.R.German, K.G.Speer, L.M.Parson and R.C.Vrijenhoek. Evolution and Biogeography of Deep-Sea Vent and Seep Invertebrates. Science 295, 1253-1257, 2002.
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C.R.German, J.Lin and L.M.Parson (eds). Mid Ocean Ridges: Hydrothermal interactions between the lithosphere and the oceans. Geophysical Monograph 148 (American Geophysical Union), 311pp, 2004.
C.R.German. Hydrothermal exploration and astrobiology: oases for life in distant oceans? International Journal of Astrobiology 3, 81-95, 2004.

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