Interview

Caroline Peacock is Professor of Biogeochemistry at the University of Leeds. She received the 2015 Houtermans medal for an exceptional contribution to geochemistry by an early career scientist. In her current research she is probing the frontiers of elemental cycling on geological timescales. *The Marine Biologist* met with Prof Peacock at the Diamond Light Source—the UK's national synchrotron.

What got you interested in science?

If I'm brutally honest, it wasn't that I was interested in science, I was just very good at it naturally and because I understood it, I found it interesting.

How did you come to conduct research at synchrotron?

I was invited to visit the synchrotron by my undergraduate final year project supervisor. I could see the potential for getting a better angle on some of the processes that I was interested in. Later, X-ray absorption spectroscopy using the synchrotron became a really important technique for my PhD.

Why is the synchrotron useful to environmental scientists?

There is growing recognition in environmental science that many processes with global importance begin with a molecular-level interaction. In my work we're talking about interactions between particular bio-essential elements and minerals in marine sediments or soils, and in order to be able to predict how those interactions take place, you need to understand how they work at a small scale.

There are only a few techniques that can look at the immediate environment around an element and give you information about how it's bonding to a particular mineral. In order to understand elemental fate and mobility, you need to understand how that element interacts chemically with its substrate, and X-abs is one of the only technologies that gives you that information.

What motivates you in this career?

I like understanding things from first principles. My kind of experiments are reductionist; you take a complex natural system and break it down into its component parts, which you can then you look at in isolation.

What questions are you trying to answer in your research?

The overarching goal of my research is to better understand the cycling of bio-essential elements in the environment, both in the past and present. The concentrations of most of the bio-essential elements in the oceans are controlled by their interactions with minerals in marine sediments. Therefore, if you don't understand those interactions you won't be able to predict a change in those cycles due to a perturbation in ocean pH, temperature or any other fluctuating conditions. If we can do that then we have some chance of understanding and predicting the cycling of bio-essential elements into the future.

Can you tell us about the European Research Council funded project MINORG?

Carbon is probably *the* bio-essential element, and MINORG is about understanding its small-scale interactions in marine sediments, and how that leads to its burial on a global scale, over geological time. That's important because, despite the fact that only a very small proportion of primary productivity is ever buried in marine sediments, it's that proportion that controls the atmospheric composition of carbon dioxide (CO_2)over geological time. Also, because that carbon is buried and not degraded, it also frees up an equivalent amount of oxygen in the earth's atmosphere, which has helped create an oxygenated surface for complex life.

So in the short term, the biological pump is very important for atmospheric CO_2 concentrations over tens to hundreds of years. But, in the long term, the burial of organic carbon in marine sediments is key for regulating and modulating atmospheric composition (in terms of CO_2 and oxygen). But we have a relatively poor understanding of what controls organic carbon burial. We know oxygen is important, but there is a rather poor empirical correlation between levels of oxygen and carbon burial efficiency (so it's an inverse relationship), but aside from that we don't fully understand what controls carbon burial. MINORG is all about the fact that carbon might become sequestered in marine sediments, in association with marine minerals.

My take on this is that the concentrations of micronutrients in modern oceans are controlled through equilibrium reactions with minerals in marine sediments. Therefore, it's not inconceivable that the concentration of carbon could also be mediated by these reactions. Microbes in marine sediments require rather small molecules, and as soon as you stick carbon to a mineral, it becomes much larger and so is fundamentally inedible to the microbes. This idea has been investigated for several decades but MINORG hopes to take this idea to a new level.

Science these days is increasingly interdisciplinary, are there particular challenges to working with biologists?

I work with a lot of geo-microbiologists and I think it's usually a case of language; often we're all talking about the same thing, but using different language to describe it. If you were to learn the fundamental language of another then I think you can easily converse across disciplines.

What are your career aspirations?

At this point in my career I'd like to create a focus of research excellence at Leeds in small-scale experimental biogeochemistry, and building on the research that we currently do there, creating something bigger than what we currently have.

Do you find there's a part of the scientific process that happens when you're not in the lab?

I get good ideas when I sit down and just talk about what I'm doing and I see how this overlaps with other people—that fosters the interdisciplinary aspect of our work. I'm part of the Cohen Research Group and we're very collegiate; for example, we meet every week for a chat over lunch and sometimes invite external speakers to our lunches whose interests align with ours. The seedbeds for ideas are the conversations we have, particularly at conferences, from small, intimate ones to international conferences.

So for you it's something that happens very much in communication?

Absolutely, yes. I've never had a great idea sat in the office, by myself. Nowadays things are a lot more collaborative; I'll have an idea, and I'll talk to my colleagues about it. They see potential, and add their input from different perspectives. We try and encourage our PhD students to be as collaborative as possible, It's crucial to be talking to colleagues, other professors, to go to the seminars in your department and interact with the community.

What advice would you give to young scientists starting their careers?

If you're aiming for a STEM path, don't specialise too early. You can't really go wrong with standard science A-levels to get a basic grounding in fundamental science, and if you can bear to throw maths in as well, that will set you up to specialize later on.

Don't do something too niche, especially for your first degree. Many universities today offer natural sciences which is a broad grounding in all things science. Keep your options open and get a broad understanding of the STEM subjects. If you learn the fundamentals and specialize later you're funnelling yourself down to a more focused approach, but you haven't cut yourself off too early.

According to most surveys, about 50% of PhD students would like to become academics but unfortunately only about 1 in 13 is actually going to make it, and even fewer end up as professors. The odds are against you, but it is about persistence, because someone's going to make it into that successful 3–4%.

It's not just about having a natural aptitude for the subject but also about hard work and drive to work through the difficult times and just keep going, it's really difficult and there are huge ups and downs.

Talking to people and forming a network of contacts will help—many postdocs are employed based on strong recommendations; and post-docs are often people that the academic already knows. You still need to apply, be independently shortlisted and have the interview, but towards the end of your PhD, if you want to get a postdoctoral research position, you need to know the kind of groups that you want to work with, and you need to be making yourself known to them. You should go visit them, give a seminar, talk to these people at conferences, network.

I used to be terrified of going to conferences, looking up all these papers and so on. It took several full conferences to finally pluck up the courage to go and introduce myself to some of the speakers. But you have to do it; you have to make yourself known to potential employers.

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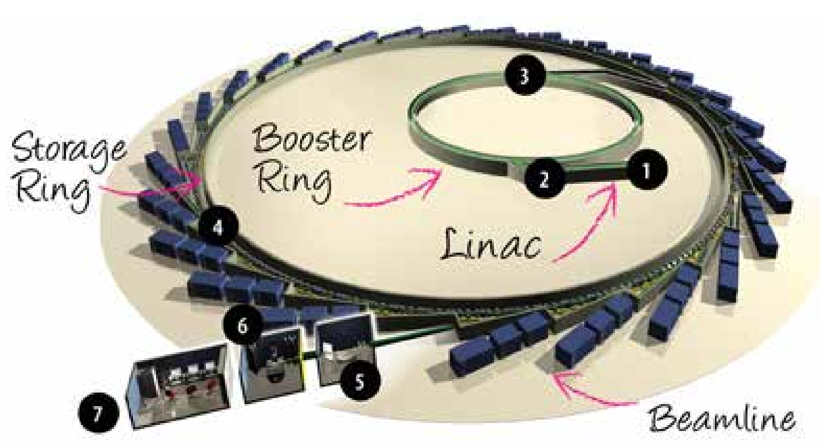
Diamond Light Source is the UK's national synchrotron.



What is a synchrotron?

An extremely powerful source of X-rays, produced by high-energy electrons as they are circulated around the machine (a particle accelerator).

How does it work?

Electron gun (1) where heated tungsten produces electrons, which are accelerated within a linear accelerator (linac) (2) before injection into the booster ring (3). Once at 100 mega-electron volts (MeV) the electrons are injected into the booster ring, where they are further accelerated to 3 giga-electron-volts (GeV) and then fed into the storage ring (4) Within the storage ring, at certain points the electrons are made to change direction at high speeds, causing them to emit energy as bright light. This light is then channelled into beamlines—each with three sections, or 'hutches'—where the scientific research is conducted. The optics hutch (5) focuses the light, the light meets the sample in the experimental hutch (6), and experiments are monitored by scientists in the control cabin (7).

Find out more at www.diamond.ac.uk