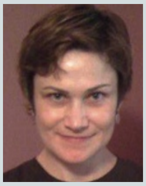
Abstractions



LAST AUTHOR

Microbial diversity and abundance has long been thought to be highest in soil environments. Now soil has a potential rival: the basalt rocks that line the ocean floor. These are carbon-poor but oxygen-rich habitats where organisms obtain energy for metabolic processes from inorganic elements such as nitrogen, iron or sulphur. Katrina Edwards at the University of Southern California in Los Angeles and her colleagues studied oceanic crust from two locations in the Pacific and found it to be surprisingly rich in microbial life (see page 653). Edwards tells *Nature* that the microbes hold important clues to global phenomena, such as carbon cycling.

Why look for microbial life in basalt rocks?
We know that chemical reactions occur between rocks and seawater, and wanted to determine to what degree microbes participate in or take advantage of those reactions. Little was known about what types of microbe can colonize rock. We expected it to be a sparse habitat, so finding 60 million microbial cells per gram of rock was a shock.

Did the microbes you found resemble organisms from other known habitats?
Most of those that we examined are not closely related to organisms that have previously been cultivated in the lab. As a result, we can't immediately describe their physiology. We did find a few groups that are closely related to cultivated organisms — for example, some involved in nitrogen cycling. A clear message from our survey is that active nitrogen cycling occurs on deep-sea rock.

What do you want to learn about these communities?
The organisms seem to be slow-growing ones that take a long time to colonize the rock. We are developing techniques to properly cultivate them so that we can study their physiology. We also want to compare the two basalt systems in this study — one around Hawaii and one at a mid-ocean ridge — with other ocean basins and the subsea floor.

Do these organisms affect the carbon cycle?
Yes. The bacteria are able to use rock and minerals as fuel to generate an estimated 500 billion grams of carbon each year — enough to be relevant to the deep-sea carbon cycle. Soon, we plan to drill into active, geologically young [less than 10,000 years old] Atlantic Ocean rock to determine how far down in the subsurface rock these processes occur.

What do you hope this work accomplishes?
I'd be excited to have more people understand that there is a 'bottom' to the ocean and that it does harbour life, which fundamentally controls the long-term chemistry of oceans. ■

MAKING THE PAPER

Martin Kennedy

Cause of most abrupt historic climate change identified in rock deposits.

Martin Kennedy has been examining cap carbonates — layers of sedimentary rocks that overlay glacial deposits from around 635 million years ago — since 1990, when he was a graduate student at the University of Adelaide in Australia. "It probably seems strange that you can study a couple of metres of rocks like this for close to two decades," laughs the geologist, who is now based at the University of California, Riverside. But the rocks may hold the key to understanding what brought Earth's most severe ice age so far — the Marinoan — to an end. And, Kennedy warns, mechanisms similar to that which he and his colleagues have uncovered could play havoc with Earth's climate today.

Cap carbonates have long fascinated geologists. Their chemical signatures indicate the occurrence of an abrupt and massive change in Earth's climate. And sedimentary deposits just above the carbonate layer contain the first fossils of complex animals. "The changes in the climate system and the first appearance of animal life in the fossil record occurred in the time interval that began with these cap carbonates," says Kennedy.

As early as 2000, he began to suspect that the cap carbonates had formed when methane clathrates — a form of ice rich in frozen methane gas — melted, releasing the gas. In 2003, he and his co-workers proposed that the extreme variety of carbon and oxygen isotopes that they had found in cap-carbonate deposits in southern China were due to a methane clathrate source (G. Jiang *et al. Nature* **426,** 822–826; 2003).

Kennedy looked for similar evidence in other regions. "I spent a lot of time walking over cap-carbonate horizons in the far corners of the world looking for these methane induced structures," he says. Ironically, he found the best examples of ancient methane seeps exposed in sea cliffs literally underneath co-author Chris von Borch's house in Adelaide. The structures had formed when methane released from melting clathrate pushed its way up through overlaying sediments.

Chemical analysis of rock samples taken from just below the cap-carbonate layer revealed an unusual mix of heavy and light oxygen isotopes. "The heavy oxygen is enriched in pore fluids during methane-clathrate formation, whereas the lightest oxygen is indicative of water derived from a melting ice sheet," Kennedy explains.

Methane clathrates remain stable in permafrost that is under pressure from a thick overlying ice sheet. But the inherent instability of ice sheets and melting at certain locations would have destabilized the clathrates, releasing methane — a greenhouse gas 30–60 times as efficient as carbon dioxide — into the atmosphere. This would have triggered a cycle of increasing temperatures, melting ice and further methane release (see page 642).

"These results suggest that the greatest global-warming event in Earth's history was caused by methane release," says Kennedy. And, he adds, because methane clathrates are trapped in Earth's permafrost today, the finding has important implications. "We are pushing the climate harder than at any other time in history," he says. "What will it take for methane to be released or for other types of feedback system that affect the climate to be activated?"

Kennedy attributes the success of this and earlier studies to meticulous sampling. "It is not a matter of knocking off a few samples and then going home. We work in great detail in the field to collect the most important and telling samples," he says. "It can take years to get to grips with a single region." ■

FROM THE BLOGOSPHERE

The editors of *Nature Nanotechnology* invited Ennio Tasciotti, the author of a recent paper in the journal (E. Tasciotti *et al. Nature Nanotech.* **3,** 151–157; 2008), to share his story of the road to success — from planning experiments to writing the manuscript — with Nature Network readers (http://network.nature.com/forums/nnano/1275?page=1#reply-4105).

Tasciotti says that, at first, the idea of writing a manuscript for publication in Nature seemed "very scary" to him. "When I first wrote my paper (I rewrote it at least 10 times) I basically wrote it thinking in Italian. Very flowery... too flowery. If I think about how many files I had gathered to generate a publication of only 8 pages... it's something that still affects me! But those 8 pages tell everything that was important to say. Scientific English is a very simple language."

His advice to prospective authors is that you don't have to use too many words, specify too much information in one sentence, or write everything you have in your mind. "Keep it simple!" Another tip is to read a lot of papers, especially those from the journal you want to publish in. ■

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