Abstractions

LAST AUTHOR
Conventional methods to convert silica (sand) into silicon use temperatures that are well above silicon's melting point (1,414 °C). Ken Sandhage, a ceramist at the Georgia Institute of Technology in Atlanta, and his colleagues have developed a method that works at a much lower temperature (650 °C) by converting intricate silica microshells of diatoms (planktonic algae) into silicon nanostructures.

How does a materials scientist get the idea to convert diatom microshells into silicon replicas?
Through luck and coincidence. I was a Humboldt fellow on sabbatical in Germany several years ago. While on a Humboldt-sponsored bus tour of Germany, I met marine biologist Monica Schoenwaelder from the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven. She told me about diatoms, these amazing single-celled algae that form intricate microscopic silica structures. My lab had been working on shape-preserving chemical reactions with macroscopic ceramics, so I started thinking about using diatom microshells as templates. I never would have thought of that on my own.

How does your process circumvent the previous constraints to making silicon?
We react silica with magnesium gas at 650 °C to create silicon and magnesia — then we selectively dissolve the magnesia. We can convert microscale silica assemblies into silicon and preserve the intricate shapes and nanoscale features — in part because the silicon is intertwined with magnesia during the reaction, inhibiting coarsening of the silicon.

What could these structures be used for?
One example is a highly sensitive and rapidly responding miniature gas sensor to detect nitric oxide or other gas pollutants. But that's really the tip of the iceberg. Silicon replicas of diatom microshells could be used as stiff, highly porous particles in high-pressure liquid chromatography to speed up purification of drugs or proteins. Alternatively, our reaction method could be applied to synthetic silica of higher purity.

Could these ancient algal organisms become the latest semiconducting craze?
A challenge with using diatom-derived silicon as a semiconductor is controlled doping. Silicon used in transistors is carefully doped to become an n- or p-type semiconductor. The silica in diatom microshells contains impurities derived from minerals in sea or lake water. Further work is needed to achieve controlled doping of diatom-derived silicon. ■

MAKING THE PAPER

Ian Harding

The depths of the ocean offer clues to Earth's glacial history.

About 34 million years ago, the boundary between the Eocene and Oligocene epochs, Earth's climate shifted dramatically from toasty temperatures in the Arctic Ocean and no ice at the poles to a rapid build-up of ice sheets in Antarctica. But little evidence exists for whether ice built up in the Northern Hemisphere during that same time.

Part of the problem is that the sediment cores obtained from deep-sea locations in the Arctic have proved difficult to date accurately, says palaeoceanographer Ian Harding of the National Oceanography Centre in Southampton, UK. So Harding's graduate student James Eldrett suggested cross-referencing microfossil data with the times of Earth's magnetic polarity reversals to date several cores collected from the Norwegian-Greenland Sea.

While perusing the original notes for one core, they noticed that a pebble found in Eocene-aged sediment had been dismissed as contamination from the drilling. When they re-examined the core, which had been in storage since 1993, they found numerous other 'dropstones' — fragments of rock carried out to the sea by ice — at different depths. The group had uncovered the first physical evidence that ice had been present in the Northern Hemisphere during the Eocene–Oligocene boundary, some 20 million years earlier than previously documented (see page 176).

The excitement about a few pebbles belied their potential importance in an ongoing controversy. In 2005, some of Harding's colleagues published a study (H. K. Coxall *et al. Nature* **433,** 53–57; 2005) based on oxygen isotope calculations from Pacific Ocean sites — concluding that Arctic ice formation at the transition between the Eocene and Oligocene epochs was a real possibility. But without physical evidence, such

studies were open to interpretation.

In the face of such scepticism, Eldrett and Harding decided to do a multidisciplinary study to develop a more reinforcing story. Their dropstone observations supported the presence of ice, but Harding wanted to know whether the ice came from glaciers or from sea ice. And, if glacial, from which land mass did the ice originate?

The characteristics of the dropstones and of the sediment grains in the ice provided clues to their origins. "A fairly rounded pebble has a huge gouge with parallel striations," says Harding. "It is a fantastic example of glacial erosion and it alerted us that we needed to investigate further." And by comparing grain-size fractions of the sediment, the team determined that the profiles matched grain sizes typically seen in icebergs, not sea ice. Also, scanning electron microscopy of tiny quartz grains from the core revealed surface textures that were "indicative of glacial processes, of being ground up in ice", says Harding.

Add to that the types of minerals and species of dinoflagellate fossils that the researchers found in the core, and the team could make a robust case that the ancient glacier had grated its way across the eastern coast of Greenland, before breaking up and melting over the drilling site.

Harding says that their work seems to indicate the existence of at least some polar ice in a world with much higher temperatures and carbon dioxide levels than the preindustrial era. But he quickly cautions the data are "far too fragmentary" to reach a definitive conclusion. "We cannot know from this one core how much ice there was or how much it fluctuated," he says. Now, says Harding, the challenge is to determine how much ice was present and how stable it was. ■

KEY ANNIVERSARY

While anticipating his 50th birthday, Shri Kulkarni, an astronomer at the California Institute of Technology in Pasadena, realized that he was closing in on his 50th *Nature* paper.

Kulkarni says that he owes his productivity mainly to his postdocs and graduate students, who he helps to motivate by guaranteeing them a good shot at getting first authorship. He has also kept the publications coming by learning new techniques and by trying not to focus too much on one topic.

Although about half of his *Nature* publications report on various gamma-ray-burst phenomena — something routinely described as 'mysterious' before 1997, he has had a lot of variety as well. His most recent paper establishes an observational basis for the linking of white dwarfs and classical novae (see page 159).

He says that he first got into the *Nature* habit by his discovery of a millisecond pulsar, but the most interesting object he found was the first brown dwarf, which now outnumber the stars.

He and his lab plan to celebrate the milestones both his birthday and his 50 *Nature* papers represent later this spring. "It'll be called a 'going downhill party,'" Kulkarni says. "It will be hard to keep up this level of productivity." ■