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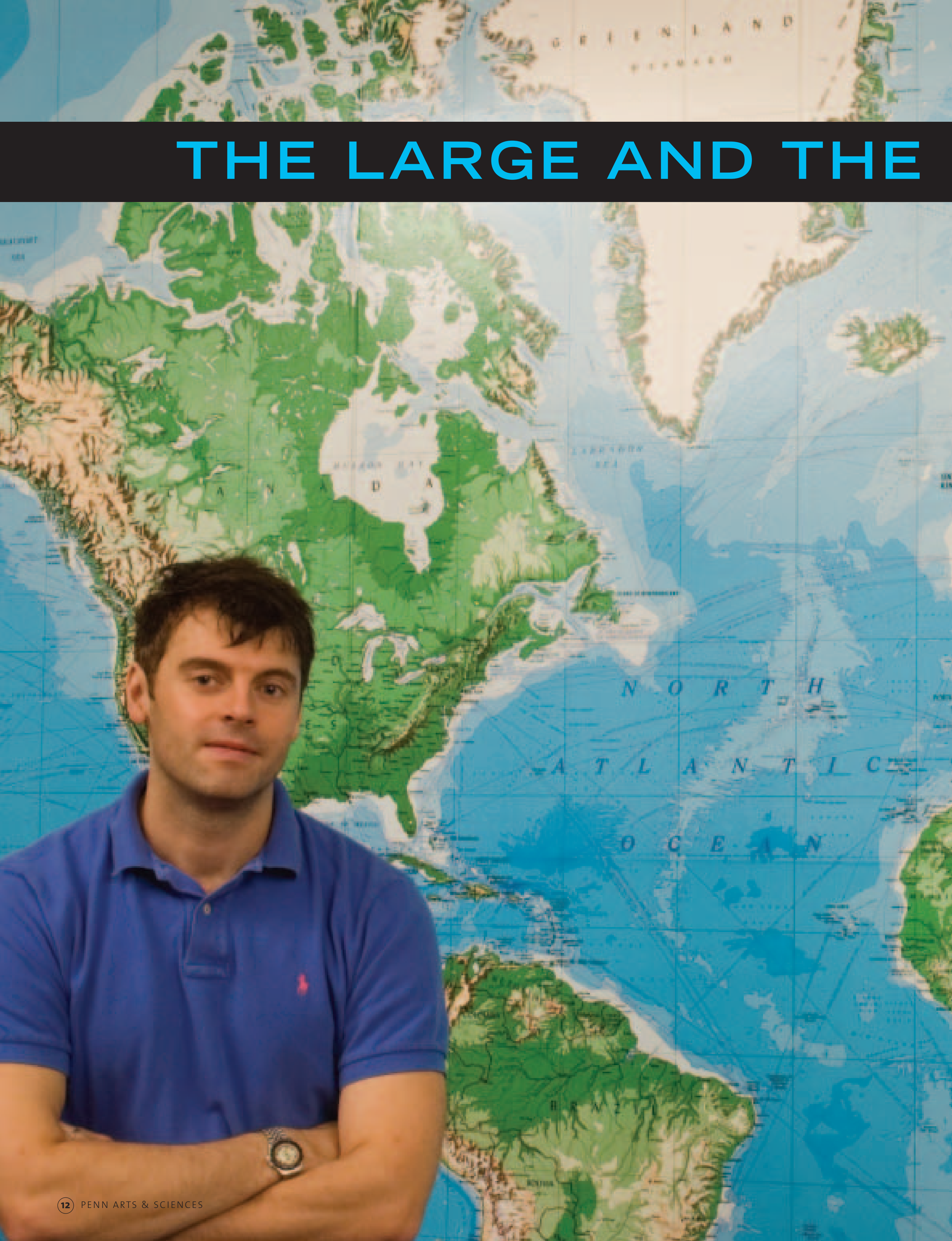

Jon Perlmutter

SMALL OF IT

Ben Horton Studies Microfossils to Puzzle Out Global Warming, Ancient Tsunamis and Modern-Day Murder

BY GIGI MARINO

Ben Horton is a big-picture guy. Just take a look at the world map that spans a width of a 15-foot wall in his office. The world looms large there on the first floor of Hayden Hall.

As the key faculty member in Penn's Sea Level Research Laboratory, he oversees projects that focus on long- and short-term rises in sea levels around the globe. And yet, his research method depends upon microscopic creatures — namely, foraminifera, which are protozoa, diatoms (single-cell algae) and pollen — to puzzle out where the level of the sea lay in earlier times. "To look at past sea levels, you have to have an indicator of where sea level was at any particular time period and place," he says. "That's where microfossils come in. Microfossils tell you about the environment around that [earlier] coastline."

Trained as a geographer at the University of Durham in England, Horton has been an assistant professor in Penn's Department of Earth and Environmental Science for the last two and a half years. During the last years of his Ph.D. work at Durham, he studied the present-day relationships between sea levels and microfossil distributions, using various statistical techniques. The research provided Horton with a key to being able to determine how sea level has changed over time. The result, he says, "was the development of a new technique to look at the reconstruction of past sea level." His modeling method allows researchers to determine exactly where sea level was in the past, which he says is significant because while other methods can tell you whether or not sea levels have risen, they cannot do so with accurate detail. Horton says his work "is at the forefront of a new generation of high precision relative sea-level reconstructions."

Various research contracts have taken him, along with some graduate and undergrad students, to Australia, Japan, South Africa, the Middle East, Indonesia, the Malay-Thai Peninsula, the east and west coasts of the United States and Alaska. As the debate over global warming grew among scientists and in the media over the last decade, Horton's work started gaining attention.

According to the Intergovernmental Panel on Climate Change, the 1990s were the warmest decade in the last 2,000 years. But there have not been enough studies to show whether sea levels are rising faster in modern times than they were in the past. "On a long-term scale, sea level and temperature have a one-to-one relationship," says Horton. "Temperature goes up, melts the ice sheet, sea level goes up. Temperature goes down, ice sheets expand, sea level goes down. I wanted to look at short-term time scales, decades instead of thousands of years. Does the same relationship hold true?"

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He can, for example, look at just a few centimeters of a sample containing microfossils and determine changes within years or decades. Looking specifically at the east coast of the U.S., he has found a moderate sea-level rise in the last 100 years, which may be more rapid than the long-term rate of rise found in the last 800 to 1,000 years. "The timing of this acceleration," he says, "may be indicative of a link with human-induced climate change."

Horton's research provides a long look backward, as he uses contemporary data to reconstruct the past. He can examine the sedimentary layers of sand sheets on a Japanese island or on the west coast of the U.S. and tell you something about the earthquake or tsunami that deposited them there, or even the time period when breakage or shifting took place in the Earth's plates deep beneath the ocean. So, when the Indian Ocean tsunami hit on December 26, 2004, Horton, who had worked in

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Indonesia for four years, knew that he had to be involved somehow. With funding from the National Science Foundation, he put together an interdisciplinary team of scientists, graduate students and undergraduates from the U.K., Singapore, Malaysia, England and the U.S.

"It was the most unbelievable field trip I've ever been on," he says. "I study the past, and you write a lot of grant applications that talk about broader impacts, saying things like, 'We want to understand earthquakes because they affect society.' But to actually go out to one of these environments and knock on people's doors and speak to them is a completely different experience. In Thailand, we went to Khao Lak, where more than 5,000 people died. It was a highly emotional trip. And just seeing the power of nature stripping the landscape bare really affected me."

The team not only gathered physical evidence about the tsunami but conducted interviews with residents about how their lives had been changed. "The physical investigations could provide data for models that may reconstruct future earthquake and tsunami events," says Horton, "with the socio-economic data providing information on how a society is affected. There's also an educational aspect. We're trying to provide people with educational materials of what you should do if you feel an earthquake. For example, one of the biggest natural signs is that prior to a tsunami wave, the water [on a beach] will draw out." A second NSF grant will allow him to travel to Sumatra over the summer to take sentiment cores that could tell him if there have been similar tsunami disasters in the past. "I am sure there have been others," he speculates, "but what we don't know is how often. Was the 2004 event a one-in-100-year event? A one-in-1,000-year event?"

Horton is so adamant about this message that he lectures his students on tsunami warning signs before they leave for spring or summer break, pointing out that the Cascadia margin, from northern California to British Columbia, shows geological evidence of repeated earthquakes and tsunamis of a magnitude similar to the Indian Ocean tsunami. The area is accumulating strain and could go at any moment, he cautions. "If you are sitting on a beach from northern California to British Columbia, you're not going to get a warning. The wave will hit within 15 to 30 minutes, depending on where it ruptures. You will have to rely on your understanding of the environment. If you see water recede, get to higher ground."

Although his Indian Ocean work was edifying, Horton says that his proudest professional moment occurred when he was called as a forensic witness to defend a woman accused of murdering her 3-year-old son. As a forensic diatomist, Horton developed a quantitative model to reconstruct aquatic environments based on how diatom species change from one location to another.

The case, which occurred in England, involved Sallie-Anne Loughran, whose son, Thomas, had drowned. Originally, she was cleared of any crime in 1991. But the forensic scientist who had first testified in her favor was later discredited, and the Crown Prosecution Service decided to reopen the investigation 13 years after Loughran was acquitted.

Horton traveled to central England and took samples from the lake where the boy was said to have drowned as well as from the bathtub, where the prosecution claimed the mother had drowned the boy herself. He identified the species of diatoms in the lake, and as he had expected, no diatoms appeared in the bath water (household purification processes

because while other methods

destroy them). He then examined slides of lung and brain tissue from the child's exhumed corpse and found the same diatoms he had identified near the boy's home in the tissue samples. "Not only did I show that this was a lake drowning," he says, "but the drowning took place in the lake near the house."

The case was dismissed before it even went to court, and Horton's findings were listed in *Whitaker's Almanac*, a publication that documents important evidence connected to British history. "This woman got accused, then was cleared of murder. I was very proud to meet her," says Horton. "In that trial, my evidence was the key. I could truly say that I made a difference."

During his Ph.D. research, Horton spent three years collecting samples at a field site near a petrochemical industry. He says, "I went there every day. It was a horrendous place, and I wanted to go someplace nice with tropical beaches. I wanted to see interesting landscapes." And that's exactly what happened. The microscopic world gave him entry into the greater world, allowing him to contribute to answering some of the biggest questions of our day and even solve a murder or two along the way. ■

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diatoms

Diatoms are single-celled algae of the kingdom Protista, which has 5,600 living species among 40,000 known species (although some say there are more than 100,000). Diatoms are characterized by their silica shell, like tiny glass houses, and are exquisite, intricate creatures, individual as snowflakes, the veritable poetry of the microfossil world. They exist in both fresh and saltwater as well as on the moist surfaces of plants and in moist soil — and even in toilet tanks. Pool owners know diatomaceous earth because it is used as a filtration element: the silica shells function well in trapping extraneous particles. Some gardeners till the soil with diatomaceous earth to control slugs. They ingest the diatoms, which literally shred them to bits from the inside out. Imagine swallowing glass.

Sea-level researchers like Ben Horton rely on diatoms for their historical accuracy. When aquatic diatoms die, their silica shells do not decay but fossilize and become part of the geologic record. Horton studies sedimentary deposits to reconstruct past sea levels from fossil assemblages contained within sedimentary sequences. Just as tree rings tell you what past environments were like (fires, floods, droughts), sedimentary deposits can inform you about their environments as well. Diatoms are the tree rings of ocean sediment. And while beautiful and poetic, they are not silent but tell the story of what happened in the world they once inhabited. —GIGI MARINO

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