# Headlines@Hopkins

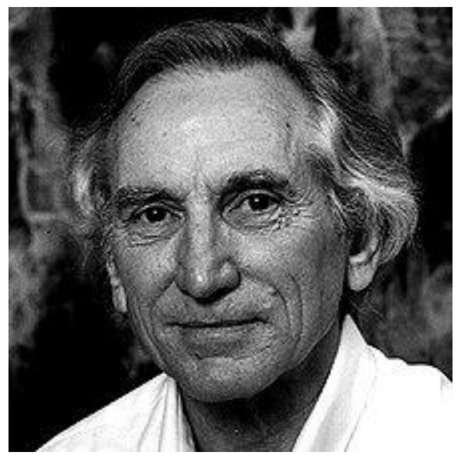
News Release

Office of News and Information
Johns Hopkins University
3003 N. Charles Street, Suite 100
Baltimore, Maryland 21218-3843
Phone: (410) 516-7160 | Fax (410) 516-5251

December 10, 2001
FOR IMMEDIATE RELEASE
CONTACT: Michael Purdy
mcp@jhu.edu

## Droplets in Salt Crystals Confirm Historic Ocean Changes

Microscopic water droplets trapped inside ancient salt crystals have provided evidence supporting a radical theory that the chemical composition of Earth's oceans has changed over the past 500 million years.



"We're not talking about gigantic changes," says Lawrence Hardie *(pictured at right)*, professor of earth and planetary sciences in the Krieger School of Arts and Sciences at The Johns Hopkins University and the originator of the theory. "It's not going to suddenly change from what it is today, for example, into something that is very alkaline, but we do see changes in the levels of some of the major chemical components dissolved in ocean water, and these changes may be significant enough to affect marine life forms."

Hardie's theory may help scientists understand the origins of Britain's White Cliffs of Dover and other mammoth chalk deposits around the globe. Geologists know that these chalk deposits were formed from the skeletons of microscopic marine creatures called nanoplankton, but they have had difficulty explaining why the nanoplankton were so abundant when the chalk deposits formed, an era in geological history known as the Cretaceous (Greek for chalk) period.

"The nanoplankton just went whacko, and because the thinking had previously been that sea chemistry was the same in the Cretaceous, it was hard to understand why," says Hardie. "But my theory suggests that there may have been higher levels of calcium dissolved in seawater at that time, and that may have fueled a nanoplankton population boom."

First proposed in 1984 but not published until 1990, Hardie's theory about changing seawater chemistry met with heavy resistance. It links changes in the levels of calcium, magnesium, potassium, and sulfate ions dissolved in seawater to oscillations in the rate of sea floor spreading at the mid-ocean ridges. The ridges are areas where tectonic plates are pulling apart, exposing underlying lava to the ocean, which then cools and forms new sea floors.

"The ruling paradigm on seawater chemistry, its major ions and such, was that there had been no change in the past 2 billion years," says Hardie. "The bulk of geochemists who tackled this problem starting in the late 1950s thought that river water coming into the ocean interacts with sediments in the ocean, and that sort of acts of like a chemical buffer system to keep the chemistry of seawater the same forever."

The latest evidence to fortify Hardie's theory comes from a project led by former Hardie student Tim Lowenstein, now a professor of geology at Binghamton University in New York. Lowenstein has been studying microscopic drops of brine in salt crystals from various times in Earth's history. The crystals enclose the tiny drops of brine, known as fluid inclusions, as they form from evaporating seawater.

Lowenstein, Hardie, and others examined the chemical content of the inclusions with a scanning electron microscope equipped with an X-ray beam adapted for chemical analysis. They found that Hardie's theory accurately predicted what they would find in the inclusions on the basis of the time in history when the salt crystals formed. They published their findings in Science last month.

For Hardie, the results are a vindication. He feels evidence that all might not be right with the "unchanging oceans" model can be traced as far back as the turn of the 20th century, when the German salt industry hired chemist E. H. van't Hoff, winner of the first Nobel prize for chemistry, to study some of Germany's massive salt deposits.

"He was trying to get some experimental evidence for how these huge masses of salt formed," Hardie says. "They assumed, like everyone else did at the time, that seawater was constant through time. But they looked at these deposits, and they found that there were very few that looked like they had come from something like today's seawater."

Scientists eventually ascribed the differences to changes that had occurred after the salts were buried. But the discovery in 1976 of hot brine springs on a mid-ocean Atlantic ridge started Hardie thinking about another possibility.

Hardie became interested in the springs because "the chemistry of the water that comes out of these springs doesn't look anything like seawater, and it also doesn't look anything like river water."

Oceanographers learned that heat from lava at the ridges was creating convection cells that drove seawater into cracks and crevices in the sea floor and out again at the brine springs. The seawater's trip beneath the ocean floor took out magnesium and sulfate and added calcium and potassium.

Hardie developed a theory that envisioned the chemical content of the oceans as the sum of the input from the sea floor brine springs mixed with the influx of material flowing in from the continents through rivers.

"It's a simple model, really, but those are the best ones," he says. "There's no heavy math; it's really nothing more than bean counting."

Using other geological evidence to assess changes in the rate of sea floor spreading, Hardie made predictions for seawater composition at several points in geological history. He has previously tested these predictions against evidence found in samples of ancient limestone, salt and other "evaporites."

"Astonishingly, this very simple model does a pretty good job. It gets the boundaries in time between changes in ocean chemistry pretty darn close, give or take 10 million years," he says.

Acknowledging with a laugh the irony such a statement carries for non-geologists, he adds, "Which for us is pretty close."

Hardie is currently working with Steven Stanley, a paleontologist and fellow Hopkins earth and planetary sciences professor, to see if they can further solidify the potential link between his theories and the nanoplankton boom in the Cretaceous period that led to the great chalk deposits. They are testing contemporary nanoplankton's reactions to seawater altered with added calcium.

Funding for the research on the fluid inclusions was provided by the National Science Foundation's Earth Science Program. Other authors on the Science paper were Michael Timofeeff, Sean Brennan, and Robert Demicco, all of Binghamton University.

**Related Sites**
Lawrence Hardie