Debating a tale told by ancient fish teeth

Geologists are looking at fossilized fish – specifically, their teeth – for chemical clues to the oceans in which these creatures lived, ate, and swam 100 million years ago.

The chemistry of seawater reflects the geologic events and climate of the times, says University of California, Berkeley, geophysicist B. Lynn Ingram. In the April 22 SCIENCE, she questions current theories about how much new crust was being formed by seafloor spreading and volcanic activity during the Cretaceous.

Ingram and her coworkers examined the amounts of strontium (Sr) in fish teeth from the Venetian Alps and northeastern Apennines in Italy. Strontium is dispersed evenly throughout the oceans, says Ingram, but the ratios of different forms, or isotopes, of the element vary. When most of the strontium in seawater has been washed into the water from land, the ratio of Sr-87 to Sr-86 is higher than when most of the strontium has come from underwater volcanic activity and seafloor spreading. The isotope ratio is accurately reflected in modern fish teeth.

Ingram found that changes in strontium ratios reflect the formation of three large areas of the crust but that the increase in seafloor spreading wasn't as great as current theories suggest.

"I think that strontium can help us understand the timing, duration, and magnitude of hydrothermal activity," says Charles E. Jones, a geochemist at the University of Michigan in Ann Arbor, "but I wouldn't say that their conclusions [about overall geothermal activity] are written in stone."

"The larger issue is that there's a strontium anomaly but not nearly as big as the amount of crustal production I've calculated," says Roger L. Larson, a geophysicist at the University of Rhode Island in Kingston. "My calculations include intrusive oceanic crust that may not have influenced strontium ratios because it was not exposed to seawater as it solidified."

Understanding these geologic events is important, says Larson, because carbon dioxide spewed out by volcanoes may have contributed to the warmer climate in the Cretaceous. "We're living in the icebox, and the Cretaceous was the greenhouse," he adds. "In order to understand how the Earth's climate works, we need to understand both ends of the system."

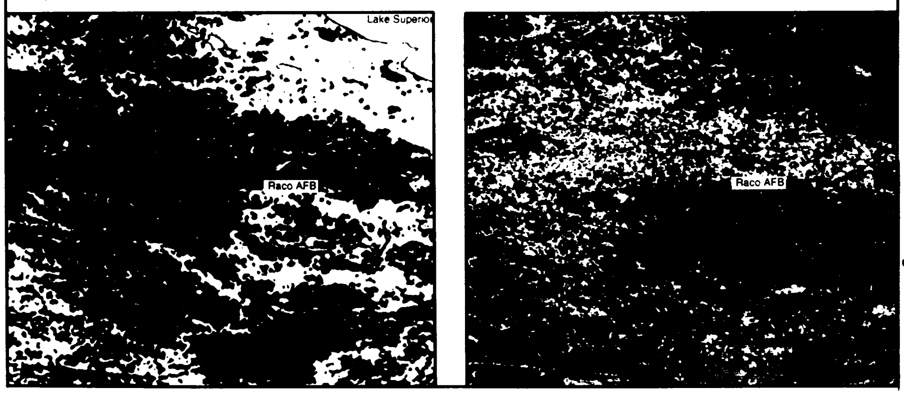
"We're basically saying that as far as [increased hydrothermal activity affects] seawater, we don't see it," says Frank M. Richter, a coauthor from the University of Chicago. "We have to rethink the way volcanism affects ocean chemistry. Maybe it is balanced out by weathering, and maybe our story doesn't raise any broad issues, but I doubt it." *– D. Christensen*

Radar paints land with colors of life

An experimental radar flying aboard the space shuttle Endeavour bounced microwaves off the forests of Michigan's Upper Peninsula this week, enabling scientists to map vegetation just emerging from a long winter. The new radar – the most sophisticated yet to fly on the shuttle – uses three different microwave frequencies to probe Earth's surface. Besides mapping plant life, the device can provide information about soil moisture, rock type, and even ocean currents. NASA built the instrument in collaboration with the German and Italian space agencies.

With data beamed down from the shuttle, researchers at the University of Michigan in Ann Arbor created two images depicting the amount and type of vegetation in a 15- by 20-mile region around Raco Air Force Base, near the southeast shore of Lake Superior. In the left map, red, orange, yellow, green, and purple hues indicate increasing amounts of biomass. In the right image, white areas represent flat, unvegetated surfaces such as water, ice-covered lakes, and bare soil. Grasses and shrubs appear in red, deciduous trees in yellow, and conifers in green and purple.

Radar images such as these can help scientists assess environmental changes, whether caused by human actions or by natural processes, according to NASA. Unlike space-borne cameras, this instrument can "see" through clouds and at night. The radar will fly on another shuttle mission in August, enabling investigators to compare how regions change between seasons. – R. Monastersky



Univ. of Michigan Radiation Lab

Taking a smash peek deep inside the proton

In the modern picture of the constituents of matter, the proton's composition appears straightforward: two "up" quarks and one "down" quark, all tied together by gluons. But there's nothing simple about how a proton is put together – or how it falls apart. Hit a proton hard enough, and it can fragment in surprising ways.

Researchers using the Hadron Electron Ring Accelerator (HERA) in Hamburg, Germany, have discovered that a proton exhibits a peculiar sort of lumpiness that apparently doesn't correspond to individual quarks or gluons. The results of high-energy collisions between electrons and protons suggest that an electron sometimes penetrates deeply enough to encounter a new kind of object buried within the proton.

"We weren't looking for this," says Allen Caldwell of Columbia University, a member of the team running the ZEUS detector at HERA. Caldwell reported the team's findings at an American Physical Society meeting this week in Arlington, Va.

Researchers have long used electron beams as probes to study the structure of the proton and other subatomic particles. Typically, when an electron transfers a lot of momentum to a proton, the collision forces the ejection of a quark. But the ejected quark can't exist by itself. It interacts with other quarks and antiquarks created out of the vacuum as it separates from what's left of the proton.

These quarks combine in various ways to create a jet of assorted subatomic particles that sprays out in the same direction as the ejected quark. The proton remnant also interacts with extra quarks and antiquarks to produce another jet of subatomic particles.

Researchers normally detect the deflected electron and two distinctive jets of subatomic particles. However, the ZEUS team found that nearly 10 percent of the time, only one jet appears. "This was a very surprising result, given that the proton was getting such a large kick," Caldwell says.

The most likely explanation is that the electron is deflected not by a quark, but by some other, unknown object – perhaps a particular combination of quarks and gluons – which then breaks up to form the observed jet and leaves behind a proton remnant that somehow stays intact.

"Different possibilities have been put forward," Caldwell remarks. "But the complete solution remains largely a mystery." *– I. Peterson*