sue is, are these the interesting water molecules?" says Henderson. Rosenbusch says they soon hope to answer that question, by introducing mutations into the bacteriorhodopsin molecule that alter proton transfer and may allow the effects of the water molecules to be seen.

Crystallographers may soon be getting such intimate views of other membrane proteins, thanks to Landau's technique for mimicking the natural environment. Eventually, they may be able to design and build artificial membranes with different lattice sizes to snare and crystallize membrane proteins of varying sizes and shapes for structural studies. Riekel also predicts that further improvements in ESRF's microfocus beamline will allow analysis of crystals as small as 5 micrometers across. "Microdiffraction has a large future for difficult-to-crystallize substances," he says. If so, protein chemists will soon see a large number of membrane proteins in their structural encyclopedia.

–**Anne Simon Moffat**

EARTH SCIENCE

More Signs of a Far-Traveled West

For 2 decades, earth scientists have argued over the proposal that chunks of North America's western edge migrated thousands of kilometers northward to their present positions. Now, a few exquisitely preserved fossils have given the theory an extra push. A team of geologists and geophysicists reports in this issue of *Science* that the superb condition of marine fossils from near Vancouver Island provides a key test of the evidence, which consists of traces of ancient magnetism in the fossil-laden rock. Seventy million years ago, they conclude, Vancouver Island was adjacent to Baja California, thousands of kilometers to the south.

After so many years, the dispute (*Science*, 5 May 1995, p. 635) is not likely to be settled by a single finding. Indeed, critics are already identifying loopholes. Still, the study, reported on page 1642 by paleontologist Peter Ward of the University of Washington in Seattle, paleomagnetician Joseph Kirschvink of the California Institute of Technology in Pasadena, and their colleagues, "could influence the fence sitters," says geologist Darrel Cowan of the University of Washington, who has written on possible geologic tests of the so-called Baja–British Columbia hypothesis.


P. WARD

Telling luster. The fine preservation of mollusk fossils like this ammonite, several centimeters across, suggested that the rock holds an accurate record of its travels.

The hypothesis originated 20 years ago in studies of the magnetism locked in rocks from the so-called exotic terranes of the Pacific Northwest—large chunks of crust that seem to have formed elsewhere and migrated to their present positions. Because Earth's magnetic field is horizontal at the equator but vertical at the poles, the inclination of a rock's magnetism shows how far north it was when it formed and locked in Earth's field. Along the west coast of North America, researchers measured paleomagnetic inclinations smaller than they should be if the rock had formed in place, as part of North America. Many paleomagneticians took that to mean that the terranes had slid up the coast from far to the south, much as California west of the San Andreas fault is sliding now.

Most geologists and some paleomagneticians disagreed. For one thing, they couldn't see the large faults that would have guided the rocks northward. Instead, they proposed that the terranes originated offshore at roughly their present latitudes and later docked with North America. The shallow magnetic inclinations were misleading, they argued, because most of these measurements came from great masses of frozen magma, which the tectonic jostling of the coast could easily have tilted from their original orientations over tens of millions of years.

Sedimentary rock would solve that problem, because it is laid down in recognizable horizontal layers. But sedimentary rocks from the largest terrane—the Insular superterrane, which makes up much of the coastal crust from northern Washington state into Alaska—seemed to have been heated long after they formed, wiping them clean of their original magnetic signature.

Kirschvink, however, realized from unrelated work he and Ward were doing in central California that temperature-sensitive fossils could be a marker for rock that hadn't been heated and magnetically altered. Ward, in turn, knew of fossils from the Texada and Hornby islands—part of the Insular superterrane off the east coast of Vancouver Island—that fit the bill. These fossils of extinct mollusks, called ammonites and inoceramids, retained the pearly luster of the living animals, implying that the paleomagnetic inclinations in the surrounding rock could be relied on. The magnetism was about 25 degrees shallower than expected at Vancouver Island's current latitude, implying that 70 million to 80 million years ago, when the rock formed, the terrane was 3500 kilometers to the south, off Baja California.

Ward and his colleagues say the condition of the fossils also bears witness against another process that could have skewed the data: compaction shallowing. Sediment can compress by 50% or more as the weight of new sediment above it squeezes out the water between its grains. Compaction can reduce any existing paleomagnetic inclination as the magnetic grains tilt toward the horizontal under the compression.

Ward and Kirschvink note that even if there had been compaction, the 10° of compaction shallowing typically found couldn't explain the 25° in their rocks. But the fossils argue against even that much compaction, says Kirschvink: "One of the indicators [of sediment compaction] is to look for compacted fossils, and they're not present in these sediments." Further reassurance comes from the carbonate globules that tend to encase these fossils, he says. These concretions began to form soon after the fossils were buried, he says, and would have welded grains of rock in place, preventing compaction shallowing. That's "a good way to stop inclination error," he says. "We can rule it out."

"Their argument is pretty good," says paleomagnetician Kenneth Kodama of Lehigh University in Bethlehem, Pennsylvania, who has studied compaction shallowing in the lab. But, says Kodama, "they haven't thought enough about whether or not the concretions could have formed after a certain amount of compaction. As they say, it may not explain all of their shallowing of inclination, but it could explain part of it." Sedimentologist Peter Mozley of the New Mexico Institute of Mining and Technology in Socorro agrees. "Typically, concretions are thought to form early, but late-stage concretions do exist," he says.

Kodama and Mozley recommend further analysis of the concretions to pin down just how much compaction actually occurred. Until then, says longtime Baja–British Columbia critic Robert Butler of the University of Arizona, Tucson, "the whole thing goes on without a definitive closure."

–**Richard A. Kerr**