EARTH SCIENCES

Kendrick Frazier reports from Seattle at the annual meeting of the Geological Society of America

Mountain building by overlapping plates

Plate tectonics explains most mountain belts on earth in a pretty straightforward way. But the usual schemes do not explain what is known as the classic Laramide orogeny, the particular kind of mountain building that occurred through Wyoming and Colorado 65 million to 45 million years ago. The Laramide deformation occurred largely without any release of magma, and was marked by local uplifts of the basement rocks rather than by broad regional folding.

In the familiar mode of subduction, a crustal plate descends at a sharp angle deep into the earth beneath a continental margin. This deep penetration in various ways "tickles" the earth's forces, causing creation of a chain of active volcanoes, an arc of seismicity and folding and thrusting.

William R. Dickinson of Stanford University and Walter S. Snyder of Lamont-Doherty Geological Observatory say the Laramide mountain building can be explained by an unfamiliar, shallow mode of subduction. They suggest that the crustal plate descended at only a very shallow angle and failed to penetrate the soft, partially molten layer beneath. The descending slab just tucked itself almost horizontally under the overlying slab at a depth of only about 100 kilometers, and no magma was generated. The wide area of contact between the two plates caused numerous local block uplifts like those observed in the classic Laramide deformation. Dickinson and Snyder also believe they see confirming evidence in the west-east progression of deformation over time.

Rock-locked undersea bacteria

Rocks 10 to 20 million years old buried 100 meters or more off the U.S. coast of the Atlantic Ocean are found to contain living organisms. The organisms are bacteria that live on small quantities of organic matter in the sedimentary rocks. The bacteria were found in samples obtained by core drilling on the continental shelf off South Carolina and Georgia. Others were found in samples from a drill site 80 kilometers south of Nantucket, Mass. The findings were reported by F. T. Manheim, M. H. Bothner and F. A. Kohout of the U.S. Geological Survey's office of marine geology in Woods Hole, Mass.

Manheim says the bacteria consume organic matter in the rocks and use the oxygen in sulfate chemical compounds of the fossil seawater trapped in the rocks. "Phosphatic strata rich in organic material appear to provide a substrate for sulfate-reducing bacteria, even after millions of years of burial in the rocks," the scientists report. The deep-rock bacteria in the ocean cores were detected by the presence of their waste products—bicarbonate and hydrogen sulfide—in the fluids squeezed from the sediment cores. At the site south of Nantucket, the bacteria lived on natural petroleum gases, mainly methane and propane, migrating through the sediments.

Long-distance travel 7,500 years ago

Excavation of early (around 5,500 B.C.) sites in Saudi Arabia, Qatar and Bahrain has turned up numerous examples of Ubaid-style pottery from southern Mesopotamia. These findings raise the question of the nature of the contact between Mesopotamia and the Arabian Gulf 6,000 to 7,000 kilometers to the south.

Petrographic, scanning-electron-microscope and X-ray analyses by Diana C. Kamilli of the University of Colorado Museum and Joan Oates of Girton College in Cambridge, England, have shown that the pottery was made in southern Mesopotamia. The paints, the ceramics and the method of firing are identical to those used in Mesopotamia. The ceramic materials are consistent with geologic sources near the sites in Mesopotamia. Without a doubt, all the wares were brought in from the north. Why? There is no evidence of permanent trade routes or permanent buildings at the Arabian sites.

But obviously a substantial number of Ubaid people did travel that far south. Kamilli believes the pottery was used for containers and cooking, not trade. "These data suggest," Kamilli and Oates say, "that fishermen or 'sea-faring merchants' from southern Mesopotamia (perhaps from Ur, Al Ubaid and Eridu) sailed south to the Arabian coast and established temporary communities perhaps to exploit the known supply of pearls or fish."

As Kamilli says, "The distances are far, but there are many examples in history of people traveling in small boats great distances for fishing. This represents an early example of long-distance sea travel. . . . "

Downgoing slabs in Pacific Northwest

The bulk of the geophysical and geological evidence confirms that the complex history of the Pacific Northwest during the last 10 million years has been dominated by the interactions between the continental crustal plate and three oceanic crustal plates: the Pacific, the Juan de Fuca and the Explorer plates. The Juan de Fuca and Explorer plates are small, young plates that became indepepdent about 7 million years ago. All three plates "have been happily trundling along the Pacific Northwest coast" in a northeast direction at rates of 2 to 5 centimeters a year for the last 10 million years, says Robin P. Riddihough of the Department of Energy, Mines and Resources in Victoria, British Columbia. In addition, the whole system has been sliding northward, so the details of resulting events get very complicated. Offshore evidence indicates that ridge spreading and convergence toward the continent are continuing today, Riddihough and colleague Roy D. Hyndman say. Onshore, volcanism, heat flow, gravity measurements, geomagnetism, and vertical movements "strongly suggest the presence of downgoing oceanic lithosphere beneath southern British Columbia and Washington," they conclude. "The Juan de Fuca plate has been subducting," Riddihough says. "I see very little evidence that it has stopped now, so we have to assume that it still is."

Sea shell 'tree rings' from the sea shelf

Just as tree rings record climatic conditions on land, a bivalve mollusc named *Arctica Islandica* has been found to record conditions of the shallow ocean by variation in the width of annual bands on its hinge plate and outer shell layer. Ida Thompson and Douglas S. Jones of Princeton University are studying this banding with methodology borrowed from tree-ring research. They have confirmed that the bands are annual, that they vary in width and that shells with up to 150 bands are available. Their working hypothesis is that minimum winter temperature is the most important factor controlling the width of the annual bands. Species of *Arctica* are not uncommon as fossils, they say. Sectioning of the shell of one species from Alberta reveals beautifully preserved banding. "Eventually," Thompson and Jones suggest, "paleo-ocean conditions may be read from fossil *Artica* shells."

Raising the sea-level drop

Many published curves of sea-level lowering for the East Coast of the United States during the last Ice Age are erroneously deep, William Dillon and Robert Oldale of the U.S. Geological Survey report. Several proposed sea-level curves for the East Coast depend on radiocarbon-dated samples collected in an area of continental shelf south of New England that new evidence shows to have subsided after formation of the samples. Thus, the samples were formed above the depth at which they were found, and sea-level curves based on the depth of the discovery are erroneously deep. No East Coast sea-level lowering during the period 15,000 to 20,000 years ago of more than 95 cm can be demonstrated, they report.