EARTH SCIENCES

Susan West reports from the meeting in San Diego of the Geological Society of America

Monsoon behavior

The monsoons are the major weather-producing circulation pattern in the Indian Ocean and Asia. But their relationship to global circulation is not well understood.

In order to study monsoon behavior through geologic time, thereby gaining insight into that relationship, James L. Cullen of Brown University and Jean-Claude Duplessy of Centre des Faibles Radioactivites in France examined the types of plankton called foraminifera present in the Indian Ocean sedimentary record. Different types of foraminifera thrive in different levels of salinity and therefore are a good record of ocean conditions. Cullen and Duplessy recognized that the intensity of the southwest monsoon determines the salinity of the Bay of Bengal. When the monsoon is intense, it carries more fresh water into the bay, reducing its salinity; when the monsoon slackens, the salinity increases. The types of plankton therefore should be an indirect record of monsoon intensity. Cullen and Duplessy studied sedimentary cores containing a record of the past 25,000 years — a period that includes the most recent transition from maximum ice age conditions to warm interglacial conditions.

They found that, according to the pattern of foraminiferal growth, the monsoon weakened at the time of maximum ice conditions and became stronger during the transition to warmer conditions. In contrast, global circulation intensifies during glacial periods. In other words, "the cycle of monsoon intensity is out of phase with the glacial cycle," says Cullen. The next step, he says, is to figure out why.

Ice Age in the Atlantic

Recent research has shown that the cooling of the Antarctic Ocean serves as an "early warning device" for the onset and retreat of an ice age (SN: 1/13/79, p. 22). But what about others of the world's oceans? According to William F. Ruddiman of Lamont-Doherty Geological Observatory, the Atlantic also shows interesting pre- and post-ice age behavior.

Ruddiman and co-workers studied the ancient North Atlantic conditions at the time of maximum ice coverage — 140,000 years ago — and minimum ice volume — 120,000 years ago. The researchers examined the oxygen-isotope ratio, which reveals ice volume, and the types of fossil plankton, which are evidence for ancient sea surface temperatures, in 40 deep sea sediment cores.

They found that, like the Antarctic Ocean, the North Atlantic warmed several thousand years before or at the same time as the ice age began to fade — as marked by the decline in ice volume. During the transition from an interglacial period (minimum ice volume) to a glacial period, however, the North Atlantic remained warm nearly halfway into the phase of ice growth and then cooled rapidly. (The Antarctic, on the other hand, cooled about 3,000 years before the Northern Hemisphere ice sheets began to grow.) The lag time in North Atlantic cooling, Ruddiman notes, appears instrumental in enhancing Northern Hemisphere ice growth. Surrounded by ice sheets, the warm ocean provided the necessary moisture and evaporation to add snow and ice to the growing glaciers. Future research, says Ruddiman, includes a look for a meaning of the lead and lag times and for what mechanism, if any, is responsible for transmitting the early response of the Southern Hemisphere to the Northern.

Uplifted North America

By looking at a map one can see that the East Pacific Rise — a Pacific spreading center where ocean crust is being formed — splits the Gulf of California and seems to run smack into North America. But what happens to it? According to William W. Hay of the Rosenstiel School of Marine and Atmospheric Science at the University of Miami, it shows up in the Central Rockies and the Great Plains.

After colliding with North America about 17 million years ago, Hay says, the East Pacific Rise slipped under the continent, creating progressive wavelike uplifts as it moved eastward. Researchers have noticed that the elevations of the Great Plains and Central Rockies are unusual; Hay says they are due to the heat flow from the underlying Pacific Rise. Among other things, he says, the model explains the continual displacement of the Continental Divide to the east and the types of deformation and "tensional effects" seen in the plains. The overriding continent also provides a tectonic model for climate: Where the continent has been stretched upward, broken into blocks and collapsed, air becomes trapped on one side of the arch and loses rainfall. The humidity drops in the basin formed by the broken blocks and creates a desert.

Prospecting by nodule

Manganese nodules, potato-size nuggets of manganese- and iron-oxides and trace elements, are found in heaps on the ocean floor, but they also can be found in fresh water streams, says U.S. Geological Survey researcher Gary A. Nowlan of the survey's Denver office. And, he says, the composition of these nodules may be an indication of an area's mineral potential.

Nowlan, who develops methods of "geochemical prospecting" for the survey's division of exploration research, began studying manganese- and iron-oxide deposits in streams of central Maine. Researchers had noted that oxides often stain or coat streambed rocks, but few, says Nowlan, have remarked on the distinct nodules — up to one and a half inches in diameter — lying in the bottom of the stream "looking like BBs." Part of the reason may be that the nodules don't occur everywhere.

Nowlan proposes that the nodules form at the "interface of an oxidizing and reducing environment." A reducing environment (oxygen depleted) causes manganese and iron to dissolve and allows them to chemically attract trace elements such as zinc, lead and copper. An oxidizing environment causes the manganese and iron and the clinging trace elements to precipitate or solidify. An example of such an interface is a bog or swamp associated with a fresh water stream — such as occurs in central Maine. Similar situations, says Nowlan, may be found in areas that were once glaciated and now have a low relief where water can stand and stagnate — areas such as Scandinavia, the British Islands, the northeastern United States and Minnesota.

The trace elements, which are leached out of the surrounding rock by groundwater, are what interest geo-prospectors. In areas where a certain mineral is known to occur, that mineral is "very significantly high" in the nodule compared with others, says Nowlan. Arsenic, for example, is usually found in concentrations of 50 parts per million or less, he says. In an arsenic-abundant area, however, the concentration was found to be about 1,100 ppm. So far Nowlan has studied only the nodules in Maine. But he hopes that by studying the way the nodules "scavenge" or pick up trace elements, he can develop a general means of analysis that can be used on the more commonly found oxide stains and coatings.

The fresh water nodules may also interest marine geologists who study the deep sea version. Though the fresh water variety are smaller and generally contain fewer trace elements, they appear to form similarly — concentric layers around a nucleus — and are made of the same types of iron and manganese minerals. And they are much more compliant subjects; as Nowlan says, "it must be easier to study the bottom of a stream than the bottom of the ocean."