Earth Sciences

Richard Monastersky reports from Baltimore at the spring meeting of the American Geophysical Union

Energetic electrons and ozone loss

Two years ago, Daniel N. Baker of the Los Alamos (N.M.) National Laboratory proposed that high-energy electrons from the magnetosphere high above the planet could rain down into the atmosphere and create ozone-destroying chemical compounds (SN: 6/13/87, p.377). Now, he and his colleagues report they have evidence these electrons may have made dents in Earth's protective ozone layer that had previously escaped notice. If true, scientists trying to trace a long-term drop in ozone levels must take account of this mechanism in addition to the human-induced destruction from halogen compounds.

Baker, now at NASA Goddard Space Flight Center in Greenbelt, Md., and his group developed the electron-ozone theory after discovering that large populations of fast electrons appeared in the magnetosphere about every 27 days during 1981 to 1984, the lowest phase of the 11-year solar cycle. In the last few years as the cycle neared its high point, the electron fluxes have weakened. The researchers hypothesized that electrons traveling in the magnetosphere at nearly the speed of light periodically penetrate down into the stratosphere and ionize atoms there. The ions form compounds with an odd number of nitrogens that are known to destroy ozone.

Linwood B. Callis of the NASA Langley Research Center in Hampton, Va., Baker and others report that satellite measurements and computer modeling support this idea. Observations show that the concentrations of odd-nitrogen compounds in the stratosphere did increase during the early part of this decade and have since decreased, they say. The electron storms may be boosting global odd-nitrogen levels in the stratosphere by 40 percent, which should strongly affect ozone, Callis says. Indeed, he reports that new satellite information suggests ozone levels in the lower stratosphere dropped by up to 14 percent from 1979 to 1985.

But the case may not be as clear as it seems. Richard S. Stolarski of NASA Goddard says other satellite and ground-based measurements of odd-nitrogen compounds report little change in their concentrations over the last 10 years. Similarly, some satellite instruments fail to show the ozone change reported by Callis. Another cause for caution is that no one knows the rate at which energetic electrons reach down into the stratosphere. Baker and Callis only have theoretical calculations of this number. Concerning the energetic electrons, says Stolarski, "I personally believe that it's a very minor effect that makes a small impact on the top of the ozone layer."

Plankton chronicles icy rerun

Sometime after 16,000 years ago, the great ice sheets that covered much of North America and Europe began to retreat, signaling the gradual return of warmer temperatures. Then around 11,000 years ago, a cold spell hit Northern Europe, Greenland and the Atlantic coast of Canada, sending these regions back into near glacial conditions for a geologically brief interlude of 700 years, called the Younger Dryas period. An oceanographer reports that ancient plankton from the Gulf of Maine can help trace the cause of this cold spell.

Many scientists believe the Younger Dryas cooling resulted from a radical redirection of meltwater flowing from the North American ice sheet. At first, most water from the melting ice drained into the Gulf of Mexico, via the Mississippi. Then between 12,000 and 11,000 years ago, most of this water detoured down the St. Lawrence and into the Atlantic. According to theory, the influx of cold, fresh water into the North Atlantic would have rerouted ocean circulation and pushed the Gulf stream south, thereby cooling land around the North Atlantic. This theory explains why geologic records from the interior of the United States do not show any cooling.

The Younger Dryas, however, did leave its mark in the Gulf of Maine. In particular, the history of a certain plankton species supports the idea that water from the St. Lawrence suddenly cooled the North Atlantic, according to Detmar Schnitker, from the University of Maine's I.C. Darling Marine Center in Walpole. Called *Thalassiosira gravida*, this species lives along ice edges. Sediment cores show that *Th. gravida* thrived when the North American ice sheet first started to retreat from the Gulf, but the plants disappeared from this area as the water warmed. Then, about 11,000 years ago, *Th. gravida* bloomed again, signaling that ice had returned. Since low-salinity water freezes more easily than salty water, this plankton pattern suggests fresh water from the St. Lawrence flooded the nearby Gulf of Maine at this time, Schnitker says.

Eyes on the Africa-Eurasia vise

In a collision lasting millions of years, the African and Eurasian plates are crashing together and forming a Mediterranean sandwich in the process. But while the entire Mediterranean is shrinking, some small regions like the Aegean sea are actually growing larger for reasons not well understood. This process also occurs in other areas of the globe where the edge of one plate slides underneath another. Now, a large group of American, German and Greek geophysicists is engaged in an experiment that may decipher the ongoing events in the Mediterranean. This project will measure the motions of numerous small blocks of crust that are shuffling about in the slowly closing vise, reports Kim A. Kastens of Columbia University's Lamont-Doherty Geological Observatory in Palisades, N.Y.

The researchers will be gauging motion with the Global Positioning System (GPS), which measures distances with extreme accuracy through ground receivers that record signals from satellites. Last year, the scientists made observations at 18 sites in the Aegean, and this year will return to these and other sites. Since a particular point only moves a few millimeters a year, it may take five years to detect motion. But Kastens says, "It's not naive to think that we'll see motions over one year."

In particular, the researchers will be studying movement along a fault that separates Turkey from the Eurasian plate. In Turkey, the plates travel in an east-west direction. But motion is oriented along a north-south axis in the Aegean. Scientists want to understand the transition between these two zones.

The sound of silent earthquakes

During an ordinary earthquake, things happen quickly. A breaking fault can move at speeds of over a kilometer a second, generating high-frequency seismic waves that travel through the Earth. In fact, seismologists use high-frequency waves with a period of one second to detect earthquakes. Sometimes, though, the Earth rings with very low-frequency vibrations of periods up to an hour long — so-called "silent quakes" because they usually avoid detection. Gregory C. Beroza and Thomas H. Jordan of the Massachusetts Institute of Technology in Cambridge have designed a program to detect and study these low-frequency waves.

Like a bell that rings only in a fundamental tone and certain harmonics, the Earth vibrates with discrete frequencies. By searching through seismic data for any low-frequency signals that match the Earth's known modes, Beroza and Jordan have identified several silent quakes. The origin of these waves is unclear, and certain silent quakes might not be earthquakes at all. However, Jordan suggests some low-frequency vibrations represent accelerated creep along a fault. The researchers hope that studying these silent quakes will help decipher how fractures grow — an important key to understanding and predicting earthquakes.