Earth Sciences

A shining theory of ozone depletion

The cause of the steadily worsening polar "ozone holes" (SN:3/1/86,p.133) and the drop in global ozone levels (SN:6/28/86,p.404) in the last few years is still a mystery. But one theory that is getting a lot of attention is an idea developed by Linwood B. Callis at NASA Langley Research Center and Murali Natarajan at SASC Technologies, Inc., both in Hampton, Va.

The key to their idea, published in the Sept. 20 JOURNAL OF GEOPHYSICAL RESEARCH, is "odd nitrogen" compounds (named for their electronic structure). These compounds catalytically destroy ozone. They are produced in the thermosphere, the topmost atmospheric layer, with the help of the sun. Callis and Natarajan think the unusually high solar activity levels in late 1979 and early 1980, during the second largest solar maximum in 250 years, led to increased production of odd nitrogen. Using satellite and ground-based data, they have found that from 1979 to 1984, stratospheric odd nitrogen levels increased by as much as 60 percent in the Southern Hemisphere and 30 percent globally.

Callis and Natarajan propose that during the polar winter, odd nitrogen molecules are caught in a vortex of winds at the poles and sink down into the stratosphere, where they attack ozone once the sunshine returns in the spring. The hole disappears every polar summer because the vortex dissipates then. Once in the stratosphere, odd nitrogen can exist for three to four years — which is one reason why the researchers think the ozone hole has persisted beyond the solar maximum.

If their theory is correct, says Callis, the presently developing Antarctic ozone hole should be no more severe than last year's and should begin to disappear next year. While he says continued industrial emissions of ozone-attacking chlorine compounds should somewhat counterbalance the effects of decreasing stratospheric odd nitrogen, he expects the declining trend in global ozone to slow, and possibly reverse, in the next few years.

No fault in Parkfield prediction

Parkfield, the tiny California town that straddles the San Andreas fault, is where seismologists are waiting for an earthquake to happen (SN:4/13/85,p.228). Because magnitude 6 earthquakes have rattled the Parkfield fault segment about every 22 years since 1857, and since the last quake was in June 1966, scientists predict that the next quake will occur in 1988, with a five-year margin for error.

Some recent studies, however, have cast doubt on this forecast. At the meeting of the American Geological Union last December, two papers suggested that possible errors in the sites of quakes prior to 1922 mean that the Parkfield "clock" is not as regular as some think.

But now, in a paper in the Sept. 26 SCIENCE, two researchers at the U.S. Geological Survey in Menlo Park, Calif., offer another line of evidence in support of the 1988 prediction. Paul Segall and Ruth Harris studied geodetic lines spanning the San Andreas near Parkfield. They used changes in the lengths of these lines, which have been monitored since 1959, to calculate the the amount of strain in the fault before and after the 1966 quake. By comparing the strain that has built up since the 1966 quake with that released by the quake, they hoped to provide a test of the Parkfield prediction that does not rely on the periodicity of earthquakes.

"Our results suggest that the strain released in the 1966 earthquake will most likely recover between 1984 and 1989," they write, "although it is possible that this will not occur until 1995." When it is recovered, "sufficient elastic strain will be stored for a [magnitude 6] earthquake to rupture the Parkfield fault segment."

Physics

Heavy water for very light particles

Astrophysicists want to know why the sun shines. The answer to that question probably involves neutrinos, some of the lightest and most elusive subatomic particles known to physics. The nuclear fusion processes that make the sun shine should produce a certain flux of neutrinos, but the one long-running experiment looking for solar neutrinos consistently records only a third as many as expected.

The explanation may be that neutrinos change their identities in flight. There are three known kinds of neutrino, but the currently running experiment is sensitive to only one kind. If a neutrino can change from one kind to another in flight, the experiment may miss a large part of the total flux. On the premise that this happens, several experiments sensitive to all three kinds are being set up (SN:8/9/86,p.88). An experiment planned for a mine near Sudbury, Ontario, would be unique among these in using the world's largest concentration of heavy water as a neutrino detector.

Heavy water is deuterium oxide: The hydrogen in it is the isotope deuterium, which has a neutron and a proton in its nucleus instead of the single proton of ordinary hydrogen. Deuterium oxide is thus two atomic mass units heavier than hydrogen oxide. In natural water 1 molecule in 7,000 is heavy water, and concentrating the heavy water is a laborious chemical and physical process.

In the late 1930s, Norway was the world's largest producer of heavy water, and that inspired an oft-televised film, "Heroes of Telemark," in which Allied agents try to blow up the plant. Today, Canada is the premier producer, and the 1,000 metric tons that the experiment will use is available nowhere else in the world, according to a recent announcement by the University of California at Irvine, one of the institutions involved.

Plans call for the tank of heavy water to be set up in Sudbury, 6,800 feet underground in the Creighton mine of International Nickel Co. to shield it from other kinds of radiation. When a neutrino coming into the tank interacts with a deuterium nucleus, it will produce a flash of light that will be recorded by the instrumentation. Ten trillion neutrinos a second should pass through the tank; 20 per day should interact.

Once the observatory is completed, scientists will be able to observe the core of the sun in virtually real time, something no other technique has been able to do, says Herbert Chen of UC Irvine, who originated the idea for this kind of detector. Other institutions involved are: Queen's University at Kingston, Ontario, the University of Guelph (Ontario), Carleton University in Ottawa, Laurentian University of Sudbury, the National Research Council of Canada, the Chalk River (Ontario) Nuclear Laboratories, Princeton (N.J.) University and Oxford University.

Superconducting waveguide for CEBAF

The first two superconducting accelerating cavities to be made by U.S. industry have been completed by Babcock and Wilcox Co. in Lynchburg, Va., for the Continuous Electron Beam Accelerator Facility (CEBAF), which is under construction at Newport News, Va. (SN:8/9/86,p.90). In the cavities, radio waves will accelerate electrons. To sustain the rate at which CEBAF will put out accelerated electrons, the cavities have to be able to pass electric current without resistance. This superconducting quality reduces waste energy and waste heat to almost nothing. The completed accelerator will require more than 400 cavities.

Hermann A. Grunder, CEBAF's director, says his greatest worry was whether industry could fabricate the cavities, but that has now been put to rest. Fabrication means working with metals unusual in industry, such as niobium. The design for the cavities was developed at Cornell University in Ithaca, N.Y.