Layers of Complexity in Ozone Hole

One more mystery has been added to the seasonal loss of ozone in the stratosphere over Antarctica. It now appears that the "hole" is an uneven one, with 2- to 3-kilometer-thick slices of ozone-poor air sandwiched within layers of only minimal depletion.

In 1985, British researchers reported the presence of a sharp ozone drop over Antarctica; previously collected data indicated that the hole made its first appearance in 1975 and has been returning each Antarctic spring. Climate researchers have been struggling mightily to explain why the hole appears (SN: 3/1/86, p.133; 10/11/86, p.239; 10/25/86, p.261; 11/29/86, p.344), but their theories have been modeled on a generalized ozone depletion.

Some scientists have put forth a chemical explanation — that the depletion is caused by chemical events spurred by the presence of chlorofluorocarbons created by industrial processes. This was bolstered this week with the announcement by the head of an ozone-research team that a chlorine-containing molecule related to chlorofluorocarbon use is abundant in the hole.

Others believe the hole is formed by dynamic air movement and mixing. A third group blames it on the sun, suggesting high solar-cycle activity produces ozone-destroying active forms of nitrogen above the stratosphere.

The new data on ozone stratification were collected by University of Wyoming researchers who went from Laramie, Wyo., to McMurdo Station in Antarctica last year. They sent up their first ozone-sensing balloon Aug. 25, before the seasonal hole began forming, and by Nov. 6 had sent up 32 more. The balloons sampled the atmosphere with sensors as they traveled to about 30 kilometers up, and beamed the results back to earth.

Ozone depletion is confined to a swath of air from 12 to 20 km up, the researchers report in the March 5 NATURE. But while the total ozone loss in that segment is 35 percent, the patch between 14 and 18 km lost more than 70 percent of its ozone from the initial high in August, and the researchers found depletions as great as 90 percent within 1- to 5-km-thick zones.

They also found great differences in adjacent layers — in some cases, a layer that had lost more than 75 percent of its ozone was adjacent to one with a loss of less than 25 percent. Another surprise, says Wyoming researcher David J. Hofmann, was the rapidity with which the depletion occurred — about half the ozone was gone after 25 days.

The findings leave both the chemical and dynamic theorists to explain the stratification and the speed at which the depletion occurs. The stratification doesn't necessarily hurt the chemical camp, Hofmann says — the layering could occur by air movements, after the ozone has been chemically depleted. But the chemists will have to explain how the depletion can be so quick.

Susan Solomon of the National Oceanic and Atmospheric Administration in Boulder, Colo., favors a chemical explanation. Solomon, who headed the U.S. National Ozone Expedition in Antarctica last year, says the Hofmann study "is a very important observation that's going to have to be explained."

The data, she says, "pose severe problems for all the models." The September depletion is earlier than predicted by either the chemical or physical model, both of which rely on the sun warming the air and predict an October depletion.

Data gathered recently by her group support the chemical theory, she says. At a congressional subcommittee hearing on ozone loss this week, Solomon said the ozone hole contains 20 to 50 times the expected level of OClO, a chlorine-containing molecule. Such chlorine molecules have been associated with chlorofluorocarbon use. But it is too early to say that chlorofluorocarbons cause the hole, she says.

The absence of the depletion above 20 km makes the solar-cycle theory unlikely, says Hofmann, since that theory predicts the greatest loss at higher altitudes. But one of the formulators of the solar-cycle theory, Linwood B. Callis of NASA Langley Research Center in Hampton, Va., says the data were collected during a period of low solar-cycle activity, when not much solar-related effect was expected; still, he prefers not to comment on what may have caused the hole in 1986, pending further analysis.

Data only alluded to in the NATURE paper are going to give the dynamicists some problems, Hofmann says. He and his colleagues found that other chemicals in the ozone-poor air were not depleted, making it less likely that the hole is caused by upwellings pulling in aerosol-depleted air. For upwellings to bring in air depleted only of ozone, and not of other trace chemicals, would take "immaculate transport," says Hofmann. "Our measurements show no upwelling."

Nonetheless, Mark Schoeberl of the NASA Goddard Space Flight Center in Greenbelt, Md., who is a proponent of dynamics, says the current research does not rule out a physical process. "Ozone is a long-lived tracer," he says. Only if all aerosols formed and decayed at the same rate and in the same place would air moved by upwellings have uniform concentrations of aerosols, he says.

Hofmann, while suggesting that the pink-and-green stratospheric clouds that form over Antarctica may somehow be a factor, is not taking sides. "I don't push any models," he says. "I take measurements." *— J. Silberner*

Hot questions in superconductivity

Last month, researchers announced they had made a material that becomes completely superconducting at 94°K (-290°F). By losing all electrical resistance 17°K above the boiling point of the inexpensive coolant liquid nitrogen, it promises to make a host of technological dreams come true (SN: 2/21/87, p.116).

Now, in the March 2 PHYSICAL REVIEW LETTERS, the composition of the new material has been revealed by Paul C.W. Chu at the University of Houston, Maw-Kuen Wu at the University of Alabama in Huntsville and their colleagues. It contains yttrium (Y), barium (Ba), copper (Cu) and oxygen (O), with the composition $(Y_{0.6}Ba_{0.4})_2CuO_4$. Previous superconducting temperature records were set with lanthanum (La)-barium or strontium-copper oxides, with a typical composition of $(La_{0.9}Ba_{0.1})_2CuO_4$.

These new data, together with provocative but sketchy information on the crystal structure of the material revealed to SCIENCE NEWS this week by scientists at the Carnegie Institution of Washington (D.C.), raise a suite of scientific questions.

Chu and Wu were guided to the yttrium material by examining the behavior of the lanthanum compounds; they found that the relative sizes of atomic elements are important criteria in superconducting. But in spite of their success at navigating past the 77°K liquid nitrogen barrier, the hunt for high-temperature superconductors still involves a good measure of alchemy. And while scientists have a sound theory of superconductivity, they have yet to agree on what makes the yttrium and lanthanum compounds tick.

The basic theory of superconductivity, worked out 30 years ago, states that electrons in a crystal can communicate with one another by forming what are known as Cooper pairs. The conductivity of a crystal is enhanced because with Cooper pairs, the electrons scatter off the crystal lattice in a coherent, rather than random, way. The problem has been to explain the mechanism that couples nor-