Halocarbons Linked to Ozone Hole

The claimed detection of chlorine monoxide in the Antarctic ozone hole links man-made chlorofluorocarbons to the hole's creation and implies that things could get worse

SINCE the 1985 discovery of a dramatic springtime thinning of the ozone layer over Antarctica, researchers have been speculating on its cause—is it chemical destruction by chlorofluorocarbons or simply a rearrangement of ozone by winds peculiar to Antarctica? At last month's meeting of the American Geophysical Union in Baltimore,* Philip Solomon, Alan Parrish, Robert deZafra, and their colleagues at the State University of New York at Stony Brook reported that they have found the strongest evidence yet supporting the chemical destruction hypothesis.

Using a technique borrowed from galactic astronomy, the Stony Brook researchers believe that they have detected roughly 0.5 to 1.5 parts per million of chlorine monoxide within the deepening hole, which is about 100 times more of the chlorofluorocarbon-generated compound than would be present if only atmospheric dynamics were at work. Whether the highly efficient destruction of ozone implied by these results magnifies the threat to the global protective ozone layer is unknown, but it can only add to the evidence that hats and sun lotion are not a sufficient response to the problem.

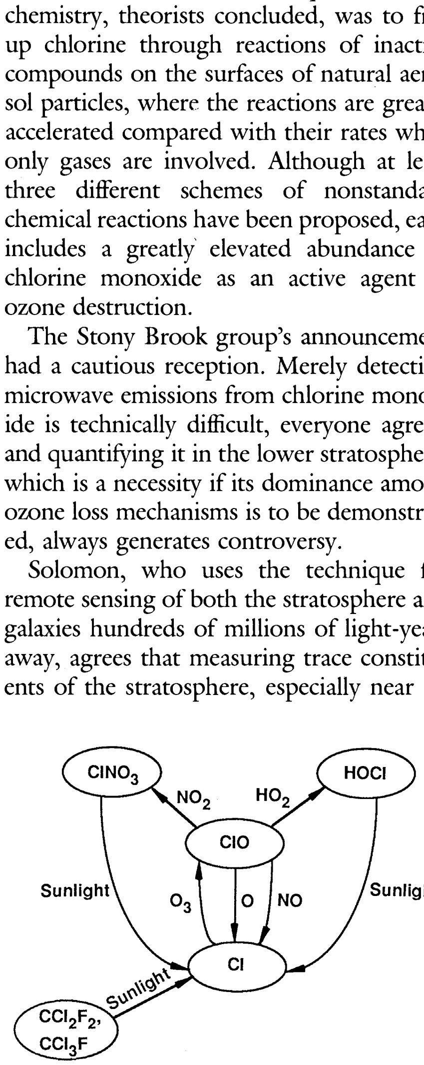
The Stony Brook researchers had taken their millimeter wave spectrometer to McMurdo Station, Antarctica, as part of the 1986 National Ozone Expedition. Their primary objective was the measurement of microwave emissions from chlorine monoxide because stratospheric chemists agreed that relatively large amounts of that compound below 20 kilometers would be a clear sign that chemical reactions were ultimately responsible for the ozone loss in the hole. Chlorine monoxide became the focus of ozone hole analyses after theorists had to modify their chemical schemes for ozone destruction to account for the abruptness of the formation of the hole.

The theorists' problem was that although there is a good deal of chlorine in the stratosphere, standard chemical theory called for more than 99% of it to be tied up in innocuous, inactive compounds such as chlorine nitrate and hydrochloric acid. Thus, chlorine's propensity to form a reservoir of inactive compounds, by the usual reasoning, meant that there could not be enough of it available in an active form to cause rapid ozone decreases.

The alternative to the inadequate standard chemistry, theorists concluded, was to free up chlorine through reactions of inactive compounds on the surfaces of natural aerosol particles, where the reactions are greatly accelerated compared with their rates when only gases are involved. Although at least three different schemes of nonstandard chemical reactions have been proposed, each includes a greatly elevated abundance of chlorine monoxide as an active agent of ozone destruction.

The Stony Brook group's announcement had a cautious reception. Merely detecting microwave emissions from chlorine monoxide is technically difficult, everyone agrees, and quantifying it in the lower stratosphere, which is a necessity if its dominance among ozone loss mechanisms is to be demonstrated, always generates controversy.

Solomon, who uses the technique for remote sensing of both the stratosphere and galaxies hundreds of millions of light-years away, agrees that measuring trace constituents of the stratosphere, especially near 20 kilometers where much of the hole's loss occurs, presents the greater problem. At the relatively high pressures in the lower stratosphere, molecular collisions would smear out the narrow-wavelength emissions of any chlorine monoxide into low, broad "wings" flanking a peak due to emissions from higher altitudes. These wings become a problem when the analyst must subtract the contribution of a nearby ozone emission peak as well as take account of a curvature of the spectrum's baseline caused by the instrument. The residual emission due to chlorine monoxide is at least a few times smaller than the amounts subtracted.



Cycle of destruction. *Chlorine monoxide (ClO) is ultimately derived from man-made chlorofluorocarbons (lower left), but its chlorine either can be sequestered in a harmless form such as chlorine nitrate (upper left) or it can participate in the catalytic destruction of ozone. The apparent detection of large amounts of chlorine monoxide in the Antarctic ozone hole suggests that reactions on aerosols may keep much of the chlorine in its ozone-destructive forms.*

Despite the difficulties, Solomon and his group are confident of their results. They emphasize that they too have been concerned about the known pitfalls of isolating a small signal from interfering noise. As evidence of their success, they note that the same procedures were applied to earlier observations from Hawaii, but no low-altitude chlorine monoxide wings appeared.

In addition, they say, several aspects of the behavior of their measurements conform to the predictions of nonstandard stratospheric chemistry. They find high chlorine monoxide in the lower stratosphere around 20 kilometers, where aerosols are thickest and much of the ozone loss occurs. High chlorine monoxide abundances in early to mid-September, when the rate of ozone loss is high, declined through late September to undetectable levels in early October, when the ozone decrease had about ceased.

The chlorine monoxide also varied with temperature as predicted. Through mid-September the stratosphere near 18 kilometers was almost −80°C, cold enough to form the mysterious condensations called polar stratospheric clouds that make the springtime Antarctic stratosphere 20 times richer in aerosols than less southerly latitudes. By early October the temperature had warmed by 20° and the clouds had evaporated, which would presumably return standard, nonaerosol chemistry to dominance. "There is a very close correlation with low temperature," said Solomon, "actually it is better than it deserves to be. And chlorine monoxide is present at the right time and in sufficient concentrations to explain the Antarctic ozone

*Spring meeting of the American Geophysical Union, 18 to 21 May, in Baltimore, Maryland. Abstracts appear in *Eos* 68, 272 (1987).

hole. The evidence is very convincing."

There is additional evidence. As reported by the Stony Brook group at the meeting, the abundance of chlorine monoxide followed a diurnal cycle. It reached a peak at midday, declined during the evening, and became undetectable during the night. All chemical theories predict just such a cycle in which chlorine monoxide formed by the action of solar ultraviolet radiation returns to a nighttime reservoir such as chlorine dioxide. The latter compound had been found in unusually large amounts at night by the expedition group headed by Susan Solomon of the National Oceanic and Atmospheric Administration Aeronomy Laboratory in Boulder, Colorado. Its presence along with high concentrations of chlorine monoxide bolsters the chemical hypothesis, but chlorine dioxide alone could not be taken as proof because it is not unequivocally linked to ozone destruction the way chlorine monoxide is.

The analysis of Antarctic chlorine monoxide having been given "a good start," as one spectroscopist put it, thoughts naturally turned to the possible implications for the rest of the globe. Malcolm Ko, Jose Rodriguez, and Nien Dak Sze of Atmospheric and Environmental Research, Inc., of Cambridge, Massachusetts, reported results of their modeling that included an assumed nonstandard chemistry. Theirs is only a one-dimension model, they pointed out, and a number of elements in it are not known as well as they need to be. No one knows exactly which reactions are occurring on Antarctic aerosols, or how the rates of those reactions would be affected by the poorly understood differences between Antarctic and lower-latitude aerosols.

Nonetheless, a preliminary model run seemed warranted, and, as expected, the results were not encouraging. When run with standard chemistry, total stratospheric ozone showed no decrease as a variety of trace gases related to human activities increased. But when nonstandard chemistry was included, total ozone decreased a whopping 16% between 1955 and 2060, mostly in the lower stratosphere where aerosols recycled chlorine from inactive reservoirs.

The dynamicists may still prevail against the chemical hypothesis, which would mean that the Antarctic ozone hole is a harmless curiosity. But if the claimed high concentrations of chlorine monoxide are confirmed, dynamics will be relegated to the role of creating a temporary experimental vessel whose conditions so favored aerosol-enhanced reactions that their effects could not escape notice. This fall's 1987 National Ozone Expedition could settle the question. ■ RICHARD A. KERR

Anthropologists Turn Advocates for the Brazilian Indians

An international movement of anthropologists is attempting to help Brazilian Indians, but some question whether advocacy is appropriate for researchers

FOR Waud Kracke, an anthropologist at the University of Illinois in Chicago, the moment of truth came early, when he was still a graduate student at the University of Chicago. In 1969, Kracke went to Brazil to do his fieldwork among the Parintintin Indians, still harboring the traditional notion that his role was to observe and record—not to intervene in the lives of native people. His plan was to conduct a study of leadership in the tribe.

But soon after Kracke arrived, a measles epidemic struck the Indians. Kracke, whose medical knowledge was largely limited to the Merck Manual he carried with him, found himself spending all of his time giving injections and making diagnoses.

"Initially, I felt guilty," says Kracke. "It wasn't what I was supposed to be doing as an anthropologist and it was very different from my expectations." Yet Kracke felt he could not very well refuse to help. It was the start of a new view of himself as an anthropologist.

Now Kracke is working with a growing international network of anthropologists who are serving as advocates for indigenous people. In Brazil, where much of the movement began, the groups are doing what they can to help the Indians gain title to their land and avoid exploitation by colonists. The network includes four major advocacy groups—Cultural Survival, based at Harvard University; Survival International, based in London; International Workshop for Indigenous Affairs in Copenhagen; and Gesellschaft für Bedrohte Völker in Germany.

It is a movement that is attracting increasing attention from academic anthropologists, according to Robert Fernea of the University of Texas at Austin. Fernea, as program chairman of the ethics committee of the American Anthropological Association, recently invited David Maybury-Lewis of Harvard University, who founded Cultural Survival, to address a special seminar on advocacy at the association's annual meeting next November. "I think our interest in advocacy is evident. We are concerned," Fernea says. "It is no longer something we can divide from our intellectual interests."

Yet although the advocacy movement has the loftiest of purposes, it raises troubling questions about the role of anthropology. At what point do researchers step over the thin line between being helpful and being patronizing? Who should make decisions about the fate of indigenous people? At what point should anthropologists stop being observers and start being participants? Should anthropologists be motivated by an imperative that is an inverse of Kipling's white man's burden?

Advocacy, says Fernea, "is no longer something we can divide from our intellectual interests."

Anthropologists' answers to these questions vary, but more and more of those who work in Brazil are coming to agree with Maybury-Lewis, who says, "We shouldn't be worried about being patronizing. It is really quite a minor issue when it comes to what is happening to these people."

If ever there were a place where advocacy is needed, say the anthropologists, it is Brazil. The 200,000 Indians who live in the vast jungle are caught in a continuing struggle as mining companies attempt to gather what is thought to be vast mineral wealth buried beneath the rain forest, lumber companies want certain increasingly rare jungle trees, cattle ranchers want to graze their herds on deforested rain forest land, and local political leaders hope to profit from development projects. "Passions run strong," says Kracke. "Everyone has a vision."

The defenders of the Brazilian Indians are up against "the endless land-hunger of the system," says anthropologist Kenneth Taylor of Survival International's Washington,