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TRUTH AND CONSEQUENCES

This issue of the *Quarterly* is dedicated to a hot topic in cold Alaska: pollution.

What do pollution, ecology, nuclear winter, seismic hazard prediction and genetic engineering have in common? They are all subjects of scientific research with potentially far-reaching economic, social and political consequences. Whether it comes in the form of answers to preformulated questions or as new, unexpected revelations, scientific knowledge about these subjects may be harbinger of security or well-being for some and uncertainty or hardship for others.

What are the social responsibilities of the practicing scientist caught in the middle? There is really only one, but it is overwhelming: that of providing *scientific truth* regardless of its consequences.

Scientific truth is not "absolute." First, it must be verifiable through the rigorous experimental and analytical procedures mandated by what is called the scientific method. Second, what is "true" in science today may not anymore be true tomorrow: scientific truth is shaped by the framework of currently available instrumental hardware and observational and computational methods. Third, scientific truth has varying degrees of "trueness," related to the degree of statistical uncertainty of the experimental information on which it is based.

What is the degree of scientific "trueness" of statements like "Air quality in Fairbanks during strong inversion conditions is bad": "Woodburners have become an urban health hazard"; "Arctic haze does not pose a threat to our population"? What is the scientific significance of statements like "Cigarette smoking causes cancer" or "There is a fifty-fifty chance that a magnitude 8 earthquake will strike Anchorage during the next 30 years"?

A scientifically untrained public has little comprehension of the statistical meaning of scientific truth. This is understandable. By genetic design, our brains are not programmed to react to environmental events on a statistical basis: *one* frightening experience, even if arising by pure chance, is enough to prejudice us forever against the circumstances related to that experience. The popularity of such nonsense as astrology is the best demonstration of our nonstatistical mode of behavior.

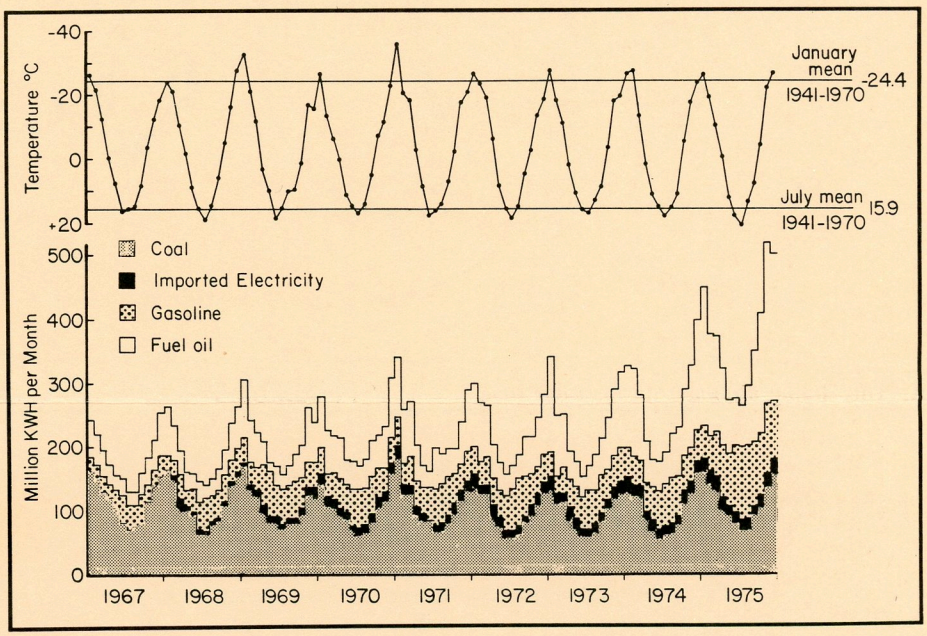
Group photo from the International Symposium on Arctic Atmospheric Pollutants (arctic haze) held in Cambridge in September 1985, funded by the Alaska Legislature. As a result of the conference the State of Alaska has been asked to take the lead in conducting a research and monitoring program to be used as an international model. The program should study urban and indoor pollution and pollution-related health problems, establish pollution monitoring stations, gather information from Natives, and strengthen science education programs.

No wonder then that the public is easy prey to maneuvers by unscrupulous elements of groups with mutually conflicting interests—conservationists, developers, political ideologists—when it comes to the interpretation of scientific truth and the implementation of measures related to its consequences.

Government decision-making based on scientific knowledge, especially when it relates to regulation and control in environmental and health matters, will always bear an element of uncertainty directly related to the nonabsolute character of scientific truth. The classical question of "how much is enough?" appears whenever scientific knowledge is to be translated into societal action or reaction. Neither the scientists nor society as a whole can do away with the related, often agonizing, dilemmas in the decision-making process. What the scientists must prevent at all costs in their quest for scientific truth is to succumb to the "absolute truths" of political, economic or religious dogmas. I view this as the scientists' most important responsibility toward the society they serve.

Juan Roederer
Director

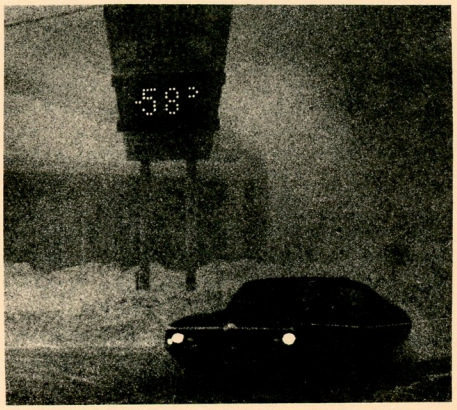
AIR POLLUTION IN ALASKA



Total energy use in the Fairbanks area, separated by fuel type and compared with mean monthly temperatures. Wood has become an important fuel type since 1975, but data beyond that year have not yet been compiled.

AIR QUALITY IN ALASKA'S CITIES

When people think of air pollution, the images that come to mind are smoky industries and big sprawling cities—pictures more suited to Los Angeles than Anchorage or to Pittsburgh rather than Fairbanks. Yet listening to the daily weather and air quality forecasts in Anchorage and Fairbanks will convince any skeptic that the air quality in these cities in winter is very bad. Alaska's city officials sometimes must issue air quality alert warnings. In Juneau's Mendenhall Valley, burning wood can bring in a stiff fine. In Fairbanks, bus rides into town become free in an attempt to reduce traffic and therefore pollution, and in extreme cases automobile traffic can be stopped altogether. In addition automobile owners now must have their vehicles inspected each year, in an effort to reduce pollution levels. Is the pollution problem really all that bad in Alaska and if it is, why is it so? Geophysical Institute researchers have spent considerable effort over the past 20 years or so studying air pollution in Alaska and present some of their findings in this issue of the *Quarterly*.



Thick ice fog at street level in Fairbanks at a temperature of −58°F on January 3, 1969. (Photo by T. Ohtake.)

ENERGY CONSUMPTION AND POLLUTION

Fairbanks, because of its cold winters, consumes an amount of energy per capita comparable to that used by much bigger cities at lower latitudes, as can be seen in the table below:

City	Energy Consumption Per Capita (arbitrary units)
Manhattan	378
Chicago	117
Fairbanks	100
Moscow	74
Sydney (downtown only)	61
Los Angeles	48
St. Louis	22
West Berlin	9
Hong Kong	0.4

The combustion of fuels produces pollutants, and the more fuel that is consumed the more pollutants are produced. Cars produce a great deal of carbon monoxide, and they are particularly bad at low temperatures when the engines must be cold-started. Smoke from wood-burning stoves has become a new pollution hazard; although wood is the "oldest" fuel, the newest stoves produce both more heat and more pollutants per unit of wood burned. Other pollutants include the gases sulfur dioxide and the oxides of nitrogen (NO, NO_2) and a number of organic compounds, as well as solid particles including a variety of elements such as lead (from gasoline), carbon (soot), vanadium, aluminum, and other metals produced from combustion of fuels in cars, power plants, and houses. The urban atmosphere is thus loaded with admixtures of various pollutants.

In Fairbanks carbon monoxide, oxides of nitrogen, lead, hydrocarbons, and suspended particulates all exceed (by up to 1,000%) the accepted standards for at least part of the year. In Anchorage the situation is not very different. How dirty the air is can be seen in the photograph of melted ice fog: the murky water contains all these pollutants.

Melted Fairbanks ice fog (left) compared to ordinary tap water; collected in December 1980.

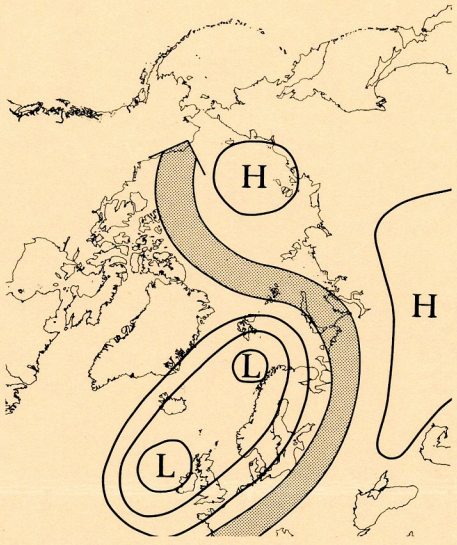
THE INVERSION PROBLEM

In Alaska the real villain in the air pollution problem is the inversion. The term inversion refers to an increase of air temperature as one goes higher above the ground; this is a common occurrence in winter in Alaska, particularly in the Interior. For example, people living in the hills near Fairbanks and Anchorage know that it can be as much as tens of degrees warmer in the hills on clear days than in the valley. These inversions are produced when the valley floor cools by infrared (heat) radiation and cold air pools in the low-lying areas. The result is a cold air mass that stays in place because it is heavier per unit volume than the air above it. This stable air mass means then that pollutants from cars and houses remain at the low level at which they are emitted, right near the surface where most human activities take place. The polluted air mass does not rise and get removed by air currents. Inversions usually form in cold, calm weather; thus pollution levels are also highest during those meteorological conditions.

ARCTIC HAZE—A DIFFERENT KIND OF AIR POLLUTION

A totally different, although also manmade, air pollution in Alaska is *arctic haze.* This pollution is produced by the heavy industries in Europe and the Soviet Union and is transported right across the Arctic Ocean into Alaska. Although its concentration is much lower than the urban air pollution discussed up to now, it nevertheless constitutes a potential problem, for example in producing acid rain and affecting climate. The pollution levels are highest each spring when clouds over the Arctic Ocean are least extensive, minimizing the chances of removing the pollution through rain or snow. By examining the chemical composition of these pollutants, it has been possible to determine where they come from fairly accurately. The arctic haze phenomenon demonstrates that we are not cut off from the rest of the world and that control of air pollution problems must be the concern of all the nations on this planet.

FOR FURTHER READING: the Geophysical Institute has published a 200-page report, *Cold Regions Air Pollution —Bibliography and Summary*, by G. Weller et al. It can be obtained free by writing to the editors of the *Quarterly.*



An example of an atmospheric pathway along which pollution is transported from industrial sources in Eurasia to arctic Alaska.

ICE FOG—AN ADDITIONAL COMPLICATION

When the temperature sinks to about -25°F, ice fog begins to form. Ice fog is a kind of air pollution, although the pollutant in this case is water. The lower the temperature the thicker the ice fog. The source of ice fog is combustion of wood, oil, gasoline, and coal—all produce water —and cooling ponds of power plants and other open water, such as rivers. Ice fog reduces visibility but is otherwise not harmful, although additional pollutants are associated with it. Thus, if one melts a sample of ice fog, a dirty soup results, as shown elsewhere on these pages.

WHAT DOES THE FUTURE HOLD?

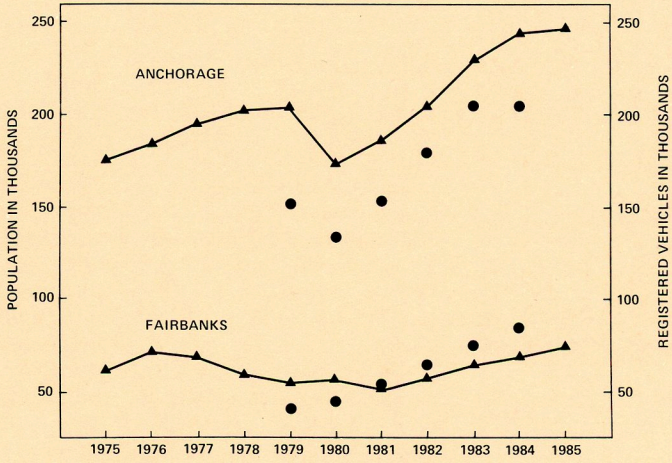
Is the air pollution problem in Alaskan cities likely to get worse? The following statistics were supplied by the Fairbanks North Star Borough:

Winter	No. of air quality violations		Highest CO level over 8 hrs
1973-74	164		35.3
1974-75	120	one-way street	28.7
1975-76	83	traffic began	27.5
1976-77	89		28.4
1977-78	68	CO-measuring	22.3
1978-79	37	location changed	15.6
1979-80	20		20.4
1980-81	30		16.8
1981-82	26		14.1
1982-83	38		17.8
1983-84	24		13.9
1984-85	26		16.8
1985-86	16*		18.5*

*1985-86 to Dec. 25 only. Air quality violation = over 9 parts per million (ppm) carbon monoxide (CO) measured over 8 hrs.

While the number of violations has gone down, due to improvements made by car manufacturers, this winter has seen the worst CO levels since 1979. A single reading in November was as high as 26 ppm. The pollution trends are functions both of weather conditions and the number of cars emitting pollutants. With the relatively mild winters of the past few years, pollution has been lower, but it increased again this year during the relatively cold early winter.

The number of cars has gone up steadily in Fairbanks and Anchorage, and pollution levels have also risen. The recently initiated I/M vehicle inspection program is expected to reverse this trend.



Graph showing increase in number of people and vehicles (and therefore pollution) in Anchorage and the Fairbanks North Star Borough. ▲ = Population; ● = Vehicles. For Fairbanks, the data for vehicles represent a broader geographic area than the North Star Borough; hence the number of vehicles shown for some years is greater than the number of people. Data courtesy of Fairbanks North Star Borough and Alaska Division of Motor Vehicles.

Recent Grants and Contracts

AIR POLLUTION IN ANCHORAGE AND FAIRBANKS

Both Anchorage and Fairbanks, Alaska are well out of compliance with Environmental Protection Agency (EPA) standards for carbon monoxide, with an average of around 30 violations per year (see other pages, this *Quarterly*). Professor Sue Ann Bowling of the Geophysical Institute has completed a study funded by the EPA that was designed tc determine the climate conditions responsible for such severe pollution in relatively small cities.

The air pollution problem in Anchorage and Fairbanks was found to be due to inversions lasting throughout the day; thus the carbon monoxide is trapped during the hours when emissions of carbon monoxide are the highest. Although the study is now complete, Professor Bowling is maintaining contact with Anchorage, Fairbanks, and the State agencies in their effort to control the problem.

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AEROSOL TRACE ELEMENTS IN FAIRBANKS

In a cooperative research effort, the Geophysical Institute's Tom Gosink and the Fairbanks North Star Borough investigated some of the unusually high concentrations of trace elements that turned up in routine Borough air samples. A second effort was to determine if the various pollutant sources (wood, coal, oil smoke, and auto exhaust) could be distinguished chemically.

The study produced a reliable method of sampling for the Borough. It was found that the source of some unusual trace elements apparently is from the wear of studded tires and from lubricants.

Analysis shows that potassium can be used as an indicator for wood smoke pollution. Smoke from coal can be readily distinguished from wood smoke and auto exhaust by gas chromatography "fingerprinting."

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ICE FOG CRYSTALS CAN SCAVENGE AIR POLLUTANTS

Ice fog is usually formed in association with high emissions of air pollutants. Nucleation and scavenging of air particles remove pollutants from ice fog, when ice crystals collect the air pollutants on their surfaces and precipitate to the ground. This may explain why melted ice fog is both dirty and smelly. Professor T. Ohtake from the Geophysical Institute, along with scientists from China and Japan, studied this air particle scavenging process with State of Alaska funds.

One result of this study shows that collisions of air pollutants with an ice crystal occur on the average every 87 seconds. Within 2 hours, typical residence time of ice crystals at an air temperature of $-38^{\circ}C$, one ice crystal may collide with about 83 air pollution particles. These values roughly agree with the average number of air pollution particles found on an ice crystal under the electron microscope.

ARCTIC HAZE CONFERENCE

The University of Alaska-Fairbanks was a sponsor of the International Symposium on Arctic Atmospheric Pollutants at Cambridge University in England, in early September 1985. Several faculty members of the Geophysical Institute attended the conference.

It was suggested at the conference that arctic haze poses no current health hazard but that pollutants and acid rain could have a direct impact on lakes where salmon spawn and on lichens, which are an essential food for caribou.

Alaska Natives, who have been noticing changes in weather, plants, and air quality over the years, were the driving force behind this conference. The conference was funded by the Alaska State Legislature.

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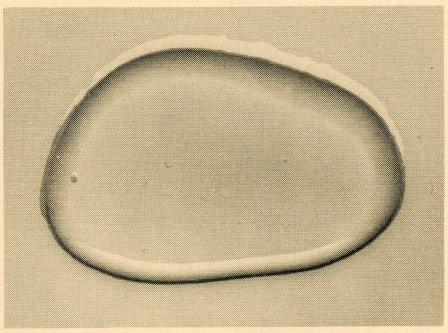

Electron microscope photograph of an ice crystal with attached, scavenged air pollution particle. Magnification is about 20,000 X. (Photo courtesy of T. Ohtake.)

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