Antarctic aerosols

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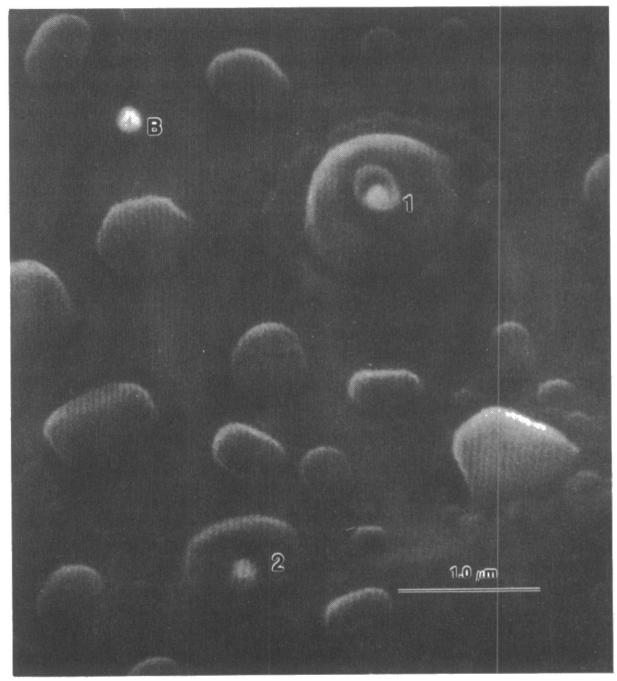
During the austral summer season of 1978–79, as part of a study of the sources and transport mechanisms of submicron particles over Antarctica, I did further work to varify a model of particle transport and removal. Of particular interest was the determination and comparison of particle loading and water vapor in the vertical air column above the central polar plateau and above an equivalent altitude at a coastal location. For the latter purpose, I conducted multiwavelength precision sun photometry measurements from the summit of Mount Erebus. I also took data on the aerosols at intermediate altitude locations on Ross Island and from the dry valleys in the Victoria Mountain Range.

In addition to the optical studies, I also collected aerosols for inspection with x-ray spectrometry. The preliminary results are that the dominant aerosol contains sulfur, but that nickel-enriched particles (presumably of extraterrestrial origin) and aluminum silicates (presumably crustal particles) are also present.

Experimental data on the aerosols are being interpreted with a model that accounts for sources, sinks, conversion, and removal processes at the polar latitudes. My previous work showed that particle size distribution is bimodal (Shaw, 1979). The smaller, Aitken particle mode is likely to consist of converted products from nucleation of trace gases, especially sulfur-bearing gases. The Aitken particles are less than 2 or 3 days old. They are produced locally over the ice cap at a rate of 4×10^{-21} grams per cubic centimeter per second ($g/cm^3/sec^1$), and they are found all through the troposphere in concentrations of between 10 and 10^3 centimeters^3. These circumstances suggest that there may be significant excess marine sources of sulfur.

Particles in the larger size mode, several tenths of a micrometer in diameter, are found in extremely low concentrations (i.e., about 0.5 centimeter^{-3}) above the polar plateau, but they may constitute the dominant mass of total particulate material in antarctic air. These larger particles come from (in their order of importance) unidentified sulfate sources, oceanic sources surrounding the continent, arid regions in the southern hemisphere, extraterrestrial sources, and oases on the Antarctic continent itself. Though there is evidence that mean flow plays some role in carrying particles to the continent, meridional transport by eddy diffusion seems to be the major transport mechanism. Preliminary analysis of the 1978–79 season's profile of water vapor and submicron particles confirms this model.

The main mechanisms of particle removal for the particles that diffuse to the continent are the clouds associated with the storm belts in the latitude range of 55° to 65°S. Those particles that diffuse over the cloud tops reach the southern polar regions and are removed relatively inefficiently by processes occurring in the turbulent boundary layer over the ice sheet. My analysis shows that the most important of the removal mechanisms are impaction on the ice sheet (2.0×10^{-14} g/cm^2/sec); impaction onto snowflakes (1.6×10^{-14} g/cm^2/sec); impaction onto ice crystals (0.2×10^{-14} g/cm^2/sec) and nucleation of ice crystals (0.6×10^{-14} g/cm^2/sec). The Aitken particles are removed preferentially by diffusion processes. These are diffusion to ice crystals (0.006×10^{-14} g/cm^2/sec) and diffusion across the 1-millimeter-thick laminar layer at the surface (0.015×10^{-14} g/cm^{2}sec), the latter accounting for the greatest Aitken particle loss. The near-surface removal mechanisms are predicted to deplete aerosol mass loading in the boundary layer by a factor of 2 to 10.



Atmospheric particles collected at South Pole onto collodian-coated electron microscope grids and analyzed with x-ray spectrometry. Electron beam creates burn marks, such as shown at B. Particles 1 and 2 give sulfur signatures.

One of the objectives of this work is to interpret the time series record of mineral particles preserved in ancient polar ice. Analysis indicates that there must be a background of particles in ice cores that emanated from southern hemisphere deserts and that were carried by turbulent mixing and deposited on the continent.

Superimposed on this background are contaminating bursts of particles from global stratosphere-penetrating volcanic eruptions. The volcanic eruptions are expected to introduce high-frequency variations in the time series of particle concentration with depth in the ice sheet, with spatial wavelengths corresponding to events lasting one-half to three years. On the other hand, longer spatial wavelength fluctuations in the background particle concentration record with depth in the ice may be attributable to changes in southern hemisphere desertification or, more likely, to changes in the strength of atmos-

pheric circulation or cloud patterns.

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Reference

Shaw, G., 1979. Considerations on the origin and properties of the Antarctic aerosol. (Submitted to *Rev. Geophysics and Space Physics.*)

Atmospheric composition using infrared techniques

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University of Denver researchers carried out two experimental programs during the 1978–79 austral summer. Both programs, which involved using quantitative measurements of the infrared properties of the antarctic atmosphere (Murcray, 1978; Williams et al., 1976), were primarily concerned with assessing man's impact on the Earth's atmosphere.

One experiment involved obtaining very high resolution atmospheric transmission spectra from Amundsen-Scott (South Pole) Station. The experiment's objectives were to obtain background data (that is, data representing, as nearly as is still possible, a natural atmosphere); to obtain data on the concentrations of both natural and pollutant-related atmospheric trace constituents; and to search for spectral features of previously undetected chemical species in wavelength regions normally masked by the HO absorptions in spectra taken from other ground sites.

The atmospheric transmission data were obtained at the South Pole on 30 November and on 1, 2, and 3 December 1978. Infrared solar spectra in the 750^{-1} centimeter to $1{,}350^{-1}$ centimeter (7.4 to 13.3 micrometers) region were recorded using a Fourier transform spectrometer of the moving-mirror Michelson type. The instrument was capable of a resolution of 0.01 centimeter (unapodized)—sufficient to distinguish lines of stratospheric species, such as ozone, from those arising in the troposphere by their smaller width. The spectra show several thousand absorption lines, which are currently being analyzed. A distinctive feature of these spectra is the remarkable transmission in spectral regions normally obscured by water vapor absorptions, because of the dry conditions and high altitude of the South Pole.

Figure 1 shows a small portion of one of the spectra. The majority of the strong spectral features in this section of the spectrum are due to NO, O_3, CH_4, and HO. A number of weaker absorption features are also related

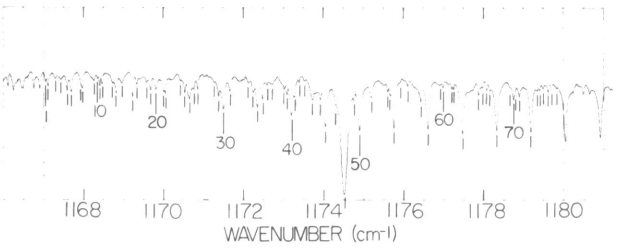

Figure 1. Selected portion of solar absorption spectrum taken 1 December 1978 from South Pole Station. Seventy-nine absorption lines have been marked in this frame (complete spectrum obtained with interferometer system consists of forty-five frames). Identifications of some of the lines are listed in the table.

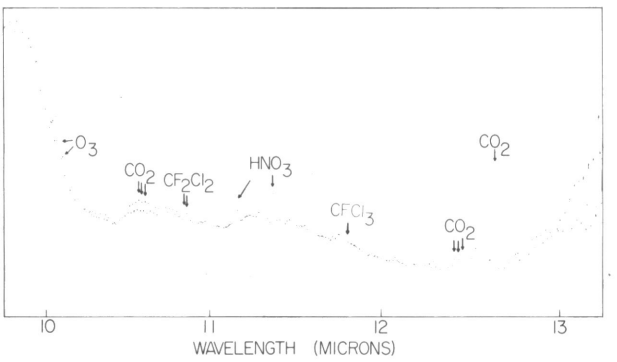

Figure 2. Atmospheric emission spectrum observed from altitude of 5.5 kilometers from LC–130R–131 over South Pole Station on 24 November 1978. Some prominent features in spectrum are identified by atmospheric constituent.

to these molecules and to such other known atmospheric species as CO and CFCl. There remain a number of absorption lines that have not yet been identified with known atmospheric molecules. When they are identified, these absorptions will enable the authors to determine the concentration of the absorbing molecules at the time the spectrum was recorded. Identification of these features is part of the ongoing analysis of the data.

The second experiment involved aircraft measurements of the spectral emission from the atmosphere in order to obtain the column density for several species as a function of latitude from 34°N to the South Pole. The data also will be evaluated for other possible effects—geographic, meteorological, or temporal.

Atmospheric emission data were obtained with a liquid helium-cooled grating spectrometer on board LC–130R–131. Successful measurements were made be-