Biological Microparticles in the Hans Tausen Ice Cap, North Greenland

By Sabine Gruber and Ruprecht Jaenicke

Abstract

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Samples from three different depths in the Hans Tausen ice core (82.5°N, 37.5°W) in Peary Land, North Greenland were examined. The aim was to determine the size distributions of the total and biological particles in the size range 0.2 µm < radius < 41.2 µm. To date, the concentration of the whole spectrum of biological microparticles including viruses, bacteria, spores, pollen, plant debris and animal fragments in ice is still unknown. Biological particles were distinguished from non-biological ones by single particle analysis. The mean concentration of the total insoluble particles in ice was 1.02E+05 per ml, of these, 3.20% were biological.

Keywords: Hans Tausen ice cap; particle size distribution; biological particles.

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Introduction

Particles included in an ice cap are deposited atmospheric aerosol particles. Assuming that the mechanisms of deposition (wash-out by precipitation or dry fallout) are constant in time, the particle concentration in ice mirrors the concentration in past air masses. Changes in the concentration and/or composition of the particles reflect as well changes in sources and sinks of particles as changes in the atmospheric circulation. Biological particles are of special interest for climate change studies. The biosphere reacts very sensitive to variations in the temperature and therefore changes in the concentration of biological particles might indicate a temperature change (Bennike *et al*. 1990).

Biological particles in ice cores may originate both from local and remote source areas. The Arctic is not a vast abiotic frozen desert. A great variety of living organisms have adapted to the cold environment. Fredskild (1966) and others found altogether 105 different species of vascular plants in Peary Land. Bennike *et al*. (1990) isolated 60 plant and 120 insect remains from the pliopleistocene Kap København Formation, a sediment in north-east Peary Land. But there are also biological particles found which derive recognizably from sub-Arctic areas. As Greenland lies north of the tree line, all tree pollen found in the ice must have been transported over a long distance. Fredskild *et al.* (1974) discovered, that in addition to local herb and grass pollen, pine *(pinus)*, birch *(betula)* and alder *(alnus)* pollen were

also found in the Camp Century ice core (77.1°N, 61.1°W). Pine, birch and ragweed pollen also occurred in the Dye-3 ice core (65.1°N, 43.5°W) in southern Greenland (Bourgeois 1990).

Methods

The ice cores were kept frozen at –80°C until analysis. The surface of the ice core was contaminated by drilling and handling processes so that it could not be used for microparticle analysis. Hence the ice had to be cleaned by cutting off the outer parts of the core with a stainless steel knife. Because of the wide size range of the particles suspended in the ice, two different methods were used to determine the size distributions of the total and biological particles. Particles with radii $r > 2.0$ µm were investigated in a light microscope. For this, the ice was melted at room temperature and a protein dye (Matthias-Maser *et al*. 1994) was added. Biological particles were stained blue, while non-biological particles were not stained. Particles with radii $0.2\ \mu m < r < 2.0\ \mu m$ were analysed in a scanning electron microscope (SEM) which was combined with an energy dispersive X-ray spectrometer (EDX). Biological particles often showed a characteristic morphology (spheres with rods or cavities) in the SEM, but not in all cases this information was sufficient to distinguish them from non-biological particles. The elemental composition of the particles was very important for identification. Biological material was characterised by a high background spectrum which was overlapped by peaks of the elements phosphorus, sulphur, potassium, calcium and sometimes chlorine. Some biological particles were unstable under the electron beam during EDX and shrank or disappeared. For classifying biological particles in the SEM/EDX, the morphology, elemental composition and the behaviour during the analysis must be considered. The total and the biological particles were counted in nine size classes. The number-, volume- and mass size distributions were calculated for both the total and the biological particles. Additionally the percentage of the particles with biological origin was determined.

Results

The size distribution of insoluble particles in the Hans Tausen ice core was determined for the size range $0.2\ \mu m < \text{radius} < 41.2\ \mu m$. Ice samples from different depths were analysed and a mean value was calculated. In Fig. 1 the mean size distributions for the total and the biological particles are plotted together with the percentage of the biological particles. In the left plot the number size distributions dN/dlogr are shown. In the Hans Tausen ice core around 10^5 insoluble particles per ml ice were found. The ratio of biological to non-biological particles rises with increasing radius. While only 3% of all particles with sizes below 2.0 µm were biological, the biological percentage rises up to 26% at radii between 10 µm to 15 µm. The smaller particle sizes are characteristic of viruses and bacteria which are mostly found in urban areas. As Peary Land is a very remote area, these small biological particles are not found and hence the biological percentage in this size range is relatively low. Spores of lichens, mosses, fungi and algae have radii larger than 0.5 µm, whilst pollen and fragments are in excess of 5 µm in radius. These particles, that are typical for remote continental regions (Matthias-Maser 1998), appear in the Hans Tausen ice cap in a much higher percentage than bacteria. Regarding the volume and mass size distributions (Fig. 1, centre and right plot) it is obvious, that the main mass is due to particles larger than 3 µm radius. This is in agreement with particle measurements in snow from South Greenland

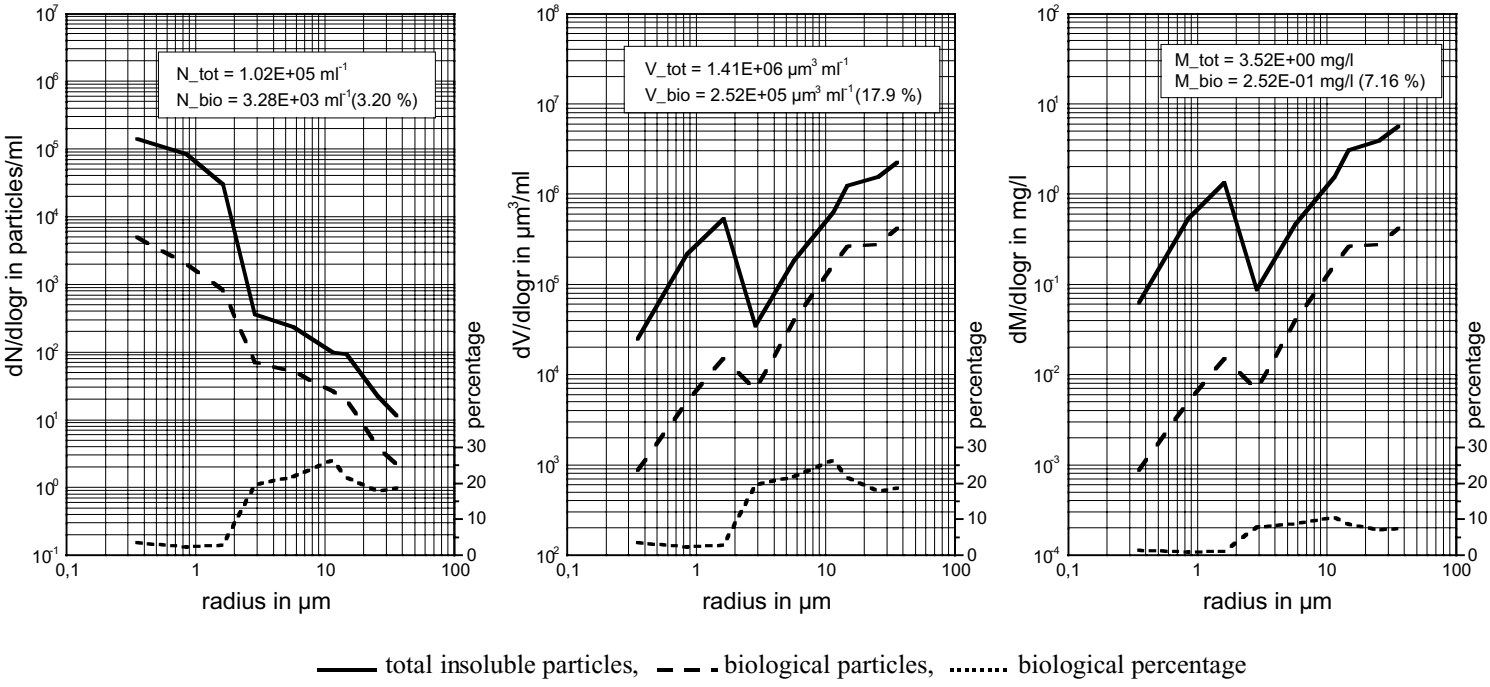

Fig. 1: Left plot: Number size distributions; centre plot: Volume size distributions; right plot: Mass size distributions (density of total particles $\rho\_tot = 2.5\ g/cm^3$, density of biological particles $\rho\_bio = 1.0\ g/cm^3$).

(Steffensen 1985). It is remarkable, that biological particles comprise nearly 18% of the total particle volume in the ice core. This corresponds to 7% of the total particle mass. Again, this is caused by the higher biological percentage in the giant particle fraction. These preliminary results show, that there exists a great variety of biological material both from local and remote sources in northern Greenland ice.

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References

Bennike, O. and J. Böcher 1990. Forest-Tundra Neighbouring the North Pole: Plant and Insect Remains from the Plio-Pleistocene Kap København Formation, North Greenland. *Arctic* 43(4): 331-338.

Bourgeois, J. 1990. A Modern Pollen Spectrum from Dye 3, South Greenland Ice Sheet. *Journal of Glaciology* 36: 340-342.

Fredskild, B. 1966. *Contributions to the Flora of Peary Land, North Greenland.* Meddelelser om Grønland 178 (2): 1-23.

Fredskild, B. and P. Wagner 1974. Pollen and fragments of plant tissue in ice core samples from the Greenland Ice Cap. *Boreas* 3: 105-108.

Matthias-Maser, S. and R. Jaenicke 1994. Examination of Atmospheric Bioaerosol Particles with Radii r > 0.2 µm. *Journal of Aerosol Science* 25: 1605-1613.

Matthias-Maser, S. 1998. Primary biological aerosol particles: Their significance, sources, sampling methods and size distribution in the atmosphere. In: *Atmospheric Particles* (ed. R.M.Harrison and R.Van Grieken). John Wiley and Sons Ltd.

Steffensen, J.P. 1985. Microparticles in snow from the South Greenland ice sheet. *Tellus* 37 B: 286-295.