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THE NATURE OF ATMOSPHERIC DUST .

Progress Report to January 15, 1955

by

Clarence Heininger and John Turkevich

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THE NATURE OF ATMOSPHERIC DUST

Progress Report to January 15, 1955

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Clarence Heininger and John Turkevich

Princeton University

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Abstract

Optical microscopic examination of air- and rain-borne dust shows most of the particles to be less than one micron in diameter. Electron microscopic examination of the same dust shows predominantly clusters of particles whose individual diameters are in the range 200-1000 Å. The residue obtained by filtering rain water through a millipore filter is found to be slightly radioactive in more than half the cases observed.

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I. INTRODUCTION

In order to study the morphology, chemical constitution, and radioactive properties of particles found in the atmosphere, air was filtered and rain water collected on the roof of the Frick Chemical Laboratory. The dust so obtained was observed in both the light and the electron microscopes. An end window Geiger-Müller tube was used to detect any radioactivity present. No attempt has yet been made to solve the problem of chemical constitution.

II. AIR-BORNE DUST

About 3700 liters of air were drawn through a millipore filter¹, type HA. Optical micrographs of the exposed surface of the filter were taken at magnifications up to 1000 times. The magnification chosen was approximately 1000 times the effective numerical aperture of the objective lens, not considering the light source. Probably the limitations of the light source place the best available true numerical aperture at about 0.6 or 0.7.

Both transmission and reflection micrographs were taken. The former were possible because treatment with immersion oil renders the millipore filter transparent. This procedure raises the question of the effect of immersion oil on the dust. In those instances when the dust-carrying surface of the filter was first lightly shadowed with chromium in a high vacuum evaporator, transmission observation showed instances of shadow but no particle. This phenomena was not seen when the dust was observed by reflection and no oil was used. The conclusion is that some dust particles are transparent when immersed in oil. (Figure I-A)

Electron micrographs at magnifications up to 100,000 times were taken of chromium replicas of the exposed filter surface

(Figure II) and also of the dust alone transferred from the filter surface to a carbon film support (Figure III). An RCA EMU-2D electron microscope fitted with a compensated double objective lens was used. The chromium replicas were prepared by vacuum evaporating a thin layer of chromium on to the filter surface, then shadowing with chromium at an angle of 45° , and finally dissolving the filter in acetone. Generally the dust particles adhere to the replica. Dust was transferred from the filter to a thin carbon film by the method of Kalmus². A small square of filter was placed dust side down on the carbon-filmed grid. This was placed on a strip of copper screening, 200 mesh, whose ends were bent down about 1/8 to 1/4 inch to form legs. The copper "bridge" was placed in a Petri dish of acetone. The acetone diffused along the screening, dissolved the filter material, and left at least some of the dust behind. About three fresh acetone baths were used for each specimen.

In the optical and electron micrographs, particles as large as twenty microns and as small as one hundred angstroms were seen. Size determination of the nominal diameters of about 250 particles seen with the optical microscope in an area of filter surface of about 0.48×10^{-4} cm.² shows 3% greater than 2 microns, 18% in the range 1-2 microns, and 79% less than one micron (Figure I-B). The electron microscope shows most particles in the 200-750 Å range. (If the great majority of these particles are carbon black, which seems possible, then many of the particles apparently in the 500-750 Å range may have reached this size by contamination growth in the electron microscope. The relative appearance of the electron micrographs of the two groups suggests this.)

The electron micrographs show these further points:

- 1) Most of the particles are found in clusters. This suggests that what is seen in the optical microscope is a cluster of small particles, not one homogeneous particle.
- 2) Most of the particles can be considered spherical to a first approximation.
- 3) In many cases the chromium replica technique shows only the replica of a particle. (The great majority of particles appear to remain with the replica.) These particle replicas are usually single, not clustered. Thus it seems that the acetone bath used in preparation of the specimen can remove single particles more easily than clusters. Either those substances soluble in acetone tend not to cluster, or single particles are easily washed away.
- 4) Some ghosts, i.e. what appear to be the remains of evaporated particles, are observed. Similarly, rings of deposited material can be found around some of the larger particles. Carbon black does not ordinarily evaporate when subjected to electron bombardment in the microscope. The existence of the phenomena suggests the presence of other, lower melting compounds.

III. DUST IN RAIN WATER

Rain water was collected by placing a cylindrical vessel, 12 inches high and 8 inches in diameter, on the roof of Frick Laboratory. About 250 mls. of the water collected during a particular rainfall were passed through a millipore filter, type HA. Transmission and reflection optical micrographs of the exposed surface were taken at several magnifications (Figures IV-A and IV-B). Measurement of the nominal diameters of about 260 particles

found on about 0.26×10^{-4} cm.² of filter shows 8% greater than 1.5 microns, 19% in the range 0.75-1.5 microns, and 73% less than 0.75 microns (Figure IV-A).

Specimens of rain water for electron microscope examination were prepared by allowing a drop of the rain water to dry on a collodion filmed nickel grid. Electron micrographs, (e.g. Figures V, VI, and VII) at magnifications up to 200,000 times show:

- 1) most particles in the 200-1000 Å range. Possibly there are more in the 200-500 Å range than in the 500-1000 Å range. Here, too, contamination may be important.
- 2) a few particles less than 100 Å in diameter, possibly as small as 30 Å.
- 3) a few particles of the order of a micron in certain samples. These are regular in shape (elliptical and hour-glass) and are not very efficient electron scatterers. They may be living cells.
- 4) many "ghosts".
- 5) some threads with diameters of about 250 Å.
- 6) great differences in contrast, i.e. the ability to scatter electrons, from particle to particle.
- 7) that the great majority of particles are, to a first approximation, spheres. This is not as true as with the air-borne dust, however.
- 8) no rings of deposited material around the particles.

IV. RADIOACTIVITY IN DUST

The incidence of radioactivity in the air and in rain water was detected by counting the millipore filter containing the dust sample under an end window Geiger-Müller tube. The sample-to-window distance was about two centimeters giving a counting

geometry in the neighborhood of 30°. The normal background is twenty counts per minute. The highest sample plus background rate observed was 28 c/m. Since at least a thousand counts were recorded in each count, the standard deviation for a net count is about one c/m.

Of four filters used to collect air-borne dust, three showed no sign of radioactivity. The fourth may be active; additional counting to improve statistics is necessary in this case. Laboratory distilled water and laboratory cold tap water is inactive. Of eight filters containing residues from rain water collections, five show significant activity. The other three are still doubtful and will be counted again.

V. REFERENCES

- 1) Lovell Chemical Company, Watertown 72, Massachusetts.
- 2) E.H. Kalmus, J. Appl. Phys., 25, 87 (1954)

Figure I-A (top)

Transmission optical micrograph of the surface
of a millipore filter, type HA, containing
air-borne dust, chromium shadowed

Magnification 500x

(1 cm. = 20 microns)

Figure I-B (bottom)

Transmission optical micrograph of the surface
of a millipore filter, type HA, containing
air-borne dust.

(1 cm. = 20 microns)

Figure II

Electron micrograph of a chromium replica of the
surface of a millipore filter, type HA,
containing air-borne dust.

Magnification 60,000x (1 cm. = 1700 Å)

Figure III

Electron micrograph of air-borne dust collected
on a millipore filter, type HA, and transferred
to a carbon film.

Magnification 40,000x (1 cm. = 2500 Å)

Figure IV-A (top)

Transmission optical micrograph of the surface of
a millipore filter, type HA, containing the residue
from filtration of 250 milliliters of rain water.

Magnification 675x (1 cm. = 15 microns)

Figure IV-B (bottom)

Transmission optical micrograph of the surface of
a millipore filter, type HA, containing the residue
from filtration of 250 milliliters of rain water.

Magnification 165x (1 cm. = 60 microns)

Figure V

Electron micrograph of the residue resulting from the
evaporation of a drop of rain water on a collodion
filmed specimen grid.

Magnification 40,000x

(1 cm. = 2500 Å)

Figure VI

Electron micrograph of the residue resulting from the
evaporation of a drop of rain water on a collodion
filmed specimen grid.

Magnification 60,000x

(1 cm. = 1700 $\text{\AA}$)

Figure VII

Electron micrograph of the residue resulting from the
evaporation of a drop of rain water on a collodion
filmed specimen grid.

Magnification 100,000x

(1 cm. = 1000 Å)