Major carbonaceous particle types in Southern African biomass smoke and in the regional haze during SAFARI 2000, as identified using analytical transmission electron microscopy (TEM)

(based on: Pósfai, M., R. Simonics, J. Li, P. V. Hobbs, and P. R. Buseck, Individual aerosol particles from biomass burning in southern Africa: 1. Compositions and size distributions of carbonaceous particles, J. Geophys. Res., 108(D13), 8483, doi:10.1029/2002JD002291, 2003.)

Particle type	Morphology	Composition	Structure	Mixing
Organic particle with inorganic inclusion	Irregular, particles are spread on the lacey support film	Carbonaceous with inorganic K-salt inclusions	Amorphous	Externally mixed in young smoke, internally mixed with sulfate and soot in the haze
Tar ball	Spherical	Carbonaceous with minor O, in cases with minor S, K, Si, Cl	Amorphous	Externally mixed
Soot	Agglomerates of 20 to 50-nm spherules	Carbonaceous with minor O, in cases with minor S, K, Si	Turbostratic graphitic layers form the individual onion-like spherules	Externally mixed in young smoke, internally mixed with sulfate in haze
Sulfate	Spherical to irregular, decomposes in the electron beam	Ammonium sulfate	Crystalline in the vacuum of the TEM	Both externally and internally mixed with organic and soot particles in the haze

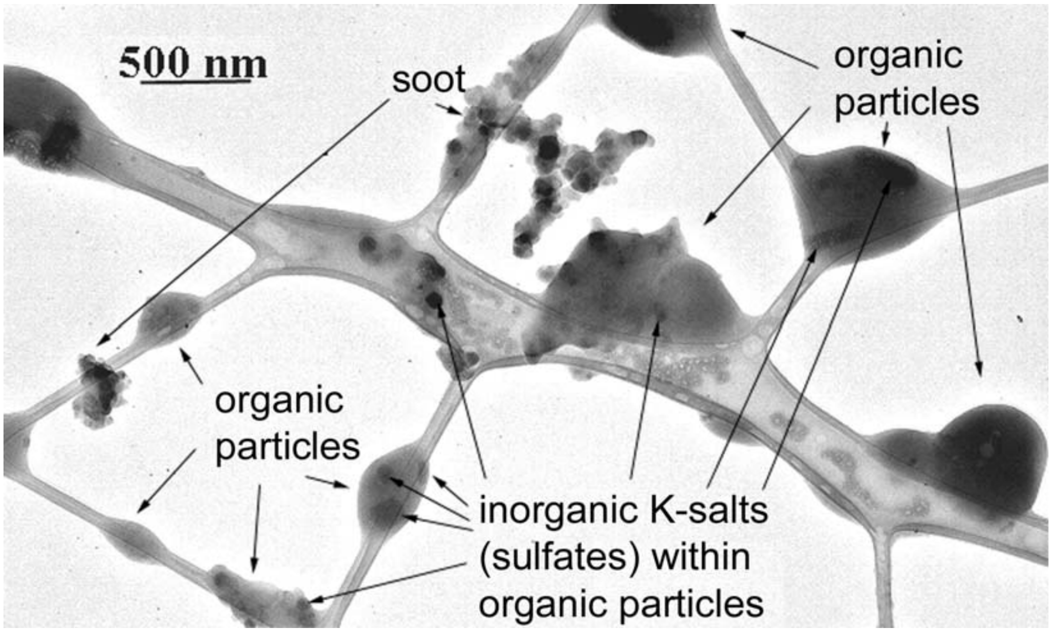

Fig. 1. A typical portion of a sample of young smoke from a smoldering and flaming fire. Particles are attached to the lacey support film; most particles are carbonaceous (organic) with inorganic K-sulfate inclusions. As a result of diffraction contrast, the inclusions appear darker than the material of their host particles. (Kruger National Park; sample 15-SS3)

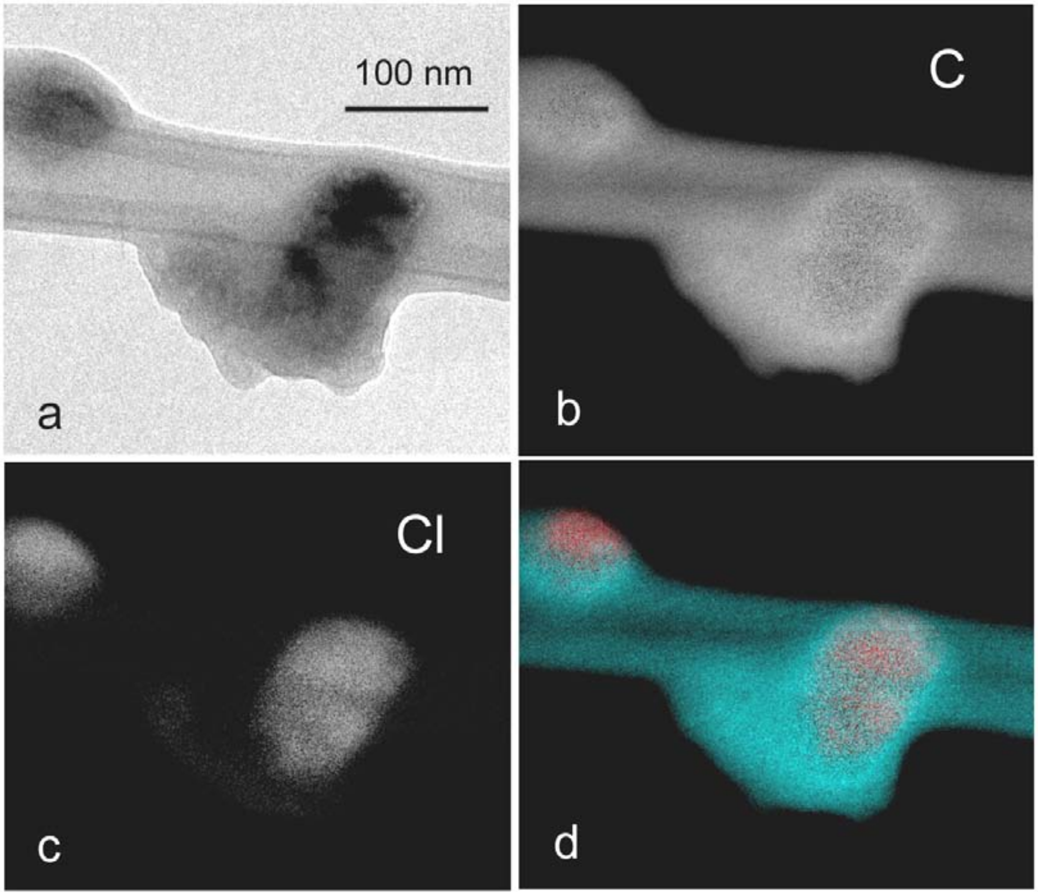

Fig. 2. Electron energy-loss maps from two KCl-bearing organic particles that are attached to a thin ribbon of the Formvar support film. (a) Bright-field image; (b) C map; (c) Cl map, and (d) a composite image showing the distribution of C (blue) and Cl (red). In (a) the dark contrast within the inclusion results from diffraction by the crystalline substance. (b) and (d) show a fairly homogeneous distribution of C in the particles, except for lower concentrations where the crystalline inclusions occur. Since the supporting Formvar substrate also contains C, there is intensity in the C map where the lacey film is present. The image in (c) indicates that Cl is only present in the inclusions. (West of Beira, Mozambique; sample 25-SY3)

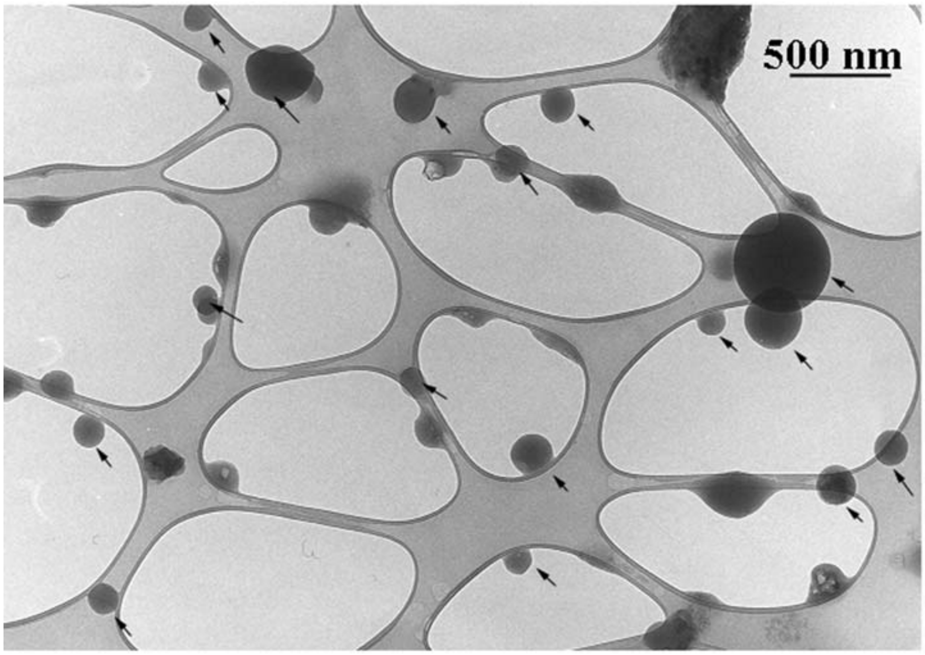

Fig. 3. Spherical tar ball particles (arrowed) on a lacey supporting film. The sample is from aged smoke of a smoldering fire 16 km downwind from the fire. Particles that are not marked by arrows are organic particles with inorganic inclusions. (West of Beira, Mozambique; sample 25-SA3)

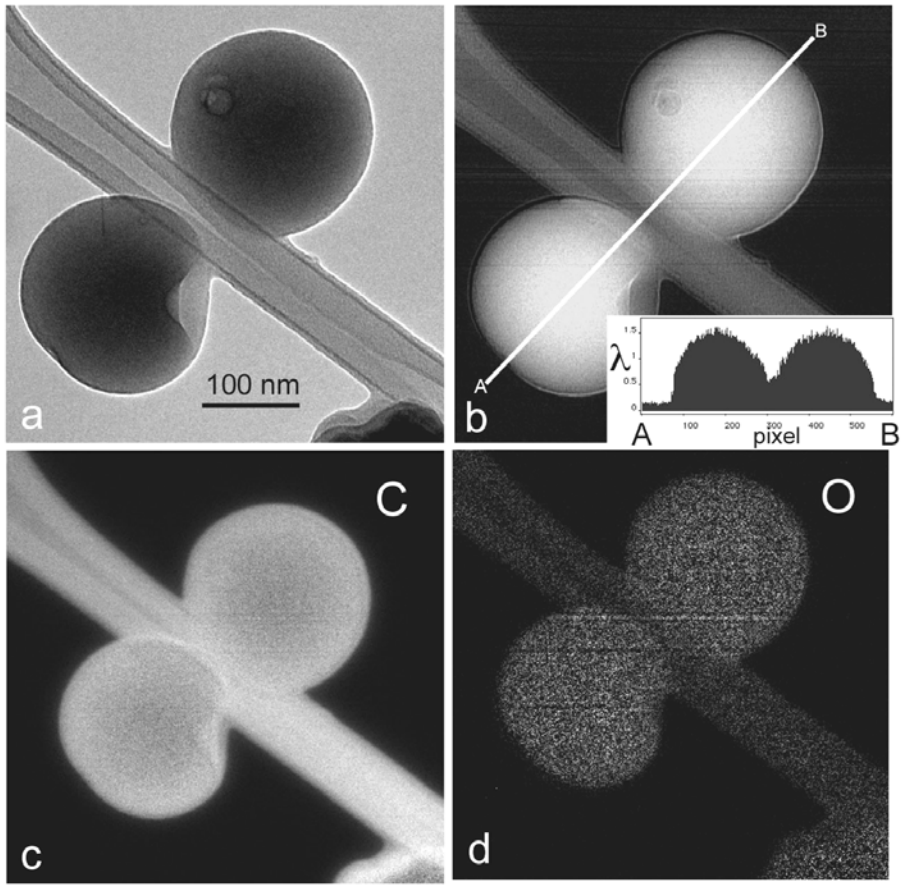

Fig. 4. Electron energy-loss maps from two tar ball particles. (a) Bright-field image; (b) thickness map; (c) C map; (d) O map. The inset in (b) shows a thickness profile from A to B. (On the vertical axis λ stands for the mean free path; $\lambda=1$ means the thickness through which the electrons take part in only one inelastic scattering event. λ is about 150 nm in such relatively light material). (West of Beira, Mozambique; sample 25-SA3)

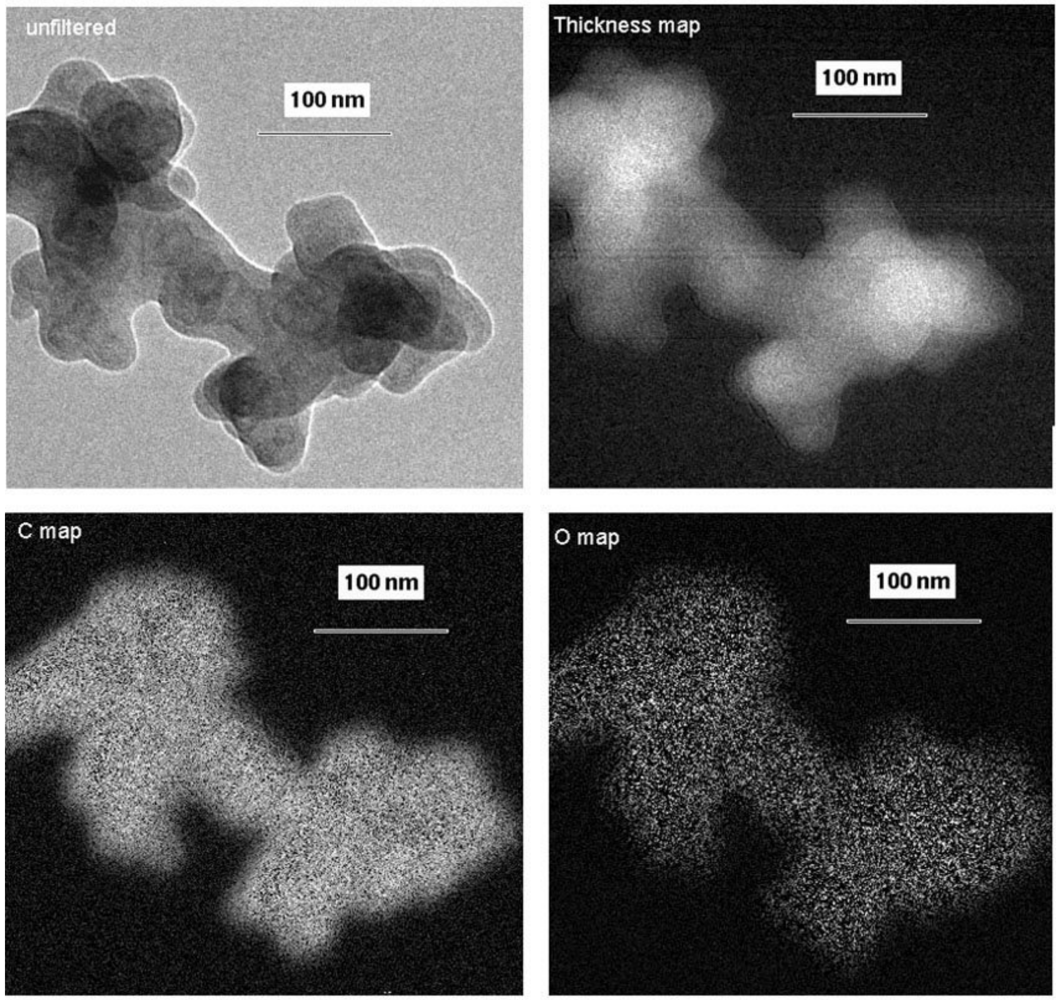

Fig. 5. Electron energy-loss maps of a soot particle from aged smoke. (West of Beira, Mozambique; sample 25-SA3)

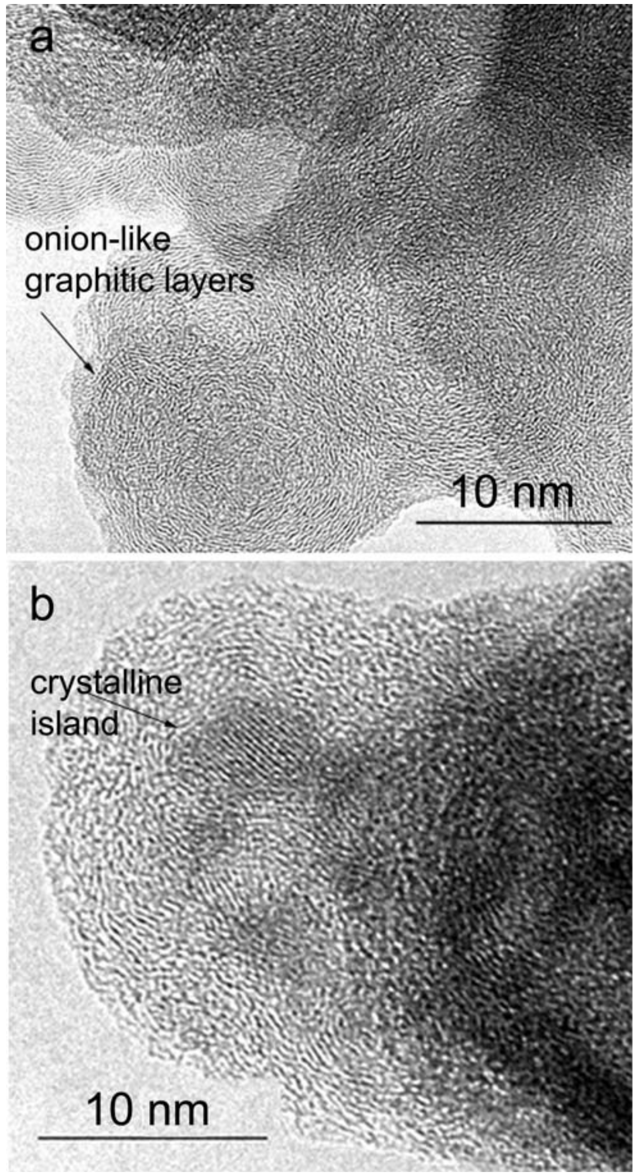

Fig. 6. High-resolution TEM images showing the distinct microstructure of soot. (a) Individual spherules consist of turbostratic graphitic layers. (b) A few nm-sized graphite nucleus within a soot globule. (Kruger National Park; samples 15-SF3 and 15-SS2)

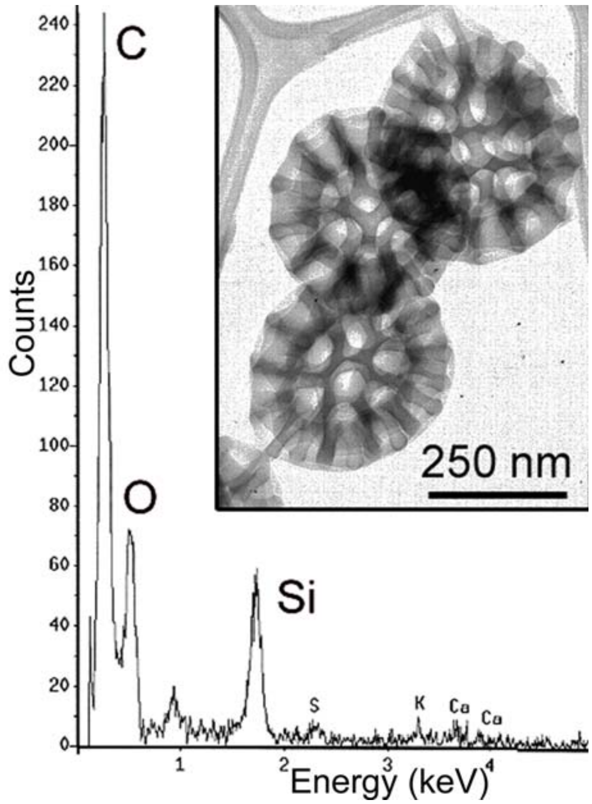

Fig. 7. Particles of biological origin from background haze, and part of a typical EDS spectrum obtained from one such particle. (Medikwe Game Reserve; sample 16-H2)

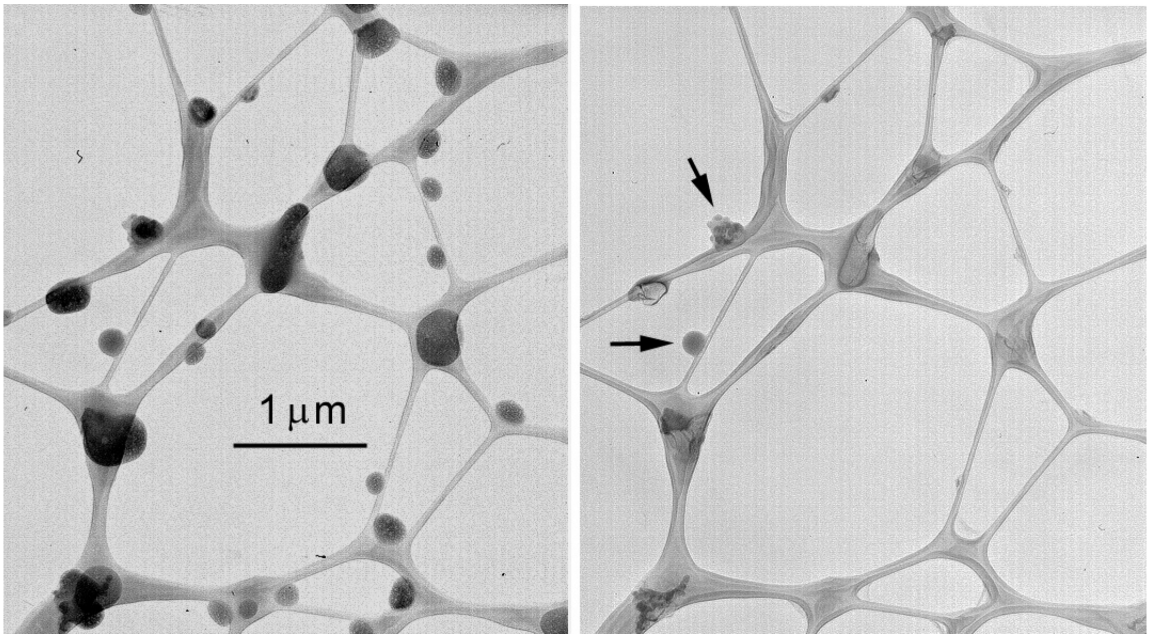

Fig. 8. A typical portion of a sample from “lower haze;” the image in (a) was obtained before sulfate particles suffered damage in the electron beam, whereas the image in (b) was obtained after the sulfates were evaporated with the electron beam. A soot particle and a tar ball (arrowed in b) remained unchanged, whereas sulfate particles disappeared, leaving behind some residues.

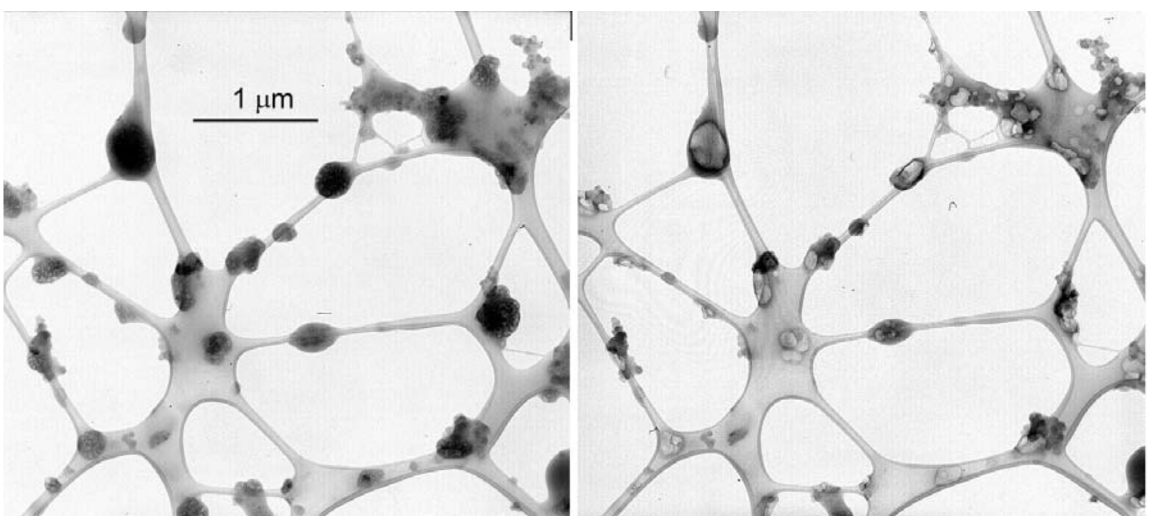

Fig. 9. A typical portion of a sample from “upper haze;” the image in (a) was obtained before sulfate particles suffered damage in the electron beam, whereas the image in (b) was obtained after the sulfate component of the mixed the particles was evaporated with the electron beam. Upper hazes were much more affected by biomass smoke than lower hazes, as indicated by the internal mixing of sulfate with organic and soot particles.