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Raman and electron microscopy of aerosol particles released above Australian salt lakes

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New particle formation above Western Australian salt lakes with pH levels from 2.5 to 7.1 was observed during several field campaigns between 2006 and 2013. Besides their high concentration of dissolved salts and the remarkable pH values, many of these salt lakes also exhibit a large organic content, originating from former eucalyptus forests and plant remains. The surrounding land, used for wheat farming and livestock gets drier by missing rain periods. One possible reason can be seen in the formation of ultrafine particles from salt lakes, which increase the cloud condensation nuclei and prevent therefore rainfall.

To identify the origin and nature of the formed particles directly with the chemistry of and above the salt lakes a 2.35 m^3 chamber made of Teflon® film was brought above the lake in 2012 and 2013. Photochemistry can take place whereas mixing by wind or transport from already existing particles is prevented. Released particles were collected on alumina foils inside the Teflon chamber using a Sioutas impactor, sampling aerosol particles of sizes between 250 nm and 10 μm. While the ultra-fine fraction of the released particles is missing, aged aggregates of the original particles could be collected using the impactor.

The alumina foils were analysed using chemical imaging and electron microscopy. A Horiba LabRam 800HR Raman microscope was used for vibrational mapping of an area of about 100 μm x 100 μm of the foils at a resolution of about 0.5 μm. The same area was analysed using a Quanta FEI 200 electron microscope (about 5 nm resolution). Besides the high-resolution image, the elemental composition could be investigated using energy-dispersive X-ray spectroscopy. This approach provided both molecular information and elemental composition at a high lateral resolution, allowing a detailed study of the deposited particles. Both optical images and the related chemical images were combined and a chemometric investigation of the combined images was done using the software package Imagelab (Epina Software Labs).

Different aerosol species related to the salt lakes and the surrounding land could be uncovered, especially inorganic compounds like silica, gypsum and sodium chloride. Furthermore, the interaction of primary released particles with volatile organic species, released from remains of the former eucalyptus forests and crop plants, could be identified. The combination of vibrational imaging and electron microscopy with energy-dispersive x-ray spectroscopy allows a detailed analysis of atmospheric aerosols based on high-resolution imaging, elemental composition and molecular information. Structure determination at high lateral resolutions uncovers different particle sources and mixing of species, as well as nucleation of volatile species on existing particles on a sub-μm scale.