Geochemical and microbiological fingerprinting of Australian airborne dust

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Map showing the major paths of dust to the oceans
Map from Sturman & Tapper

Australia is the major dust supplier in the southern Hemisphere
Salt lakes, with groundwater just below the surface, and flood plains are the prime source of dust in Australia.
Dust storms are often generated during significant meteorological re-organisation of wind regimes & fronts that create significant shear zones at ground level. 

E.g. principally in early Spring and Autumn.
Little is known about the chemistry and microbiology of Australian dust - this has been the purpose of our work through a multidisciplinary approach by members of the Australian National University, Monash University, University of Bremen and the MPI of marine microbiology in Bremen and principally funded by the ARC.
Our approach

- Sedimentological properties of dust
- Major, trace and REEs geochemical analyses
- Organic chemistry and $\delta^{13}C$ of lipids
- Microbiology and DNA recovery from dust
- Meteorological conditions related to dust events
- Future work: magnetic properties of dust
Example: the dust storm of 22/23 October 2002 which transgressed a large portion of eastern Australia, some of which rained down over Canberra.
Forward trajectories starting on Oct. 20, 2002 confirm that the dust plume originated from the NW of NSW (Cobar) and it was 1.5km high over Canberra and dew point was reached there, so it rained mud.
Systematic collection of overflow river sediments in the Murray Darling Basin
Lanthanides minerals: insoluble in water

Element normalised to Canberra dust

River sample [< 5μm fraction]
Dust samples & Murray Darling Basin samples

Cobar area

Canberra dust

A, B, C: from Western Australia
Potential pollen source area: around BOURKE with the following main vegetation types: open *Eucalyptus* woodland with a lower stratum of *Acacia* & *Callitris*; open mixed *Eucalyptus* & *Callitris* woodland + grasses
Source apportionment of lipid compounds in GC-MS trace of Canberra dust sample

- General vegetation: 48%
- Conifer burning: 31%
- Biomass burning: 3%
- Urban & contamination: 17%
- Angiosperms: 1%

Data produced by K-U Hinrichs
Interpreted by E. Schefuß
Dr Enno Schefuß’ findings

The organic geochemical signature is predominantly determined by molecular markers for lipid contributions from fresh plant biomass and biomass burning. The vegetation source of the directly emitted plant lipids as well as their thermal combustion products was likely dominated by conifer trees (C₃ plants) with some angiosperms (flowering plants) in low abundance.

Professor K-U. Hinrichs’ findings

Bacteria and fungi have also been detected. In the unlikely event that the lipids are exclusively bacterial, the concentrations would correspond to $\sim 2 \times 10^{10}$ cells g$^{-1}$ dry dust.
39 operational taxonomic units were obtained by sequences with >97% similarity

DNA analysis of the Canberra dust

Cyanobacteria
Acidobacteria
Planctomycetes
Firmcutes
Bacteriodes
Probacteria

Clones obtained by Raeid Abed
Many of the affiliates to cultured species recovered in the Canberra dust originate from soils and desert crusts, usually first isolated from areas far away from Australia

The Cyanobacteria clone is related to a bacterium known to be associated with corals [eg. black band disease]

Brain coral infected with black-band disease

Taken from USGS web site
Another major dust event affected Sydney in Sept. 2009 as well as a large part of SE Australia, including Canberra during the night.

Our meteorological colleagues at Monash predicted the event, and that enabled us to sample the dust fallout efficiently.

One example of our investigations relates to the microbial fingerprinting of the dust for comparison with dust from the Oct 2002 event.

Also, geochemical analyses carried out by Dr M. Norman (ANU) showed that throughout the night, the chemical composition of the dust changed as the plume picked up new material along its course.

Red haze envelopes Sydney Harbour Bridge.
Amber Hooper available ABC web site.
Dishes placed at 2 hours interval
Current work with colleagues from Monash [meteorology] and ANU [microbiology]
Different microbial colonies growing on the air filter placed on a growth medium.

Work and photograph taken by Chris Munday, ANU PhD student.
Lake Gnarpurt, March 2008. A lake with permanent water until recently. This lake harboured lots of blue green algae. It is possible that cyanobacterial compounds from the wet lake episodes are becoming airborne and entering the food chain downwind as cattle feeds on grasses coated with cyanobacteria compounds.
A few hours later on St Patrick’s Day.... March 17th
Attempt at placing sampling equipment during the dust storm
Wind blown sediment, organic compound and microbes blown onto an agar plate
Sampling during the dust/deflation event
Microbial colonies growing on agar within less than a day

Work and photograph taken by Chris Munday
Twice-weekly, 24h
Air filtering at several locations in Australia
We are targeting:
• what is in the atmosphere,
• also dust sources, such as desert [microbial] desert crust,
• organic compounds in lake floors, mats and soils,
• geologies of different ages and geochemistries.

The eventual aim is to reconstruct what ends up in the ocean & determine the possible effects due to dust fall in the marine realm.
Tether balloon sampling planned for Sept. 2010

2007-8 sampling Stations. In 2009, we sampled the NW coast of WA

Map prepared by M.Bausch
Trajectory of an airmass at different altitudes showing an (and dust particles) can travel from Australia as far as Antarctica.

Images prepared by A. Wain, BOM
Thank you