Analysis of Atmospheric Particles Deposited onto Mesquite Leaves in the Central Arizona - Phoenix LTER Area

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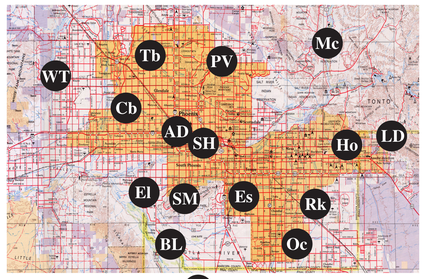
Purposes of Work

- To use leaf surfaces as monitors for deposition of atmospheric particles.
- To measure the spatial deposition patterns of particle types throughout the Phoenix area. This information is useful for:
  - Measuring the resolution at which particle types change along a gradient from the urban core to the natural desert.
  - Observing the transport paths of particles from distant sources.
  - Validating and improving air quality models.

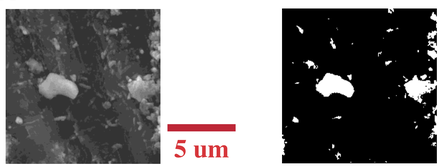
Methodology

- Mesquite leaves were collected on June 19 and 29, 2001, from 28 sites (15 sites for each day have been analyzed and the results are presented here):



- AD ADOT - I-10/I-17
- BL Beltline Road
- Cb Camelback & 91st Ave
- El Elliot & 59th Ave
- Es Estrada Park
- Ho Hosanna Church
- LD Lost Dutchman
- Mc Fort McDowell
- Oc Ocotillo & Val Vista
- PV Paradise Valley Mall
- Rk Recker & Knox
- SH Sky Harbor
- SM South Mountain
- Tb Thunderbird Park
- WT White Tanks

- Individual particles on the leaf surfaces were analyzed using an electron microprobe.
- The particles were distinguished from the leaf surface by converting the back-scattered electron image to a binary image, in which the particles appear white and the substrate black.



- Single-particle compositions were determined with Energy-dispersive X-ray Spectrometry (EDS).
- The particles were assigned by elemental composition into pre-defined particle types with the statistical routine EXPLOR [1].

Results

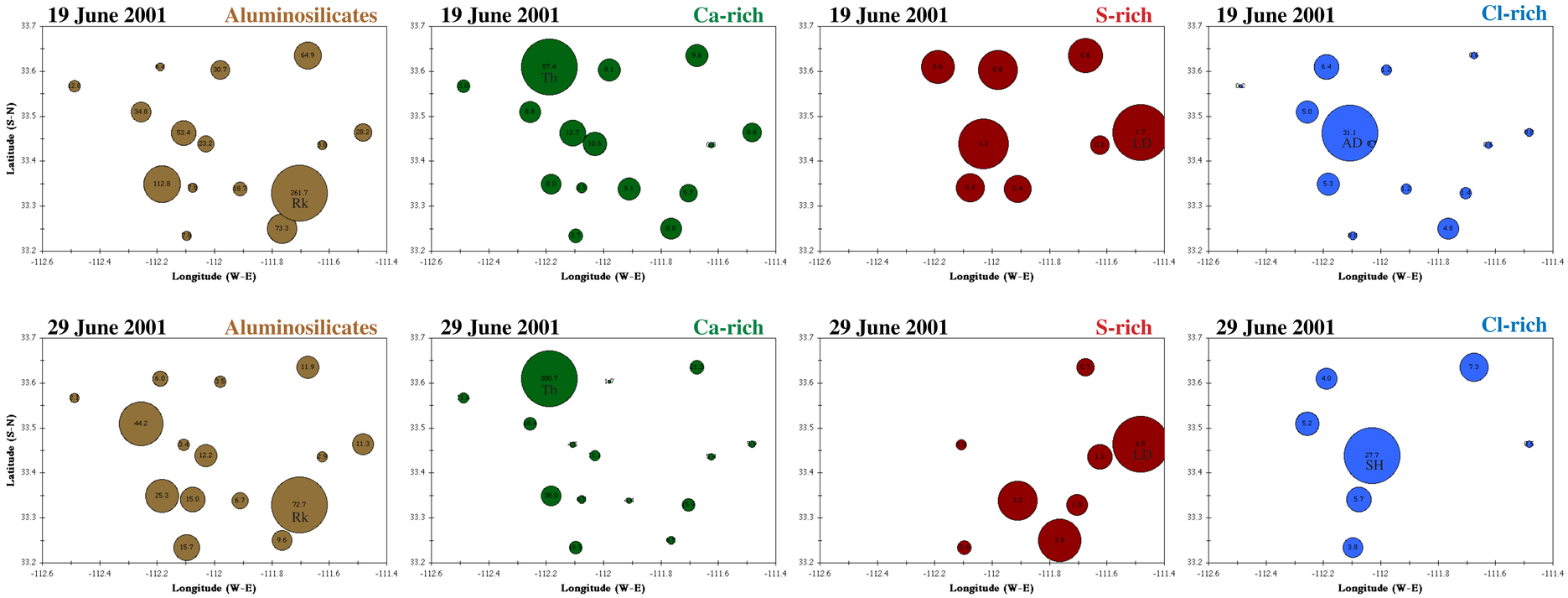


Figure 1: Bubble plots showing the spatial deposition patterns of four particle types on both analysis days. The bubble sizes represent the relative particle concentration (number of particles/cm² of leaf) on each plot. Note that the relative bubble sizes apply only to the individual plots, not among different plots.

Discussion

- The spatial deposition patterns are similar for both analysis days.
- Aluminosilicates are most abundant in the southern part of the sampling domain, at the Elliot and Recker sites. These sites are in agricultural areas, so the aluminosilicates are likely generated locally.
- The Ca-rich particle types are most abundant in the northwest, at the Thunderbird site. This sampling site is in a large grassy park under a busy road, so the Ca-rich particles could be from fertilizer and/or cement that is locally generated.
- The S-rich particle types are most abundant in the East Valley at the Lost Dutchman site.
  - Note that none of the sites in the western half of the sampling region have S-rich particles.
  - During a field experiment, PAFEX-II, conducted in the summer of 1998 in the East Valley, atmospheric particles were collected on filters. The S-rich particles were most abundant.
  - Possible sources of the S-rich particles are coal-burning power plants located about 120km northeast of the Phoenix area. The particles are transported from the power plants to the East Valley by regional-scale down-slope winds (see Figure 2 at right).
  - Because of terrain changes, these down-slope winds may not reach the West Valley, which would explain why no S-rich particles are observed there.

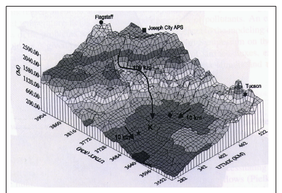


Figure 2 [2]: A map of the complex terrain surrounding the Phoenix area (marked with X). A coal-burning power plant is located in Joseph City. The drainage flow through the mountains to the Phoenix area is indicated.

- The Cl-rich particle types are most abundant in the central part of Phoenix, at the ADOT and Sky Harbor sites. Particles with chlorine as the primary element are not common; however, chlorine is present in the leaf material. These particles are likely small particles consisting of Si, S, Ca, and possibly K. Because they are small, the electron beam also detects the leaf material (Cl, K). Because these particles are most abundant in central Phoenix near major freeways and because they are small, the Cl-rich particles most likely originate from freeway emissions. Those containing Si could be reentrained road dust. Those containing Ca could be cement particles. And those containing S may be motor vehicle emissions.

Conclusions

- Leaves can be used as sampling substrates to monitor deposition of atmospheric particles with electron microscopy.
- Particles on leaves can be used to measure the spatial deposition patterns of indiviual particle types, patterns determined by tranport paths superimposed on the regional distribution of local particle sources.

Future Work

- Complete electon microscope analyses of remaining 13 sampling sites for both days and recluster all of the data.
- Collect leaf samples from the same sites during the winter and compare the results with those from the summer.
- Analyze filters that were placed in a single tree, and analyze the leaves that were collected at the same time.

References

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[2] Fernando, H.J.S., Lee, S.M., Anderson, J.R., Princevac, M., Pardyjak, E., and Grossman-Clarke, S. (2001) Urban fluid mechanics: Air circulation and contaminant dispersion in cities. Environmental Fluid Mechanics, 1, 107-164.