



Task 2.2 Particulate Matter

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Overview

- Goals of the particulate matter work
- Equipment
- Scanning electron microscopy analysis
- Results
- Conclusions
- Directions

Goal of the PM_{2.5} Program

- To develop advanced sampling and analysis methodologies for particulate matter that can be used for source apportionment and to assist in health studies.

Three Primary Activities

- Collect and characterize $PM_{2.5}$ samples using the instruments in the sampling trailer.
- Develop and improve automated SEM characterization techniques.
- Provide detailed characterization information.

Equipment – Trailer and Instrumentation



Trailer – Instrumentation

- Aerodynamic particle sizer (APS)
 - Measurement: particle sizing 0.2–30 μm
 - Sampling rate: 15 minutes
- Scanning mobility particle sizer (SMPS)
 - Measurement: particle sizing 0.013–0.8 μm
 - Sampling rate: 15 minutes (average of 2)
- Sequential air sampler (SAS)
 - Measurement: total mass <2.5 μm
 - Sampling rate: 24 h (EPA 40 CFR 40–53)

Trailer – Instrumentation

- Tapered element oscillating microbalance (TEOM)
 - Measurement: total mass $<2.5 \mu\text{m}$
 - Sampling rate: 15 minutes
- Automatic cartridge collection unit (ACCU)
 - Measurement: CCSEM filter sample $<2.5 \mu\text{m}$
 - Sampling rate: 48 hours

Trailer – Instrumentation

- Burkhard seven-day recording volumetric spore trap
 - Measurement: CCSEM moving tape sample – PM_{2.5} and PM₁₀
 - Sampling rate: 1-hour time resolution
 - Particle size cut point about 0.5 micrometers
- Weather station
 - Measurement: Local weather conditions
 - Sampling rate: 15 minutes
 - Augmented by Weather Service data and HYSPLIT modeling

Samples for SEM Analysis

- Burkhard seven-day recording volumetric spore trap
 - Measurement: CCSEM moving tape sample
 - Sampling rate: 1-hour time resolution
 - Particles down to 0.5 μm are imaged and analyzed
- Automatic cartridge collection unit (ACCU)
 - Measurement: CCSEM filter sample
 - Sampling rate: 48 hours
 - Particles down to 0.1 μm are imaged and 0.5 μm are analyzed

Burkhard S ampler



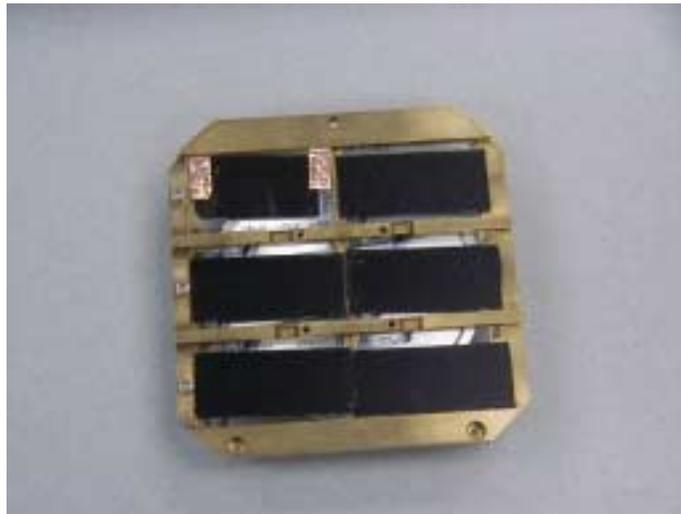
- The Burkhard sampler is an impactor – it does not collect with equal efficiency.
- Particles are impacted on carbon tape, which:
 - Allows direct introduction of the sample to the SEM.
 - Provides particle dispersion.
 - Is time-resolved.



Sample Preparation



- Each 24-hour period is represented by 48 mm of carbon tape.
- Tape is cut to 48-mm segments and placed on standard petrographic slides.
- Six days can be loaded at one time for automated analysis.
- Samples can be directly introduced into the SEM.



Scanning Electron Microscopy

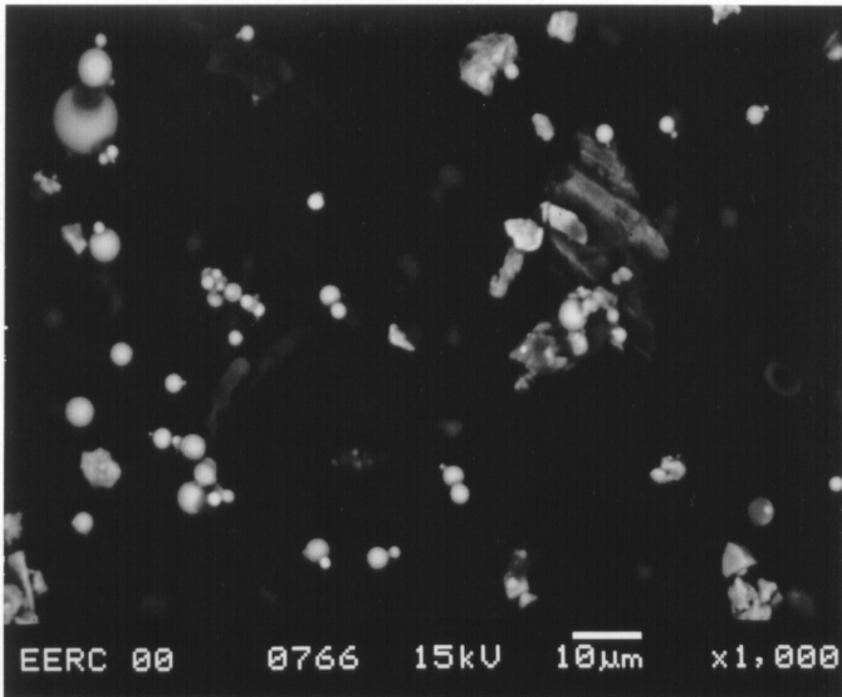


- Morphological analysis is
- An automated technique has been developed that determines the size, shape, and chemistry of several thousands of particles per sample which can be resolved into hourly events.
- These hourly events can be related to the local weather conditions monitored at the site.
- Particles as small as $0.5 \mu\text{m}$ are characterized.
- Two magnifications are used – 500X for particles $>2.5 \mu\text{m}$ and 2500X for particles $<2.5 \mu\text{m}$.



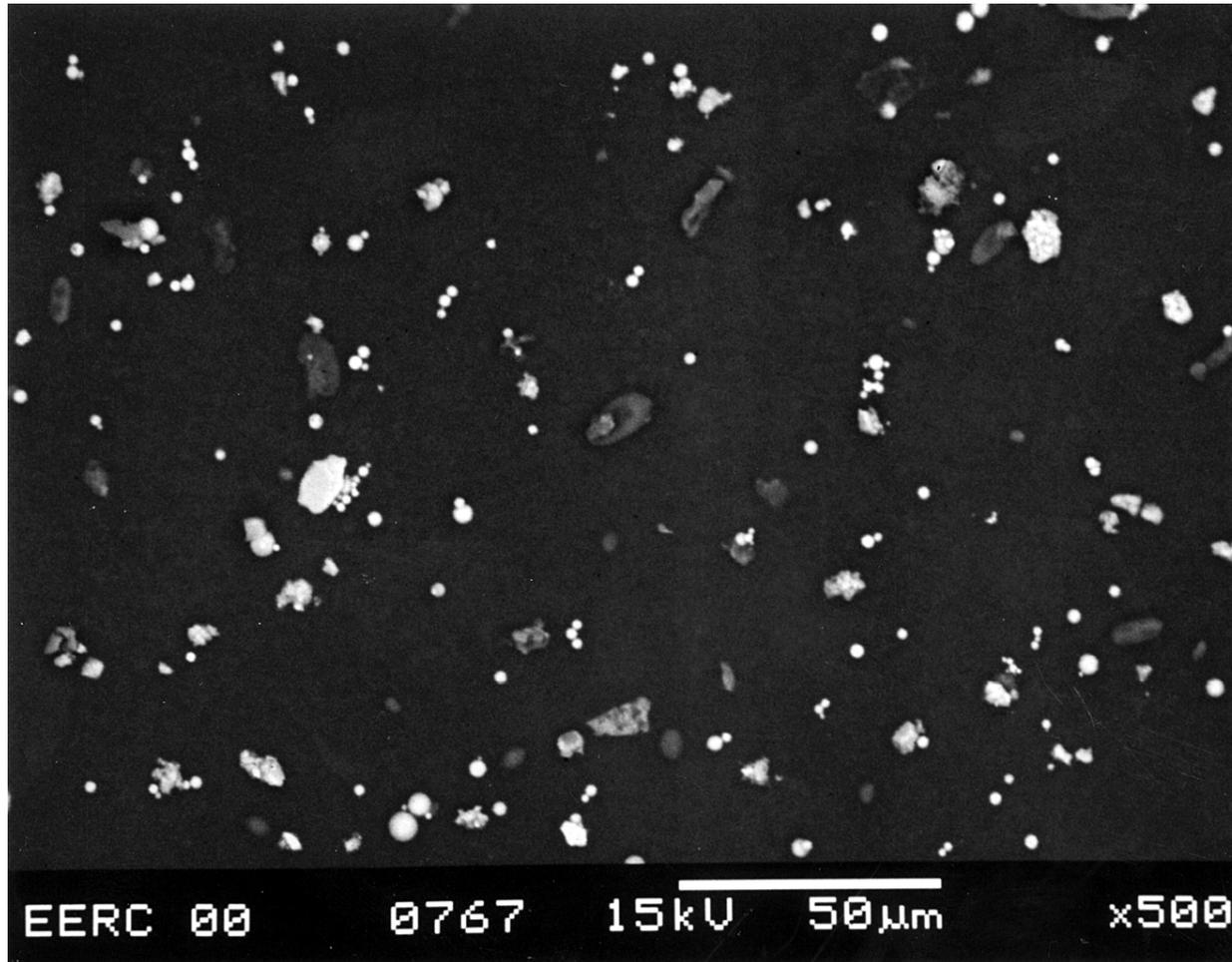
SEM Morphological Analysis

Particle Typing



- Pulverized coal combustion primary particles
 - Silicate and aluminosilicate or iron rich materials spherical.
 - Sulfates are typically small and are in agglomerates

Rural Site

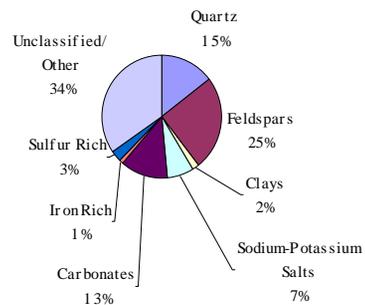


Particle Analysis

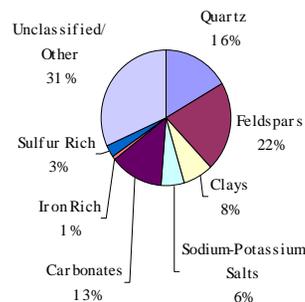
- The x-ray spectrum for each particle is matched against standards and a chemical type assigned.
- The spectrum is quantified and saved for statistical analysis.
- Other information collected includes particle area, perimeter, maximum, minimum, mean diameters, circularity, and particle location on the sample.

Particle Typing

Particles $\leq 2.5 \mu\text{m}$

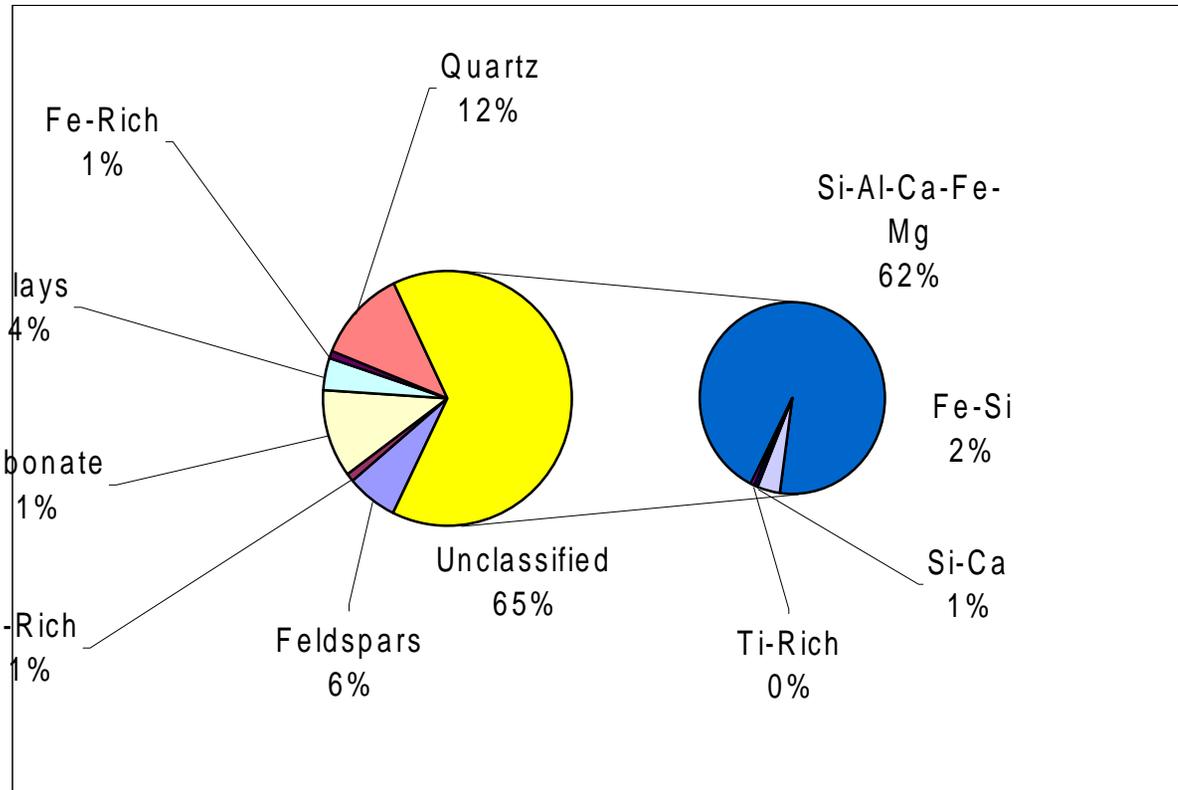


Particles $> 2.5 \mu\text{m}$



- Mineral groups tend to be rather well defined.
- Eight major groups have been identified and are used to classify the results:
 - Quartz
 - Feldspars
 - Clays
 - Na-K salts
 - Carbonates
 - Fe-rich
 - S-rich
 - Undclassified

Rural Site Results



Time Resolution

- Twenty-four frames per sample are acquired and analyzed, representing each hour in a 24-hour period.
- Analyses are performed at 2-mm (1-hour) intervals in the X direction.
- The number of particles per frame is typically in the hundreds of particles.

HYSPLIT Model

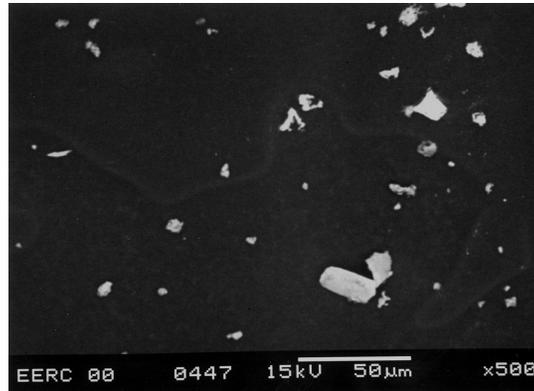
- Hybrid single particle lagrangian integrated trajectory model (HYSPLIT)
- Source of the HYSPLIT Model
 - NOAA's Air Resource Laboratories Real-time Environmental Applications and Display System
- How HYSPLIT works
 - Uses puff and particle dispersion techniques
 - Puff in horizontal and particle in the vertical

HYSPLIT Model

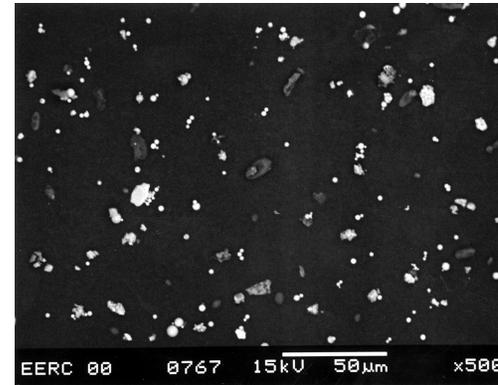
- Lagrangian Type
 - A cluster of particles released at the same point will expand in space and time, simulating the dispersive nature of the atmosphere.
 - Air concentrations are calculated by summing the mass of all the particles in a grid cell.
 - Utilizes database of weather conditions in modeling.

Burkard/SEM Images

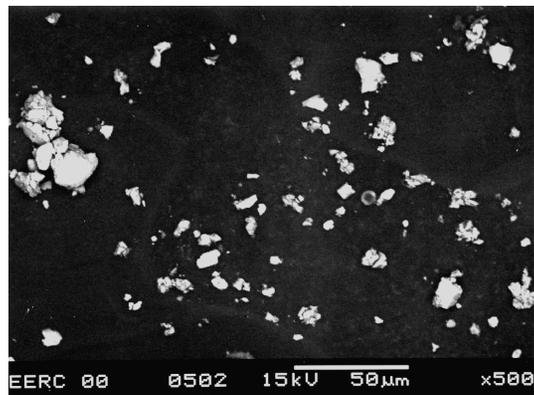
Wind
N



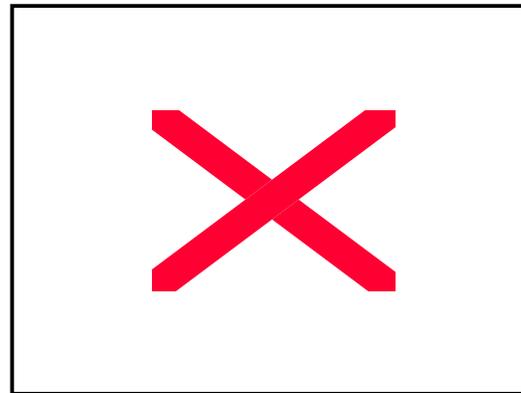
Wind
N



Wind
SE



Wind
S



HYSPLIT Model Results (NW) -- A

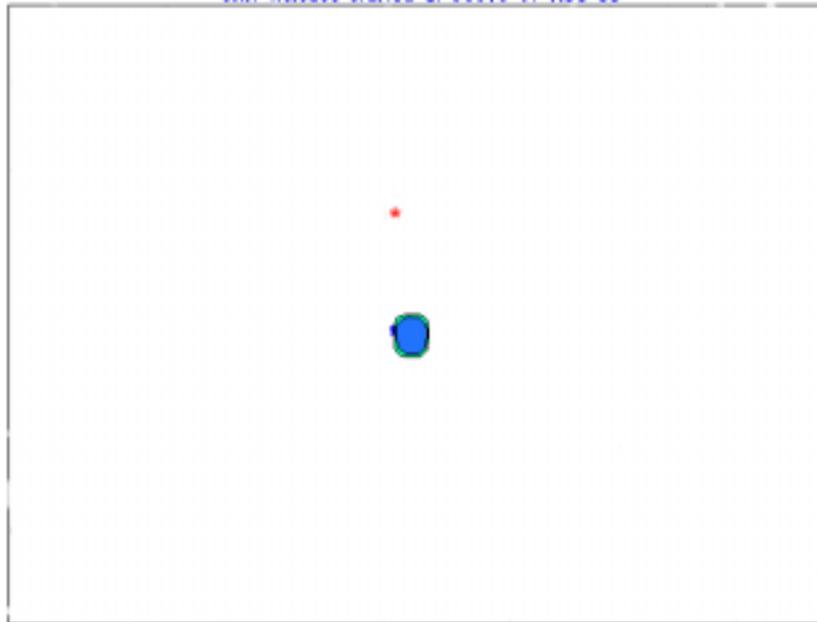


NOAA Air Resources Laboratory

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National Oceanic and Atmospheric Administration

Average Concentration from 00000 m TO 00010 m (Unit /m3)
Averaged from 07UTC 17 AUG 00 TO 08UTC 17 AUG 00
UNIT Release started at 06UTC 17 AUG 00



1.0E-10 1.0E-12 1.0E-14 > 0.00 2.8E-10 Maximum of square

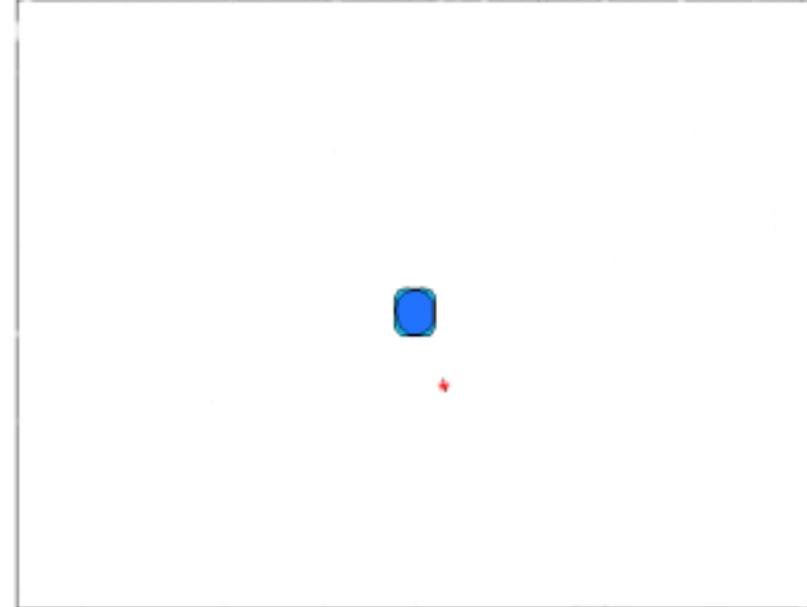


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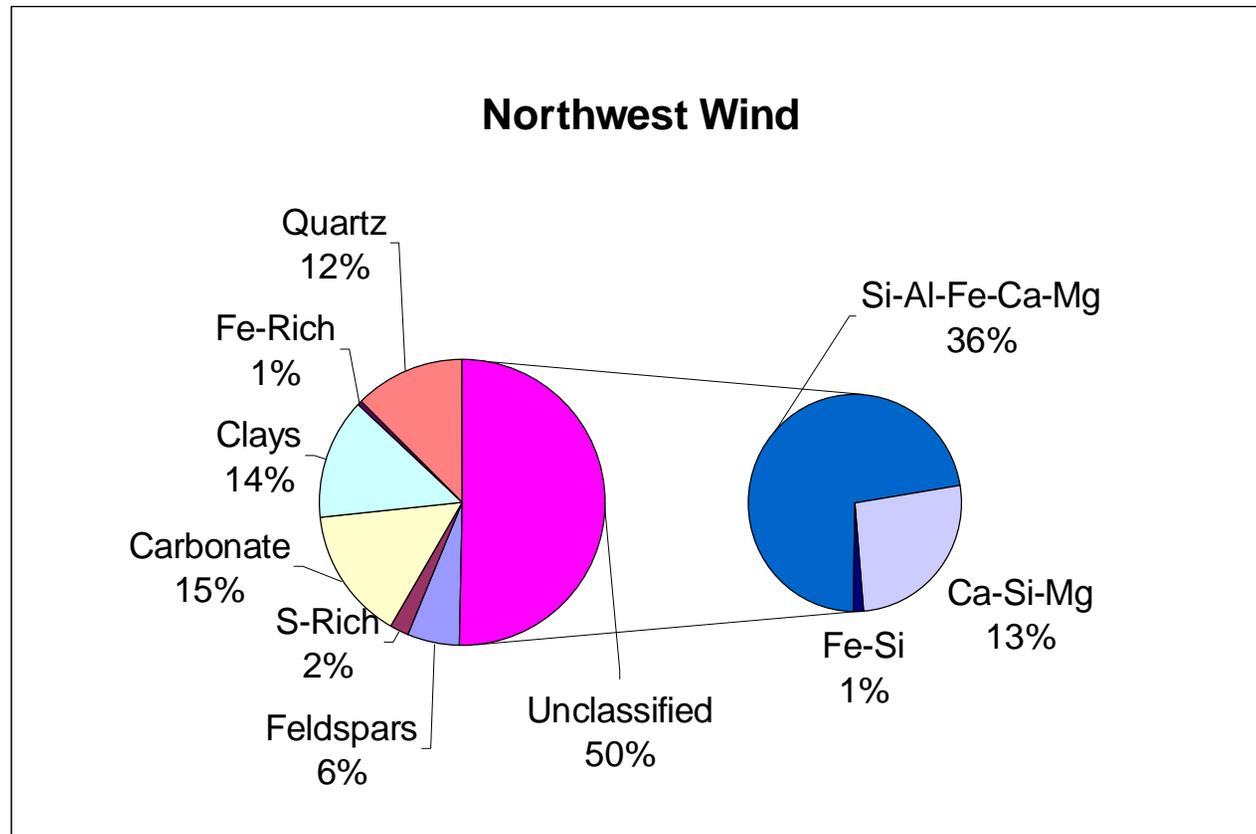
National Oceanic and Atmospheric Administration

Average Concentration from 00000 m TO 00010 m (Unit /m3)
Averaged from 06UTC 17 AUG 00 TO 07UTC 17 AUG 00
UNIT Release started at 06UTC 17 AUG 00



1.0E-10 1.0E-12 1.0E-14 > 0.00 1.1E-10 Maximum of square

Rural Site Results Peak A



EERC

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HYSPLIT Model Results (SE) -- B



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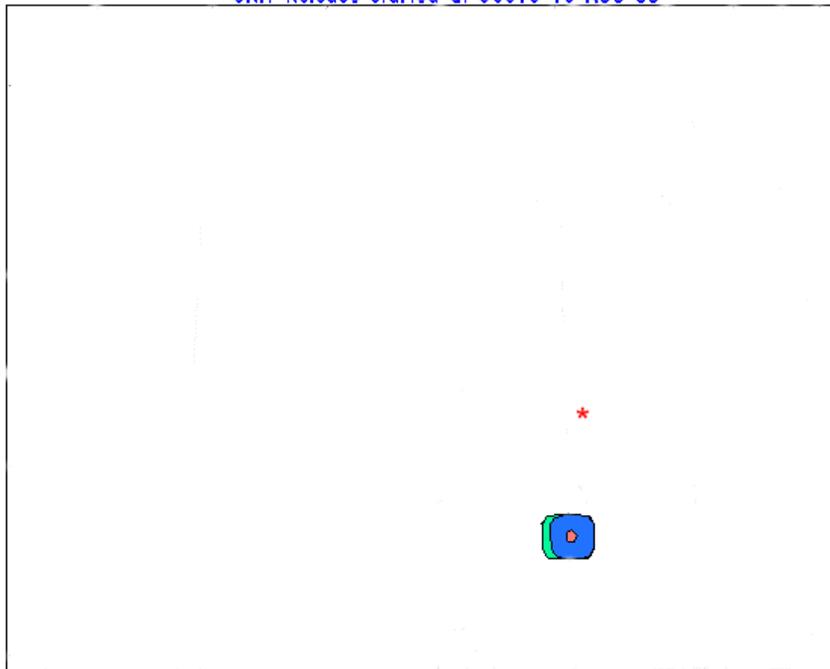
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National Oceanic and Atmospheric Administration

Average Concentration from 00000 m TO 00500 m (Unit /m3)

Averaged from 06UTC 16 AUG 00 TO 07UTC 16 AUG 00

UNIT Release started at 06UTC 16 AUG 00



B.8E-11 Maximum at square



NOAA Air Resources Laboratory

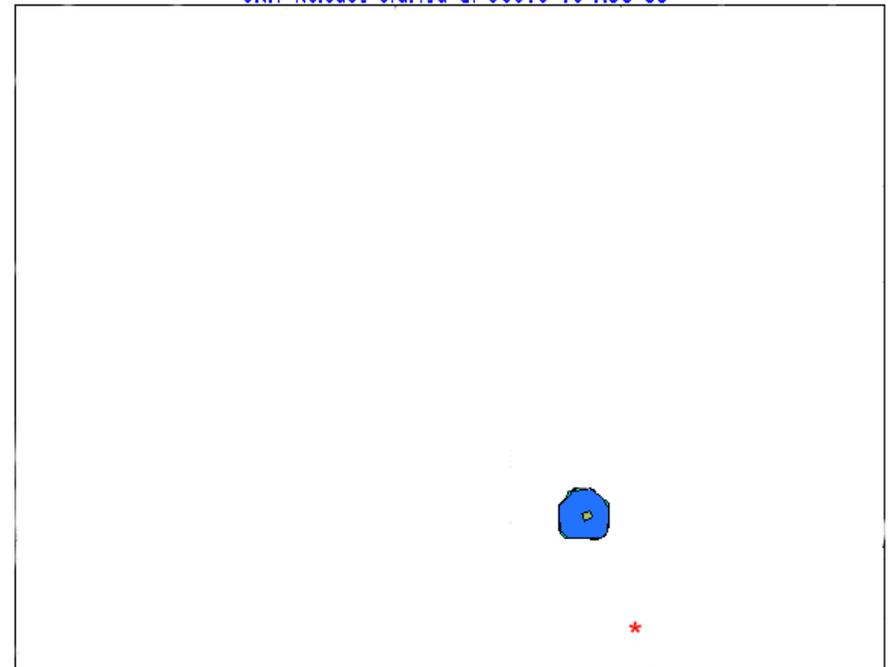
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National Oceanic and Atmospheric Administration

Average Concentration from 00000 m TO 00500 m (Unit /m3)

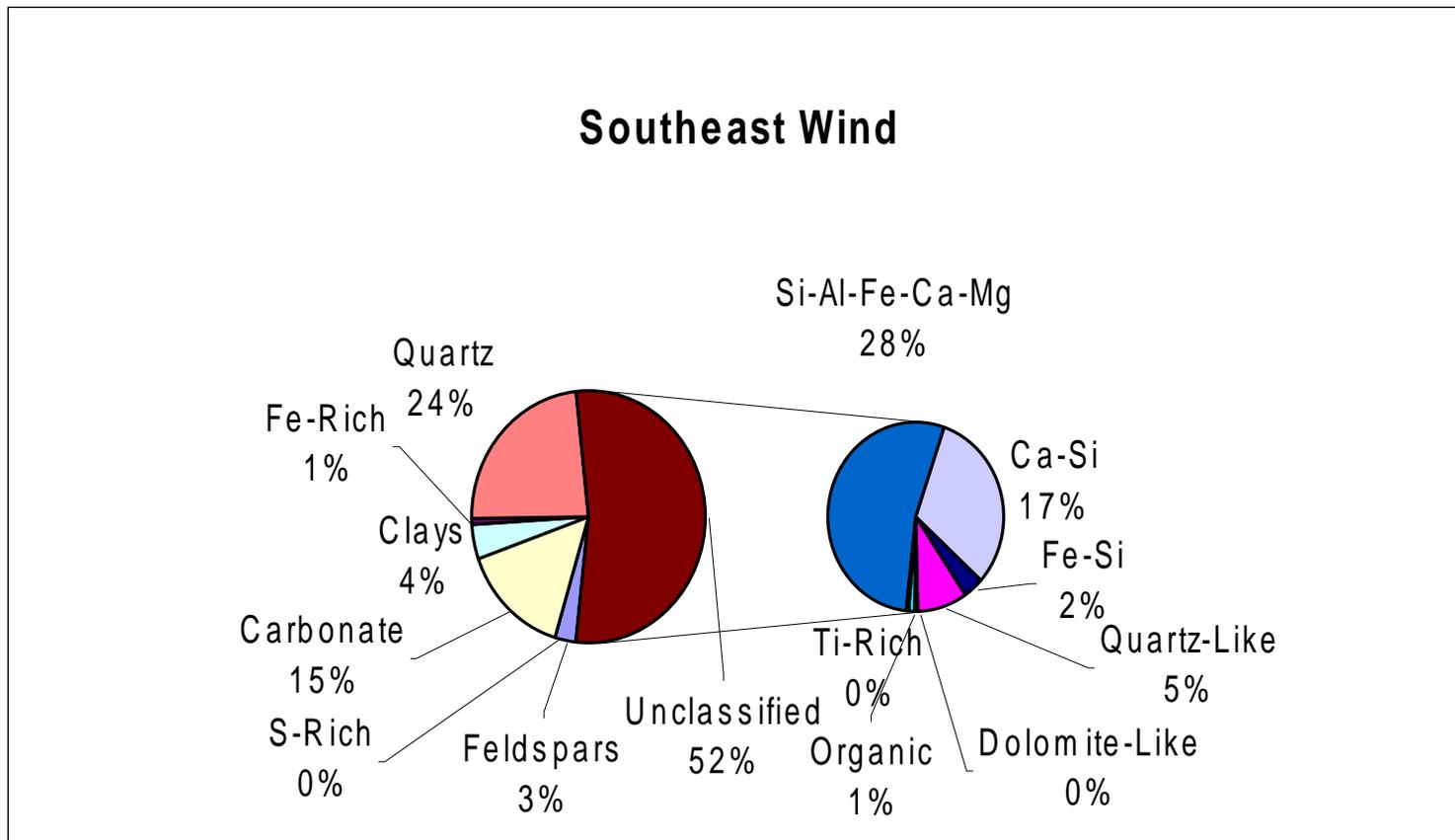
Averaged from 06UTC 16 AUG 00 TO 07UTC 16 AUG 00

UNIT Release started at 06UTC 16 AUG 00

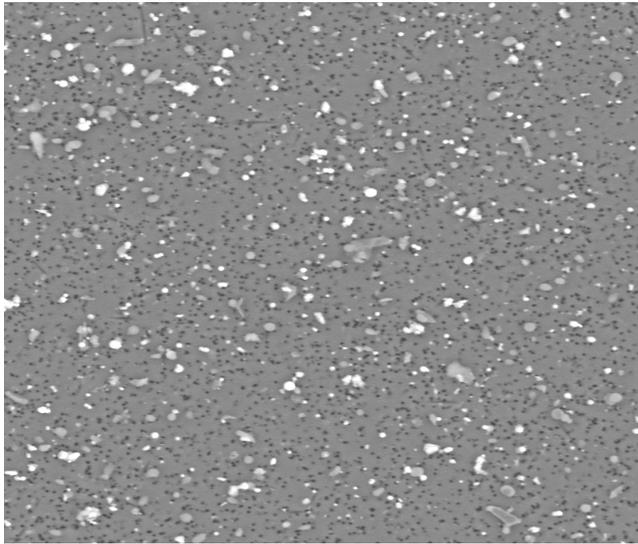


6.7E-11 Maximum at square

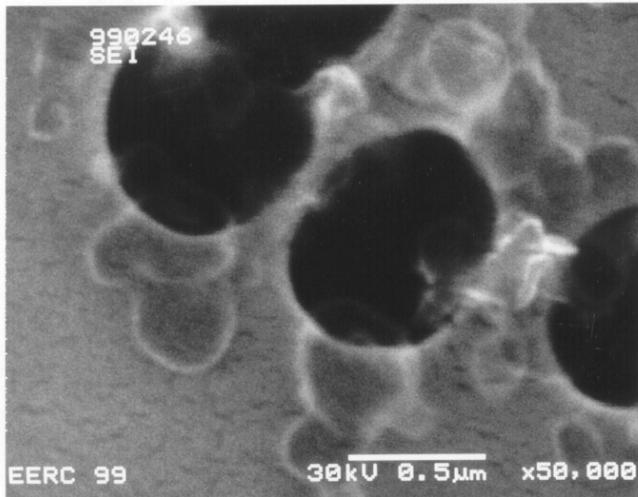
Rural Site Results Peak B



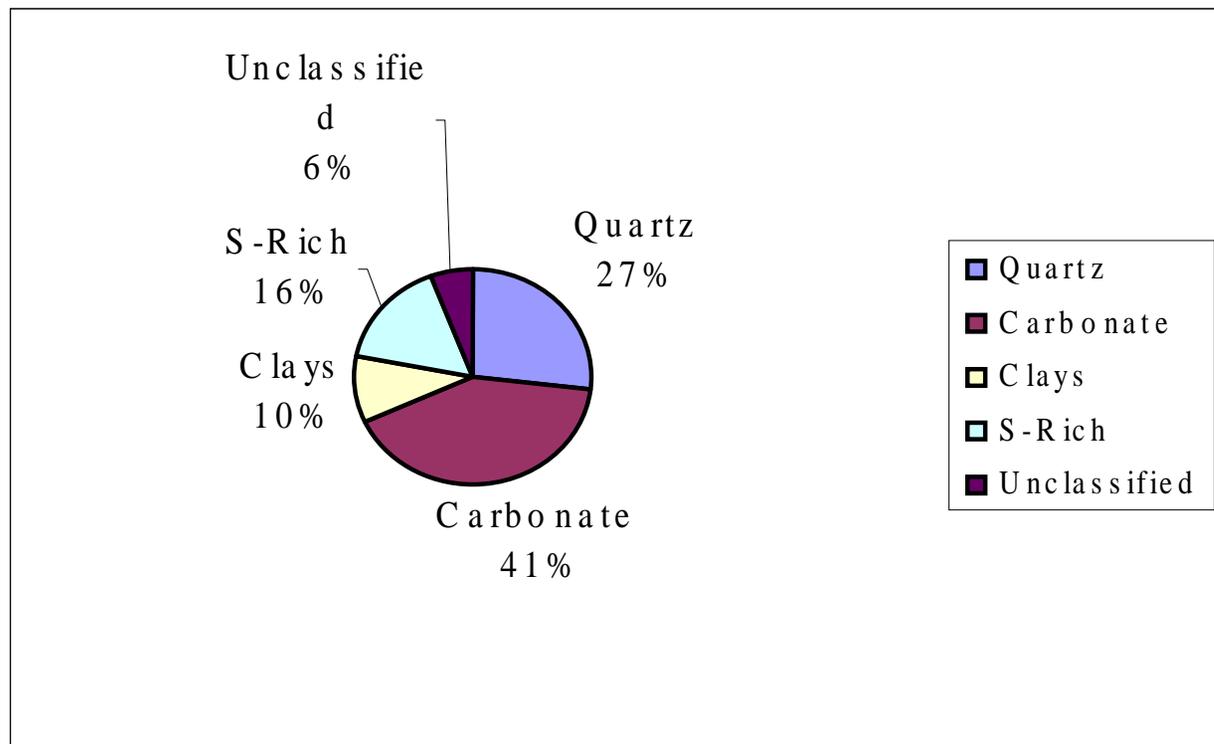
ACCU Samples



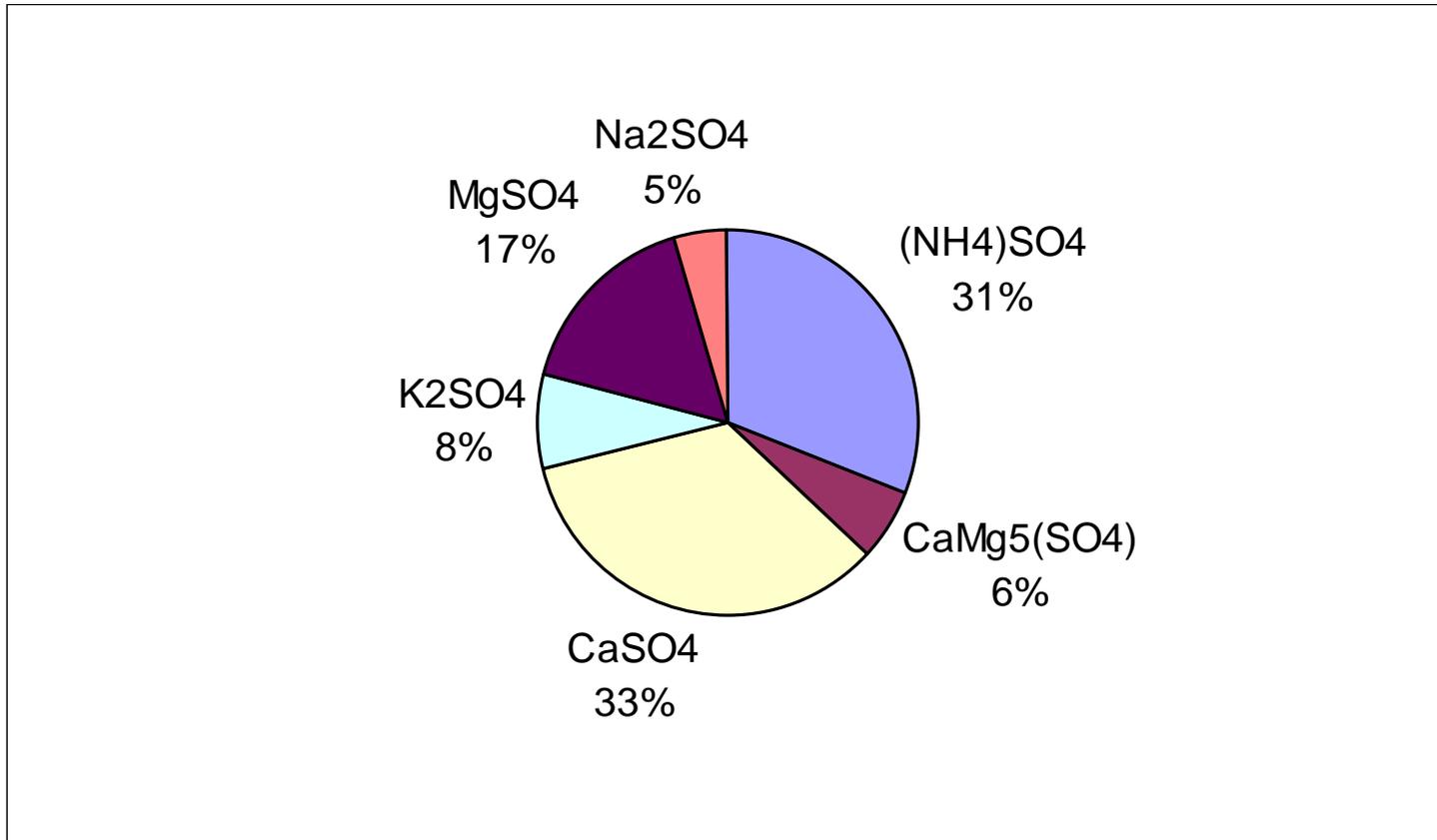
- Examine and classify submicron particles
- Automated the analysis
- Sizing to 0.1 μm
- Composition below 0.5 μm difficult



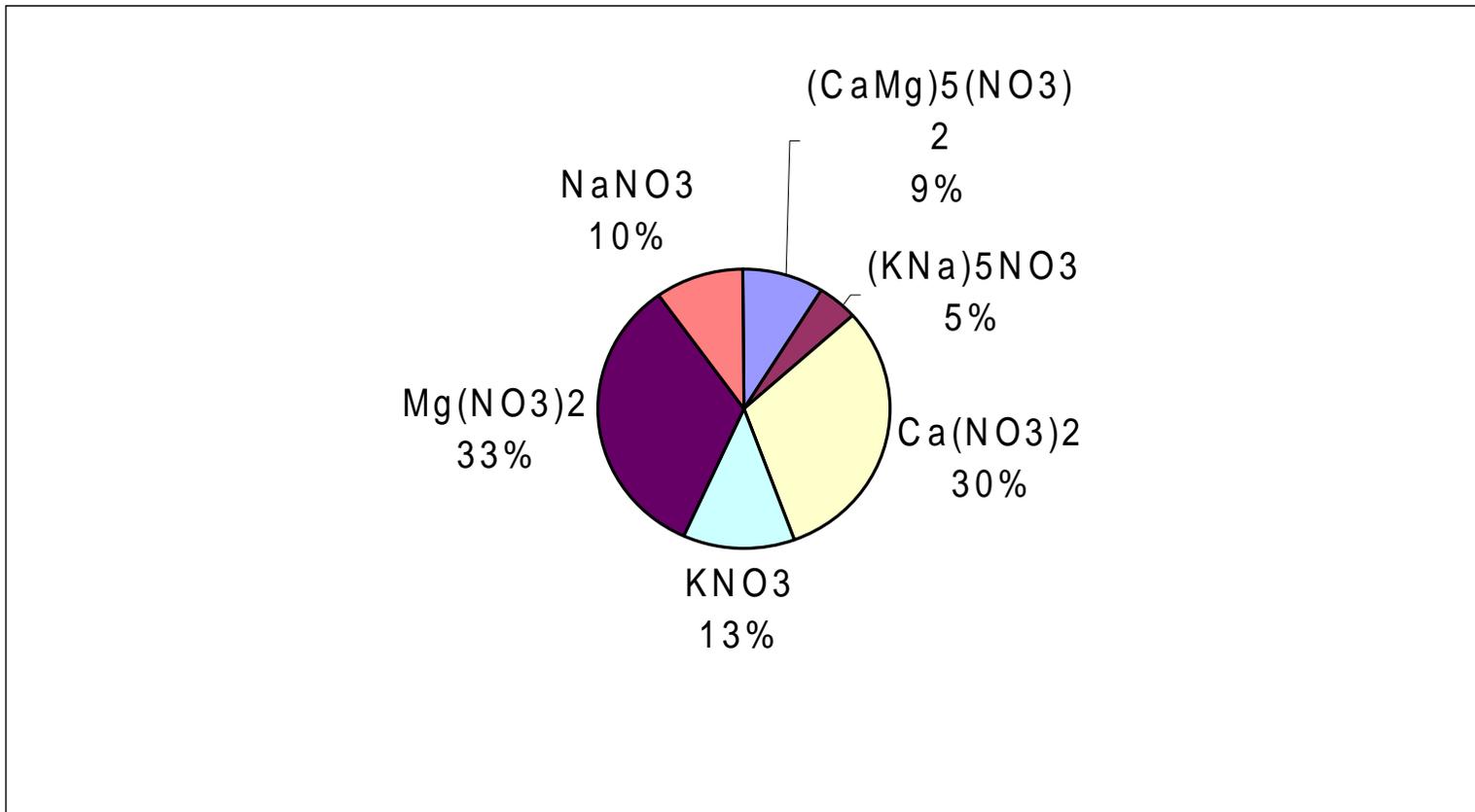
Phases from ACCU Filter Sample



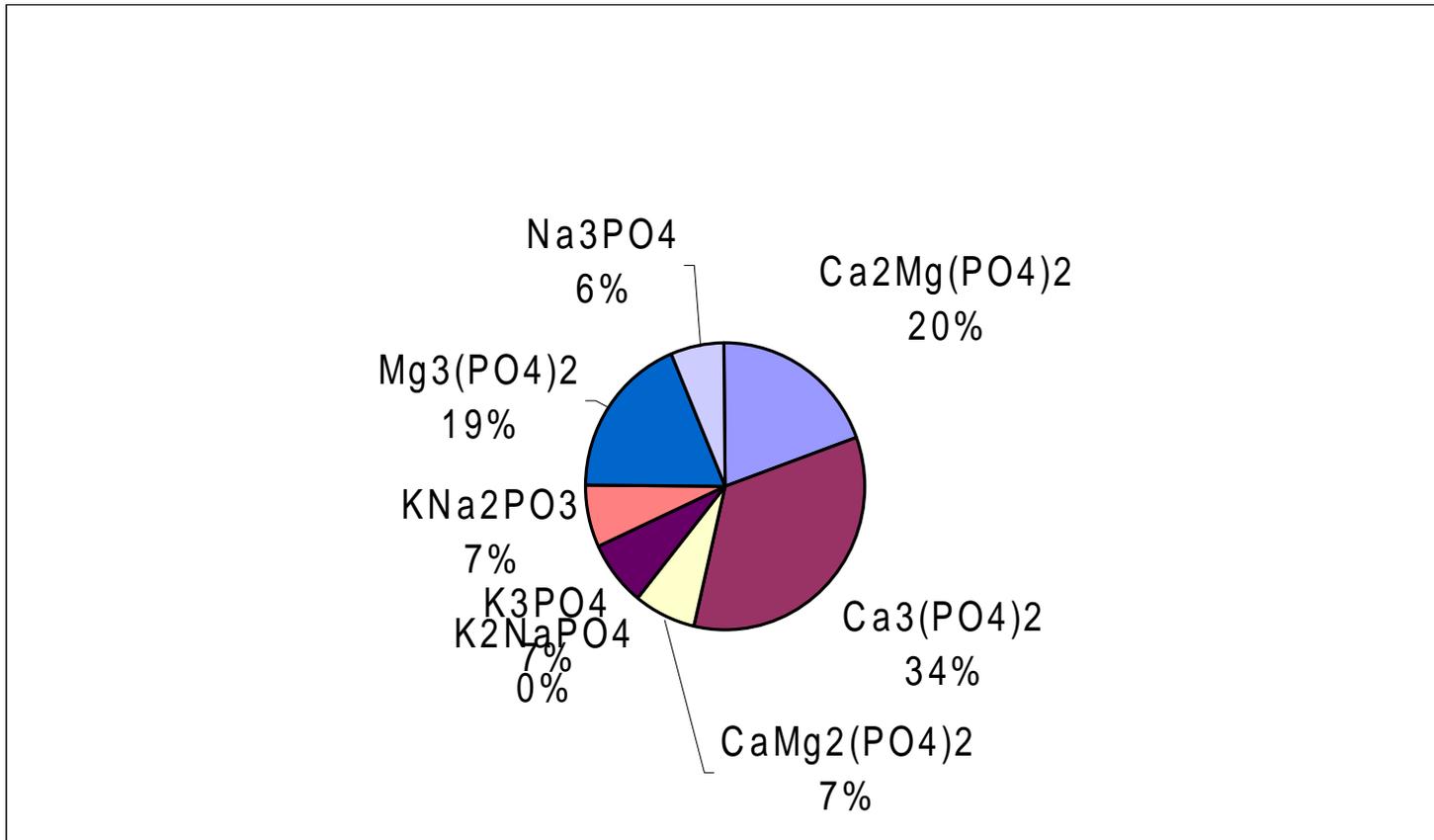
Sulfates



Nitrates



Phosphates



Summary and Conclusions

- SEM techniques – size and composition data of crustal and combustion products down to 0.5 μm .
- Burkhardt spore sampler provides samples that can be characterized with SEM for time resolved analysis
- ACCU sampler for less than 2.5 μm
- Sulfate, nitrate, and phosphate analysis and speciation appears possible with SEM – more validation needed