*Teaching Notes – Classifying and Measuring Aerosol Particles*

**Overview:**

The purpose of this lesson is to learn how aerosol particles are collected, imaged, classified and measured. Students will watch videos of the collection process in the Pico Mountain Observatory and the imaging process in the lab at Michigan Technological University. Even though students will be measuring the particles with rulers, it is similar to how the scientists measure particles using a computer program. This lesson will take at least 2 - 55 minute class periods.

**The Lesson:**

To start the lesson, use the PowerPoint provided.

*Day 1 Classify*

* Slide 1 – Intro slide showing SEM (Scanning Electron Microscopy) images
* Slides 2-4 – Answers to previous day’s questions
* Slide 5 – Picture showing the ICO (International Chemistry Observatory) on Pico Mountain
* Slide 6 – Notes on aerosols
* Slide 7 – Notes on transport of aerosols
* Slide 8 – Graphic illustrating local pollution and long range transport
* Slide 9 – Video questions for students to answer
* Slide 10 – Approximately 7 minutes – video of aerosol collection in the ICO
* Slide 11 – Differences between soot and dust with today’s task (end of classification portion of lesson)

*Day 2 Measure*

* Slide 1 – Measuring aerosols intro showing the outcome using ImageJ (the computer program scientists use to measure aerosol particles)
* Slide 2 – Notes – what happens to soot as it travels
* Slide 3 – Photos of aerosol particles at different stages of aging
* Slide 4 – Video questions for students to answer
* Slide 5 – Approximately 8 minutes – video of SEM imaging
* Slide 6 – Directions on how to measure particles

Discuss the answers to the introduction questions if you didn’t have time the previous day to do so. Next, discuss what an aerosol is (small particle in the air). Soot is an organic aerosol; it contains carbon. Dust is mineral and could be from deserts in Africa. The color of the aerosol particles determines scattering or absorption of the sun’s radiation (to be discussed in an upcoming lesson). Aerosols can be transported in two ways; local pollution stays below the boundary layer and, therefore, is not collected on Pico. Aerosol that is long-range transported can have a source in the United States, Canada, Africa, and on a rare occasion, Europe and travels in the free troposphere to Pico. This is what scientists on Pico are concerned with. On the graphic illustrating pollution, point out the boundary layer and that the summit of Pico Mountain is just above it. Have students write down the two video questions and answer them during the video. The video on slide 17 was taken in the ICO on Pico Mountain. Inside are several instruments and one contains filters for scanning electron microscopy and transmission electron microscopy. Aerosols are collected on those filters and students will observe how they are changed. Finally, hand out the packet of particle images. Students should first classify the particle as either soot or dust.

On Day 2 of this lesson, students will measure the aerosol particles they classified the previous day. The first slide for this day is slide 19 and it depicts the before image and after image using ImageJ, a computer software program used to measure particles. It also shows how the measurement results are displayed in microns. The measurements students will be looking at are “Perim” (perimeter), “Feret” (max. length), and “MinFeret” (max. width). Scientists also look at the area and roundness. In terms of roundness, the closer to 1.00 the measurement is, the rounder it is. For example, the soot particle in image 2 has a roundness of 0.482 and the smaller, soot particle on image 5 has a roundness of 0.896. Again, the rounder and more compact, the more the particle has aged (been in the atmosphere longer). The video for this lesson explains how filter samples are prepared for the SEM and images taken. This was filmed in the lab at Michigan Technological University. For more information on the microscope, visit <http://electronmicroscopy.org/More_Resources.htm> and click on “Hitachi S-4700 FE-SEM” on the left side column. There you will find resources pertaining to the microscope used to make these images. Follow the directions below as an example of how to measure the particles.

Example:

Pores in filter



Type: \_\_**Dust**\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_**3.1**\_\_\_\_\_ cm

Perimeter: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Max Length: \_**5 cm = 806.5 nm**\_

Max Width: \_**4.6 cm = 741.9 nm**\_

Have students measure each particle indicated in their packet using the following directions:

1. Measure the scale (ex, 500 nm = \_\_\_\_\_\_\_\_cm) on each image (not all scales are the same)
2. Carefully measure the perimeter, maximum length and maximum width.
3. Convert measurements to nanometers using the conversion from the scale.
4. Convert measurements so they all have the same units. 1000 nm = 1 µm

***\* Answers provided have been generated by ImageJ (computer program). The students’ answers may not be exactly the same, but should be close. \****

Answers are provided:



Type: \_\_**Dust**\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: **2972 nm = 2.972 µm**\_

Max Length: \_**894 nm = 0.894 µm**

Max Width: \_**721 nm= 0.721 µm**\_

1



Type: \_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_**2335 nm**\_\_\_\_\_\_\_\_\_

Max Length: \_\_**546 nm**\_\_\_\_\_\_\_\_

Max Width: \_**298 nm**\_\_\_\_\_\_\_\_\_

2



Type: \_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_**4770 nm**\_\_\_\_\_\_\_\_\_\_

Max Length: \_**914 nm**\_\_\_\_\_\_\_\_\_

Max Width: \_**505 nm\_**\_\_\_\_\_\_\_\_\_

3



Type: \_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_**1257 nm**\_\_\_\_\_\_\_\_\_

Max Length: \_\_**302 nm**\_\_\_\_\_\_\_\_

Max Width: \_\_**260 nm**\_\_\_\_\_\_\_\_\_

4



Type: \_\_\_**Dust**\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_\_**2864 nm**\_\_\_\_\_\_\_\_\_

Max Length: \_**936 nm**\_\_\_\_\_\_\_\_\_

Max Width: \_\_**472 nm**\_\_\_\_\_\_\_\_\_

5



Type: \_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 1.00 µm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_\_**1433 nm**\_\_\_\_\_\_\_\_\_

Max Length: \_\_**403 nm**\_\_\_\_\_\_\_\_\_

Max Width: \_\_**310 nm**\_\_\_\_\_\_\_\_\_\_

6



Type: \_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_\_**1093 nm**\_\_\_\_\_\_\_\_\_

Max Length: \_**280 nm**\_\_\_\_\_\_\_\_\_

Max Width: \_\_**229 nm\_**\_\_\_\_\_\_\_\_

7



Type: \_\_**Dust**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 1.00 µm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_\_**3668 nm**\_\_\_\_\_\_\_\_\_

Max Length: \_\_**1322 nm**\_\_\_\_\_\_\_\_

Max Width: \_\_**794 nm** \_\_\_\_\_\_\_\_\_

8



Type: \_\_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_**1995 nm**\_\_\_\_\_\_\_\_\_\_

Max Length: \_\_**561 nm**\_\_\_\_\_\_\_\_\_

Max Width: \_\_**445 nm**\_\_\_\_\_\_\_\_\_\_

9



Type: \_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_\_**3936 nm**\_\_\_\_\_\_\_\_

Max Length: \_\_**881 nm**\_\_\_\_\_\_\_\_

Max Width: \_\_**515 nm**\_\_\_\_\_\_\_\_\_

10



Type: \_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_\_ cm

Perimeter: \_\_**2092 nm**\_\_\_\_\_\_\_\_

Max Length: \_**459 nm**\_\_\_\_\_\_\_\_\_

Max Width: \_\_**374 nm**\_\_\_\_\_\_\_\_

11



Type: \_\_\_**Soot**\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Scale: 500 nm = \_\_\_\_\_\_\_\_\_ cm

Perimeter: \_\_**1145 nm**\_\_\_\_\_\_\_\_

Max Length: \_\_**295 nm**\_\_\_\_\_\_\_\_

Max Width: \_\_**254 nm**\_\_\_\_\_\_\_\_\_

12

Questions:

1. Of the soot particles, which ones would you consider “round”?

***4, 7, 9, 12***

1. What causes the particles to become more round?

***Aging in the atmosphere, more time in atmosphere leads to more compaction***

1. Where do you think the dust particles came from?

***Desert regions, Africa, gets blown and caught in a wind belt and carried northward***

1. How do you think you would be able to determine the source of the dust particles?

***Check the date of the sample, check weather patterns for that day and previous couple days, any severe weather event (i.e.: dust/sand storm)***

1. Based on your notes, tell the “story” of particles 2, 9, 11, and 12.

***(answers may vary, but should include the following)***

1. ***smaller soot particle, parts are compacted indicating it travelled some in the atmosphere, not very aged, not very round***

9. ***smaller soot particle, compacted and round, aged in atmosphere due to long range transport***

11. ***small soot particle, elongated and not round, has not been in the atmosphere long***

12. ***very small soot particle, compact and round, travelled long period of time/distance in atmosphere***