

Micrometeorites

TEA Workshop

April 17, 2004

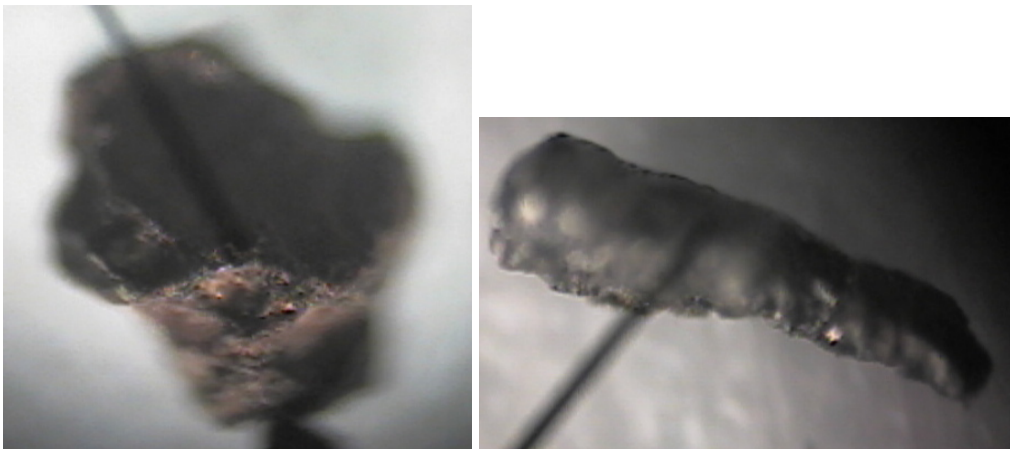
Most of the meteorite material that reaches the surface of the Earth is really small in size. That's a good thing, of course, because the big ones are catastrophic. The biggest impacts wiped out lots of the species on our planet, and the evidence is good that this happened many times during the history of life on Earth.

Every day, several tons of extra-terrestrial stuff is swept up by the Earth as it travels around the Sun. (By extra-terrestrial stuff, we don't mean little green men. Just material *not originally from the EARTH*)

- Why is so much of this material small in size?
- How can we find it, or intentionally collect it?
- How can we organize it?
- How can we understand our collection as part of the work that meteorite scientists do?

Contents :

- 1) Mining micrometeorites
- 2) Collecting micrometeorites
- 3) Curate and understand your collection



2 micrometeorite candidates collected in June 2003 by students at Roosevelt High School, Seattle. These objects had surfaces that looked as if they'd been melted, and pitting as if eroded by very hot fast moving air as they entered the earth's atmosphere.

1) Mining Meteorites

If 2 tons of meteorites are reaching the Earth every day, where are they? They must be all around. One question that is worth looking at is the size distribution of meteorites. That is, for a given sample, what fraction is less than one gram, between one and two grams, etc? Because there is a limited supply of meteorites available, we will instead look at a more readily available material to get a better understanding of how to measure the size distribution of a sample.

Investigation A: Size Sorting

Using a container of dirt, mud, sand, stream sediment, or similar material you've collected, find the total mass of the original, unsorted material. Then use a set of meshes or screens to sieve, or sort the material. Start with the screen with the biggest holes first, and carefully put aside all the material that won't pass through, and find the mass of that material. Repeat with progressively smaller screens.

Prepare a data chart that looks something like this:

Source of original material: _____ Mass of original material: _____

Screen Grid size	Mass Removed	% of Original Mass	Description of material sorted at this level

Make a plot of screen size vs. % of original mass sorted.

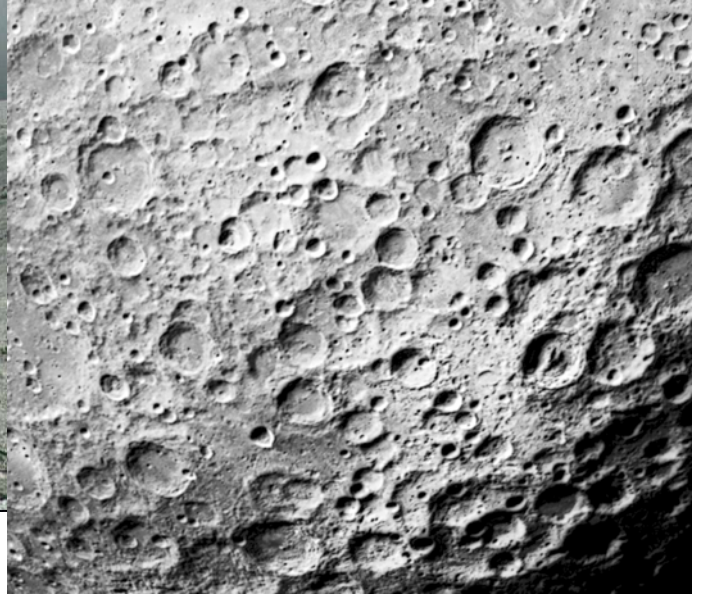
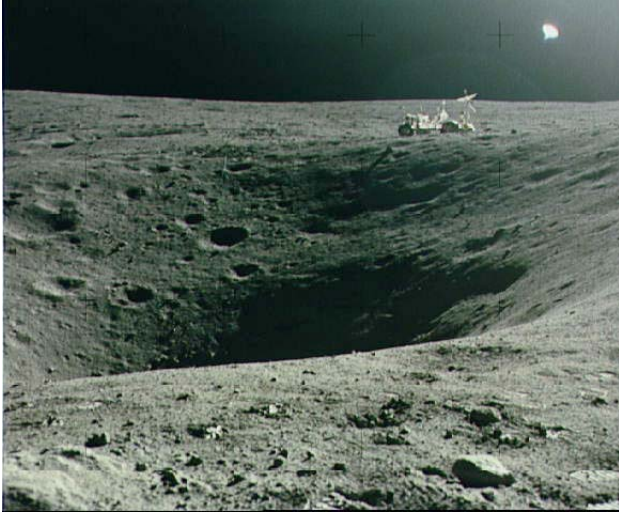
Areas for further study or comparison with other student groups

- Is there a mathematical pattern in your sample? Might that pattern suggest what % to expect if you sorted using different size screens that were smaller, or larger, or in between those you actually used?
- Would drying your original sample make a difference? Why?
- Would your physical treatment of the sample make a difference? For example, considering the following changes: Forcing material by hand through the screen? Shaking the screen? Should you control this? How?

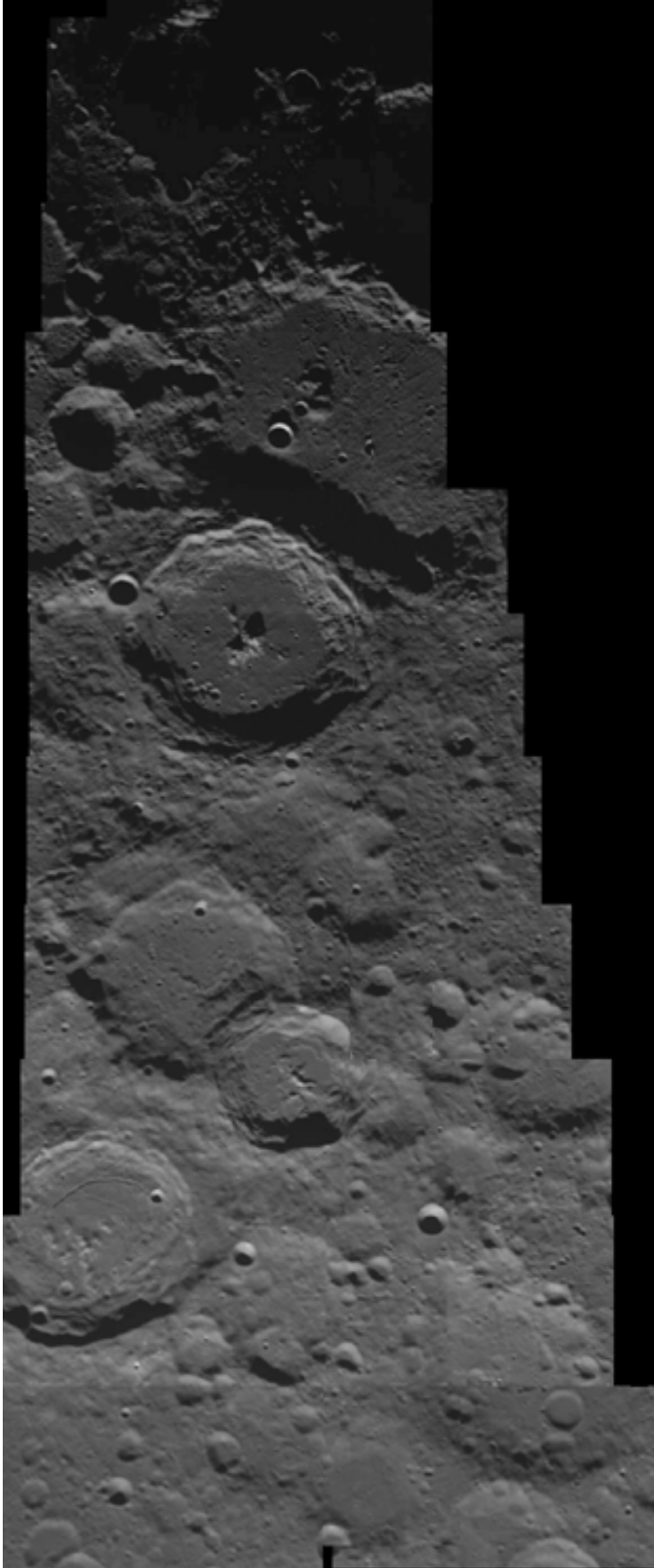
d) Do samples from different places show different patterns? How can you account for this? Are you the first agent to sort the material you've collected?

e) What evidence does this investigation provide that most meteorites are likely to be quite small? What sorting mechanisms might be in place to ensure most meteorites are quite small? Why are most meteorites in museum collections grape sized or larger?

f) Compare what you think you know about meteorites to a picture of the moon. Count the number of craters at different sizes. Can you demonstrate a mathematical pattern? How might that pattern be different on the earth?



3 views of the earth's moon, showing many craters of different sizes. As you look for smaller and smaller craters, what happens to number of craters you find? What does that suggest about the size distribution of the meteorites that struck the moon? Should the distribution of the craters that hit the Earth be any different?



Investigation B : Finding Magnetic Material

A fraction of the meteorites that reach the Earth have a high iron content and can be attracted by a magnet. But obviously not everything that can be attracted by a magnet is a meteorite! There's lots of material in the earth that is attracted to a magnet, and of course, humans have made a lot of stuff with iron, so anywhere there's people, there's going to be lots of iron bits on the floor, in the street, in the dirt.



Teachers sort & examine material collected from rain gutter splash blocks

i) Your teacher's given you a microscope and a magnet. The magnet will already have some dust particles stuck to it. Figure out a way to remove some of the dust that's already stuck to the magnet, and get it into view in the microscope. That's easy to say, but not so easy to do. What are the challenges?

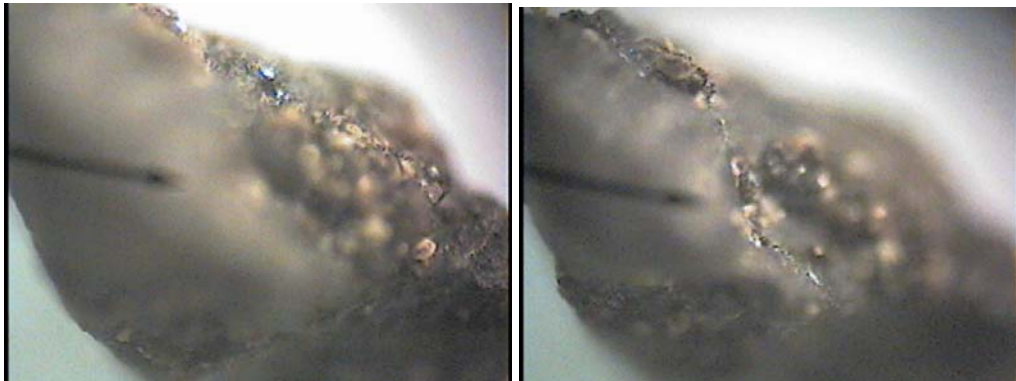
Draw some pictures of what you've found, and try to note the magnification of your view, and the approximate size of these pieces. Try to write some verbal descriptions of the kind of stuff you found stuck to the magnet, and speculate on where this stuff came from and what it might be.

ii) Take a small ziplock bag, and put your hand in it, and run it over a dusty corner in your room. (Behind a computer is usually pretty dusty!) Look at the outside of the bag. Why did dust stick to it? Look at some dust under the microscope. Draw some pictures of what you've found, and try to note the magnification of your view, and the approximate size of the dust pieces. Try to write some verbal descriptions of the kind of stuff you found stuck to the bag.

iii) Now that you've got a pretty good idea of what could contaminate your collecting, put the magnet inside the bag, and work around the room. Can you locate any kinds of magnetic material that is new? Again, draw, write, and speculate.

iv) Try using your magnet tool with some of the dirt samples you sorted in Investigation A. What kinds of material are new to you?

v) Can you identify some outdoor sources of dirt that is likely to be highly enriched in meteorites? In general, you probably want to look at places where the dirt and dust from a large area is collected in a small place: a parking lot, a splash block, or try at the bottom of a downspout from a roof. What can you find in these places? What characteristics of a microscopic rock make it a viable candidate as a micrometeorite? What typical sources of terrestrial contamination exist in these places? As you gain experience, is it possible to easily eliminate pieces of cars, tools, nails, and likewise select viable micrometeorite candidates?



2 images of the same micrometeorite showing possible pitting and fusion crust, and the difficulty of taking photographs through a microscope with a very short depth of field. Most of the object is out of focus at any one time. This experimental image was obtained using a video recorder connected to a flexcam, handheld against the eyepiece of a decent high school microscope.

2) Collecting Meteorites

It's all been "mining" so far, in that we've gone out into nature and tried to find a "mother lode", a place where meteorites have rained down and been gathered up by accident. Let's plan a meteor collector that will automate the process of collecting and decontaminating for us.

- Where would you put such a collector and why?
 - What are the key parts of such a collector?
 - What's the simplest possible collector you can imagine?
 - Why would it be best to build a simple collector before making something more complicated?
 - If you made a more complicated collector, what else would it do?
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Investigation C : Make a Simple Detector.

Construct your simple meteorite collector and use it to find answers to the following...

- i) How much magnetic material is falling on a square meter in a year? a day?
- ii) Is there a greater flux during meteor showers?
- iii) To what extent does terrestrial contamination enter a collector?
- iv) Are there some detector sites in your city that collect more magnetic material?
- v) If you run the detector indoors, does it collect magnetic material for which you can rule out extra-terrestrial origin?
- vi) Are there design improvements that would improve collection efficiency or reduce the amount of contamination?
- vii) Make an advertising poster for your collector, emphasizing its design excellence and long-term benefits. Or write a grant (real or imagined) for funding to support the construction of additional improved detectors.



Several views of a simple rooftop collector. The basketball creates a belly in the plastic, keeping it from flapping in the wind. Below the ball is a hole, so that rainwater can wash the plastic into the blue funnel, held up by a can with gravel in it. Runoff passing through the funnel runs near a strong magnet (not visible) on the outside of the funnel. Iron-rich particles are captured on the inside of the funnel and can be removed for study.



3) Curate and Understand Your Collection

As you've learned about microscopic magnetic material in our environment, hopefully you've gained some skill at sorting magnetic meteorite candidates from other contaminants. How can you organize a collection of micrometeorites? How does your organized collection fit in with the collections of meteorites in museums and universities?

a) Develop a standard, quick, and inexpensive method for photographing your best candidates. Lighting is crucial, as is depth of field. Do some or all of your subjects require more than one photo? Organize your photos systematically, in a way that parallels your storage system for the actual rocks. Does photographing through a microscope produce the best results? Is there other equipment available that produces better results?

b) Develop a storage system for your samples that makes it easy to record important information about them. What records are worth keeping? What are important design considerations for such a system? Has someone already invented such a system? Can you afford it or adapt it to your needs?

c) Develop tools for handling your samples. Can you make an electromagnetic tool with a switch to pick up a sample, move it to a new place, and let it go when the switch is turned off?

d) Build a catalog of your collection. Can you organize it to make it useful to someone else? Can you publish it on the Internet? Can you make it expandable as your work continues? Can you create a database that other researchers can add to?

e) Document your methods, and develop a manual which addresses your successes and problems.

f) Align the organization of your collection with professional collections. Work with a local or regional meteor expert, books, or Internet resources. Remember to consider that your collection is limited to the small fraction of micrometeorites that have magnetic qualities.

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<http://tea.rice.edu/> <http://icecube.wisc.edu> <http://www.wcer.wisc.edu/scalemsp/>

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