Secrets of Sand

By Pamela Borne Blanchard

Focus

Hidden on every sandy beach is a mystery waiting to be solved. Just where did the sand come from? Did it travel very far? Sands betray the secrets of their history to the skilled sleuth. The focus of this folio is to introduce students to the physical properties that characterize sand samples. The activities focus on guiding the student through observations of color, grain size, and sorting.

Background

Sand is the geological term applied to particles with a diameter between 1/16 mm and 2 mm. Another use of the word "sand" that has little to do with grain size is in reference to an accumulation, or deposit, of small particles, such as a sand dune. Most sand starts life as a rock. Over time, wind, rain, rivers, and frost break down the rock into smaller particles. These small particles are carried downhill by running water and deposited along our rivers and coasts. The once mighty mountain is reduced over time to a large pile of sand.

Sands collected from different environments vary widely in their characteristics and reflect the geologic history of their source area. There are four common sources of sands: skeletal remains of organisms, weathering of continental granitic rocks, weathering of oceanic volcanic rocks, and grains precipitated from water. For instance, sands collected from the beaches in the Bahamas or Cancun are commonly dominated by carbonate grains made from broken mollusk shells, sea urchin spines, and coral debris. Sand is rare in the deep ocean, which is mainly mud. However, careful washing of these muds over very fine mesh reveals the carbonate remains of minute ostracodes (a tiny crustacean) and planktonic foraminifers (a floating one-celled organism). Sands collected from near mid-ocean ridges in the ocean are dominated by particles of basalt from nearby underwater volcanoes. Sands collected from beaches on the point bars of rivers or from beaches along the coast are commonly dominated by quartz and feldspar, two silicate minerals found in continental rocks. These are not the only environments in which interesting sand can be found. Sand from the Great Salt Lake of Utah is composed of nearly perfect spheres. These sand grains were precipitated out of the highly salty water. This type of sand grain has the unusual name of *oolite* (a Latin word for "egg").

The color of sand grains often provides clues to the types of rocks and minerals from which our sand samples originate. For instance, several beaches in Hawaii are famous for their black or green sand. The colors of these sands come from the minerals that make up volcanic rocks, such as lava and olivine. The tan sands of the Mississippi River sediments are made mostly of quartz (clear, white, tan, pink), and feldspars (white, pink) that have weathered out of the granites and sandstones within the Mississippi River watershed.

> In every grain of sand is a story of earth.
> - Rachel Carson

Grade Level	Subject Areas	Process Skills	Vocabulary
Middle School (6-8)	Earth Science	Observing, Describing, Measuring	Sand, Physical Property, Sorting, Angularity, Sediment, Lithification, Sedimentation

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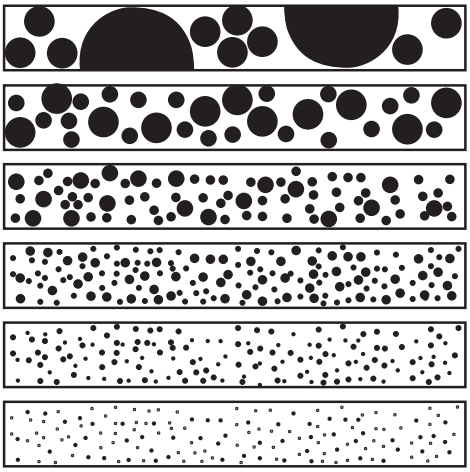
MAKING SENSE OF SAND GRAIN SIZE

Wentworth Class Scale
Diameter (in Millimeters)



Boulder, >256 mm

Cobble, 64-256 mm

Pebble, 4-16 mm

Granule, 2-4 mm

SAND, Very Coarse, 1-2 mm

SAND, Coarse, 0.5 - 1 mm

SAND, Medium, 0.25 - 0.5 mm

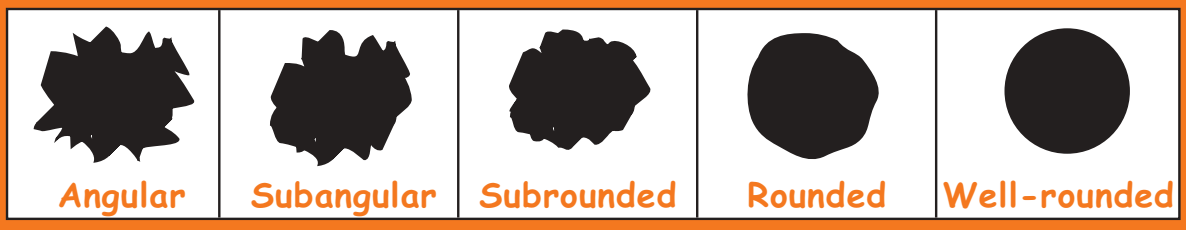
SAND, Fine, 0.125 - 0.25 mm

SAND, Very Fine, 0.0625 - 0.125

Silt, 0.0039 - 0.0625 mm

Clay, < 0.0039

MAKING SENSE OF SAND GRAIN ROUNDNESS

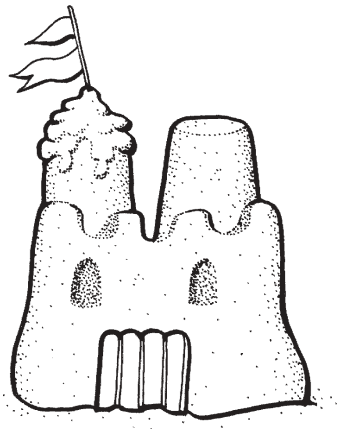


To see a world in a grain of sand
and a heaven in a wild flower,
hold infinity in the palm of your hand
and eternity in an hour.

-William Blake, Auguries of Innocence

Secrets of Sand

Pre-lab preparation



Prepare sand-holding devices for each sand sample. A simple permanent sand sample holder is an index card with a strip of double-stick tape placed on it. Each index card is then labeled with the collection and location information. Other temporary sample holding devices include 2x2 deep wells and petri dishes. Each should be labeled with location information.

SOAR set-up (see *SOAR How-To Book*)

SOAR set-up #4, Stand and View using the 30X lens.

Procedure

(1) Discuss with students what they already know about sand.

What is sand and where do we find it?

What materials in the classroom are made of sand? (*Glass, concrete, etc.*)

What are some other uses of sand? (*Gardening, road construction, sand blasting, de-icing roadways, etc.*)

Discuss what geologists mean by the term "sand". (*It refers to a particular size range of sedimentary particles, 0.0625 to 2.0 mm in diameter.*)

Is all sand the same? In what ways can sands differ from one another? (*Size, shape, different types of mineral grains, sorting, amount of organic matter*)

Do beaches in different places have different kinds of sand? (*Yes. Sands are dependent on the types of rocks that are eroding along the shore or within the watershed that the river drains.*)

(2) Develop the concept of *physical property*.

What is a *physical property*? What are some physical properties that you can observe about sand? Have students brainstorm a list of properties. Guide their suggestions until they have listed the following physical properties: color, size, composition, angularity and rounding, presence of magnetic minerals. They will probably come up with several others. All must be properties that can be observed and measured.

Discuss the other types of observations scientists can make about sand. *(The discussion should include the following areas: sorting, shape, shininess, etc.)*

(3) Have students observe their sand samples first without magnification.

Students will work together in small groups to make this first set of observations. Pass out duplicate sand sample cards to each group of students. Students should fill their answers in on the **blackline master** entitled *Secrets of Sand* provided in this folio.

Observe the physical property of grain color. What color is it? Are all the sand grains the same color, or are they different colors? List the top three colors of your sand.

Observe the physical property of grain size. Use your grain size chart to help determine the size of your sand grains. Into what Wentworth Classification range does your sand sample fit? Are all your sand grains the same size or are there a variety of sizes?

Grade Level:
Middle

Group Size:
Small group

Summary:
Sand samples from different beaches are each unique. They provide a fun medium for students to practice science and math process skills.

Objectives:
- To observe physical properties of a sand sample.
- To graphically represent the distribution of diameters of a random sample of sand grains.
- To draw conclusions from data gathered with SOAR.

Materials:
- The Scope-On-A-Rope
- Several sand samples
- Grain size finders (see diagram)
- Small magnets
- Angularity chart (see diagram)
- Sand holding device (see set-up recommendations

Duration:
Two 40-minute class periods. More time might be needed depending on depth/breadth of observations.

Extensions:
Geography, creative writing, cooking, art

Vocabulary:
Sand, physical property, sorting, angularity, sediment, lithification, sedimentation

National Science Standards:
Earth & Space Science (5-8)
- Structure of the earth system

Unifying Concepts (K-12)
- Constancy, change and measurement

Use SOAR to make the following observations.

(4) Now use the SOAR to look at your sand. Focus on the color of the sand grains and their sizes.

What color is it? What sizes are the grains in your sand? Are they all the same size and shape? What is the diameter of the biggest grain? The smallest grain? Use a monitor ruler to determine these measurements.

(5) Discuss with students how their observations of sand with and without SOAR compare.

List differences in observations between the two methods of observing your sand. What was similar? What most surprised you about your sand sample when you saw it magnified?

(6) Observe the physical properties of roundness and angularity.

Are most of the grains rounded or smooth, or are they rough and jagged (angular)?

(7) Observing the physical property of grain shape.

Describe the shape(s) of the grains of sand? (Spheres, rods, discs, irregular blobs, etc.)

(8) Observe the physical property of composition.

Are the grains of sand made of the same material? What observations enabled you to arrive at your answer? How many different types and colors of sand grains can you find? Do you see anything that looks as if it's made of several sand grains all glued together? If so, this is a sedimentary rock fragment. If your samples have rock fragments in them, are all the fragments from the same kind of rock? Is some of the sand made from the remains of living organisms (shell fragments, small organisms, etc.)? Does your sand have any magnetic minerals? (**Important**: Do not place the magnet directly in the sand. Instead, place the magnet on the outside of the container that holds the sand sample and move it around.)

(9) Wrap-up.

Looking at the observations you just made, did you discover anything unexpected or surprising about your sand samples?

Extending the Activity

The blackline master entitled "Sand Sorting" takes students through an activity that has them gather random data on sand grain diameters. The data are then graphed and the results interpreted to determine if the sand sample was well-sorted or poorly sorted.

Materials needed for each group: transparency metric ruler with millimeter markings, sand sample card, transparency marker.

SOAR set-up #4: Stand and View with 30X lens.

Time allotment: one class period.

Group size: small groups. Can be done independently as a learning station.

Teacher hints: If a sample is "well-sorted" this means that the sand grains are approximately the same size. If it's poorly sorted, there will be a wide scattering of grain sizes. Graphically, a "well-sorted" sand will have most grains fall into one or two sizes adjacent to one another. A poorly sorted sample will have bars scattered from one side of the chart to another.

Assessment Strategies

Give students new sand sample cards and have them describe the physical properties of their samples (i.e., color, shape, roundness, sorting, and composition). Have them determine what class on the Wentworth Scale their sample belongs in by taking the average diameter of 25 random grains from their sample.

> Little drops of water, little grains of sand,
> Make the mighty ocean, and the pleasant land.
> So the little minutes, humble though they be,
> Make the mighty ages of eternity.
>
> Julia Carney, *Little Things*

SeaScope IDEA: Start an Arenology (Sand) Collection

Sand is easy to collect, everyone can participate, and best of all, it is free! Sand collections can easily be started and expanded by encouraging students and friends to collect sand samples while on vacation during holidays and summer breaks. Volunteer collectors need to record their name(s), as well as the place and date of the collection on slips of paper tucked into the containers they collected the sand in. It is helpful if this information is also written in permanent marker on the outside of the bag/box/film canister as well. Locality information and the collector's name are recorded into the "deposit" book when the donation is made.

Secrets of Sand - Activity One
OBSERVING PHYSICAL FEATURES

Name:_____

Date:_____

The ***physical properties*** of a sand sample tell a geologist many things about the history of a particular sand's area, such as a beach. Here we will look at the physical properties of sand in order to tell a story of this sand sample's geological history.

Sand Sample Name or ID Number _____

A. Examine your sand specimen. Use the grain-size finder and sorting chart as a guide to answer the following questions about the **color**, **grain size** and **sorting** of your sand sample. Color tells the geologist what types of minerals might make up the sand. Grain size tells the geologist how fast the water might have been moving and/or how far the sand was deposited from shore. Sorting can tell the geologist whether the sand was deposited quickly or if it gradually settled out of a current. Some tools to help understand sand are found on the next page.

1. Is your sample many colors or all one color? _____
2. Are the grains all about the same size? _____

   If the grains of sand are mostly all the same size, the sample is what geologists refer to as "well sorted". If there is a wide range of grain sizes, the sand is considered to be "poorly sorted".

3. Is your sample *well sorted* or *poorly sorted*? _____
4. How would you define **sorting** in your own words? (Use a complete sentence.)_____

   _____

   _____

B. **Roundness** and **angularity** (a big word that means how sharp the edges are) can tell the geologist how long a sand particle might have been in a stream or river. Observe your sample with your eyes and with Scope-On-A-Rope.

5. Are the grains smooth and rounded? _____

C. The **shape** of the sand grains can also tell the geologist about the types of minerals that make up the sand. Again, observe your sample with your eyes and with Scope-On-A-Rope.

6. What shapes are the grains of sand (spheres, rods, discs, irregular blobs)?

   _____

D. **Composition** of the sand sample tells the geologist where the sand might have originally come from.

7. Is your sand sample all made of one type of grain? _____

   If it is a mixture, how many different minerals or fragments are in it? _____
8. Does some of the sand consist of small broken pieces of rocks? _____
9. Is some of the sand from living things? _____ A lot, or a little? _____
10. Are there any minerals in your sand sample that are attracted to a magnet? (Borrow a magnet from your teacher to check this physical property.) _____

SeaScope Folio: Secrets of Sand - Activity Two Name:_____
SORTING IT ALL OUT! Date:_____

Representing our sand data graphically allows us to see if there is a pattern in our data. This lab will help you to make some measurements on a sand sample and then check to see if there is a pattern to your sample's grain size.

Sand Sample Name or ID Number _____

A. Prepare a measuring tool (a monitor ruler) to use with SOAR. Set up the SOAR using set-up #4 (Stand and View using the 30X lens). Get an overhead transparency sheet from your teacher and carefully tape the sheet to the TV monitor on the top and bottom edges of the transparency. With a standard ruler, measure the diagonal length of your TV monitor and write it on the corner of the transparency. Take a metric ruler and have a group member hold the SOAR so that you can see the millimeter markings. Trace the millimeter (mm) markings onto the transparency sheet using a transparency pen. Label your transparent monitor ruler with the distance between the two markings.

B. With your new monitor ruler, measure the diameter of 24 random particles of sand. (A random sample of diameters will give you the best representation of your overall sample, so don't try to pick all the biggest or smallest grains. Perhaps your group members can come up with a strategy to pick a random sample.) Record your measurements in the chart below.

Sand grain #	Diameter (mm)	Sand grain #	Diameter (mm)	Sand grain #	Diameter (mm)
1		9		17	
2		10		18	
3		11		19	
4		12		20	
5		13		21	
6		14		22	
7		15		23	
8		16		24	

C. Create a bar graph that compares the diameters of the grains.

1. Take your largest diameter and subtract the smallest diameter to get the **range** in diameters for your sand sample. The range of your sand sample is _____mm.
2. Divide your range by five. This will give you your **category size** (abbreviated "cat. sz" below). Round your answer to the nearest whole number. The category size of your sand sample is _____ mm.
3. Take your smallest diameter and add your category size to it. Finish filling in the equation below.

____	+	_____	=	_____	+	_____	=	_____	+	_____	=	_____	+	_____	=	_____	+	_____	=	_____
smallest	+	cat. sz	=	xxxxx	+	cat. sz	=	xxxxx	+	cat. sz	=	xxxxx	+	cat. sz	=	xxxxx	+	cat. sz	=	xxxxx

4. Prepare your graph. The six numbers in the boxes in step 3 will be your range numbers for your bar graph. On a separate sheet of paper, draw a horizontal axis. Label the horizontal axis with the range numbers. Give your horizontal axis the title: *Sand grain size*. Draw a vertical axis connected to the left side of your horizontal axis. Counting by two, label the vertical axis with numbers 2-24. Label this axis, *Number of sand grains*.
5. Count up the number of grains that fall within each range. Enter the data on your graph by creating a bar that rises to the number of grains that fall within each range.

D. Understanding and interpreting your sand grain data.

One thing the bar graph tells us is what geologists call "sorting". If you have only one group of bars (rather than two groups or a spread of bars), geologists say that the sand is "well-sorted," meaning the grains are pretty much all one size. If you have two groups of bars, or a spread of bars, then your sand is "poorly sorted". According to your graph, what type of sorting does your sand sample have?

Extensions

Language Arts: Sand Grain Saga

Tell the "life story" of an individual grain of sand from your sand sample. Here are some questions to help you think of things you might include in your story. Who were its "parents"? How was it "born"? Where was it "born"? Where did it come from? Does it have any "brothers and sisters"? What happened to it while "growing up"? Did it travel? Change shape? Change size? How did it get to be the way it is today? How did it get to be where it is found today? Where was it found? Incorporate ideas of **weathering**, **erosion**, and **transportation**.

Extend the story into the future: What will become of the sand grain? Will it go anywhere else? Incorporate ideas of **sedimentation** (a word that means *the process of sediment being deposited*) and **lithification** (a big word that means a *process that turns sediment into rock*).

Art: Sand Painting

Sand painting is an ancient Southwest Indian art. Medicine men created sand paintings to ask for healing or blessings. These sacred paintings were made after the sun went down and then were destroyed before sunrise. To make your own sand paintings, you will need a piece of fine-grained (100) sandpaper (one for each student), white glue, colored sand, paper towels, carbon paper, and toothpicks or cotton swabs. A day or two before you plan to have your students create their sand paintings, you need to make the colored sand. To do this, mix in a plastic bag: one cup dry sand, one capful of rubbing alcohol, and food coloring. Allow this colored sand mixture to dry completely. Have students draw a simple landscape or southwestern design on white typing paper. Have students color in their design with crayons or colored pencils using the same colors you have chosen for the colored sand. Have students use carbon paper to transfer (trace) the outline of their design onto a sheet of fine-grained sandpaper. Students will then fill in with a thin layer of glue the areas on their sandpaper that are the same color on their drawings. Toothpicks or cotton swabs can be used to spread glue. Sprinkle the colored sand over the glue. Let the glue dry completely before shaking off excess sand onto a paper towel. This excess sand can be returned to the plastic bag and saved for another drawing. Allow each color of sand to dry completely before adding the next color.

Geography

Locate the source of your sample of sand on a map (either a world map or a map of the United States).

1. What continent is your sand from? _____

   What country is your sand from? _____

   What state, if it is from the United States? _____
2. What is the latitude and longitude of the source of your sand sample?

   _____
3. What is the name of the nearest river to the east of your sand sample?

   _____
4. What is the name of the nearest river to the west of your sand sample?

   _____
5. What is the name of the nearest ocean to your beach location?

   _____

Home Economics: Sand Tart Cookies

Make sugar cookies from your favorite recipe. Roll your cookies in powdered or granular sugar after they have cooled.

Resources

Educator References

Frazier, J. J. 1996. **Sand Studies**. The Science Teacher, v. 63, pp. 14-17.

Lord, S. 1996. **Sand Art Craft Kit: Create Your Own Sand-Sational Works of Art!** (Scholastic's Creativity Zone), Scholastic Trade. Synopsis: A book-and-activity kit introduces young readers to the sand portraits of the Navajos and Tibetan Buddhists and explains how to make special works of art and a sand garden with the enclosed colored sand and craft paper. ISBN: 0590202529; Reading level: Ages 9-12.

Mack, W. N. and Leistikow, E. A. 1996. **Sands of the World**. Scientific American, v. 275, no. 2, pp. 62-67.

Metzger, E. P. 1992. **The Nitty Gritty of Sand**. Journal of Geological Education, v. 40, pp. 338-342. This journal article inspired the present activity. It contains more great sand activity ideas and extensions.

Michel, H. B. 1986. **The Mystery of the Pink Sand**. Sea Frontiers, v. 32, pp. 404-408.

Points, L. and Jauck, A. 1997. **Ribbons of Sand: Exploring Atlantic Beaches**. Sierra Press, 32 pp. Synopsis: Contains color photographs of sand and animals found on beaches. Paperback. Reading level: Ages 9-12; ISBN: 093936557X

Villasenor, D. 1996. **Tapestries in Sand: The Spirit of Indian Sand Painting**. Naturegraph.

Wanless, H. R., and Tedesco, L. P. 1988. **Sand Biographies**. Sea Frontiers, v. 34, pp. 224-230.

Wendt, D. 1985. **Hawaiian Sands: More Than Meets the Eye**. Oceans, v. 18, no. 6, pp. 40-45.

Winston, J. and G. Billy. 1988. **Life on a Grain of Sand**. Sea Frontiers, v. 34, pp. 76-78.

Tradebooks

Shannon, B. 1999. **The Sand Castle**. Morrow, William & Co. *A girl starts to build a sand castle at the beach, and others come along to help make the moat, path, wall, and road around it.* [ISBN 0688161944]

Warner, G. C. 1990. **Mystery in the Sand** (Boxcar Children, No 16). Albert Whitman & Co. *Reading level: Ages 9-12.* [ISBN: 0807553727]

WWW Links

Minerals Close-Up

US Geological Survey Western Region Geologic Mapping Team and the National Park Service
http://www2.nature.nps.gov/grd/usgsnps/rxmin/mineral.html#quartz

Singing Sands

Did you know sand can whistle? It can! It can also make a booming sound so loud that people have to shout to be heard over it! Two web sites talk about this phenomenon.

- The Learning Kingdom's COOL FACT OF THE DAY, July 7, 1998, *Sand sounds*.
  http://www.cool-fact.com/archive/1998/07/07.html
- Scientific American's Ask the Expert: *What are "booming sands" and what causes the sounds they make?*
  http://www.sciam.com/askexpert/physics/physics36/physics36.html

Sand Close-ups

Working with SOAR you know that sand samples can look very different from one another depending on where they are collected. This web page shows what sands look like under the microscope.

Microscopy Image Gallery: Exploration of the Month, February 1999.
http://resolution.umn.edu/MMS/ProjectMicro/gallery.html