No Ordinary Sandy beach

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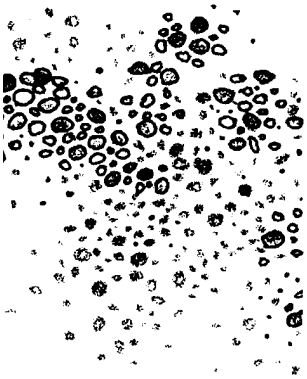


Key Concept

1. The observable characteristics of sand grains provide clues to the origin of the sand.

Background

What is Sand? How is it Formed?

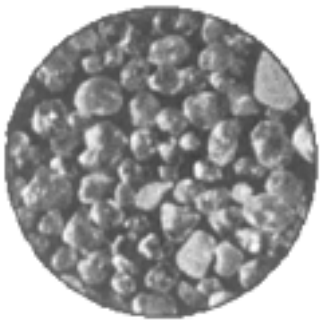
Hidden on every sandy shore is a mystery waiting to be solved. Where did the sand come from? How far did it travel, and through what lands did it pass? Did it come from a blazing volcano, a wave-battered coral reef, or a calm lagoon?

Careful observation and thought can answer these and other sand questions. An arenologist, a marine geologist specializing in the study of sand, can tell the source of the sands, the climate in the source area, the distance and environments through which the sands have passed, and the character of the environment in which they were found.

Just what is sand? Sand is usually defined as a mass of unconsolidated, granular material with grain sizes between 0.0625 mm and 2.0 mm in diameter. Particles smaller than these are called silt or clay, while larger particles are called gravel. The type of "unconsolidated, granular material" differs widely.

There are four common sources for sand: weathering of continental granitic rocks, weathering of oceanic volcanic rocks, skeletal remains of organisms, and grains precipitated from the water. Most sands are formed by the weathering of rocks.

Characteristics of Sand



- **MINERAL** sand

  Mineral sands come from the weathering of the rocks which make up the earth's continental crust. Granite and other igneous and metamorphic rocks form the bulk of the continental crust. Water, chemicals, and temperature changes breakdown these rocks.

When a granite rock first begins to weather, a coarse gravel is produced. Each particle is usually composed of several minerals. As the weathering process continues, these larger particles are broken down to individual mineral grains. Quartz, which is abundant in this rocks, especially resists further chemical and physical breakdown. As a result, sands derived from weathering of continental rocks gradually become dominated by quartz crystals as the other grains are dissolved and broken down in the weathering process. This chemical purification may require thousands of miles of transport. Pure quartz sands are often referred to as glass sands and are sometimes used in the production of glass.

Quartz sand grains are clear or opaque. The darker colored grains found in most continental sands vary depending on the source rocks and can be used to trace sands back to their origin.

- **VOLCANIC** sand

Just as mineral sands come from the weathering of the rocks which comprise the earth's continental crust, volcanic sands are derived from the weathering of the earth's oceanic crust. Most of the oceanic crust is comprised of a very dark, dense volcanic rock called basalt. Volcanic islands, lava from volcanic eruptions, and the bottom substrate of the ocean basins are all made of basalt.

The black sand beaches of Hawaii, Tahiti, and the Canary Islands are formed from basalt. The sand grains are usually polished obsidian or basalt from nearby volcanoes. Some may contain tiny holes where air was trapped in the cooling lava. Transparent, greenish olivine grains are also common components of oceanic sands.

- **SHELL** sand

A third source of sand is the skeletal remains of plants and animals. Shell sand contains almost exclusively small pieces of shells, coral, or the skeletal remains of animals. Many invertebrate animals and a number of algae possess skeletons made of calcium carbonate or silica. In contrast to sands weathered from granites and basalts that may have traveled thousands of miles from their source, skeletal grains are usually produced near their site of deposition and are a record of nearby environments.

Fragments of corals, coralline algaes, and mollusks are often common in skeletal sands. Starfish and sea urchin spines and sponge spicules (the internal skeletal part of a sponge) are also durable enough to show up in these sands. The shells of mollusks may abrade in a sandy environment, breaking down into flat grains of sand. Sea urchin spines and sponge spicules often produce an elongate grain of sand. Foraminifera, a simple animal that produces a sand-sized shell called a test, are abundant in many lagoons and nearshore. Tests of foraminifera are a very common and beautiful component of beach sands.

Although skeletal sands are physically less durable than most land-derived sands, most beaches contain some skeletal grains. Young skeletal grains still possess the surface marks characteristic of the organisms from which they came. The degree of preservation of these marks is an indication of the abrasion to which the sand has been subjected and, hence, to the age of the grains.

- **PRECIPITATE** sand**

A fourth, and much less common, type of grain is one that precipitates from mineral material dissolved in the water. In many shallow, tropical areas, warm ocean water enhances the normal rate of precipitation of calcium carbonate. The precipitated calcium carbonate forms egg-shaped grains called ooids. When cut open, an ooid looks much like an onion. The "onion's" layers are formed by the gradual precipitation of calcium carbonate on the grain's outer surface.

Of course, not all sand is found on beaches. In fact, the bulk of the world's sand is found in deserts, or buried in underground deposits. It has been estimated that the world's sand could cover the entire United States with a layer 5 kilometers thick. A small hand lens or magnifying glass is all that is needed to begin reading the intriguing stories of our planet stored in just a handful of this ocean of sand.

** This type of sand was omitted from the student data sheet since it is difficult to collect. Do include it, however, if you are lucky enough to collect some ooid sand.

- **FAR** from the origin

  Sand grains that are far from their source of origin tend to share these features:

  - grains tend to be about the same size
  - no remains of living things are visible
  - smooth edges on the grains (eroded by water or wind)

  Grains released by weathering of mineral or volcanic rocks may travel great distances before being deposited on a beach. For example, mineral rock that has weathered may travel by water down rivers or by wind across sand dunes. As these grains travel, they are subjected to physical and chemical destruction. Physical abrasion causes grains to become smooth and spherical. The rate at which a grain of sand becomes round depends on the grain's durability, size, the size of other grains in the sand, the energy of the environment (wave action, etc.) and the time the grain is transported. It is common to see very round, polished grains of sand on a high-energy beach very near the source material.

- **NEAR** the origin

  Sand grains that are near to their source of origin tend to share these features:

  - parts from living things are still visible
  - many different sizes of mineral grains are present
  - the sand grains are angular (sharp), rough and/or coarse

  Shell sands and other skeletal sands are usually found on the beaches where they were produced.

  Mineral sand that contains many different sizes of grains and grains with edges that are very rough and sharp, has probably come from source material near the beach where it was collected.

Additional information about sand may be found in the following articles:

Palmer, Alfred C. "Sandy Science" Science Scope, November-December 1987, pages 22-23.

Vandervoort, Frances S. "Sands-on Learning". The Science Teacher, April 1989, pages 52-55.

Wanless, Harold R. and Leonore P. Tedesco. "Sand Biographies." Sea Frontiers, July-August 1988, pp. 224-230.

Materials

For the class:

- sand samples
- overhead transparency of sand types (see master included at the end of this teacher background section)
- overhead transparency or poster listing the locations where the sand samples were collected
- dissecting microscopes (if available)
- several small, clear petri dishes (for use with scopes)
- several magnets
- dropper bottles of vinegar (one per group)
- U.S. or world map

For each student:

- small plastic portion cups (2 oz.)
- hand lens
- small pieces of paper about the size of a 3" x 5" index card
- "Sand Lab Data Sheet"

Teaching Hints

In "No Ordinary Sand", students observe a variety of sand samples and, from the observed characteristics, predict the origins of the samples. Aside from what they can learn about sand in particular, there are some more general points about science that they should become aware of - the utility of keen observation, and the idea that small details can yield significant bits of information.

Collecting Sand Samples

Leave the tacky tourist shops behind, and begin a collection of sand samples from your travels! Empty film cannisters work great for collection. Immediately label the sample including the following information:

- place of collection (be as specific as possible)
- date of collection
- name of person collecting the sample.

The beach sand samples should provide a good mixture of different kinds of sand - mineral, volcanic, shell, etc. Begin collecting the samples early for best results. If you can't visit exotic beaches in person, ask people you know who are going to visit various beaches around the world to collect samples for you,

or write to schools or other institutions in areas from which you would like sand. (For guaranteed results, send them a film canister and a self-addressed, stamped envelope!) A film canister or two is sufficient for an entire class.

Also, many marine educators have large sand collections and connecting with them for a sand swap can increase your collection quickly. Hold your own sand swaps after summer travels or spring break vacations.

When collecting volcanic sand samples, note that islands near the continents may be:

- drowned hills or mountains
- moraines - formed from glaciers, or
- exotic terrains - from transform faulting.

Therefore, it is important that you obtain the volcanic sand samples from islands in the middle of the ocean.

The bibliography contains information on how to obtain the INVESTIGATING SANDS AND BEACHES Activity Kit which contains eleven different sand samples.

Preparation

1. Make a sand "sampler" for each group of six students by pouring a small quantity of six **different** sand samples into separate plastic cups. Use more than six different types of sand so that the teams have different combinations of sands, with some sand samples the same, but not all six. Label the plastic cups with a code that is meaningful to you, but not to your students!

2. Prepare a reference slide, petri dish, or other clear, shallow container labelled with the location of collection for each sand sample distributed to students. To prepare the reference sand slides or containers:

    - mix water with white glue that dries clear so that the resulting mixture is very thin.

    - smear the thinned glue in the middle of the slide or container.

    - sprinkle the sand sample on the glue. NOTE: use just a dash of sand, a little is better than a lot, so that the edges of the individual sand grains can be observed.

    - label the location of collection using a small piece of masking tape on one side of the slide or container.

The completed, labelled slides or containers of sand serve as a checking station for students in this lesson.

Procedure

1. Divide students into working groups of six and distribute a sand "sampler" to each group.

2. Distribute a hand lens to each student and instruct her to examine one of the sand samples carefully and describe the sand on a 3x5 card or piece of paper.

3. When all of the students have finished their descriptions of the sand samples, direct each group of six to put their sand samples and description cards in the middle of their working place. Designate one student in each group to "shuffle" the description cards.

4. Have each group of six students rotate to a different set of sand samples and description cards. Their challenge will be to match each of the six sand samples with the correct description card. Upon completion, have students return to their own sample and card to see if it was matched correctly by the other students.

5. As a class, discuss and list the observable characteristics of the sands examined.

6. Explain that the observable, physical characteristics of sand provide some clues to its origin. Ask students for their ideas about the ways sand is created and what observable characteristics might result.

7. Distribute a "Sand Lab Data Sheet" to each student and discuss the physical appearance of the different sands listed in each column (i.e., mineral, volcanic, or shell sand). Encourage students to share their ideas regarding the appearance of each type of sand. Build on their ideas to provide information about each sand type. On the chalkboard, record the different characteristics of each sand type. See the "Background" section of this lesson for help. Use the overhead of sand types as a "visual aid" as each type of sand is discussed.

8. Have each student in a group observe her sand sample, again, and complete the chart on the data sheet, recording observations and inferences for her sample.

9. Display the list of locations where the sand samples were collected and ask each student to guess where he thinks his sample was collected.

10. Display the reference sand slides or containers labelled with the location of collection and have students check their guesses by comparing their samples with the sand in the containers or on the slides.

11. Allow time for students to observe a variety of samples for comparison. If available, dissecting microscopes greatly enhance the enjoyment of this activity.

12. Challenge students to locate the source of their sand sample on a U.S. or world map.

Key Words

arenologists - scientists who study sand; students and collectors of sand

basalt - a dark rock that is volcanic in origin; the most common rock under the ocean floor

granite - an igneous rock composed of several minerals; often composed of: quartz, feldspar and biotite or mica

igneous rock - a rock that is volcanic in origin

metamorphic rock - an igneous or sedimentary rock that is changed by heat, pressure or a combination of these factors

obsidian - formed when hot lava reaches the surface and cools instantly so that no crystals form; looks like a piece of glass

Extensions

1. Have your students bring in sand samples from family trips and create a display board showing some of the sand samples with their source marked on a U.S. or world map.

2. Try these experiments from Sandra Calkins, Richfield, Idaho on your sand samples:

A. Physical Change

Have students think about how rocks and shells break up to make small grains of beach sand. To demonstrate, take a piece of granite, sandstone, or other rock and, using a protective covering, smash it with a hammer. Have

students observe the resulting pieces. Have students use coarse sand paper on pieces of shells to demonstrate how the sand on a beach can wear down shells.

Have students examine some mineral beach sand that contains particles of all different sizes, including pebbles or small rocks. Challenge them to sort the sand grains using a toothpick or other sharp tool. To help students understand the origin of a sandy beach, have them compare the sorted sand grains to the pebbles and rocks that were smashed with a hammer. Can they find the same types of minerals in the rocks?

B. Chemical Change

A simple acid test using vinegar (an acid) will help identify shell matter in the sand samples. Shell material will "fizz" as the calcium carbonate in the shells reacts with the vinegar.

To help students understand this test, prepare three containers:

- in one container, place broken shells with salt water
- in the second container, place broken shells with vinegar (an acid)
- in the third container, place broken shells with ammonia (a base).

Have students predict what will happen to the shells in each container. Observe the shells after several hours. What happens after one week? two weeks?

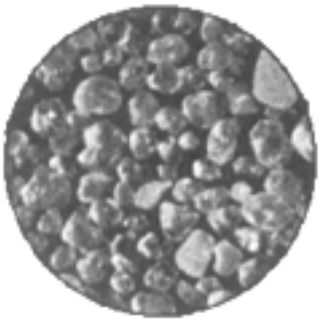
C. Magnetic Attraction

Have students place a pinch of sand on a sheet of paper. Then, have them move a magnet under the paper holding the sand. If some of the grains are attracted and can be moved around with the magnet, they are likely to be the mineral, magnetite. Magnetite grains are black or very dark gray.

No Ordinary Beach Sand
overhead transparency master

Types of Beach Sand

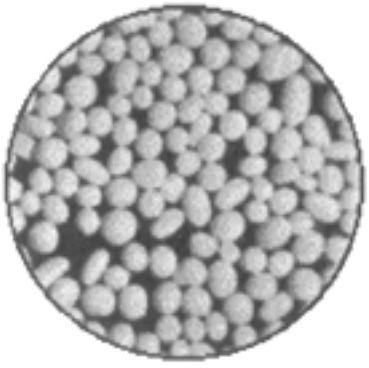
Mineral Sand



Volcanic Sand

Shell Sand

Precipitate Sand



No Ordinary Sandy Beach Data Sheet

	Mostly mineral sand	Mostly volcanic sand	Mostly shell sand	Near or far from origin
Physical appearance				
Observations				
Inference				

I think this sand sample was collected from_____

(Check the list of locations where these sand samples were collected)

What did you successfully infer ("figure out") about your sand sample?