SEDIMENTARY ROCKS

Teacher Guide
including
Lesson Plans, Student Readers, and More Information

Lesson 1 - Overview of Sedimentary Rocks

Lesson 2 - Classifying Sedimentary Rocks

Lesson 3 - Sand (Lab)

Lesson 4 - Sedimentary Rocks (Lab)

Lesson 5 - Sandstones Through Time

designed to be used as an Electronic Textbook
in class or at home

materials can be obtained from the Math/Science Nucleus

EARTH SCIENCES - SEDIMENTARY ROCKS

Lesson 1 - Overview of Sedimentary Rocks

MATERIALS:

reader

Objective: Students are introduced to processes that form sedimentary rocks.

Teacher note

Sedimentary rocks are made in the presence of water, whose pieces or sediments are cemented together. Sediments are produced by different forms of weathering such as glaciers, rain, snow, freezing, thawing, and plant growth. All three categories of rocks, sedimentary, metamorphic, and igneous rocks become weathered. The sediments are then cemented together, forming new sedimentary rocks.

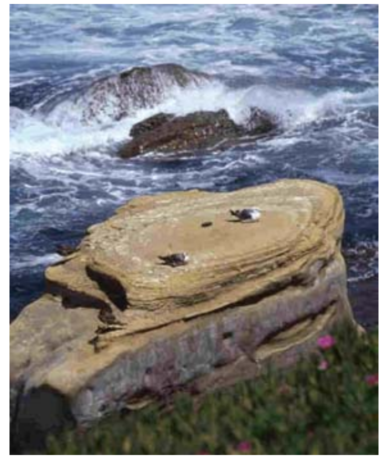
You may want to use sand as an example of sedimentary rocks forming today. Ask students if they have ever been to the beach, or played in the sand. Ask them if all sand is alike. No, they are different because the characteristics of the sand reflect the rock that it eroded from. Talk about how sand is created from weathered rocks. Sometimes these rocks weather into a coarse grained sand and sometimes they weather into a fine grained sand. When sand sized particles become cemented together, they form sandstones.

The majority of the rocks on the surface of the Earth are sedimentary. Anywhere that water has been will create a deposition of sediments. However, igneous rocks are the most abundant throughout the crust of the Earth.

The key point in this reader is for students to realize that sedimentary rocks provide a history of the evolution of the Earth, especially within the last 1 billion years. In later chapters (Stratigraphy, Past) we will explore how we interpret the record.

Hour glass

Sand has been used to describe many human qualities. A vagabond has been referred to as "driftless like grains of sand." Time is "sand that drifts forever." We are all but a "grain of sand on the beach." Children can spend endless hours on the beach, creating sand castles, or digging a giant hole to reach the other end of the world. Sand is clean to play with because it can cover you up, but not make you dirty. Children look at sand falling through an hour glass fascinated by every grain that falls. Sand is loved so much by children that adults have created sand boxes where their children can play.



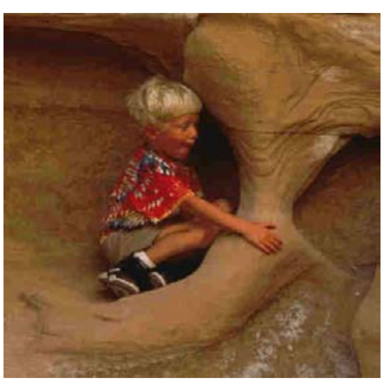
Waves crashing along the California coast (La Jolla)

It's funny to think that sand can be associated with two opposite **climatic** conditions. Water that crashes upon ocean beaches compared to the hot sun and wind that shifts sand in deserts like Death Valley or the Sahara Desert. In both situations some kind of erosion of the surrounding rock has created the sand. Cement binds the grains, forming sandstone a **sedimentary rock.**

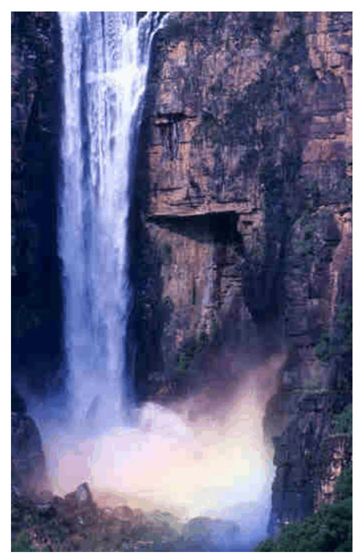
Glacier

There are many conditions that create sediments or particles. Physical breaking of rocks can occur in several ways. The rushing power of a river or waterfall causes small pieces of the rock to break and travel within the stream. When the water slows down it will **deposit** its load. Wind can be strong enough to act as a natural "sand blast" to slowly chip away at soft rocks. **Glaciers**, are so powerful that they can grind the rocks into very small particles. Cold and warm weather cycles also help to break rock. If water gets into a crack and then freezes, it expands. This weakens the rock and will cause it to break with time.

Chemical break up of the rocks also occurs. As water travels upon rocks or other substances, it can cause the elements within the substance to break down and dissolve in the water. It will later precipitate out and help cement particles together.

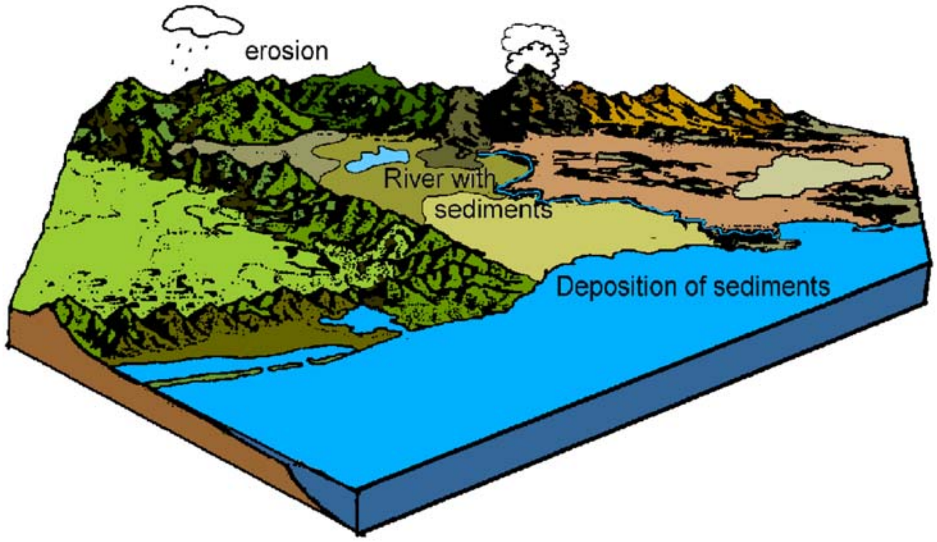


Hollows Capitol Reef National Park in Utah eroded by wind



Jim Jim Falls in Australia

Sedimentary rocks have one thing in common, they all have something to do with water. Even the sands in the desert, are later cemented by water that **percolates** through the sand. There are many types of sedimentary environments. There are streams, rivers, oceans, coral reefs, beaches, deserts, and glaciers. The picture shows many of these different environments.



Many environments form sedimentary rocks that have distinguishing features. For example, sandstone is common in beach or desert environments, while **mudstone** and **siltstone** are common in quiet, deep **marine** environments


Sand ripples along beach in South Carolina

Geologists study ancient sedimentary rocks to determine what **sedimentary environment** they formed in. Determining ancient environments is very important to understand the history of the Earth. It helps geologists understand how the Earth's surface has changed over time. Since most ancient organisms live around environments where sedimentary rocks are formed, paleontologists need to know the ancient environments.

One way to study environments is to compare the sedimentary structures in ancient rocks with sedimentary structures forming at present in modern sedimentary environments. From looking at today's environments, geologists can learn how **sedimentary structures** form. If the rock shows the same sedimentary structure as the modern sediment, then the rock probably formed in the same way. This is an important way of understanding what happened in the past, even if the deposition occurred millions of years ago.


Ripples preserved in sandstone

Sedimentologists are a specific group of geologists who study sedimentary rocks and how they form. Most rocks that you find on the surface of the Earth are sedimentary rocks. They study rocks on the land and rocks that are forming. Geologists map the different type of rocks and can explain how the rocks were deposited. Sedimentary rocks that are in the process of forming can be found at the bottom of oceans, deltas, and lakes. They look at sediment cores to determine how the process of **sedimentation** produces these rocks.

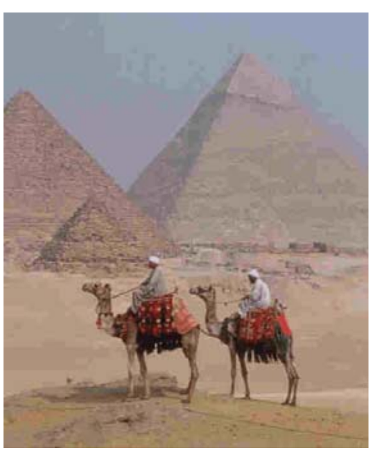
Coring the deep sea

Sedimentologists in Sakhalin, Russia

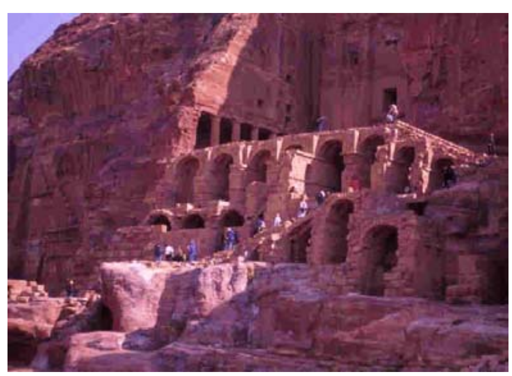
Statutes of King Ramses II tomb in Egypt, carved in sandstone.

Sedimentary rocks have also been used by ancient people to create statues, tombs, and homes. The Great Pyramids of Egypt are composed of limestones with many fossils in them. The fossils are a large, one celled protozoa called foraminifera. Legend has it that the Egyptian workers would find some of these 1-2 cm “grains” and thought they were the remains of a snack that their gods had eaten overnight.

When building material was scare, early people used sandstone to carve their home into the sides of mountains. Artists also used the easily eroded sandstones to create statues for all to marvel at their civilization.



Pyramids at Giza in Egypt



Jordan Capitol of Nabataian Kingdom

EARTH SCIENCES - SEDIMENTARY ROCKS

Lesson 2 - Classifying Sedimentary Rocks

MATERIALS:

reader
chart

Objective: Students learn how to read a sedimentary rock chart.

Teacher note

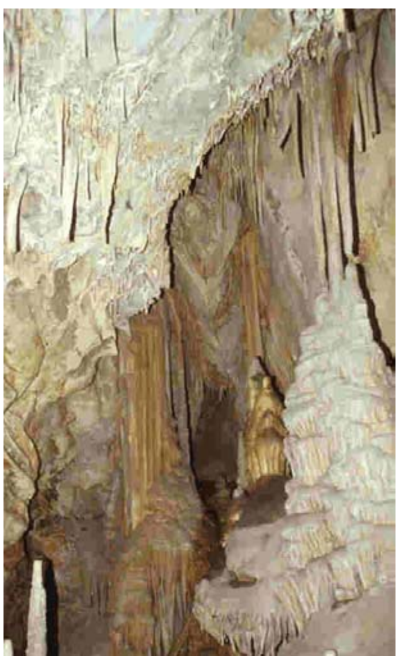
Naming rocks can be complicated, if not approached systematically. This reader and chart provides the key elements of identifying sedimentary rocks.

The chart is divided into 2 parts, clastic and chemical. The reader provides the information to help students understand the division. In lab, students will be using the chart to help identify rocks. Go over this chart and make sure students know how to use and derive information from the chart.

Ask questions like, "How large are the grains of mudstone?" or "What is chert called if it contains fossils?"

Mt. Brockman, Australia (sandstone)

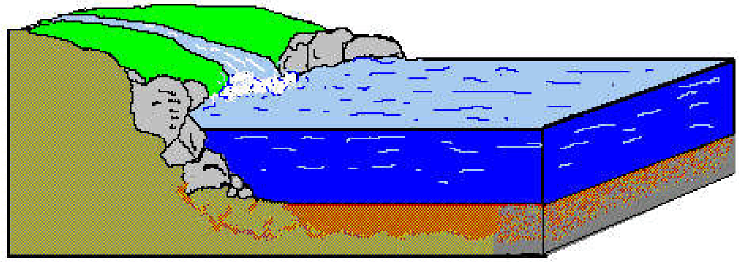
Sedimentary rocks form at the Earth's surface. Geologists divide sedimentary rocks into two major types, based on what they are made of and how they form. **Clastic sedimentary rocks** are composed of pieces of rock, minerals, or fossils that have been cemented together. Sandstone is an example. **Chemical sedimentary rocks** form by **precipitation** or the growth of new minerals in water. Precipitation can create large sedimentary structures like **stalactites** and **stalagmites**, which grow in caves.



Stalactites and stalagmites

The formation of both types of sedimentary rocks begins with the **weathering** of any igneous, sedimentary, or metamorphic rock at the Earth's surface. **Physical weathering** processes break rocks down into pieces or sediments. **Chemical weathering** dissolves minerals in the rocks and them precipitates them.

Gravel along a river bed



Particles move into the open ocean or lake from a river and settle by size and density.

Once sediments are formed during weathering, the particles are transported by the action of streams, wind, glaciers, or gravity. Eventually the **clastic** sediment is deposited, usually in a low area like a lake or the ocean.

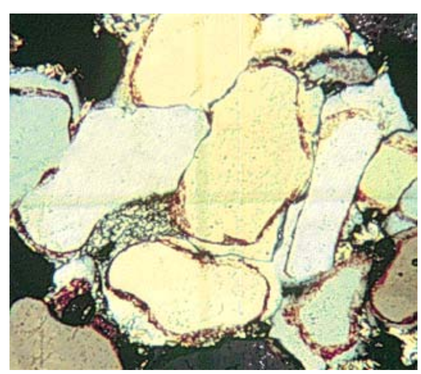
Imagine a stream flowing out of the mountains into the ocean. As the water flows quickly downhill, it carries all kinds of sediment particles, from mud to sand sized grains, to larger gravel and pebbles. As the stream enters the ocean, the water slows down and deposits the sediment. The heaviest sediment grains (gravel and pebbles) drop out first and the lightest (mud), settles to the floor of the ocean further offshore. A major factor to classify clastic sedimentary rocks is the size of the sediment.

Organisms that live in environments where sediments are formed will die. Their remains accumulate and are incorporated into rocks. When you find fossils in rocks they are referred to as **fossiliferous sedimentary rocks**.

Conglomerate

Sediments are transformed into sedimentary rock through **cementation**. This is a process that precipitates minerals in the spaces between sediment particles. As sediments are deposited, water moves through the pores between the grains. The water commonly contains dissolved silica (SiO_2) or calcium carbonate ($CaCO_3$). If the chemical conditions are right, quartz or calcite crystals will precipitate in the spaces between the sand grains. They will grow until the spaces are filled up and **interlocking**. The crystals cement the sediment together, creating solid rock.

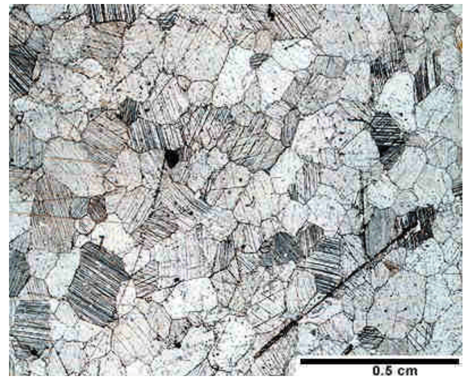
Cemented gravel and pebbles form a sedimentary rock called conglomerate. Artificial cemented rocks (sand and gravel) is called **concrete**. Cemented sand forms sandstone and mud-sized particles make mudstone and siltstone. The type of cement also helps classify the sedimentary rock.



Grains become cemented together

Dissolved elements and compounds produced during chemical weathering follows a different path. This material is transported down the stream to the ocean but is not deposited. Organisms aid in the creation of chemical sedimentary rocks. Sometimes the **ions** of SiO_2 or $CaCO_3$ are absorbed by organisms. They use the minerals to create their shells or skeletons. Most skeletons are composed of the mineral aragonite (a form of calcite) or opal (a form of quartz).

Opaline (form of quartz)



Lithographic Limestone - a recrystallized fossiliferous sedimentary rock

After a fossiliferous sedimentary rock forms, the minerals that make up the fossils may undergo **recrystallization**. The crystals dissolve and **precipitate** when conditions are right. Recrystallization destroys the original fossils and produces chemical sedimentary rocks.

There are other chemical sedimentary rocks that follow are produced by different processes. Coal, is an example of a chemical sedimentary rock that is derived from plant matter that has been buried. Coal comes in 3 major forms including **anthracite** which is a hard coal, **bituminous** which is softer, and **lignite** which is the softest with recognizable plant remains.

Anthracite coal

The rich coal fields in the East Coast of the United States were created during the **Carboniferous Period** (about 350-300 million years ago) when huge swampy forests of giant ferns, reeds and mosses, which were around grew taller than our tallest trees today. As these plants died and fell into the swamp water, new plants grew to take their place and when these plants died, still others grew. In time, there was a thick layer of dead, decaying plants in the water. **Decomposition**, chemical alteration, and burial pressure formed different coal types.

Carboniferous forest

SEDIMENTARY ROCK IDENTIFICATION CHARTS

CLASTIC SEDIMENTARY ROCKS

GRAIN SIZE		ROCK NAME	MINERAL COMPOSITION	ROCK NAME IF IT INCLUDES FOSSILS
finer than sand < 1/16 mm	*SMOOTH*	MUDSTONE	Clay	DIATOMITE (diatoms) RADIOLARITE (radiolarians) FOSSILEROUS MUDSTONE or SILTSTONE
	GRITTY	SILTSTONE		
sand size (1/16 to 2 mm)		SANDSTONE	quartz (quartz sandstone)	FOSSILEROUS SANDSTONE
			rock fragments, feldspar, quartz, mica (graywacke)	
			quartz, feldspar (arkose)	
coarser than sand (>2mm)	*rounded grains*	CONGLOMERATE	quarts, feldspar, rock fragments	FOSSILEROUS CONGLOMERATE
	angular grains	BRECCIA		FOSSILEROUS BRECCIA

CHEMICAL SEDIMENTARY ROCKS

DESCRIPTION	ROCK NAME	MINERAL COMPOSITION	WITH FOSSILS
microcrystalline	CHERT	quartz	RADIOLARIAN CHERT
crystalline	GYPSUM	gypsum	
crystalline	ROCK SALT	halite	
crystalline	DOLOMITE	dolomite	
crystalline	LITHOGRAPHIC LIMESTONE	calcite	FOSSILIFEROUS LIMESTONE
spongy, crumbly	COAL	no true minerals, various stages of altered plant remains	PEAT
spongy brown			LIGNITE
hard, black to brown			BITUMINOUS
hard, shiny dark			ANTHRACITE

EARTH SCIENCES - SEDIMENTARY ROCKS

Lesson 3 - Sedimentary Lab I

MATERIALS:

Sedimentary Sand Kit
Swift GH
reader

Objective: Students describe sand particles.

Teacher note

Sand can be viewed using different techniques. You can have them view the sand by having the student put a little sand on tape (or any sticky surface) and glue it to an index card or just sprinkle some grains on a slide. The main point you should emphasize is that sand reflects its parent rock from which it was eroded. It is this difference that we are looking for in this exercise.

You might want to get sand that is local, river sand, lake sand or sandbox sand, and have each student compare their sand with the samples provided in the kit. You may want students to bring in sand the next time they go to the beach and have them compare it to the sands in your classroom.

Enclosed is a master of size, sorting, and roundness chart. Each group of students should have a copy of this chart. Have them sprinkle a little sand on the sheet and then compare. They can return the grains to the bag.

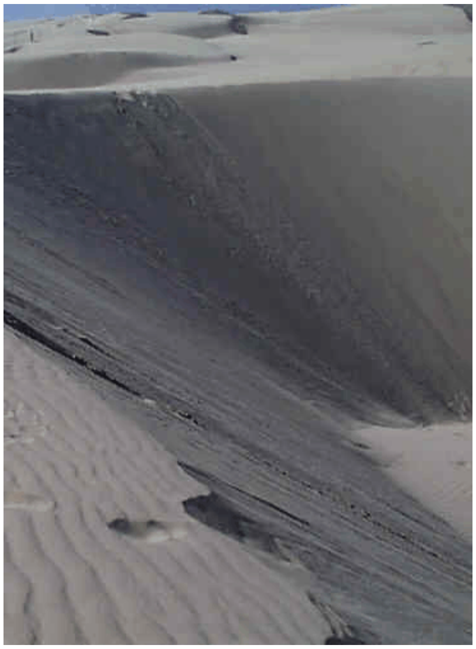
If you have a microscope or a set of hand lenses, have the students try to record what kind of "little rocks" they see. In many cases color will help them identify the different types of rocks (i.e. the red grains).

Answers for size, roundness and sorting are sometimes subjective depending on the sample the students are looking at. For example Eel River can be answered: 25- greater than 7 mm; angular - subrounded, very poorly sorted

The following web sites may be helpful:

Pasadena Community College, Sand Center
http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/

Internet Center for Sand
http://www.netaxs.com/~sparky/sand.html



Pismo Beach, California

Sand is very important in the manufacturing and the oil business. Pure **quartz** sand is used in glassmaking (because quartz is chemically made of the same components as glass), computer industry (silicon from quartz), sandblasting and sandpaper industries (because of the hardness of quartz). Other types of sands are also used to make pottery, to line the hearth of acid steel furnaces, for molding metal casts, and abrasives (garnet predominately). Sand is very important to the **cement** business. Without sand you would have no **concrete**. There would be no large buildings, no highways, no slab housing, and no large pipelines (especially sewage).

Deposits of sand under the surface of the Earth are also important because between the grains of sands there is pore space that can be filled up with water or oil. Sand acts like holding tanks for these liquids, just waiting for humans to tap them.

Geologists identify sedimentary rocks based on their **texture** (appearance) and their mineral composition. The texture of clastic sedimentary rocks can describe the grains of sand in the rock. In this lab, you will consider three textures. First, we will look at the size of the sediment particles. For example, "sand-sized" means particles from 1/16 to 2 mm in diameter. The grain size of sediments usually decreases as a stream transports grains downhill to the ocean or large lake.

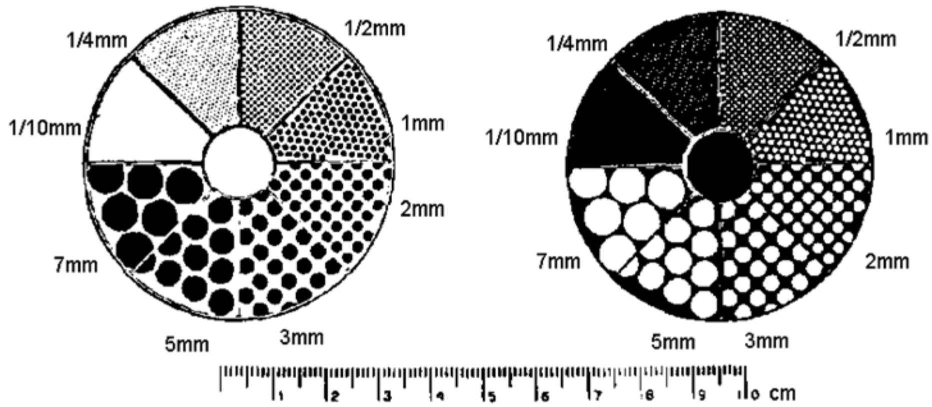
The second feature is **roundness**, defined as the presence or absence of corners and sharp edges on the particles. Particles with many edges are "angular". Particles lacking edges are "rounded". Particles get rounder as they are transported; their corners get broken off as they bump against other particles and the streambed.

Finally, the **sorting** of particles is a texture that indicates how long the sediments have been in the water system. Poorly sorted sediments show a wide range of grain sizes, while well-sorted ones have similar sized grains. Like rounding, sorting increases with transportation.

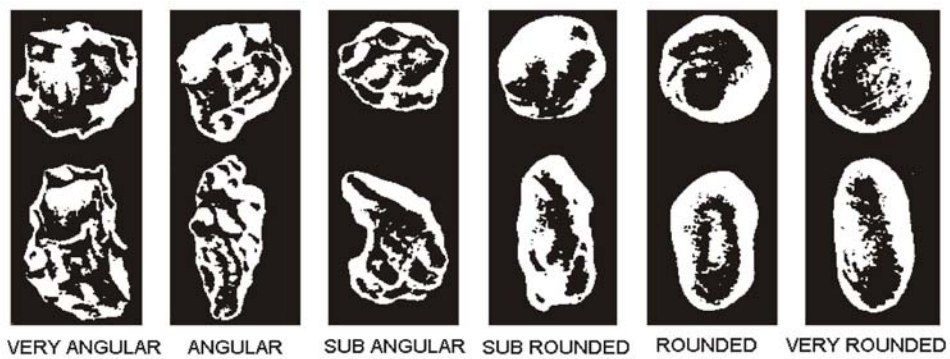
Rodeo Beach, California

Massawa, Eritrea, Africa

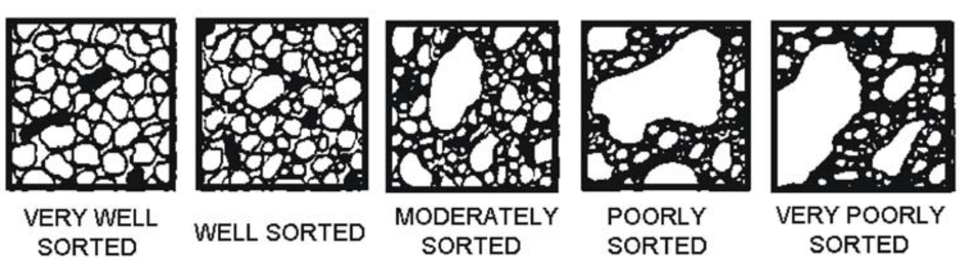
SIZE: You have two circles with dots that are the size that is written along the outside of the circle. There is a dark circle and a light one. Decide which one to use depending on the color of the sand. Sprinkle a little sand on the paper and find the size that the particles fit into. In most cases there will be a range of sizes. Size just tells you how long a particle has been eroding in the system. The longer it has been moving in the system, the particle will be generally smaller.



ROUNDNESS: Compare the particles in your sand with the pictures of roundness. You might need a hand lens or microscope, but a little imagination is fine. The rounder a particle, the longer it has been moving. In the diagram the most rounded are on the right, the most angular is on the left.



SORTING:
Sorting refers to the range in size of particles. If a sample has big and little grains it is not well sorted, but if all the particles were of the same size it would be very well sorted. Sorting is due to how the sand particles settled down. If sand is deposited in a turbulent area, the sand would not be well sorted. However, if there is a quiet setting it would be well sorted. Also, wind can carry small particles to areas on a beach or desert (sand dunes), and these sands are well sorted. In the diagram poorly sorted is on the right, and well sorted is on the left.



EARTH SCIENCES: SEDIMENTARY ROCKS LABORATORY I

PROBLEM: How can you describe grains of sand?

HYPOTHESIS:

PROCEDURE:

1. BEACH SAND - NORTH CAROLINA

Sand is weathered material, or sediment. It represents the stage between weathering of solid rock and the cementation and formation of a new sedimentary rock. Sand contains much information. The composition of sand tells where it came from. For example, sand from volcanoes is very different than sand from granite. The sorting, roundness, and grain size of sand all change as it is transported; the grains get small and rounder, and are more uniform in size.

A. This sand was collected near Charleston Beach, South Carolina. What type of weathering do you think created this sand?

B. Using the texture charts, what are the size, sorting and roundness of this sand?

C. Describe the different types of sand in this sample.

2. BEACH SAND, RODEO BEACH, CALIFORNIA

This sand is from the opposite side of the United States. It has a very different source area than the sand in Question 1.

A. Using the texture charts, what are the size, sorting and roundness of this sand?

B. Describe the different types of sand in this sample.

C. Compare this sand to the sample in question 1. How is it similar or different? What does this mean about the source area and history of two sand samples?

3. EEL RIVER, NORTHERN CALIFORNIA

Northern California has more rain then southern California. The Eel River transports sediment eroded from the mountainous area nearby.

1. Describe the different rocks you see.

2. How is this different than Rodeo Beach?

4. PALM SPRINGS, SOUTHERN CALIFORNIA DESERT

This area is a high desert located between mountain ranges in the Colorado Desert. This geography gives Palm Springs its famed warm, dry climate. Known for 354 days of sunshine and less than 6 inches of rain annually, summer temperatures reach well into the 100's.

Describe the texture of the sand?

What environment was this created in?

5. PONZA, ITALY

Situated in the Mediterranean Sea, this small volcanic island has remnants of volcanic explosions. You may also find small pieces of pottery that may be as old as Roman times.

Describe the sand?

How can you identify the volcanic component?

6. MASSAWA, ERITREA

Southern part of the Red Sea on the African side. While camels roam the desert, a rich marine life offshore is revealed by this sand.

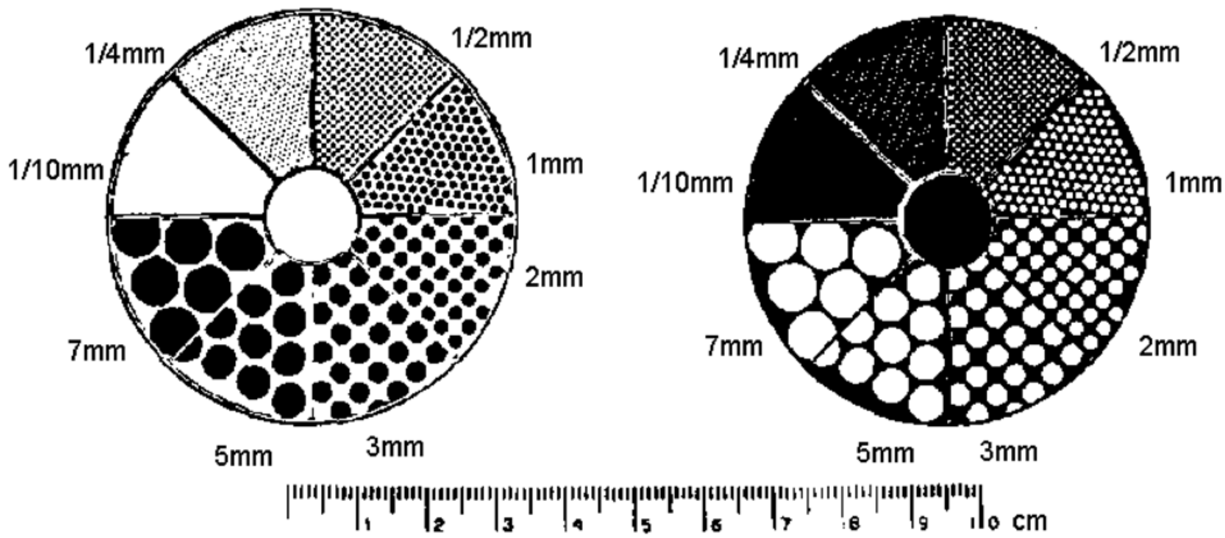
Describe the sand?

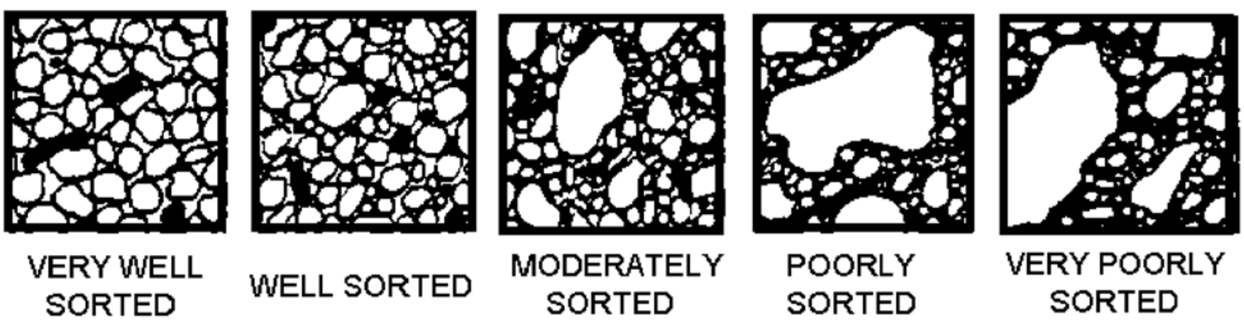
How many organisms can you identify?

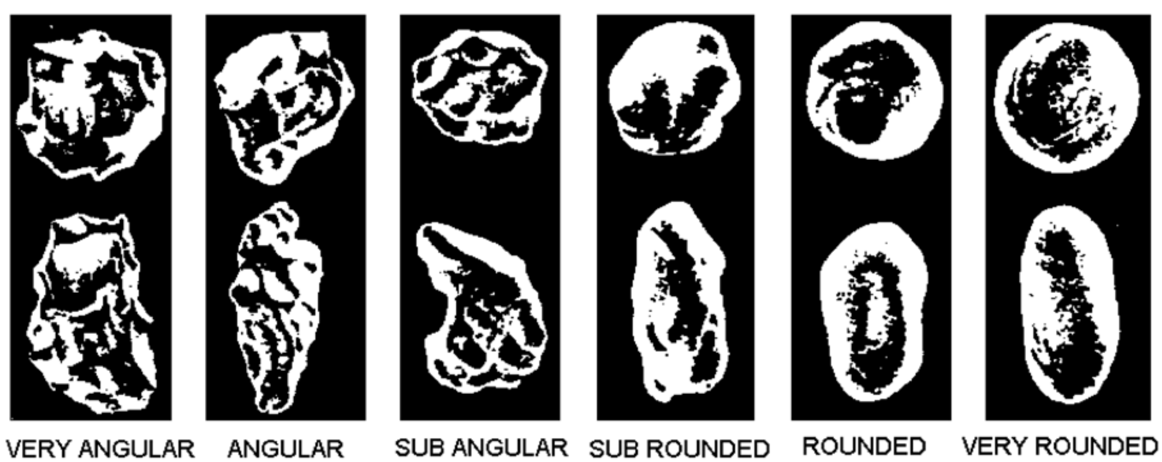
Fill in the table below using the samples provided by your instructor.

ROCK/SAND	size	roundness	sorting
Charleston, South Carolina			
Rodeo Beach, California			
Eel River, Northern California			
Palm Springs, Southern California			
Pismo Beach, Southern California			
Ponza, Italy			
Masawa, Africa			

SIZE, SORTING, AND ROUNDNESS OF SEDIMENT PARTICLES







EARTH SCIENCES - SEDIMENTARY ROCKS

Lesson 4 - Sedimentary Rock II

MATERIALS:

reader
hand lens
Sedimentary Rock Kit

Objective: Students describe and compare sedimentary rocks.

Teacher note

Make sure students know how to use a hand lens. The lens should be to the eye and then bring the sample back and forth.

Students should read the paragraph for each sample and then look at the samples. It will help them answer the questions. You may substitute your own rocks for this lab. We highly recommend that if you have sedimentary rocks in your local area to include them in this exercise.

Look at the following samples of sedimentary rocks. Remember that these are just small pieces that represent an entire **depositional** environment. Deriving information from small samples does not give you the full story. Your sample may have been created in 1 day, and then took 100 years to be cemented together. But the entire rock formation where your piece was collected may have taken millions of years to form.

Use a hand lense to look at the samples in detail. Answer the questions while looking at the sample.

Grand Canyon - a more complete picture

Limited information

EARTH SCIENCES: SEDIMENTARY ROCKS LABORATORY II

PROBLEM: What would you look for to help you identify sedimentary rocks and the environments where they formed?

HYPOTHESIS:

PROCEDURE:

PART I: Answer the following questions. Be sure to examine each specimen using the classification charts to help you.

1. CHERT

Chert is composed of microscopic quartz (SiO_2) crystals. The formation of chert is very puzzling because chert rarely can be found forming today. However, some ancient cherts contain fossils of radiolarians (visible only with a microscope), which are a type of one celled protozoa that live in the ocean. When radiolarians die, their shells sink to the deep ocean floor. This suggests that many ancient cherts were formed in deep marine water. Cherts can be red, black, white, or gray in color.

A. Describe the color of this rock

B. Chert is sometimes used to make roads and highways. Why do you think chert is a good material for this purpose?

C. If chert contains radiolarians, in what environment did this rock form?

2. SANDSTONE

A. What shape are the rock and mineral particles that make up this sandstone?

B. Describe the size and sorting of the particles.

C. Was sandstone cemented together or melted together? Explain your answer.

3. MUDSTONE

Mudstone is a fine grained clastic sedimentary rock. Mudstones are composed mainly of clay minerals, quartz, and mica, but the composition has to be determined by a microscope. Many mudstones consist of very thin layers, about as thick as the pages in a book, called laminations. Mudstones range in color from gray to white, brown, red, green to black. Mudstones indicate a quiet water, low energy sedimentary environment, like the deep ocean or a lake bottom.

A. Does your mudstone sample make a thud or a ring when lightly (6 inches from tabletop) dropped?

B. Are the grains in mudstone visible?

C. Does mudstone feel smooth or coarse?

D. Is mudstone layered or banded?

4. DIATOMITE

Diatomite has the same size particles as mudstone. However, the particles aren't clay or quartz, but are the skeletons of a one celled plant called diatoms. Diatoms live near the ocean surface. When they die, their skeletons accumulate to create a mudstone-like deposit of on the sea floor.

A. What is the relative density of this diatomite (light or heavy?) Explain your answer.

B. What is the size of the particles making up this diatomite?

C. Diatoms are one celled plants that either live in marine or fresh water. Radiolarians are one celled protozoa that eat diatoms. Radiolarians only live in marine water. If there are both diatoms and radiolarians in this rock. Where did it form?

D. Put the diatomite sample on the tip of your tongue. What happens?

You have just found out that there is a mineral called kaolinite in this rock. Kaolinite is very effective at absorbing water. What over the counter medicine has "kao" in its name?

What mineral do you think is in this medicine?

5. SHALE

Shales are similar to mudstones in composition and texture, but are composed of slightly larger particles. They are also deposited in quiet water environments.

A. Examine this specimen with a hand lens or microscope. Can you describe the roundness, sorting and size of the particles?

B. What kind of material (hint - what mineral?) may cement the particles in your shale sample together, if any? How can you tell?

C. Does your sample show any other interesting features?

6. LITHOGRAPHIC LIMESTONE

Lithographic limestone is composed of the mineral calcite ($CaCO_3$). The mineral crystals are very small. They are visible as tiny sparkles when you look at a piece of it in bright light. Lithographic limestones are created in two ways. Most are composed of microscopic skeletons of marine plants and animals, which were cemented together after they died. Others formed by mineral precipitation from lake or ocean water.

A. Describe your specimen.

B. Are crystals visible?

C. Lithography is a type of printing, often used for illustrations. Why do you think this type of rock was used for this purpose?

7. FOSSILIFEROUS LIMESTONE

This type of limestone is made from visible fossils that have been cemented together. Most fossiliferous limestones formed in the ocean. They may contain fossils of molluscs like clams and snails, coral, or crinoids (sea lilies), or even fish bones. This type of rock contains important information about the history of life on Earth.

A. Describe your specimen. What color is it? How much of the rock is composed of fossils (give a percentage)?

B. Identify the fossils in the rock, if you can.

8. COAL

Coal is composed of fossil plants which have been buried, heated, and put under pressure. These changes have altered the original plant material into simple hydrocarbon compounds. These burn easily, which is why coal is used as a fuel. There are three types of coal: anthracite, bituminous coal, and lignite. Anthracite is shiny black and hard; bituminous coal is duller and sometimes a black brown color; and lignite is dull brown and soft.

A. Describe your specimen.
B. Which type of coal do you have?

C. Compare your specimen of coal with charcoal. Describe the similarities and differences.

9. QUARTZ is a mineral with the chemical composition SiO_2. It is a common cement in sedimentary rocks; it forms the “glue” which holds the grains together. Quartz cements form when water carrying dissolved quartz flows through the spaces between sediment grains. Given the right chemical conditions, quartz crystals will begin to precipitate on the surfaces of the grains. As the crystals grow, they fill up the spaces, making a solid rock.

A. Why is quartz a good cementing agent?

10. GEODE. A geode is formed when an open space in a rock is filled by precipitated minerals, usually calcite or quartz. Like making cements, this happens as water flows through the open space. The crystals begin forming around the edge of the space, and grow inward. To be a geode, there must be some remaining open space in the specimen. Geodes that completely "fill up" are called thunder eggs.

A. How could you determine what mineral makes up this geode?

B. How can you identify if a rock is cemented by quartz?

11. CALCITE ($CaCO_3$) is another common sedimentary rock cement. It forms in a similar fashion to quartz cement, by precipitation of minerals in the spaces between sediment grains, making a solid rock.

A. How can you tell if you have calcite cement? (Hint: what chemical reaction helped you recognize calcite in the minerals lab?)

B. Which cementing agent is harder, calcite or quartz? Explain your answer.

PART II.

Using your answers to the above questions and the identification charts, fill in the table below.

ROCK/SAND	DESCRIBE ie. color, sorting, crystals	ENVIRONMENT THAT IT WAS FORMED IN
lithographic limestone		
fossiliferous limestone		
chert		
sandstone		
mudstone		
diatomite		
siltstone		
quartz		
calcite		
geode		

EARTH SCIENCES - SEDIMENTARY ROCKS

Lesson 5 - Sandstones through Time

MATERIALS:

reader

Objective: Students explore the ancient sand dunes of Zion National Park, Utah.

Teacher note

Zion National Park, Utah is a good example of using sedimentary rocks to understand how the layers of rock were formed. The cliffs of the eroding rocks reveal a vertical time slice back to the Permian, over 270 million years ago. Zion shows sedimentary rocks that were formed in water and desert conditions.

The following web links can help you understand the process more.

http://www2.nature.nps.gov/grd/parks/zion/ - the official National Park Service website on the geology of Zion National Park. Describes geological history of the park area, and also has information on natural history and tourism.

http://www.desertusa.com/magjan98/dunes/jan_dune1.html - a good site describing the origin of sand dunes. It has additional interesting links to the biology of desert regions. Written by a biology professor at Palomar College (California).

http://waynesword.palomar.edu/ww0704.htm#Introduction - informational site on sand dunes

http://oldsci.eiu.edu/geology/parks/norris/zionnps.htm - stratigraphy of Zion National Park

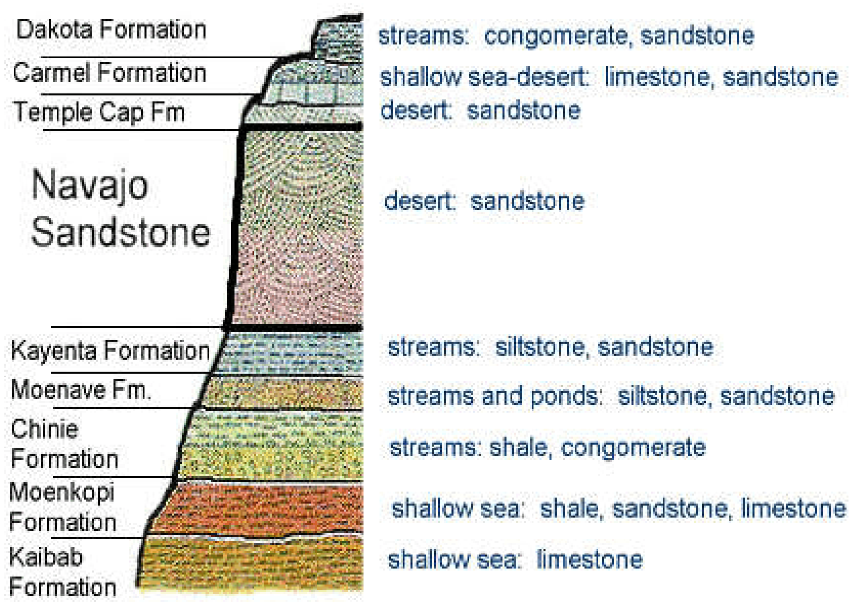
Zion National Park

Zion National Park is a very special place in southeastern Utah. It hosts the most diverse collection of native plants in Utah, almost 800 different species. Parts of the park were inhabited by Native Americans over 1000 years ago. The ruins of their dwellings are still visible today.

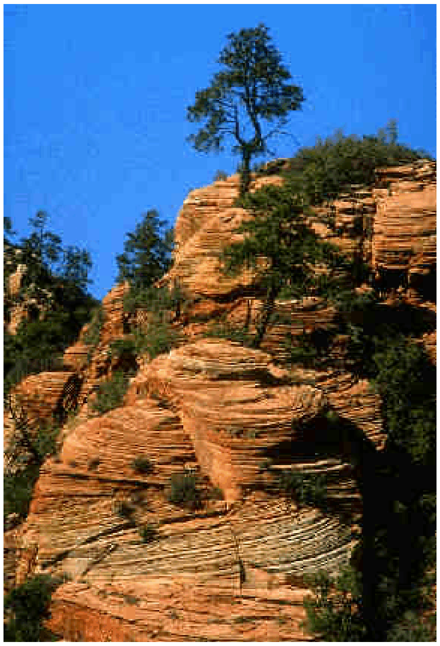
The first sights you will notice about the park are the towering cliffs and **monoliths** of sedimentary rock. The cliffs are many different colors. These features are especially beautiful in Zion Canyon. Here they form some of the tallest sandstone cliffs in the world, rising over 700 meters above the canyon floor. These sandstones are over 3,000 meters in thickness and record about 240 million years of **deposition.**

Indian Petroglyphs

If you were to look closely at the rocks in the cliffs of Zion Canyon, you would observe rocks composed largely of sandstone called the Navajo Sandstone. The sand grains in the Navajo Sandstone are very well sorted and highly rounded. The sand is composed almost completely of quartz and therefore classified as a quartz sandstone.



The Navajo Sandstone is referred to as a **formation**, which is a unit of rocks that can be mapped for a long time. There are other rock formations throughout the park that indicate changing environments through time, as shown in the diagram. The Navajo Sandstone occurs in distinct beds. A **bed** is a layer of sediment or sedimentary rock. Most beds form as sediment is deposited.



Navajo Sandstone cross bedding

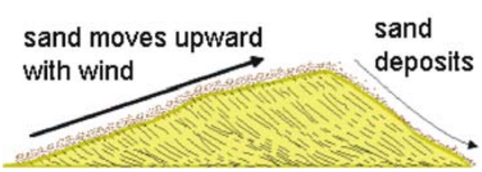
The Navajo Sandstone is the largest unit in Zion National Park. However, the rocks that are younger were deposited in wetter conditions. The Navajo Sandstone was deposited during desert conditions which continued for about 20 million years. The Navajo Sandstone was formed when the dinosaurs were rulers of the Earth.

In the Navajo Sandstone you see thick, almost **horizontal beds,** which may be up to 7 meters in thickness**.** Within these thick horizontal beds are thinner structures that show **cross bedding**, because they are angled with respect to the horizontal beds. The picture shows both horizontal and cross beds. Cross bedding indicate that sediments were deposited by a steady flowing **current** of either water or wind. So how do geologists know the Navajo was deposited in desert conditions?

It was hard for geologists to determine that the Navajo cross bedding were once sand dunes, because cross bedding is created in many different ways. Cross-beds of many different shapes and sizes are also made in water environments, such as beaches, rivers, and the deep-sea.

Sand dunes in Colorado

Geologists have used the study of sedimentary environments to understand the Navajo Sandstone. They have discovered that the cross bedding in the Navajo almost exactly resemble the cross bedding that form in sand dunes. **Sand dunes** are mounds of sand moved by the wind. They commonly form in dry Earth surface environments.



The formation of a sand dune and a cross bedding structures

From observing active sand dunes, we know how they form cross bedding. Viewed from one end, sand dunes have a flat back side and a steep front side. The wind blows up the back side of the dune. If the wind moves fast enough, it will pick up and transport sand grains up the back of the dune. When the wind goes over the top of the dune, it slows down. This causes it to drop the sand grains it was carrying. The cross-bed gets flatter at the bottom because some of the sand rolls down to the bottom of the dune and piles up.

Sand dunes become sedimentary rock through **cementation**. This happens in several stages. First, after the sand dune forms, it is usually buried below the Earth's surface as newer sand dunes cover it. Second, during and after the dune is buried, water within the ground begins to move through it. The water flows in the spaces or **pores** between individual sand grains. This water often contains dissolved silica (SiO_2) or calcium (Ca) and carbonate ($CaCO_3$). If the chemical conditions are right, the third stage, cementation, will occur. Quartz or calcite crystals will precipitate in the spaces between the sand grains. They will grow until the spaces are filled up, effectively cementing the sand together.


Sand Mountain in Fallon, Nevada

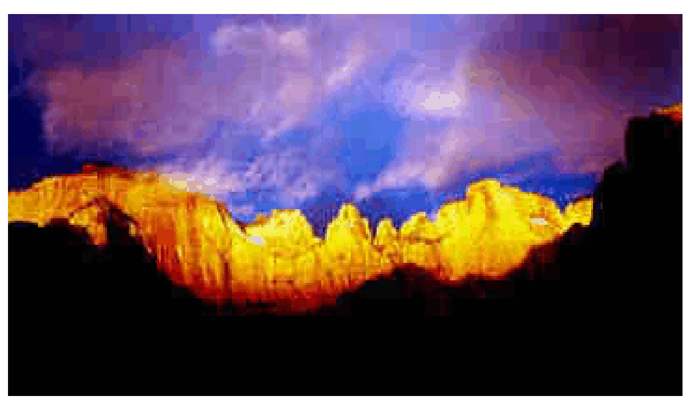

Sand dunes in Oregon, USA


Navajo Sandstone

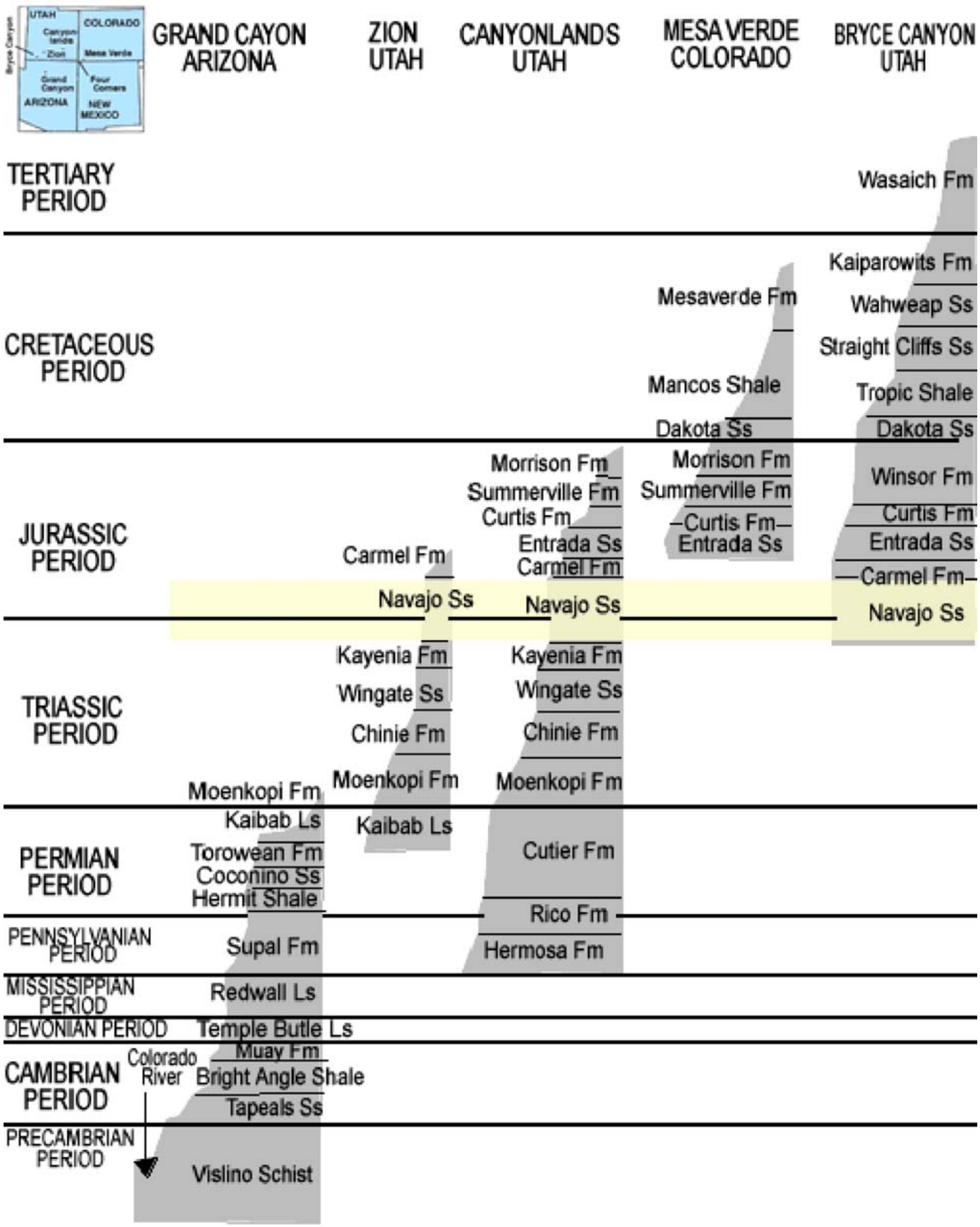
Sand dunes are common in two modern sedimentary environments: beaches and deserts. The size and shape of the beds in the Navajo Sandstone, along with other sedimentary features found in it, indicate that the Navajo formed in a desert environment. Land fossils in the Navajo, including petrified wood and the footprints of lizards and dinosaurs, further suggest that the unit formed during the early Jurassic Period of the **Mesozoic Era**, about 150 million years ago.

The Navajo Sandstone does not occur just in Zion National Park. It is found over an area of 1,500,000 square miles of the Southwestern United States. This indicates that when the Navajo Sandstone formed during the **Jurassic Period**, this part of the United States was like the modern Sahara Desert of Africa. It was a very hot, dry, and windy place. Great seas of sand dominated the landscape.

If you ever go to Zion National Park on vacation, be sure to look closely at the rocks. Try and imagine a time when this area was a desert, covered by fields of giant sand dunes.


Sunset on the cliffs of Zion National Park

Distribution of Sedimentary Rocks of southwestern United States



Earth Science- Sedimentary Rocks - Unit Test

Part 1. Definitions Match the number of the term or concept in Column 1 with the letter of the correct definition in Column 2.

Column 1	Column 2
1. weathering	a. a descriptive word to describe sediments
2. clastic sedimentary rock	b. a type of clastic sediment
3. sand	c. a sedimentary rock composed of compressed plant material
4. roundness	d. a sedimentary rock composed largely of the mineral calcite
5. limestone	e. the destruction of rocks at the Earth's surface
6. stream	f. the movement of sediment by wind, water, or ice
7. coal	g. minerals which can cement sediment together
8. transportation	h. a rock composed of pieces of preexisting rock, cemented together
9. Quartz/calcite	i. a sedimentary environment
10. sorting	j. the range of grain sizes in a sedimentary rock

Part 2. Multiple Choice Choose the best answer to complete each statement.

1. Sedimentary rocks form:
    a. in the core of the Earth
    b. around or near water
    c. on Jupiter
    d. in magma chambers

2. Weathering occurs in the following except:
    a. streams
    b. oceans
    c. volcanoes
    d. glaciers

3. Weathering produces
    a. new minerals
    b. pieces of rock
    c. dissolved material
    d. all of the above.

4. The texture of a sedimentary rock is:
    a. how heavy it is
    b. what it smells like
    c. what it looks and feels like
    d. how hard it is

5. Which of the following is not usually considered a sedimentary environment?
    a. volcano
    b. desert
    c. stream
    d. glacier

6. Sedimentary rocks are classified using:
    a. color
    b. smell
    c. composition and texture
    d. origin

7. Chert is a rock composed of:
    a. calcite
    b. sand
    c. borate
    d. quartz

8. Diatomite contains:
    a. sand grains
    b. fossils and clay minerals
    c. gravel
    d. pebbles

ANSWERS:

Part I
1-e
2-h
3-b
4-a
5-d
6-i
7-c
8-f
9-g
10-j

Part II
1-b
2-c
3-d
4-c
5-a
6-c
7-d
8-b