

# EDUCATOR RESOURCE GUIDE

A STORY 1.7 BILLION YEARS IN THE MAKING

# GRAND CANYON

RIVERS OF TIME

AS SEEN IN **IMAX**<sup>®</sup>



[grandcanyonriversoftime.com](http://grandcanyonriversoftime.com)



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## The Rock Cycle

New crust is continuously being added to the Earth. Rocks that form the Earth's crust were once molten, then cooled and hardened. These are called *igneous rocks*. Basalt, granite and pumice are examples of common igneous rocks. When the rocks become exposed, *weathering* reduces the rocks to *sediment*. This loose rock material is transported or *eroded* by streams, wind, glaciers, and landslides. Eventually the sediment will accumulate in layers and become *compacted* and *cemented* by minerals to form *sedimentary rocks*. Sandstone, shale, and limestone are examples of common sedimentary rocks.

Rocks can become deeply buried and then changed by pressure and heat to form *metamorphic rocks*. Marble, schist, and slate are common metamorphic rocks. If the rocks are buried even deeper they can *melt*. The melted rock or *magma* can return to the Earth's surface through volcanic eruptions. Some igneous rock cools slowly beneath the Earth's surface to form *granite*.

Sometimes igneous rocks can undergo metamorphism directly. Sometimes metamorphic rocks can be weathered and eroded. Now the cycle is complete. These processes can be repeated and are called the *Rock Cycle*.

Here is one example of a rock's progress through the rock cycle: An igneous rock cools underground to form granite. The granite becomes weathered and eroded to form sediment sand. The sand becomes compacted and cemented to form sedimentary rock sandstone. The sandstone can be subjected to pressure and heat forming the metamorphic rock quartzite.

### Questions

1. What is needed to change sedimentary rock into metamorphic rock?

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2. What is needed to change a metamorphic rock into an igneous rock?

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3. What is needed to change an igneous rock to a sedimentary rock?

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4. Rocks can take "short cuts" in the rock cycle. Describe how a sedimentary rock can form new sedimentary rock.

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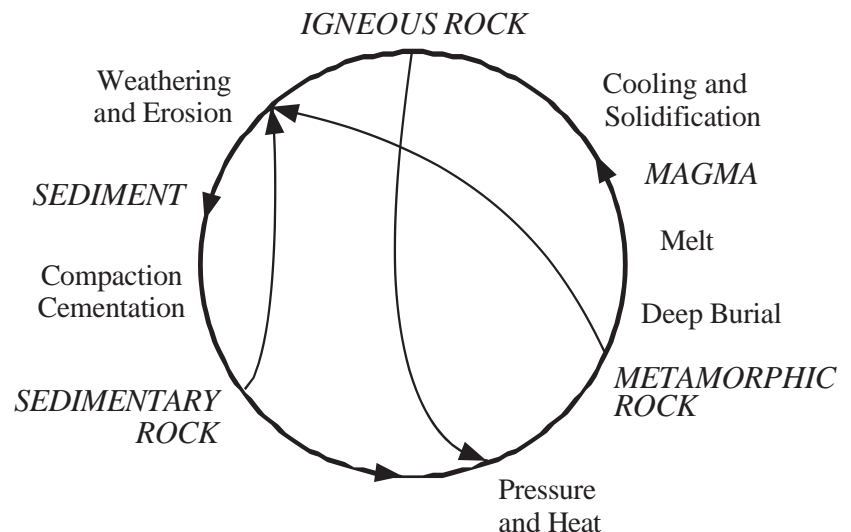


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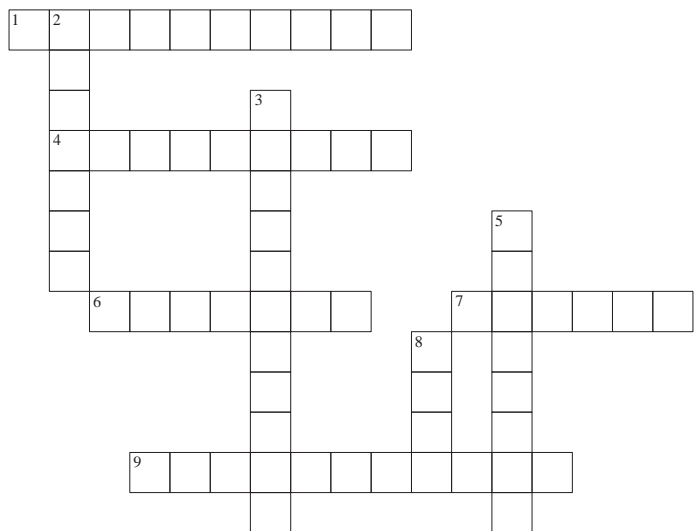
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5. Trace the path an igneous rock could take to become metamorphic rock.



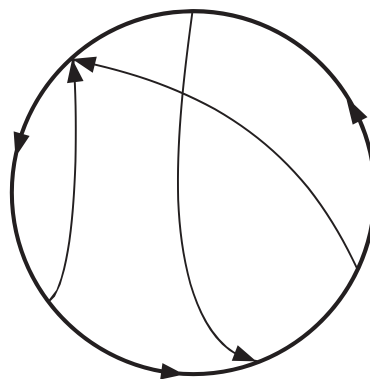
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## Build a Rock Cycle



### Directions

Complete the crossword puzzle with words related to the Rock Cycle. Then label the blank Rock Cycle diagram by using the words you used to complete the crossword puzzle.



### Clues Across

1. The geologic process that wears down rocks
4. The end product of weathering
6. Magma produces rock
7. This matter combines with sediments to produce sedimentary rocks
9. Layered rocks composed of rock or fossil

### Clues Down

2. The geologic process that transports sediments
3. Rocks changed by heat or pressure
5. This changes limestone to marble
8. To become igneous rocks, deeply buried rocks must first \_\_\_\_\_

## Life of a River

### YOUTH

V-shaped channel  
Steep slope  
Straight slope  
Few, small tributaries  
Waterfalls and rapids are common  
*Eroding force: Cuts downward*

### MATURITY

Wide Valley  
Moderate slope  
Channel wanders  
Distinct flood plain  
Tributaries are common  
*Eroding force: Cuts downward and sideways*

### OLD AGE

Broad flood plain  
Gentle slope  
Large meanders  
Oxbow lakes  
Levees, deltas, marshes  
Limited, but large tributaries  
*Eroding force: Cuts sideways to create width of channel*

### Questions

1. You can use the chart above and your observations from the film Grand Canyon: Rivers of Time to determine the "age" of the Colorado River. In which stage is the Colorado River where it flows through the Grand Canyon?
2. The Colorado River is brown and muddy. Why is this so? \_\_\_\_\_
3. Which of the three river stages deposits the most sediment? Why? \_\_\_\_\_
4. How does the Colorado River cut through solid rock like it did in the Grand Canyon? \_\_\_\_\_
5. What happens to the sediments carried by the Colorado River? \_\_\_\_\_

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## Weathering and Erosion

*Weathering* is a process that wears down and breaks rocks into smaller particles. These particles are called *sediment*. In this handout you will investigate *physical* and *chemical* weathering.

### Physical Weathering

Physical weathering relies on the physical forces of heating and cooling, ice wedging, and impact. You can observe the effects of ice forming in the cracks in rocks. To do that you need plaster of paris, water, styrofoam cup, small water balloon, stir stick, and a freezer.

#### Procedure:

1. Mix water with plaster of paris until it is smooth and the consistency of yogurt. Allow the plaster to thicken slightly.
2. Fill a small water balloon with water and tie it tightly so that it is about the size of a ping pong ball.
3. Push the water-filled balloon into the plaster mixture in the styrofoam cup. Hold the balloon in the plaster until the plaster thickens enough to keep the balloon from rising.
4. Place the cup with the plaster and balloon into the freezer overnight.
5. Describe what has happened to the plaster and cup after the water in the balloon froze.

#### Questions:

1. What caused the cup and plaster to crack? Why?

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2. Describe how this process would occur naturally. Can you list places where this is happening in nature?

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### Chemical Weathering

This type of weathering occurs when rocks are dissolved or chemically changed. Rocks can absorb moisture and the moisture can combine with minerals. Sometimes the minerals dissolve or disintegrate to release mineral grains from rocks. Rocks can also react directly with chemicals in the air such as oxygen. Oxygen will cause *oxidation* or rusting or iron compounds. Water from rainfall can mix with carbon dioxide or sulphur dioxide to produce acid. Have you heard of *acid rain*? Acid rain can react with rocks and dissolve them.

To do this activity you need steel wool, tap water, salty water, marble (the rock, not a child's toy), limestone or seashell: *dilute* acid (CAUTION: Acid can be dangerous when not used properly: be sure to do this activity under the supervision of an adult).

#### Procedure A:

1. Place a piece of steel wool in a dish and sprinkle it with water.
2. Place a second piece of steel wool in another dish and sprinkle with salty water.
3. Record what happens to both samples over a week's time.

#### Procedure B:

1. Drop weak acid on marble, limestone, or a sea shell.
2. Describe the effect of the acid on the sample.

#### Questions:

1. Describe your observations of the steel wool with salty water and tap water.

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2. Steel wool is made from iron. When it oxidizes, or rusts, it turns orange-red. What color do you think iron compounds in rock will turn when they oxidize? What kind of compounds are in the red rocks of the Grand Canyon?

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## Reviewing What You Learned

### Directions

Find the terms from the Word List in the Word Search. Words may be printed horizontally, vertically, or diagonally.

### Word List

BASALT	HEAT
EROSION	IMAX
PRESSURE	POWELL
IGNEOUS	CEMENT
GRANITE	SAND
MELT	MARBLE
SCHIST	
SANDSTONE	
COLORADO RIVER	
GRAND CANYON	
SEDIMENTARY	
WEATHERING	
METAMORPHIC	
SEDIMENTS	

Z	C	I	W	Y	B	O	P	V	W	K	P	L	Z	U	P	J	O	E	V
R	G	I	C	L	N	U	D	H	F	S	S	R	E	F	T	C	Q	U	O
T	G	Y	H	E	G	M	L	M	T	L	V	R	E	V	T	I	S	D	L
A	U	S	R	P	M	N	A	M	E	T	D	E	A	S	M	Q	J	M	Z
Q	Z	T	D	Y	R	E	I	R	I	L	N	V	A	A	S	G	G	V	B
R	X	N	S	R	E	O	N	R	B	D	T	I	X	B	R	U	J	K	G
Y	A	E	A	A	O	C	M	T	E	L	J	R	T	A	J	S	R	R	N
S	A	M	N	T	Y	L	X	A	A	H	E	O	N	B	U	H	A	E	P
M	M	I	D	N	I	H	L	S	T	K	T	D	N	G	O	N	E	S	S
T	S	D	S	E	P	C	A	E	T	E	C	A	D	X	I	T	R	U	M
X	X	E	T	M	X	B	F	S	W	A	M	R	E	T	Q	J	O	R	S
F	Z	S	O	I	X	G	I	T	N	O	L	O	E	W	M	E	S	Y	R
J	G	H	N	D	H	H	X	Y	A	J	P	L	M	G	N	U	I	K	Y
P	K	Z	E	E	C	G	O	T	P	E	B	O	J	G	J	I	O	T	Q
S	M	F	G	S	I	N	F	A	U	Y	H	C	I	F	U	X	N	W	T

**Define the words below using your science book or the handout "*The Rock Cycle*."**

basalt:

Grand Canyon:

cement:

igneous rock:

Colorado River:

sedimentary rock:

erosion:

metamorphic rock:

## Materials made possible by the California Museum Foundation

### To the Educator

These materials are intended to be used in conjunction with viewing of the IMAX film *Grand Canyon – Rivers of Time*.

### Objectives

After students have viewed *Grand Canyon – Rivers of Time* and used the classroom materials, they should be able to: discuss the rock cycle; discuss the major rock types found in the Grand Canyon; discuss the influence of physical and chemical weathering on rocks; and discuss the stages in a river's life cycle.

### Materials in this Package

I. This Teacher's Guide

II. Four Student Handouts:

- 1 The Rock Cycle
- 2-3 Build a Rock Cycle and Life of a River
- 4 Weathering and Erosion
- 5 Reviewing What You Learned

### Suggested Sequence of Use

1. Make arrangements for attending the IMAX Theater and view the film *Grand Canyon – Rivers of Time*.
2. Review the **Discussion Questions for Use Before Viewing** in this **Teacher's Guide** and use those that are appropriate to your class and grade level.
3. Duplicate and distribute the appropriate **Student Handouts** when called for, if they are consistent with your curriculum.
4. Review the **Discussion Questions for Use After Viewing** in this **Teacher's Guide**, and use those that are appropriate to your class and grade level.

### Discussion Questions for Use Before Viewing

1. Duplicate and distribute **Student Handout 1**, "The Rock Cycle." Key vocabulary words are *italicized*. Some students may need help in reading the passage and interpreting the diagram. The processes are cyclic and proceed counter-clock-wise. Many rocks can be seen in the film; use the handout to review the three major rock types (*igneous, metamorphic, sedimentary*) and processes (*weathering, erosion, compaction and cementation, burial, heat and pressure, melting, etc.*)

*Answers to questions:* 1. Pressure and heat 2. Deep burial and melting 3. Weathering, erosion, compaction and cementation. 4. Sedimentary rock can be directly weathered and eroded, then deposited to become compacted and cemented.

2. **Student Handout 2**, "Build a Rock Cycle," can be used either as a *quiz* or to *reinforce* concepts from Student Handout 1. *Answers are:* Across: 1-weathering; 4-sediments; 6-igneous; 7-cement; 9-sedimentary. Down: 2-erosion; 3-metamorphic; 5-pressure; 8-melt. Using the terms from the crossword puzzle, students' rock cycle diagrams should look like that from Student Handout 1.

### Discussion Questions for Use After Viewing

1. Ask students to identify as many rock types as they can that they saw in the film. The walls of the Grand Canyon contain three major rock types: Sedimentary-sediments deposited by wind or water are compacted and cemented to form great cliffs of sandstone, limestone or slopes of shale. Metamorphic-sedimentary and igneous rocks have been buried, subjected to pressure and heat and eventually altered to form the Vishnu schist seen in the film. Igneous-molten rocks cooled slowly and were later exposed in the canyon; some lava flows occur in the western part of the Canyon.
2. Duplicate and distribute **Student Handout 3**, "Life of a River" and discuss the chart with your students. Ask students to identify stages in the life cycle of the Colorado River which flows through the Grand Canyon. *Answers to questions:* 1. The Colorado River is a youthful river in the Canyon. Farther downstream students may notice a widening of the valley where the river is reaching maturity. 2. The river is muddy because of the sediments it is carrying. 3. Rivers deposit the most sediments during old age. As rivers slow down they are unable to carry as much sediment as they can when the water rushes along the river channel. 4. The swift current carries tons of silt, sand grains, and boulders. These sediments act like "drill bits" and have cut through more than a mile of solid rock in the deepest part of the Grand Canyon. 5. Sediments are deposited behind dams along the Colorado River. 3. Ask Students how they think the canyon got so wide in places. Most will answer that running water caused this. Actually most of the 18 miles between canyon rims is caused by mass wasting (rock slides) rather than rainfall runoff or the Colorado River. Rock particles are loosened from



canyon walls because moisture in the cracks repeatedly freezes and thaws. The Colorado River has been uplifted so rapidly (from frequent periods of mountain building in the Colorado Plateau) that most of its energy is used to cut downward through rock and to transport sediment.

4. Duplicate and distribute **Student Handout 4**, "Weathering and Erosion". These are student activities designed to demonstrate selected aspects of physical and chemical weathering. The materials are common, easy to obtain, and safe for students to use. *Answers to questions (Physical Weathering):* 1. The ice cracked the plaster and cup. As water freezes it expands. Since the balloon was constrained by the plaster, the freezing water had no room to expand. 2. Moisture seeps into the cracks in rocks; repeated freezing and thawing enlarges the cracks and sometimes works rock particles (up to the size of boulders) loose. Yosemite National Park is a classic area; local mountains; other rocky areas where freezing occurs. *Answers to questions (Chemical Weathering):* 1. Both samples should rust; the sample in salt water should rust quicker than the steel wool in tap water. 2. The rocks should turn orange-red or yellow-orange. The rocks in Grand Canyon contain iron compounds.

5. Duplicate and distribute Student Handout 5, "Reviewing What You Learned" and discuss the directions with your students.

## Key For Word Search

. C . . . . . P . . . . .  
. . I C . . . . . R . . . . .  
. . . H E G M . M . . . . . R E . . I . . .  
. . S . P M N A . E . . E . S M . . . .  
. . T D Y R E I R . L . V . A S G . . . .  
. . N S R . O N R B . T I X . R U . . G  
. A E A A . . M T E L . R . A . . R R .  
S . M N T . L . A A H E O N . . . A E .  
. . I D N . . L S T . T D . . . N E . S  
. . D S E . . A E T E C A . . I . R U .  
. . E T M . B . S W A M R E T . . O . .  
. . S O I . . I T N O . O E W . E S . .  
. . . N D . H . Y A . P L . . N . I . .  
. . . E E C . O . . E . O . G . . O . .  
. . . . S . N . . . . H C I . . . N . .

## Other Free Classroom Materials

### General geology:

U.S. Geological Survey  
Geologic Inquiries Group  
Mail Stop 907  
Reston, Virginia 22092

### Careers:

Education Director  
The American Geological Institute  
4420 King Street  
Alexandria, Virginia 22303

## Selected References

Collier, Michael. 1980. *An Introduction to Grand Canyon Geology*. Grand Canyon, AZ: Grand Canyon Natural History Association.

Franklin, Jacque and Huey, George. 1983. *Where Do I Look*. Grand Canyon, AZ: Grand Canyon, AZ: Grand Canyon Natural History Association Children's Book.

McKee, Edwin D. 1966. *Reading the Rocks: A Guide to Geologic Secrets of the Canyons, Mesas, and Buttes of the American Southwest*. San Francisco: Sierra Club.

Powell, John Wesley. 1895. *Exploration of the Colorado River and its Canyons*. Washington, D.C.: Smithsonian Institution. Reprinted by Dover Press, 1961, New York.

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