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2015 Summer Institute on China

Dunhuang Caves & Weathering

Class
6th Grade Earth Science

Standards
Next Generation Science Standards MS-ESS2-2 and MS-ETS1-4

Organizing Questions
1. What are the different effects of weathering on the landscape? On man-made structures?
2. What contributes to the weathering of the Mogao Caves?
3. What things can be done to prevent deterioration of the structure?
4. What are people doing at the site to protect the caves?

Introduction
This lesson will review what the class has learned so far about the Earth's surface and factors that affect its shape (wind, rain, plant growth, etc.). Students will discuss how those factors differ across various environments and use a graphic organizer to demonstrate how they would affect the earth's surface. We will then look at the factors specific to a desert environment. Students will briefly learn about the Mogao caves' historical beginnings and its current situation in terms of exterior physical deterioration. Our slideshow will show pictures and diagrams of the unpreserved caves and their environment.

Students will plan ways to prevent further deterioration and explain why they have chosen their particular preservation techniques. They will then create a model cave and implement their proposed preservation plans. We will discuss what weathering events can occur and the effectiveness of their plans. The teacher will assess the students' understanding of weathering factors, the quality of their preservation plan, and the reason their plan and reasoning. Students would then be shown the current state of the caves and learn about specific preservation techniques from the slideshow. This activity could be extended for students wanting to create preservation plans for other sites in different environments, or who want to simulate their plan using a model.

Objectives
1. Students will define different factors that contribute to weathering (physical and chemical weathering)
2. Students will analyze the environment to identify weathering factors at a site.
3. Students will discuss, and then learn about, what can be done to preserve the Mogao caves.
4. Students will create a preservation plan that can be discussed and / or tested.
5. Students will appreciate the challenges faced by geologists working to preserve these sites in harsh environments.

Materials

1. Reading material on weathering, 1 set per student
2. Attached graphic organizers "Types of Weathering in…" & "Weathering in Mogao Grottoes" model, 1 copy per student
3. Link to Slideshow of Mogao and surrounding environment (#1-9: Desert & Caves Before and #10-18: After) https://docs.google.com/presentation/d/1VjkurDGYXk-OJrCM6dYp0TAXsv2mjbW4Il5ET1-zfWQ/edit?usp=sharing
4. Attached activity write-up "Preservation of the Mogao Grottoes", 1 copy per student

Equipment

1. Projector
2. Computer (for teacher)

Teacher Prep

1. Cover weathering material in class.
2. Make copies of the handouts.
3. Make sure projector is set up and functioning properly for the slideshow presentation
4. Optional Extension Activities: Prepare Handouts for "Ancient Site Preservation Plan" or Prepare Handouts for "Lab: Weathering at Mogao Grottoes"
5. Prepare sandstone brick or sedimentary rock model for each student/pair/group. Teachers will need preservation materials (cardboard/recycled boxes, cotton balls, liquid glue, clay, popsicle sticks) and weathering materials (spray bottles/water, blow dryers and playground sand).

Time

One 50-minute class period, plus one optional 30-50 minute class period for the extension activity

Procedures

Day 1

1. Warm up (3 minutes)
    a. Students will quickly discuss with a partner what processes of weathering they have learned about so far, i.e. Physical (erosion from water or wind, pressure release, plant growth, ice wedge), Chemical (rust, acid rain), etc.
    b. As a class, discuss a few examples of weathering processes and describe how each affects the surface of the earth differently.
2. Graphic Organizer (8 minutes)
    a. Hand out a copy of "Types of Weathering in…" graphic organizer to each student.
    b. Students can collaborate with their table groups by each completing one environment, or they can work individually.
    c. Teacher can decide whether to review answers as a class or go over the factors specific to each environment using an answer key.
3. Introduce Caves and Problem (10 minutes)
    a. Ask the class, "What are some man-made structures that you have learned about in your history / social science classes?" (Answers can include the Pyramids, the Great Wall of China, Stonehenge, etc.). "Does weathering affect them?" Use this discussion to introduce the Mogao Caves at Dunhuang and show the slideshow.
    b. Introduce the Mogao Caves with slides 1-9 on the attached slideshow:

i. Slide 1: "The Mogao Grottoes is a famous world cultural heritage site in the western Gansu Province, China. This historic site contains 45,000 square meters of priceless Buddhist murals, 2,500 painted sculptures, and 492 caves. Now imagine you are in the Gobi Desert in China…" Discuss with the students what you would sense: sights, sounds, smells, etc.
ii. Slide 2: "Dunhuang has mountains made of sandstone and sedimentary rock."
iii. Slide 3: "Caves were built in these mountains from the 4th to the 14th century C.E."
iv. Slide 4: "They were commissioned by and built for Buddhist monks, who would enter the caves to pray and meditate."
v. Slide 5: "The interiors of the cave were decorated with paintings, statues, and shrines."
vi. Slide 6: "The caves were abandoned for roughly 400-500 years before being rediscovered in the 1900s."
vii. Slide 7: "By then, many of the caves were deteriorating or buried in the sand."
viii. Slide 8: "What factors contributed to this weathering in the desert?" Have the class discuss.
ix. Slide 9: "When the caves were rediscovered, people knew that the art and contents of the caves were extremely valuable cultural resources and that they needed to be studied and preserved." List and describe some of the natural factors that contribute to the caves' weathering in the Types of Weathering handout's Desert box (i.e. Abrasion – sandstorms damage cave entrance / cliff face; Erosion – rainstorms erode the top of the mountain and bury entrances; Dissolution – pollution and acid rain dissolve sediment on the mountainside etc.).

4. Group Design Solutions (15 minutes)
    a. Instruct students to draw cave entrances on the mountain on their Weathering in Mogao Grottoes handout.
    b. Refer back to the Types of Weathering graphic organizer to discuss the weathering factors and effects as a class.
    c. Ask the class, "What will happen to the caves eventually?" (Possible responses: collapse, become buried, wear away)
    d. "As scientists, you must prevent the destruction and closing of the caves. Think about what can be done to preserve the caves without disturbing the original art."
    e. In groups, have students discuss possible solutions to preserve the caves. Model discussion techniques and how to critique others' reasoning.
    f. Have students use their Mogao Grottoes handout to draw and label a diagram for each idea.
    g. Using the Preservation of Mogao Grottoes handout, students must list each idea and explain their reasoning.
5. Wrap-up Discussion Slideshow (14 minutes)
    a. Ask volunteers to present one of their ideas and reasons for implementation.
    b. After volunteers share, continue with the slideshow presentation, using slides 10-18 to explain current preservation techniques at the caves:
        i. Slide 10: "A concrete façade is used to consolidate the surface and prevent further erosion."
        ii. Slide 11: "This detail shows the layer of concrete and layer of artificial surface."

iii. Slide 12: “This prevents wind and water from further eroding the outside surface of the caves.”
iv. Slide 13: “A layer for vegetation was planted in front of the caves.”
v. Slide 14: “This prevents abrasion from sandstorms from damaging the surface.”
vi. Slide 15: “Poplar trees were used because of their fast growth rate. These were planted roughly 30 years ago in the 1980s.”
vii. Slide 16: “ A synthetic fence was put in place to reduce sand accumulation above the grottoes.”
viii. Slide 17: “A grass grid of desert vegetation was planted as a natural windbreak.”
ix. Slide 18: “Beds of different sized gravel rocks were spread out to collect windblown sand and sediment. Monitoring stations (bottom right) and sand accumulation instruments (bottom left) are installed in the beds.”

c. Revisit Organizing Questions (What things can be done to prevent deterioration of the structure? What are people doing at the site to protect the caves?)
d. Discuss with students how their ideas compare with those carried out at the site.

Day 2 – Optional Extension Activities (choose one)

1. Ancient Site Activity (30 minutes)
   a. Ask students to think about another cultural heritage site or ancient structure from another civilization. Brainstorm a list on the board. Possible sites: Pyramids of Giza, Machu Picchu in Peru, Mayan Pyramids in Central America, Coliseum in Rome, Parthenon in Greece.
   b. Individually or in groups, students will create a preservation plan similar to the Mogao Grottoes using the following guiding questions:
      i. What kind of environment is this site in?
      ii. What weathering factors would affect this site?
      iii. What preservation ideas would you implement to save the site from deterioration?
      iv. Why would you use these techniques? How could they be tested for effectiveness?
   c. Students can make preservation plans using a picture like our Mogao Grottoes worksheet, create a diorama, or make a video report / slideshow.
   d. Students will use the Ancient Site Preservation Plan write-up to record their ideas and reasoning.
   e. Have students present their plans to the class.
2. LAB: Test Solutions and Observe (50 minutes)
   a. Using a sandstone model or brick, students will dig out their own cave. You can make the brick using sand, gravel, dirt, glue, and water – something that can be eroded or dissolved away when “weathering” is simulated.
   b. Students should then use whichever materials to implement their proposed plan from the Weathering in Mogao Grottoes handout.
   c. Students can use materials from home or materials can be provided for each group: glue, clay, cotton balls, toothpicks, popsicle sticks, recycled cardboard, tape, etc.
   d. After students have created their preservation sites and have had time for them to dry / set, they must explain their reasoning for each idea for the pre-lab questions:
      i. How can you implement this idea without damaging the cave?
      ii. How will this method prevent damage?

iii. How will you measure the effectiveness of this method?

e. Teacher will simulate weathering effects for each model for a controlled amount of time:
   i. Rainstorm – spray bottle or gardening pump with X amount of water (ex. 30mL)
   ii. Sandstorm – hairdryer or fan and playground sand or gravel for X amount of time and sediment (ex. 1 cup of sediment poured over 30 seconds of blow drying / fanning).
f. After testing each preservation site, students must record observations and changes to their models.
g. Students will evaluate their preservation sites and plans using the post-lab questions:
   i. How did your idea(s) prevent damage?
   ii. Which was the most effective? Least effective? Why?
   iii. What would you have changed in your preservation plan?
   iv. What would you have changed in the weathering simulation?

Assessment

1. "Types of Weathering In…" Handout – See rubric
2. "Weathering in Mogao Grottoes" Handout – See rubric

Grading: 0 to 4 point scale
Day 1
"Types of Weathering In…"
4pt- Students should have at least 2 responses or diagrams for all four environments with definitions and descriptions
3pt- Students have 1 response with definition and description for all four environments
2pt- Students have 1 definition or description for each of the four environments
1pt- Students missing response for one or more boxes
0pt- No responses

"Weathering in Mogao Grottoes"
4pt- Students have 3 Preservation Ideas drawn, labeled and described
3pt- Students have 2 Preservation Ideas drawn, labeled and described
2pt- Students have at least 2 Preservation ideas drawn
1pt- Students have 1 Preservation Idea
0pt- No Preservation Ideas

Bibliography & Background Information
ESS2.A: EARTH MATERIALS AND SYSTEMS:
http://www.nap.edu/openbook.php?record_id=13165&page=181

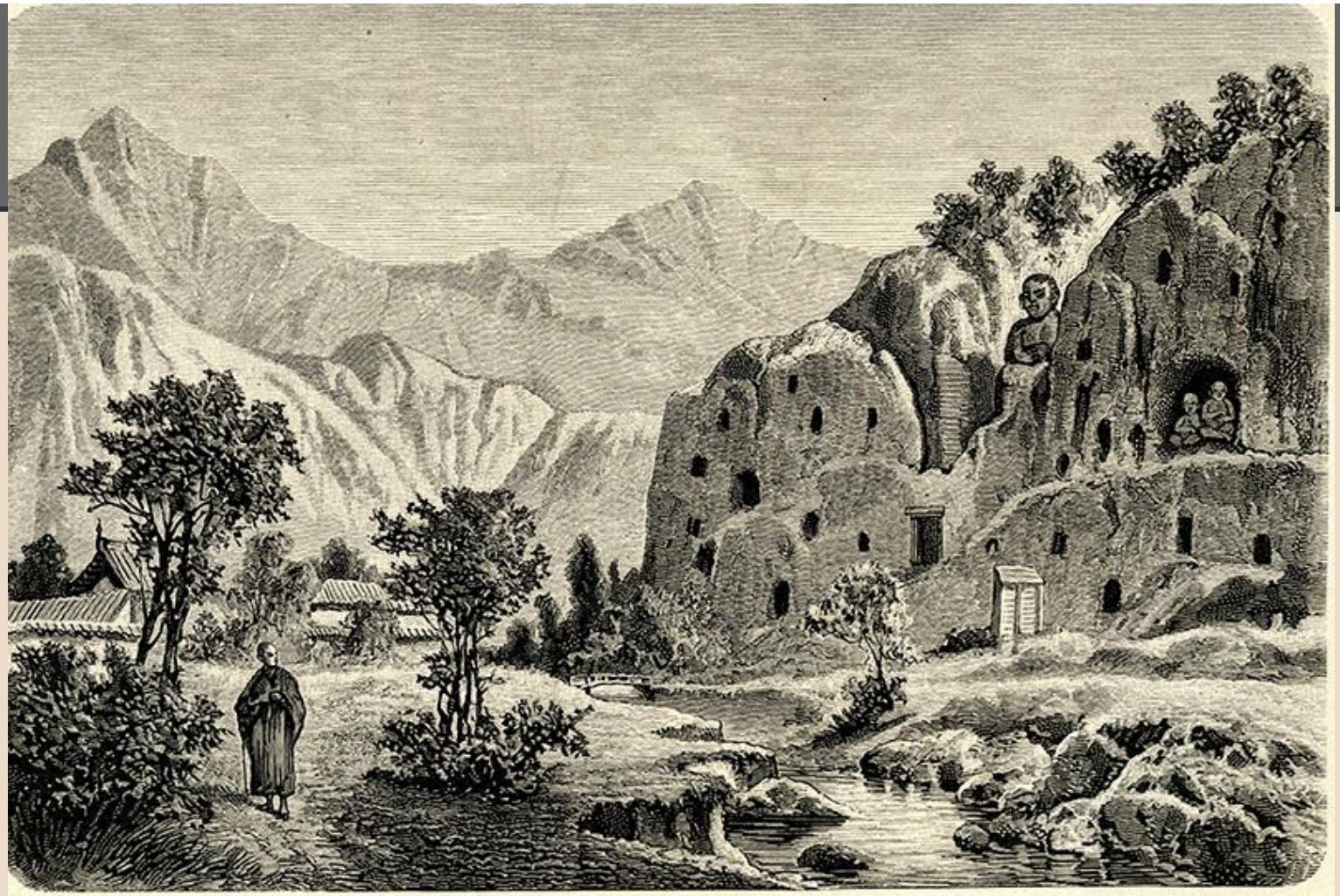
Weathering and Soil Graphic Organizers: Woodgrove Highschool
(http://www.loudoun.k12.va.us/Page/76148)

4 Types of Physical Weathering:
http://www.loudoun.k12.va.us/cms/lib4/VA01000195/Centricity/Domain/11412/PDF%202%20The%204%20Types%20of%20Mechanical%20Weathering%202011.pdf

2 Type of Chemical Weathering:
http://www.loudoun.k12.va.us/cms/lib4/VA01000195/Centricity/Domain/11412/PDF%203%20The%202%20types%20of%20chemical%20weathering%202011.pdf

Scientific Reports Article: The sand-deposition impact of artificial gravel beds on the protection of the Mogao Grottoes
http://www.nature.com/srep/2014/140311/srep04341/full/srep04341.html

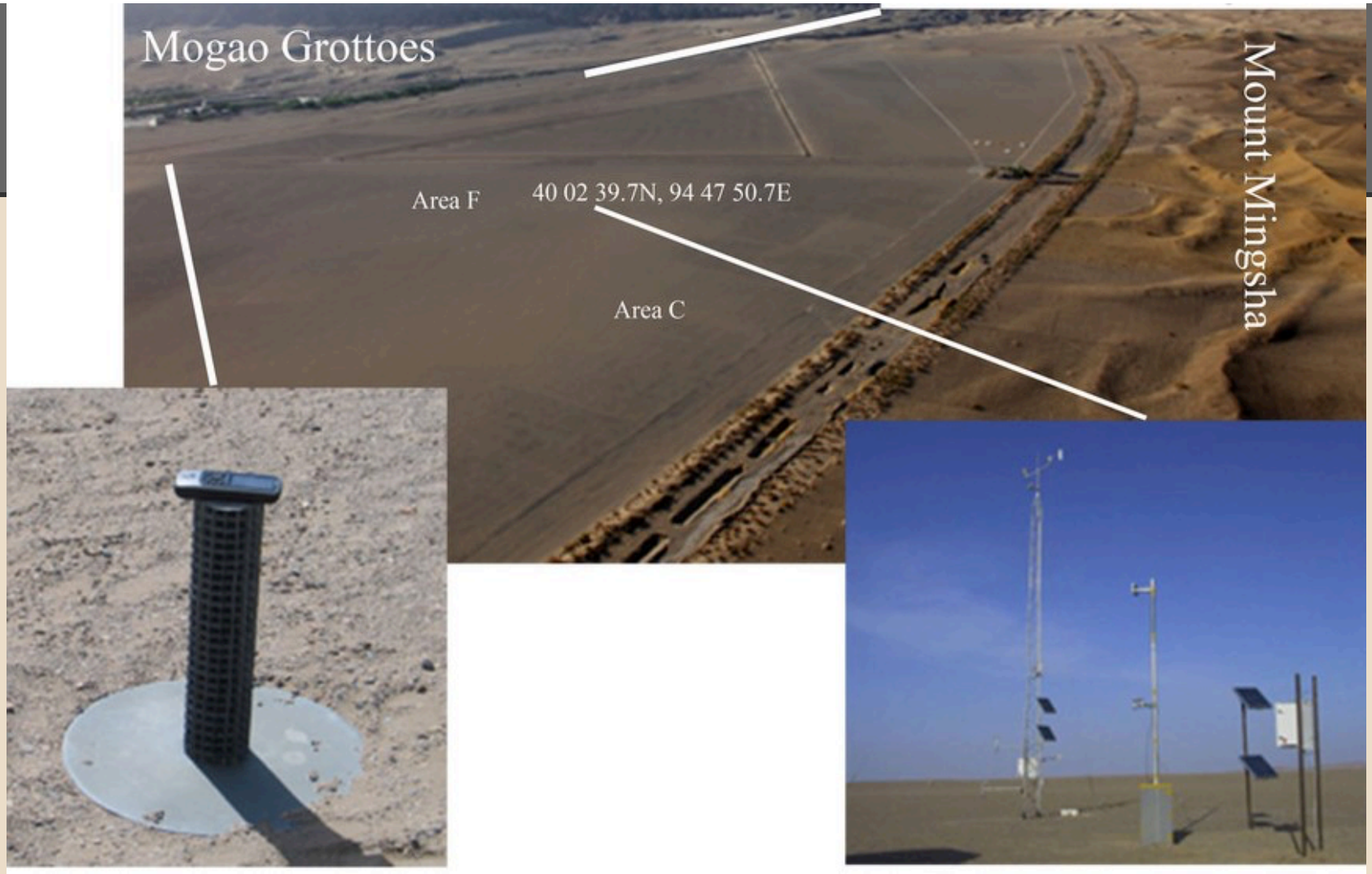
Mogao Grottoes in the Gobi Desert



Kloſter Tſien-fu-tung.


(C)NII/ToyoBunko

Poplar Trees


Mogao Grottoes
Area F
40 02 39.7N, 94 47 50.7E
Area C
Mount Mingsha

Name_____

Ancient Site Preservation Plan for

Your site:_____

Describe site & surrounding environment	Weathering factors that occur there

Describe each idea and explain reasoning in the chart below

Preservation Idea	Specific Weathering Effect	Reason for implementation

Name_____

Name _____

Preservation of the Mogao Grottoes

Describe each idea and explain your reasoning in the chart below

Preservation Idea	Specific Weathering Effect	Reason for implementation

Name _____

KEY: Preservation of Mogao Grottoes

EXAMPLE RESPONSES

Preservation Idea	Specific Weathering Effect	Reason for implementation
Sand fence at the top of the mountainside	Erosion from falling sand and sediment from rainstorms and wind	A fence will catch all the sediment at the top of the mountain and prevent it from falling across the surface. This will save the cave entrances from collapsing and keep them from getting buried or blocked.
Concrete wall around the cave entrances	Erosion or dissolving from rain and water	This will make the surface stronger and protect it from dissolving in acid rain or washing away in a rain storm,

Name _____

Planting bushes in the front of the mountainside	Erosion and abrasion from sandstorms	This will keep a protective layer in front of the mountain to keep strong sandstorms from blowing sand and rocks into the mountainside and caves entrances.

Name_____

LAB: Weathering In Mogao Grottoes

Pre-lab: Complete the chart for each idea implemented.

Preservation Idea	How will this prevent damage?	How will you measure effectiveness?

Name_____

Lab: Weathering simulation procedures

Weathering effect	Materials Used	Time or Amount

Post-lab: Evaluate Preservation Ideas in the chart below

Preservation Idea	Observation	Results/Effectiveness

Name_____

1. Which Preservation Idea was the most effective? Why?

_____
_____
_____
_____
_____

2. Which Preservation Idea was the least effective? Why?

_____
_____
_____
_____
_____

Name_____

3. What would you change in your Preservation Plan?

_____
_____
_____
_____
_____

4. What would you change in the Weathering Simulation to make it more accurate or specific?

_____
_____
_____
_____
_____

Name _____

Types of Weathering in…

List or draw effects on each environment

Forest	Mountains
Coast	Desert

Name _____

***ANSWER KEY**: Types of Weathering in…*

Possible answers: List or draw effects on each environment

Forest	Mountains
● Plant root growth ● Abrasion from streams ● Dissolving from acid rain	● Pressure release ● Ice wedging ● Abrasion from glaciers ● Oxidation/rust

Name _____

Coast	Desert
● Abrasion & Erosion from waves ● Oxidation/rust	● Wind abrasion from sandstorms ● Rain erosion ● Ice wedging ● Dissolving from acid rain