How Did Rocks and Rivers Shape the Great Lakes?

The rocks in the Great Lakes Basin are of two main types: metamorphic/igneous and sedimentary. The metamorphic/igneous rocks formed long ago, when molten rock hardened and the heat changed other rocks nearby without melting them. This happened over one billion years ago.

The sedimentary rocks in the Great Lakes Basin formed in an ocean that covered most of the basin beginning about 600 million years ago. Different types of rocks formed as the depth and shape of the ocean changed over a long period of time. The ocean disappeared from the area about 225 million years ago. In this ocean, many different types of sedimentary rocks formed in a wide variety of environments. Shales formed in deep water, sandstone along coastlines, and limestone and dolomite in warm shallow seas.

OBJECTIVES

After completing this activity, each student will be able to:

*   Relate the hardness of rocks to topography and lake depth.
*   Describe the topography of the Great Lakes area.
*   Relate the pre-glacial drainage system to the present size and position of the Great Lakes.

Sources

Modified from "Topography of the Great Lakes," "Formation of the Great Lakes," and "The Erosion of Niagara Falls" by Dan Jax. In *Great Lakes in My World*. 1989. Lake Michigan Federation.
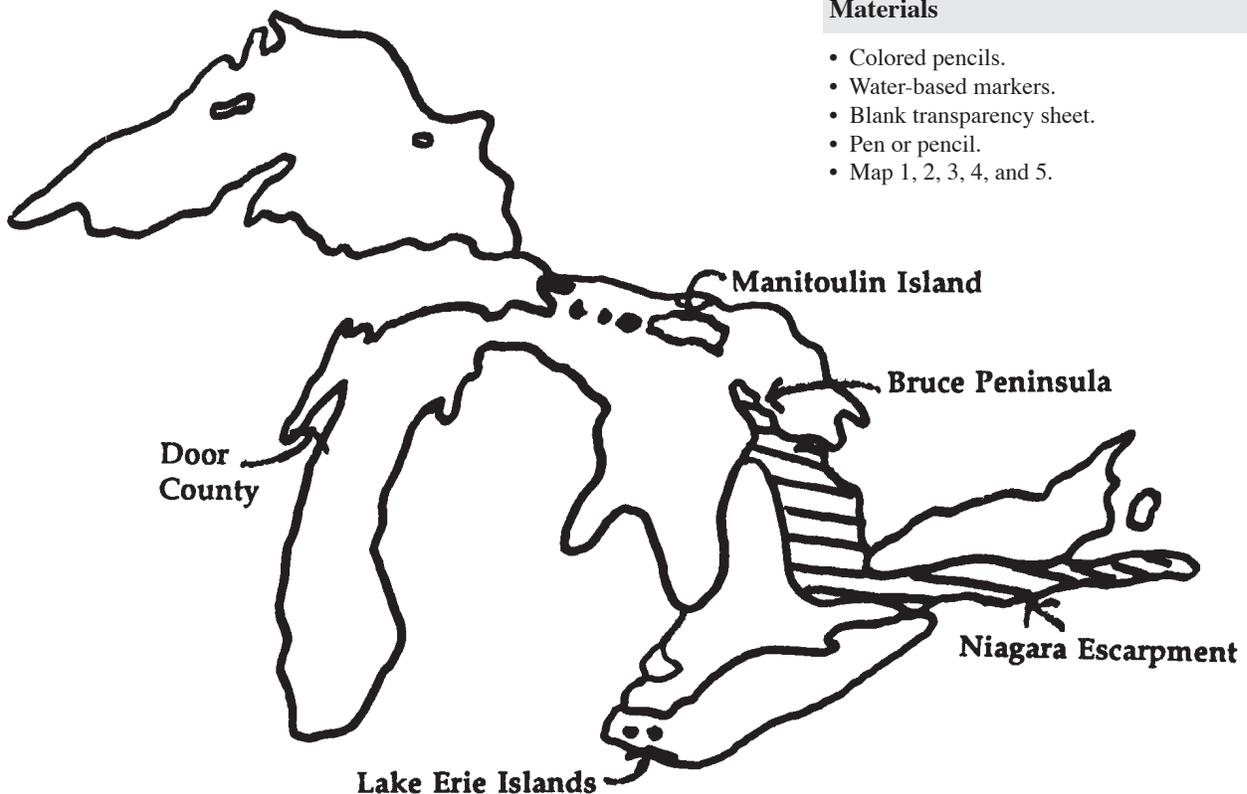
Earth Systems Understandings

This activity addresses ESU 1 (aesthetics and value), 4 (interactions), and 5 (change through time).

Materials

*   Colored pencils.
*   Water-based markers.
*   Blank transparency sheet.
*   Pen or pencil.
*   Map 1, 2, 3, 4, and 5.

Map 2. Areas of High Topography in the Great Lakes Basin.

In the Great Lakes Basin some of the hardest sedimentary rocks, called dolomite, formed at a time about 350 million years ago called the Silurian.

Question

What tourist attraction is found in the Silurian rock area? (Niagara Falls)

Answer to Procedure

1. It is Silurian rock, which is resistant to erosion and more resistant than the surrounding rock layers.

2. These islands are made of rock that resisted erosive processes while the rocks around them eroded away.

3. The peninsulas are made of Silurian rocks, which have withstood erosion from the action of the Lakes.

4. The rivers flowed the same way that the water flows through the lakes today.

5. Huron: Huronian River
   Michigan: Laurentian River
   Erie: Erigan River

PROCEDURE

Different types of rocks resist erosion to different degrees. Hard rocks will erode slower (less) than softer rocks. In the Great Lakes Basin, some of the hardest sedimentary rocks, called dolomite, formed at a time about 350 million years ago called the Silurian.

Refer to Map 1 of the activity "How were sedimentary rocks in the Great Lakes basin formed?" This shows the distribution of rocks in the Great Lakes Basin. Use a blank transparency and water-based markers and trace the area of the Silurian age rocks from Map 1. Also use dotted lines to outline Lake Superior and Lake Ontario.

Map 2 included with this activity shows the areas that are generally higher in elevation than the areas right around them. Overlay your transparency on Map 2. Make sure the outlines of Lake Superior and Lake Ontario match.

An escarpment is a place where the slope of the land is very steep. In many cases it can be best described as a cliff.

1. Why does the Niagara Escarpment rise higher than the surrounding area?

2. Explain why the Manitoulin Islands in Lake Huron and the Lake Erie islands are islands.

3. Explain why the Bruce Peninsula in Ontario and Door County in Wisconsin "stick out" into their respective lakes.

Before the Great Lakes formed, the Great Lakes basin was occupied by a river with many tributaries (branches). The accompanying map shows what it may have been like.

4. How are the directions that the rivers flowed related to the shapes of the Great Lakes?

5. Which ancient rivers preceded the following:
   Lake Huron?
   Lake Michigan?
   Lake Erie?

The name "Laurentian" comes from the name for all of eastern Canada. It comes from the St. Lawrence River that drains the Great Lakes.

The large arrows at the top of Map 3 indicate the direction in which glaciers moved from near the present day Hudson Bay area. As the glacier moved through the area, it deepened and widened the river valleys. As the glacier retreated and melted, these low areas filled with water and became the Great Lakes.

Table1. Maximum Depths of the Great Lakes.

LAKE	MAXIMUM DEPTH
Huron	245 M (804 ft.)
Ontario	230 M (752 ft.)
Michigan	280 M (925 ft.)
Erie	63 M (211 ft.)
Superior	400 M (1333 ft.)

Using colored pencils and the information in Table 1, on Map 3, color in the lake with the greatest depth. Use a different color to shade in the shallowest lake. Label these two lakes the deepest and shallowest, respectively. Use a third color to shade in the other three lakes. They are all about the same depth.

7. Is the deepest lake north or south of the other lakes ?

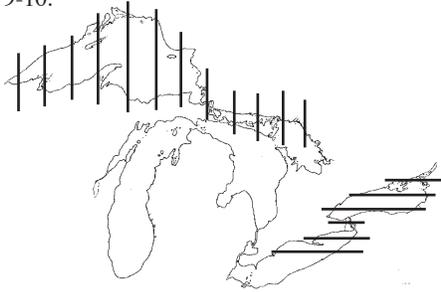Map 3. Preglacial River System in the Great Lakes Region.
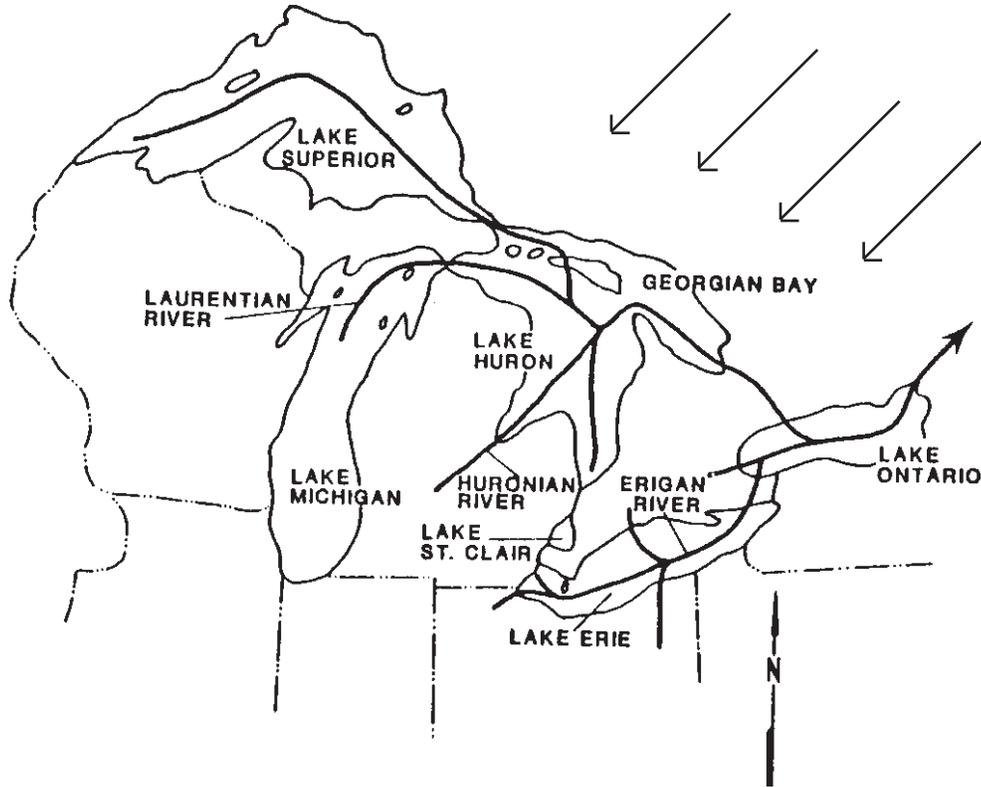
Source: Forsyth J. In *The Great Lake Erie*, 1993.

7. Lake Superior is the deepest and the northern-most lake.

8. Lake Erie is the shallowest and southernmost lake.

9-10.

11. It is the shallowest of the lakes because the glacier was thinner in the southern part near present day Lake Erie.

12. The softest rock is found in the eastern basin. This would most likely be the deepest part.

13. You might guess that Lake Erie was the deepest because it has the softest rock, but the glacier was also thinner in this region.

14. The glacier was thickest in the north. This allowed Lake Superior to be the deepest because ice weighed the land down more.

Technology Note

For Question 12, see the Great Lakes Forecasting System at http://superior.eng.ohio-state.edu/ for an image of water surface elevation of Lake Erie.

8. Is the shallowest lake north or south of the other lakes?

There are two main things that contributed to how deeply the lake basins were eroded by the glacier. One of these is the hardness of the rocks under the lakes. The hardest rocks are under Lake Superior and the northern half of Lake Huron.

9. Use your pencil or pen and draw vertical lines on Map 1 where the rocks are the hardest.

The softest rocks are under Lake Ontario and the eastern one-third of Lake Erie.

10. Draw in horizontal lines on Map 1 where the rocks are the softest.

The other thing that contributed to the depth of the lake basins was the thickness of the glacier. In general, the thicker the glacier, the more it erodes. The glacier was thicker nearer its source (Hudson Bay to the north) and was thinner toward its edge to the south. Use Map 1 and the above explanation to answer these questions.

11. Why is Lake Erie the shallowest of the Great Lakes?

12. What part of Lake Erie would you expect to be the deepest? Why?

13. If you thought that the hardness of the rock under each lake basin was the only factor that controlled the depth of the basin, which lake would you choose to be the deepest? This lake is not the deepest. Why not?

14. Lake Superior has some of the hardest rock in the region underneath it. Why is it the deepest?

REVIEW QUESTIONS

1. How is the composition of a rock related to how quickly it will erode?

2. Identify four places in the Great Lakes area where the rocks are hard and so they rise above the rocks around them.

EXTENSIONS

Do you think there is a connection between geologic rock layers and other resources in a specific region? Observe maps 4 and 5 and answer the following questions.

1. Map 4 shows a representation of sources of iron ore and coal. Note their locations. From what you have learned about the rock types in the Great Lakes region, why do you think iron ore is plentiful here and not in other areas of the basin? Note on Map 5 which areas import and export iron ore. What area seems to be most dependent on iron ore imports?

2. Which areas export coal? Where is a large coal region located relative to the Great Lakes (Map 4)? Why might the coal be located here?

3. Use Map 5 to answer the following questions: What areas along the Great Lakes export grain? Where is the highest density of exports? Consider the rock layers you have studied. What kinds of rock layers predominate in this area? Why would grain grow better here than in other areas?
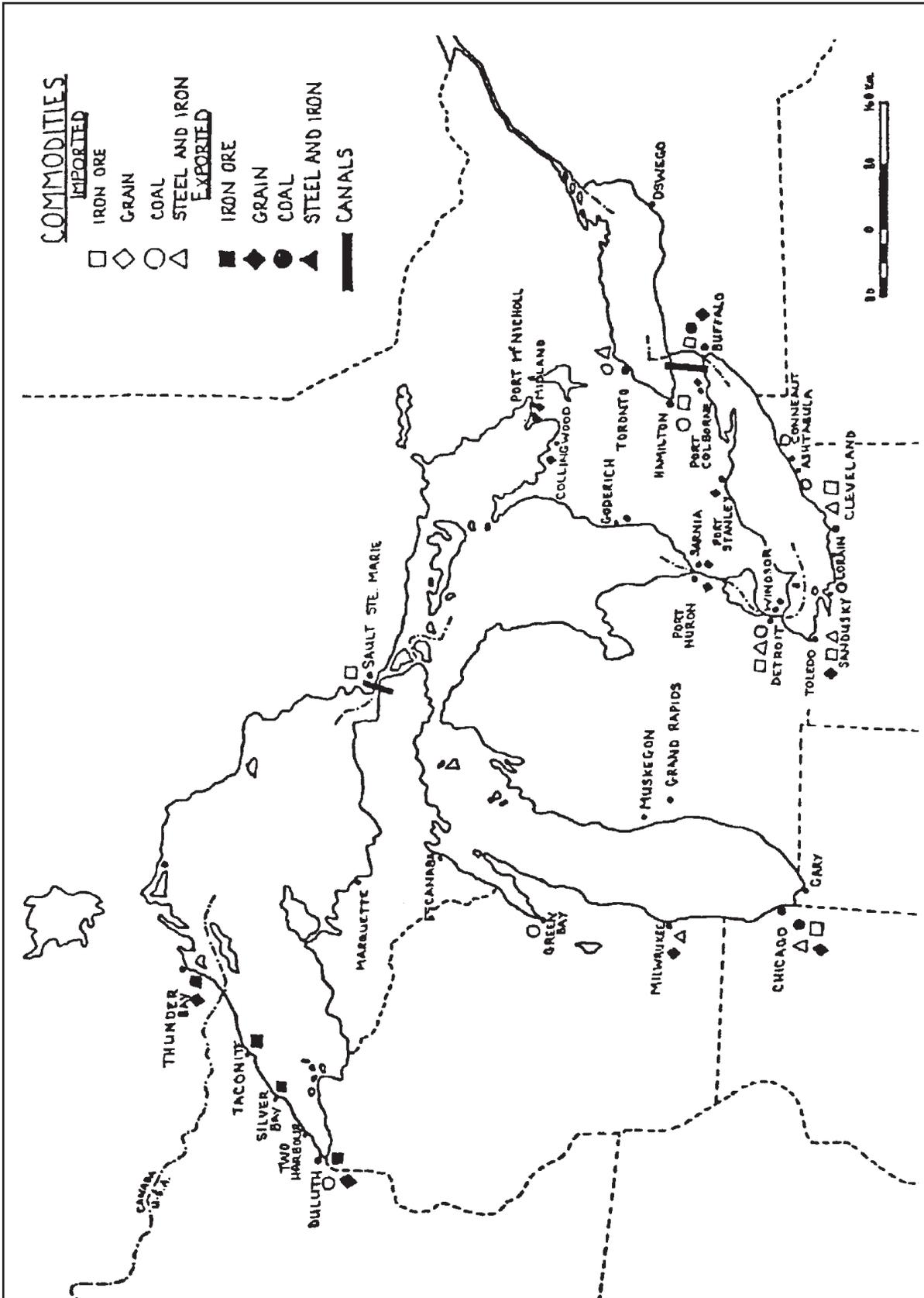
Ideas for Extension Activities

1. Students should recognize that this is an area of Pre-Cambrian rock. Iron ores are often associated with igneous rocks from which they can be commerically extracted. In sedimentary rocks, iron ores may exist but are not accessible. The Lake Erie basin displays several areas relying on imports. For more activities related to economic geology, use the shipping module.

2. Coals are associated with former swamps. The previous activity notes Pennsylvanian rock as being known for coal. It is found south of Lake Erie and in central Michigan.

3. In shales, the basins of the Great Lakes formed. Also in shales lowlands are created that are more suited to grain production than are hilly areas where rock layers tend to be harder. The land shared by Lakes Erie, Huron, and Ontario has Devonian and Ordovician rock, which is known for shales. It is also an area with hard rock such as that forming the Niagara Escarpment.

Map 4. Iron Ore and Coal Deposits.

Source: *Discover the Five. A Great Lakes Investigation*, by Brent Dysart, Lynn McGuire and others. Waterloo County Separate School Board, Ontario.

Map 5. Major Commodities Shipped in the Great Lakes.

COMMODITIES

IMPORTED
□ IRON ORE
◇ GRAIN
○ COAL
△ STEEL AND IRON

EXPORTED
■ IRON ORE
◆ GRAIN
● COAL
▲ STEEL AND IRON

▬ CANALS

OSWEGO

PORT M'NICHOLL
MIDLAND
TORONTO
COLLINGWOOD
GODERICH
HAMILTON
PORT COLBORNE
BUFFALO
CONNEAUT
ASHTABULA
CLEVELAND
SARNIA
PORT STANLEY
WINDSOR
SANDUSKY LORAIN
PORT HURON
DETROIT
TOLEDO

SAULT STE. MARIE

MUSKEGON
GRAND RAPIDS

MARQUETTE
ESCANABA

GREEN BAY

MILWAUKEE

CHICAGO
GARY

THUNDER BAY
TACONITE
SILVER BAY
TWO HARBOUR
DULUTH

CANADA
U.S.A.

Source: *Discover the Five. A Great Lakes Investigation,* by Brent Dysart, Lynn McGuire and others. Waterloo County Separate School Board, Ontario.

## Apply what you have learned: the erosion of Niagara Falls

The "Falls of the Niagara River" (Niagara Falls) formed when the glacier melted away from the Niagara Escarpment about 12,000 years ago. The water flowing in the Niagara River ran over the escarpment and formed the "Falls." Over the last 12,000 years the falls have not stayed in the same place. They have eroded upriver to their present position. Figure 1 is a cross-section (side view) and a top view of Niagara Falls and the rocks that are found there.

1. When the water flows over the falls and hits the bottom, which rocks will be eroded more, the hard ones or the soft ones?

2. Draw a cross-section to show what will happen to the cliff as the softer rock gets eroded faster than the harder rock.

3. As this continues, what will eventually happen to the harder rock on top?

4. Over time, how will the position of the falls change?

5. The falls have moved about 11,250 m in 12,000 years. What is the average rate of movement per year?

Answers

5. The falls have moved an average of 0.94 meters/year.

Figure 1. Niagara Falls.

Cross-section

Top View
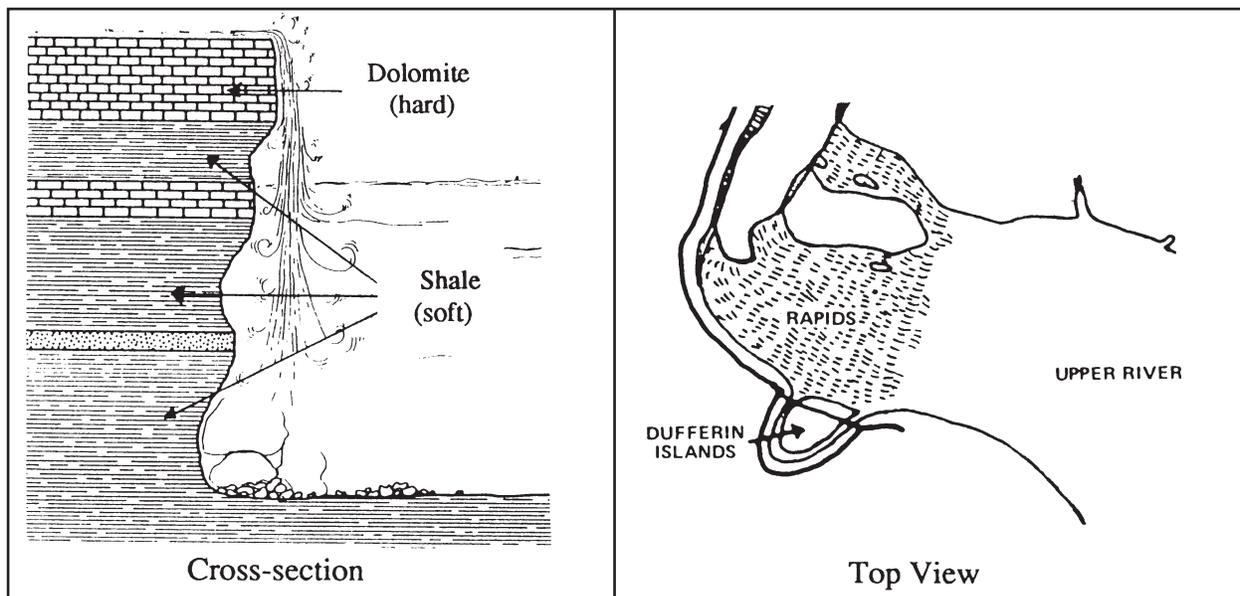
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Forsyth, Jane L., 1993. The Geological Setting of the Great Lakes, In *The Great Lake Erie. A Reference Text for Educators and Communicators*, Rosanne W. Fortner and Victor J. Mayer, Eds., Columbus: Ohio Sea Grant.

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