What Evidence of Glaciation Exists in the Great Lakes Region?

Have you ever seen Lake Erie? Have you seen pictures of it? Maps? Does it change? Do you think the Great Lake nearest you has changed over time?

You may have seen or heard of waves on the lake destroying houses along the shore. These are certainly changes that can be seen. But does the lake change in size? Was it once bigger than it is today? Or has it moved? Although the lake may seem to be a permanent feature, it is not. All lakes are temporary. They exist for a few thousand years and then disappear. Will this happen to Lake Erie? To your Great Lake?

The Great Lakes Basin was once covered by the ice of continental glaciers. About 15,000 years ago the last ice melted to expose the lake basin. There have been minor advances and retreats of glaciers since then causing the level of the water in the lakes to rise and fall. How do scientists determine these past lake levels?

OBJECTIVES

When you have completed this activity you will be able to:

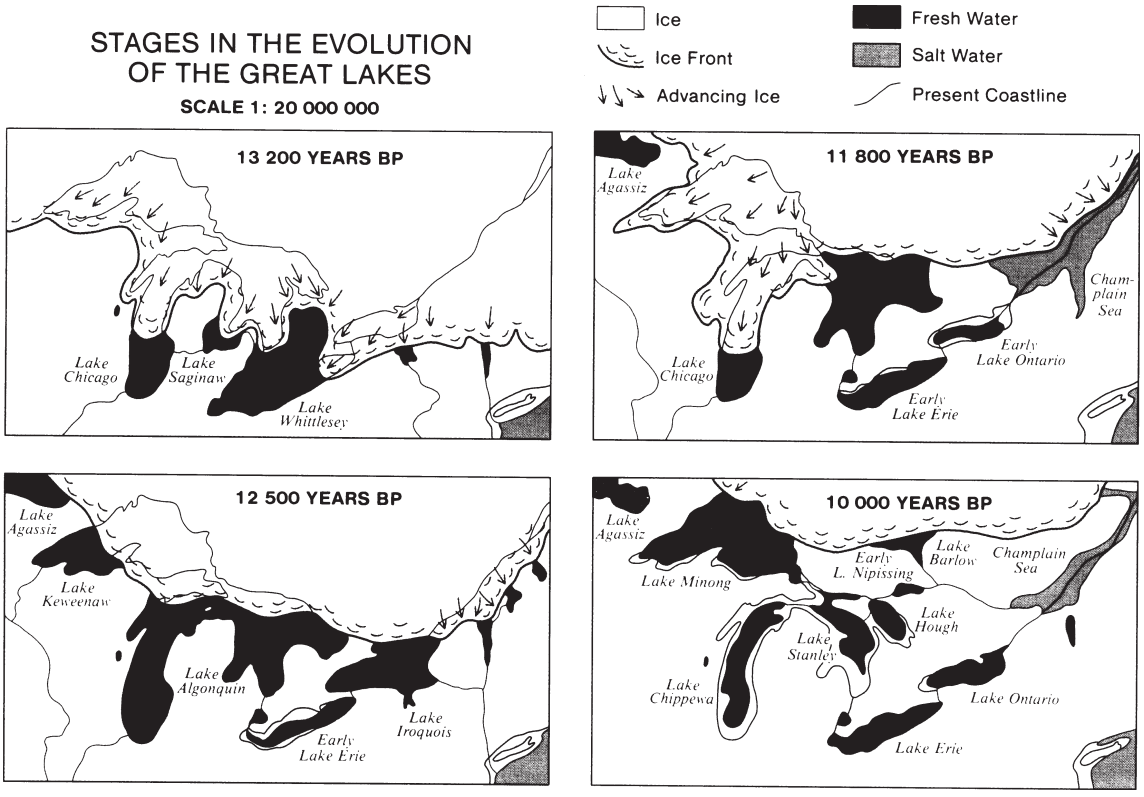
- Identify the evidence of ancient beach ridges.
- Become aware of the uses of ancient beach ridges today.

Source

Modified from OEAGLS EP-3," Ancient Lake Shores" by James D. Comienski, Lakewood Public Schools, Ohio, and Victor J. Mayer, The Ohio State University.

Earth Systems Understandings

This activity examines evidence found in land features of past land and water interactions (ESU 4 and 5).



Teacher's Notes

Overview: In this investigation, students work with topographic maps and profiles to identify beach ridges in northern Ohio. They learn how to determine the ages of the ridges and how they were formed.

The questions are designed to lead the students to closely examine an area near Lake Erie to identify evidence of former Lake levels. They can apply this activity to their own area within the Great Lakes. Students can obtain maps from state divisions of geological survey.

Prerequisite Student Background: Students should be able to read a topographic map and construct a profile. They should also be somewhat familiar with the glacial history of the Great Lakes Region.

Note: Information to teachers is enclosed along the side so that teachers can cover this portion of the activity if photocopies are needed for classroom use.

Materials

- Topographic map – the Madison, Ohio quadrangle.
- Road map of Ohio
- Graph paper.
- Metric ruler.

One copy of each of the following should be posted in the classroom: An Ohio road map, copy of the map from the publication: The Beach Ridges of Northern Ohio (included within this activity on teacher pages).

Other USGS shoreline quadrangles can be obtained so that students can see more examples of ridges.

Part A

What evidence is there that the level of Lake Erie has changed?

Objectives

When you have completed this activity you will be able to:

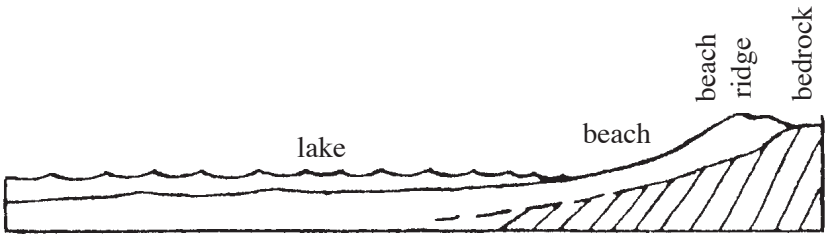
- Describe the evidence of past water levels of Lake Erie and other Great Lakes.
- Use topographic maps and topographic profiles to locate evidence of past water levels.
- Describe the processes by which ancient lakes changed size over time.

Procedure

Most lakes are contained in basins and have flat, gently sloping floors. Wind causes waves, which in turn produce currents that act along the shores of lakes. These currents carry and deposit sand and form beaches. Perhaps you can remember swimming from a beach. If so, you know what the sand looks like and how it feels.

Figure 1 is a cross section (a side view) of a beach. Notice the flat floor of the lake, the gently sloping beach area itself, and a ridge at the top of the beach. This **beach ridge** is formed of sand thrown up by the action of waves.

Figure 1. Cross Section of a Beach.



Worksheet Questions

1. What is the contour interval of the map of the Madison area?

2. Examine the lower left portion of the topographic map. Compare the area immediately north of (above) the Penn Central Railroad with the area south (below) to the map's lower edge. How does the spacing of the contour lines in these areas differ?

3. What does the difference in the spacing of contour lines mean about the difference in topography in the two areas?

4. What evidence is there on the map that the lake once extended through the area north of the Penn Central Railroad?

5. Using graph paper, construct a topographic profile across North Ridge, Middle Ridge, and South Ridge. Start the northern end of your profile where Red Bird Road T-intersects with Chapel Road. The southern end should then be where South Bates Road intersects Interstate 90.

6. What difference between the three ridges does the profile reveal?

7. What do you think caused each of the three ridges?

Vertical Exaggeration
Vertical exaggeration is determined for the scales to which the profile is drawn. Graph 1 is a reduced image of a topographic profile originally drawn to a vertical scale of 1 inch = 50 feet and a horizontal scale of 1 inch = 2000 feet. The horizontal line would have to be extended 40 times or the vertical line compressed 40 times to make the scales the same. Therefore, we say the vertical exaggeration is 40:1 or 40x. To redraw the profile using a scale of 10:1, your vertical scale would have to be 1 inch = 200 feet. A profile with this scale will be harder for the students to graph but will give a more realistic look at the slope of the land.

A profile with vertical exaggeration of 10x is included as Graph 2.

Answers

1. 10 feet contour. This is located under the scale of the map.

2. North of (above) the Penn Central Railroad, the contour lines are farther apart than south of (below) the Penn Central Railroad.

3. Where contour lines are closer together, the area has more relief, or is "hillier." Where contour lines are farther apart, the slopes are gentle or nearly flat. Therefore, there is a change in topography between the two areas.

4. The area north of the Penn Central Railroad is flat, similar to the lake bottom in Figure 1. In addition, there are areas of swamps. There is evidence that the lake may once have extended over this area.

5. Be certain students use graph paper for the profile, and that they accurately record each contour line. You will need to provide additional copies of graph paper, because the profile will be about 34 cm long. If the profile is not done very carefully, the ridges may not be apparent on the profile.

6. The profile shows that the three ridges occur at different elevations.

7. Each one of these ridges is a beach ridge. They mark the previous beaches or boundaries of Lake Erie. They are built up by wave action as described in the explanation accompanying Figure 1.

Teacher's Note

A completed profile is included in Graph 1 with a vertical exaggeration of 40:1. This scale makes identification of the ridges easier, but greatly exaggerates the vertical, making the gently sloping "old lake" floor appear hilly. Here would be an excellent opportunity to discuss vertical exaggeration in more detail. Have your students redraw the profile using a vertical exaggeration of 10:1 and discuss the importance of considering scale when examining data.

8. Middle Ridge is not as prominent as the North or South Ridge. The lake's edge may not have been there long enough to build up a higher beach ridge. Middle Ridge may have been smoothed out by flooding during an increase in lake level.

9. North Ridge = 675 feet
   Middle Ridge = 695 feet
   South Ridge = 725 feet

10. North Ridge = Lake Warren
    Middle Ridge = Arkona
    South Ridge = Lake Whittlesey

11. There are 8 stages.

12. The oldest stage is 13,500 years before present.

13. Elevation indicates the lake stage.

14. Here the answers may vary because we are asking the students to "think." The actual cause was the retreat and readvance of glacial ice, opening up new lake drainage outlets and closing older ones (as described in "Background Information").

8. One of the ridges is not as prominent as the other two. What could be the reason for this difference?

9. Determine an "average" elevation for each of the three ridges.

10. Compare the elevations of the three ridges to the data in Table 1. What historical lake stage does each of the ridges represent? Label them on the profile.

A **stage** of the lake was a time when the lake level remained the same long enough to build a beach and a beach ridge.

11. How many stages has Lake Erie had? Refer to Table 1.

12. How old is the oldest stage?

13. What evidence do geologists use to tell what stage a ridge belongs to?

14. From what you have learned so far in the set of land/water interaction activities, what do you think could have caused the different stages of Lake Erie?

Could the hills you walk around near the lake that is closest to your home possibly be old beach ridges?

Table 1. Age and Elevation of Beach Ridges around Historic Stages of Present Lake Erie.

Years Before Present	Lake Stage	Elevation of Beach Ridge in feet
0	Erie	573
	Lundy (3 ridges)	620-640
12,700	Warren	690
	Wayne	660
12,800	Whittlesey	735
13,000	Arkona	690-710
	Maumee III	780
13,500	Maumee II	760

Glacial ice caused the variation in the levels of Lake Erie. As the glaciers retreated, they uncovered different outlets for the lake. These outlets were at successively lower elevations. When a new one was uncovered, the lake dropped fairly suddenly to a new level. Occasionally a glacier may have readvanced over an outlet, blocking it. In this case, the lake level rose once again, and the beach ridge was eroded by the higher lake. This may be the reason that Middle Ridge is so much lower than North and South Ridge.

Review Questions

1. What evidence is there that indicates that Lake Erie has been larger than it is today? How do these features form?

2. What caused the level of water in Lake Erie to change?

Extensions

1. Do research on the career of limnologist. How would a limnologist apply the concepts of this activity? What training is required for such a career?

2. Would it be possible to find fossils from different years in the beach ridges? Would the fossils be different enough to indicate stages, or are the years in Table 1 relatively close from the perspective of geologic time?

3. Determine how much glacial evidence exists in your state. What topographic features might have been formed by glacial action? How are the state's soils, lakes, and other resources related to the action of ancient glaciers? Share your findings with the class.

Answers

1. Two ways are the following: a large, relatively flat area with several swamps and poor drainage, and ridges of sand and gravel (beach material) roughly paralleling the present shoreline. These ridges formed by wave action along the lake shore.

2. The level of water in Lake Erie fluctuated as the lake's outlet was changed by the retreats and readvances of glacial ice.

Background Information

Beach ridges are formed by storm waves, similar to the berms along the ocean beaches. An excellent source of background reading concerning their formation is *Waves and Beaches* by Willard Bascom; see the chapter on beaches. Each ridge represents an ancient beach formed along the shore of Lake Erie at a time in the past when the elevation of the lake was much higher than it is today. These higher lake levels were caused by the glacier damming the lake's outlet. As the ice front retreated, a series of newer and lower outlets were exposed, so the lake level lowered, changing the outlines of the lake and thus the beach patterns. Several times the ice readvanced, causing the lake level to rise and submerge the beach ridges made during a previous stage. The higher water would then scatter the materials making up the beach ridges and smooth them.

Materials

- Topographic map of the Madison, Ohio, area.
- Road map of Ohio.
- Map from *The Beach Ridges of Northern Ohio*.

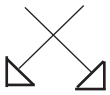
Teacher's Notes

This activity leads the students to discover how people have made use of beach ridges. Evidences of changes in sea level are also discussed.

Answers to Procedure

1. North and South Ridges have a highway along their entire length. Middle Ridge also has a highway along most of its length.

2. The beach ridges were used as highways for a variety of reasons. The bedrock surface on each side of the ridges is covered by glacial till. These areas are generally swampy, due to low relief and poor drainage. Therefore, the buffalo in Ohio's early history chose the drier, better drained beach ridges for their trails. The Indians, hunting the buffalo, naturally followed the same trails. When the settlers moved into and across the state, they also followed these "established routes," as did the modern highway builders.

3. A sand pit, as indicated by 

4. There are two sandpits and a quarry along Middle Ridge and one gravel pit on South Ridge.

5. People are quarrying sand and gravel from the beach ridges for use in concrete for construction.

6. Middle Ridge cemetery is located here.

7. There is one cemetery on each of the North and South ridges and two cemeteries on Middle Ridge.

PART B

How have people used beach ridges?

OBJECTIVES

When you have completed this activity, you should be able to:

- Describe how people have made use of the beach ridges associated with Lake Erie.
- Describe some evidence of past changes in the water level of the oceans.

PROCEDURE

The beach ridges have been very useful to the inhabitants of northern Ohio. What are some of these uses?

1. Examine the three beach ridges on the Madison map. What human-constructed feature do they have in common?

2. Why do you think the beach ridges have been used for this purpose?

3. What type of human-constructed feature is located just southeast of North Perry and north of US Highway 20?

4. How many features similar to this do you find on Middle Ridge? On South Ridge?

5. What use of the ridges is implied by these features?

6. What type of human-constructed feature is located at 41˚47'30"N, 81˚02'30"W (just west of the pond)?

7. How many other features of this type can you find on the three ridges?

8. How many do you find that are NOT located on one of the three ridges?

9. Why do people prefer to locate these features on beach ridges?

10. Ask your teacher for a different map. How many beach ridges can you identify on this new map? (Try to obtain one perhaps from Lake Erie and one from another of the Great Lakes.)

11. What stages do they represent?

12. Which of the human-constructed features you identified in Steps 1 to 8 are found on the ridges on this map?

These beach ridges extend throughout northern Ohio. They indicate the location of the shoreline of the lake and the amount of area occupied by the lake at each of its stages. Your teacher will have a map of northern Ohio posted on the bulletin board. This map locates each of the beach ridges.

13. In an earlier part of this activity you learned that the people living in this area built many of their roads along the beach ridges. Using your road map and the map on the bulletin board, identify the major highways that have been built on beach ridges. Mark each of them on your road map. Label them with the name of the stage of the beach ridge.

14. List on your work sheet all of the uses people have made of beach ridges in the areas you have studied.

Answers

8. There are three cemeteries on this quadrangle that are not located on the ridges; two of these are on the glacial till forming the lake floor. The other one is in the hills to the south.

9. People tend to locate cemeteries in high areas where drainage is good and flooding is minimal.

10. Answers for this and subsequent questions will vary, depending upon which quadrangle the students have available. Possible quadrangles to use from Lake Erie are: Geneva, Perry, Mentor, and Eastlake, OH.

13. See the beach ridge background page.

14. Answers will vary but should include roads, cemeteries, and pits for obtaining construction material.

Teacher's Notes

Marine terraces are evidences of a higher sea level because they are formed by wave action. An example would be Palos Verdes Hills, California (photograph pg. 209; *Investigating the Earth*, 4th edition, 1987).

Perhaps you could discuss other evidences of sea level changes such as fossil ripple marks, seamounts, and fossilized sea life found in sedimentary rocks on land.

You have learned in this investigation that the movement of glaciers caused changes in the level of Lake Erie and that the beach ridges provide evidence of such changes in lake level. The oceans have also had different levels of water. Figure 2 illustrates some of the evidence of higher sea level (marine terraces) and lower sea level (wave-cut cliff).

Glaciation is also one of the causes of recent variations in sea level. As the glaciers have melted, the water returned to the sea, raising its level. Water locked up in the glacial ice has come from precipitation collected over the oceans. The removal of this water lowered the sea level greatly. If the present-day glaciers should melt, sea level would probably rise from 40 to 50 meters.

When sea level is lowered, the size of the continental shelf decreases, thereby decreasing the habitat of shelf-living organisms. Shorelines become broad, relatively flat areas. Land plants and animals can extend their ranges outwards. The climate of local areas may be affected by the change in its proximity to a large body of water.

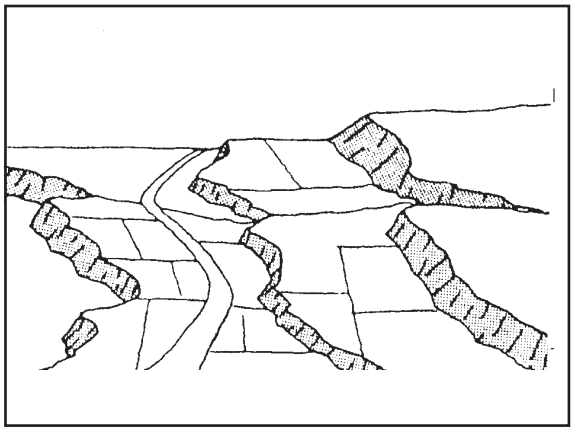
Many scientists believe that increased amounts of greenhouse gases in the atmosphere will increase global temperature. This could result in an increase in sea level worldwide.

15. How would changing sea levels as a result of global warming affect habitats of marine animals and plants in coastal areas. What adaptations do you think organisms would need in order to live along the changing coastline?

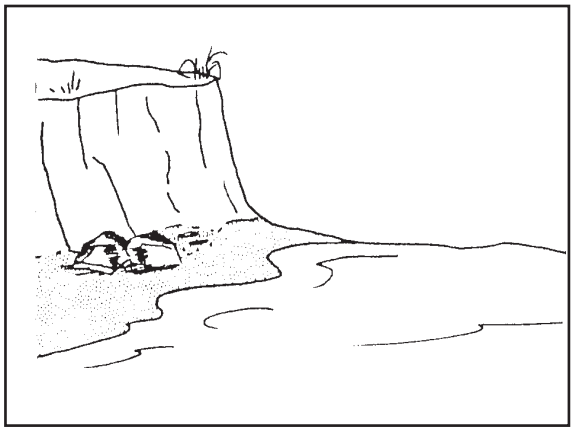
16. What might be some economic impacts associated with changing sea levels? Discuss your ideas with the class.

Figure 2. Evidence of Sea Level Changes.

Marine Terraces



Wave-Cut Cliff



Review Questions

1. Discuss three ways that people have used beach ridges.

2. Many types of fruit require well-drained soil. Why would beach ridges be good places for orchards?

Answers

1. People use beach ridges for highways, for cemeteries and as sources of sand and gravel.

2. The beach ridges and the immediate areas are composed largely of gravel covered with soil. The area is better drained and therefore provides an excellent location for orchards.

Extension

Do research about your state for geologic features related to glacial evidence. Some of the following are examples of resources for your use.

IL Geological Science Field Trips; for example, Livingston, La Salle and Vermilion Counties, which show various forms of glacial evidence. Also, Glacial Map of Illinois and other geologic maps.
IN Department of Natural Resources Geological Survey state bedrock and glacial boundaries maps, generalized geologic map of IN.
MI Department of Environmental Quality, Geological Survey Division, Map of Quaternary Geology.
OH Department of Natural Resources, Division of Geological Survey, geologic map and cross section of Ohio.
ON Ministry of Northern Development and Mines, Map of Geology and Principal Minerals of Ontario.
PA Department of Environmental Protection, Topographic and Geological Survey, Glacial Deposits of Pennsylvania.
WI University of WI Extension, Geological and Natural History Survey, Maps of Ice Age Deposits and Bedrock Geology.

Contact your state's Geological Survey Division or province's Ministry of Northern Development and Mines.

References

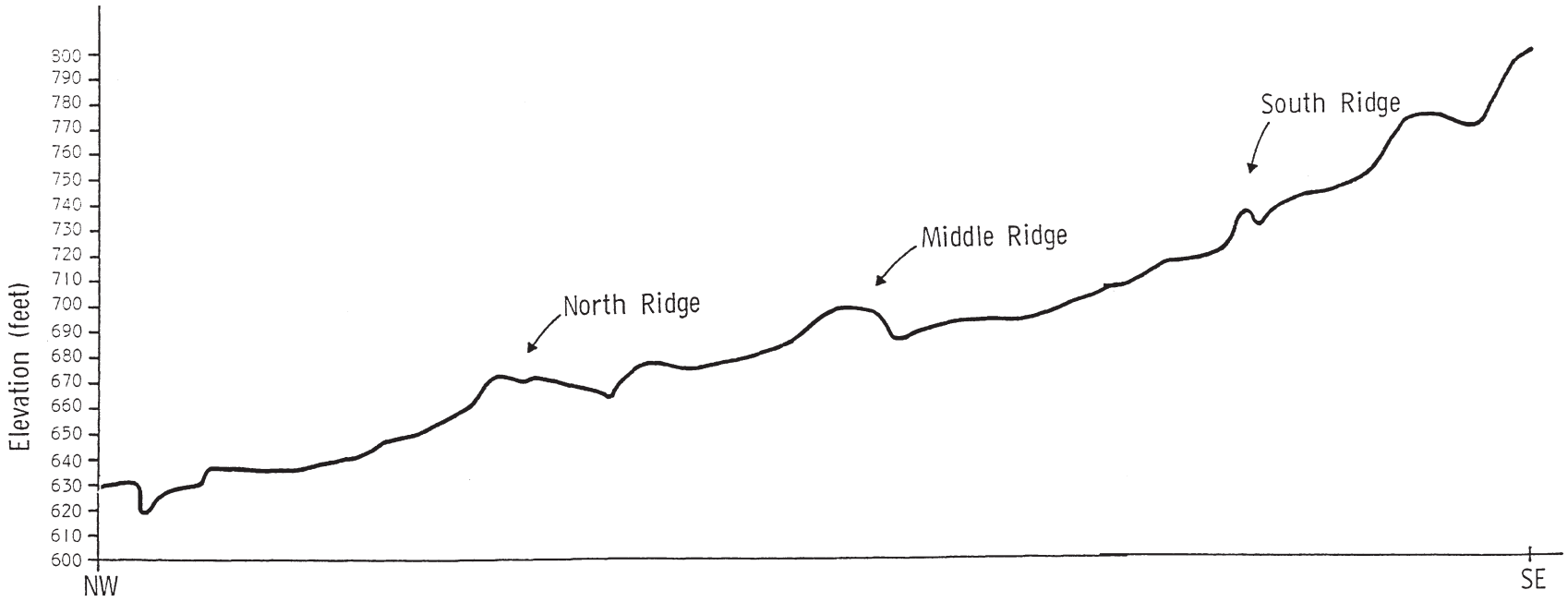
Forsyth, Jane, 1959. *The Beach Ridges of Northern Ohio*. Ohio Geological Survey Information Circular No. 25, Columbus, Ohio, illus. 10 pp.

Bascom, Willard, 1980. *Waves and Beaches: the dynamics of the ocean surface*. revised and updated. Garden City, N.Y.: Anchor Press. 366 pp.

Earth Science Curriculum Project, American Geological Institute, Willliam H. Matthews III, et al. 1987. *Investigating the Earth*, 4th ed. Boston: Houghton-Mifflin, illus. 560 pp. (pp. 190 & pp. 362).

Hesser, Dale T. and Susan S. Leach, 1987. *Focus on Earth Science*. Charles E. Merrrill Publishing Co., Columbus, Ohio, illus. 560 pp.

Graph 1.



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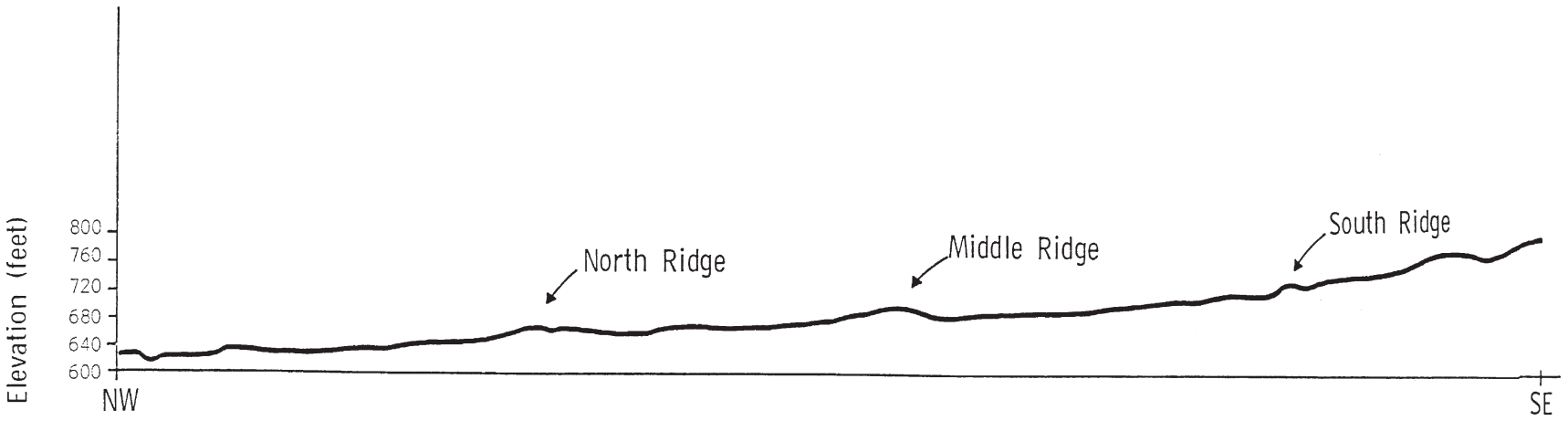
Graph 2.



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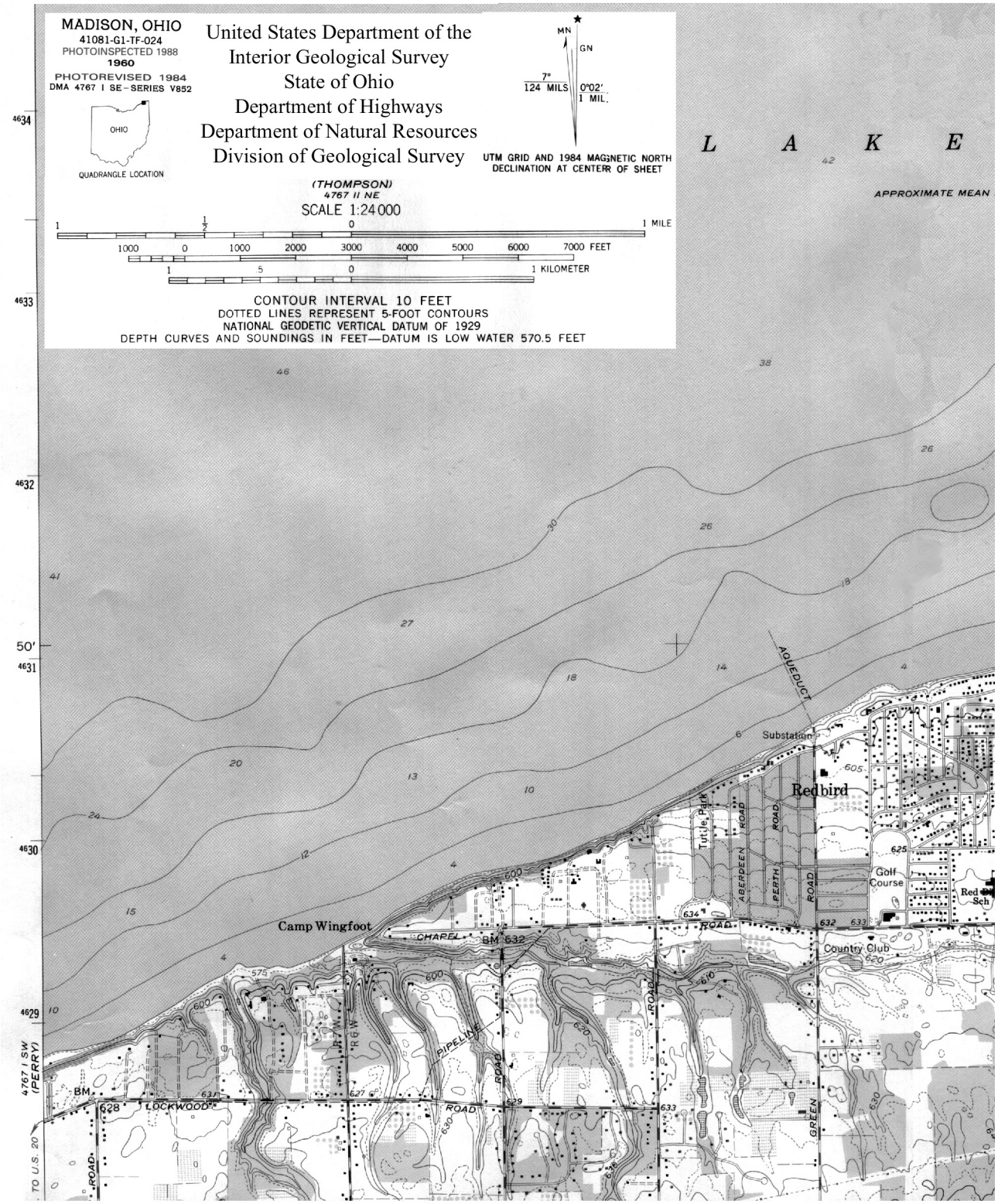
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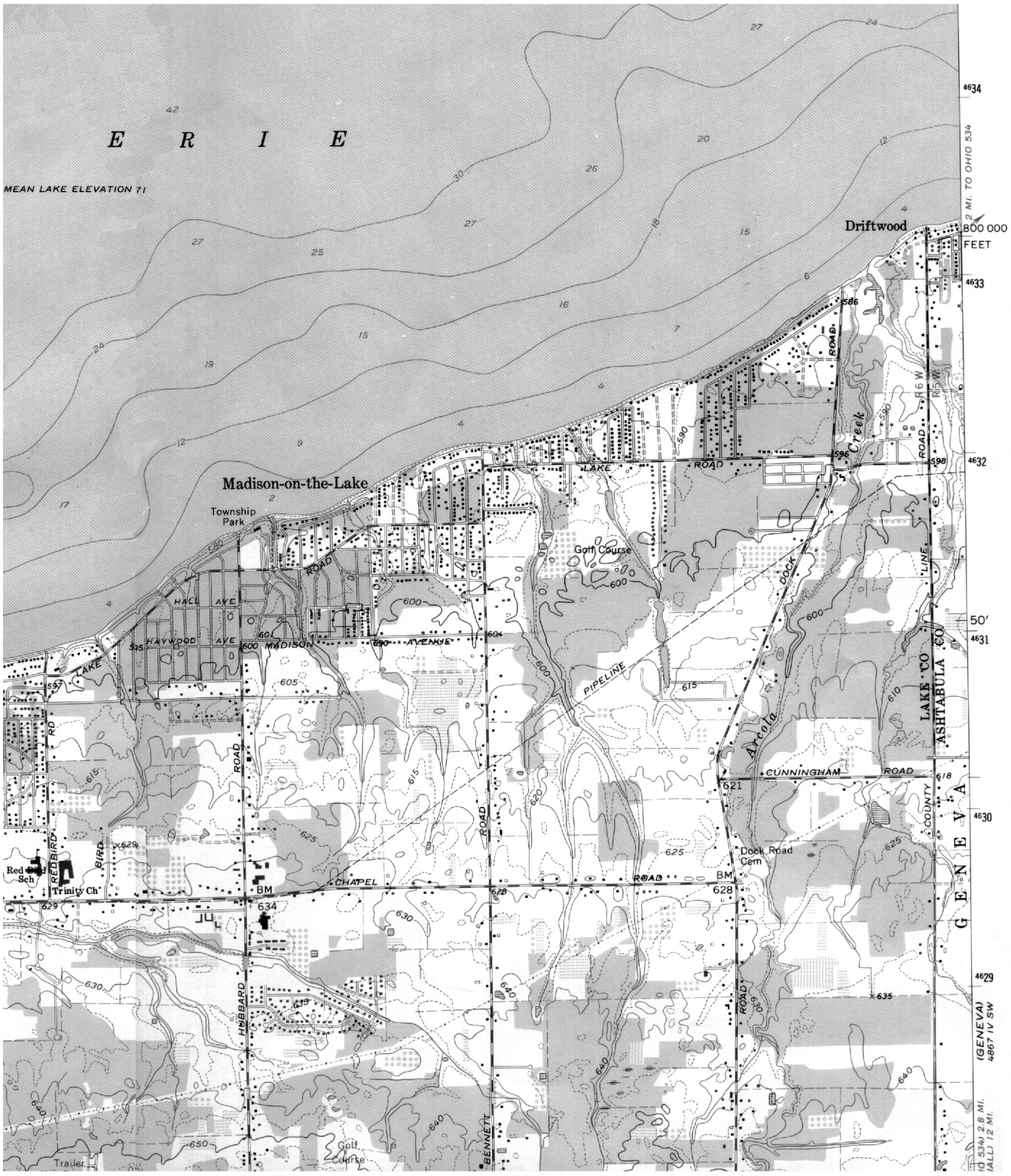

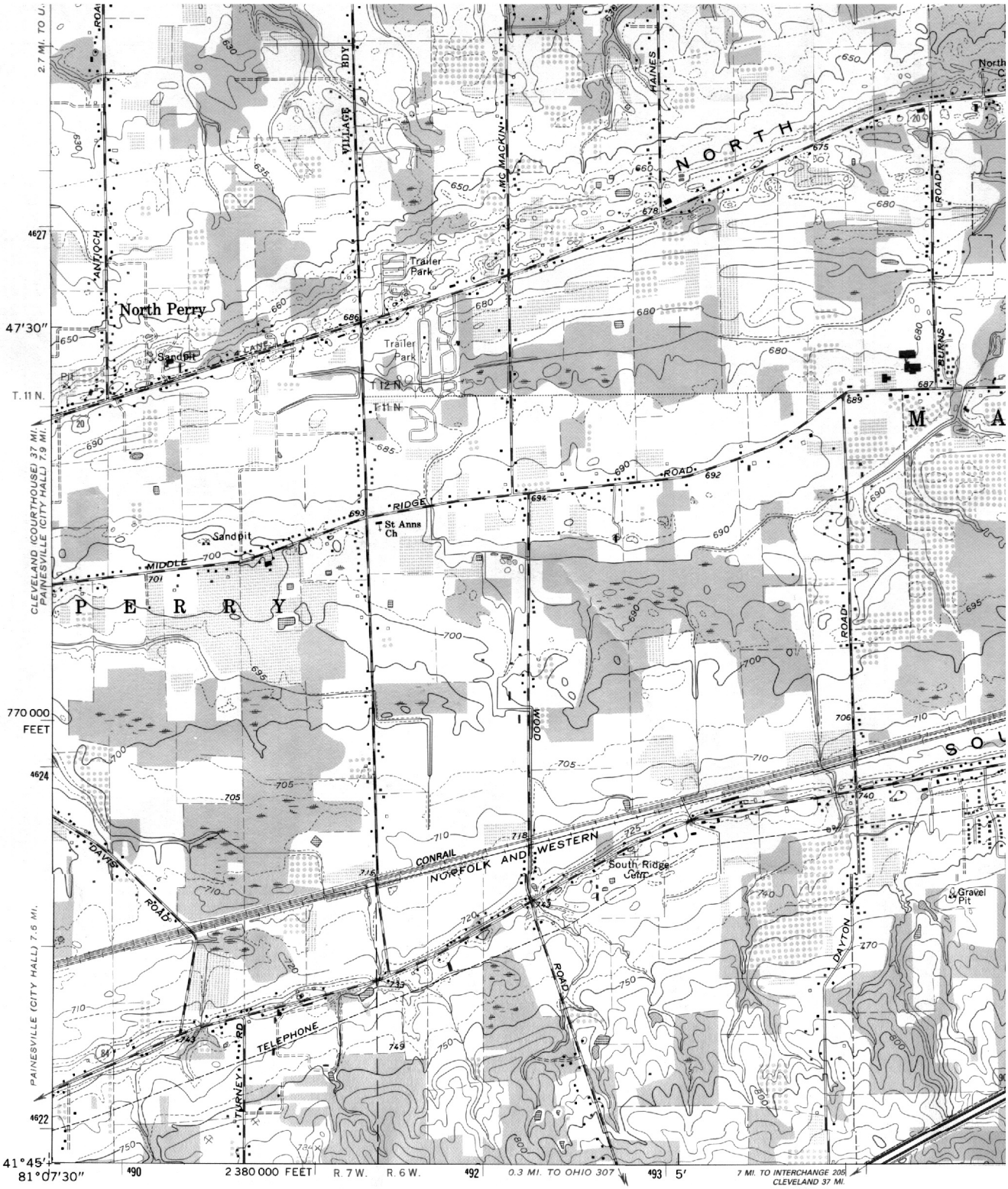
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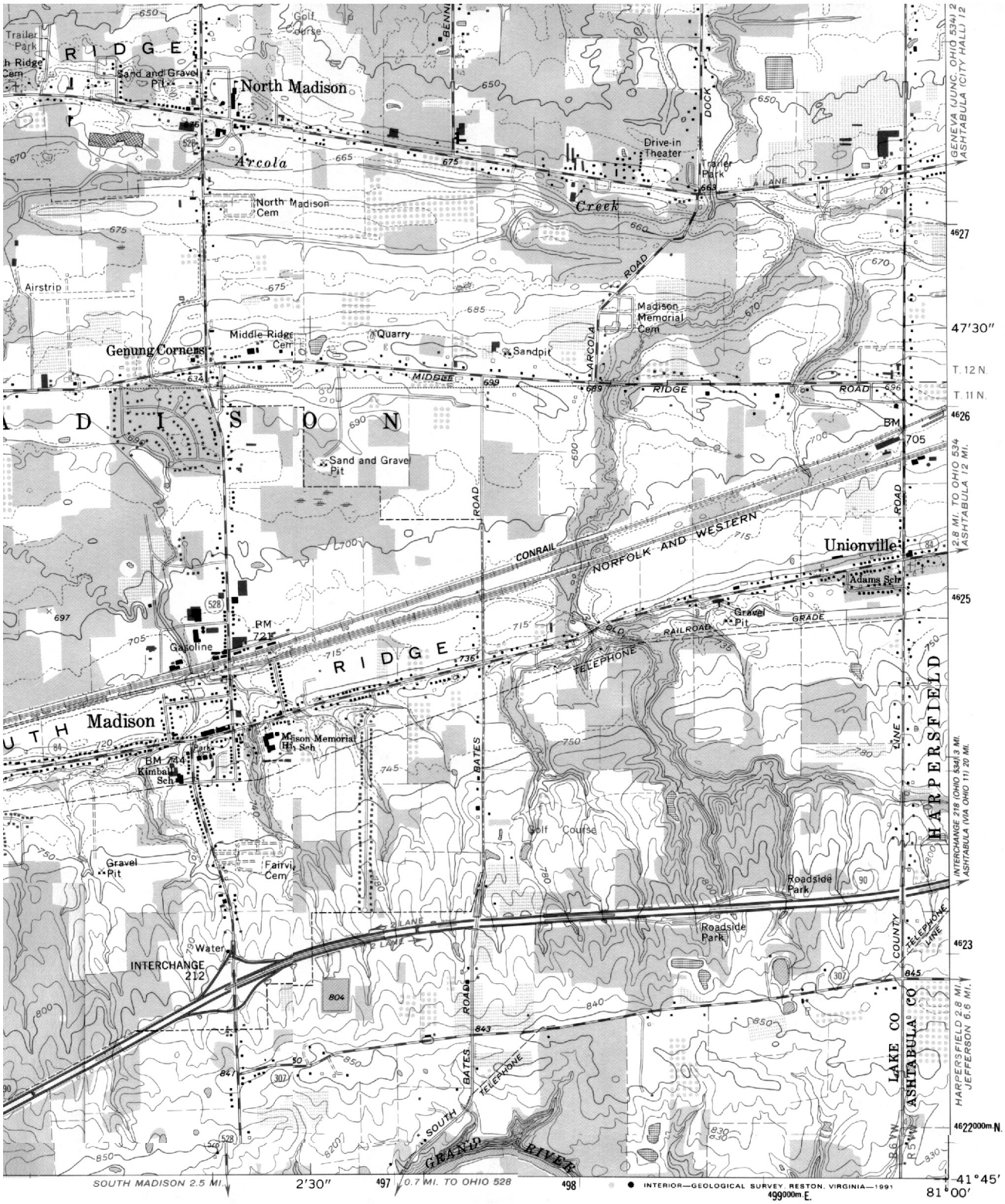

Background Page: Some beach ridges around historic stages of present Lake Erie.
Source of Art: Ohio Sea Grant Manual for Stone Lab