



# Modern and Ancient Tides

A lesson plan to be used in conjunction with the *Modern and Ancient Tides* poster and booklet available from the Indiana Geological Survey.

## Overview

Students will discover how tides operate and realize that there are different ways to measure time. They will also see one way that geologists are able to interpret ancient environments of deposition.

## Objectives

Students will:

- learn what causes tides and what effect tides can have on the movement of sediments (sedimentary processes)
- be able to relate modern sedimentary processes to ancient sedimentary processes
- learn a technique that geologists use to understand ancient sediments

## Grade levels

7-12

## Time needed

2 hours

## Subjects to integrate

- Astronomy
- Geology

## Main Topics

- Astronomical controls on tides
- Tidal influence on sediment deposition
- Measurements of time

## Skills

- 3-D visualization of Earth-Moon-Sun system
- Data generation
- Graphing comparison of modern to ancient data sets
- Data interpretation

## Materials

1. *Modern and Ancient Tides* poster and booklet.\*
2. Predicted modern tide data—available from the National Oceanic and Atmospheric Administration Web site at:  
[http://www.co-ops.nos.noaa.gov/tp4days\\_old.html](http://www.co-ops.nos.noaa.gov/tp4days_old.html).
3. Slab(s) of tidal rhythmite core\*\*, or photocopy of core (included with this lesson plan).
4. Graph paper (such as 10 squares per inch) or suitable computer graphing software.
5. Metric ruler or caliper (or binocular microscope fitted with a calibrated eye-piece scale).

\* The Indiana Geological Survey's Web site at:

<http://www.indiana.edu/~igs>

has animations of some of the tidal cycles discussed in the *Modern and Ancient Tides* poster and booklet which could be used as more dynamic examples of equilibrium tidal theory. To access the animations select "Before Our Time" in the Indiana Geology Today area of the site, then click on "Tidal Time."

\*\* Slabs of tidal rhythmites from the Hindostan whetstone beds may be purchased from the Indiana Geological Survey. Contact the IGS for more information:

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Indiana University  
611 North Walnut Grove  
Bloomington, IN 47405

phone: 812-855-7636

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## Background

Tides are the periodic rise and fall of the ocean each day and sometimes twice a day as a result of the gravitational attraction of the Moon and, to a lesser degree, the Sun on the Earth. Because the Moon is closer to the Earth, its tide-raising potential is approximately twice that of the Sun. The rise and fall of the tides can vary from decimeters to several meters depending on the location of the observer. An extreme example is the Bay of Fundy in eastern Canada. There you can walk out onto the tidal flat at low tide early in the morning and by late morning or early afternoon you could be under more than 15 meters of water (called high tide) if you stayed in one spot. Six hours later you would once again be on relatively dry ground.

The rising tides are called flood tides and the falling tides are termed ebb tides. The magnitude of the daily rise and fall is referred to as tidal range. Not all coastlines have a tidal range comparable to the Bay of Fundy, but all ocean-facing coastlines have tides. Large lakes, such as the Great Lakes, also have tides, but they are very small, generally just a few centimeters, and are not noticeable.

## Procedure

### overview

After an introduction to basic tidal theory students can begin to generate their own data sets utilizing modern tide data, ancient tidal rhythmites, or both. For the lower grades especially it may be advisable to introduce only the first three tidal cycles illustrated on the *Modern and Ancient Tides* poster: Semidiurnal Period, Synodic Period, and Tropical (Semidiurnal) Period.

If possible, pair up students and allow each pair to decide who will perform each task. Students should work in pairs so that one student can measure laminae thickness and the other can record the measurements. Each student or pair of students can create his or her own bar chart by graphing tidal rhythmite laminae thickness versus laminae number; with lamina number one being the oldest. It is recommended that the students use either slabs or cores that contain thick lamina (individual lamina greater than several millimeters thick). Alternatively, the instructor could reproduce an enlarged photocop-

ied image of the core (or use the one included with this lesson plan) that will allow the students to measure directly on the paper.

### steps

1. Distribute a core (available from the Indiana Geological Survey) or photocopy of a core (included with this lesson plan) to each student or pair of students.
2. Instruct students to assign a number to each lamina, then measure the lamina's thickness with the metric ruler, caliper, or binocular microscope, and record the measurement next to its number.
3. Using the data gathered in step 2 and graph paper or computer graphing software, students will then create a bar chart similar to the first chart in the "Ancient Tidal Records From Core" column on the *Modern and Ancient Tides* poster.
4. Using the poster as a guide, students will then identify on the chart:
  - at least three sets of dominant-subordinate tidal deposits
  - at least one neap-spring-neap cycle
  - at least one equatorial passage of the moon (crossover)
5. Ask students to identify sets of dominant-subordinate deposits and a neap-spring-neap cycle on the core or photocopy of a core.
6. Instruct students to repeat steps 1–4 using data for modern tide predictions obtained from NOAA (see item 2 in the "Materials" section on page 1) in place of the core. Students should record the height of each high tide ("H" on the NOAA chart) next to a number for that tide (with number one being the first high tide on the chart); then create a bar chart similar to the one created in step 3. For more advanced students, the exercise can be expanded to include tide data from several modern harbors. The students could compare their rock data to the modern records and explain the similarities or differences.

## Suggested Assessment

1. Interview your students by asking them to explain why there are two high tides per day along many ocean coastlines of the world and why there is an inequality between the heights of the morning and evening high tides. Inquire as to whether or not, based on tidal theory, they would expect to see this inequality if they were standing on a modern tidal flat on the Earth's equator (*no*), New York City (*yes*), or the north pole (*no, because the inequality is so extreme in an equilibrium Earth that only one high tide per day would be observed*).
2. Ask the students to match the poster illustrations of the tidal cycles showing the various Earth-Moon-Sun configurations with graphs from modern or ancient tidal data sets.
3. Ask the students to predict when would be the best time of the month to sail large ocean-going ships into a harbor (*during spring tides*).
4. Solicit opinions from the students on what might be the dominant tide-raising forces on oceans that may exist on the moons of Jupiter (*Jupiter and the other moons*).

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*We would greatly appreciate your input regarding this lesson, especially if you choose to use it in your classroom. Please send your comments to:*

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812-855-1324

or

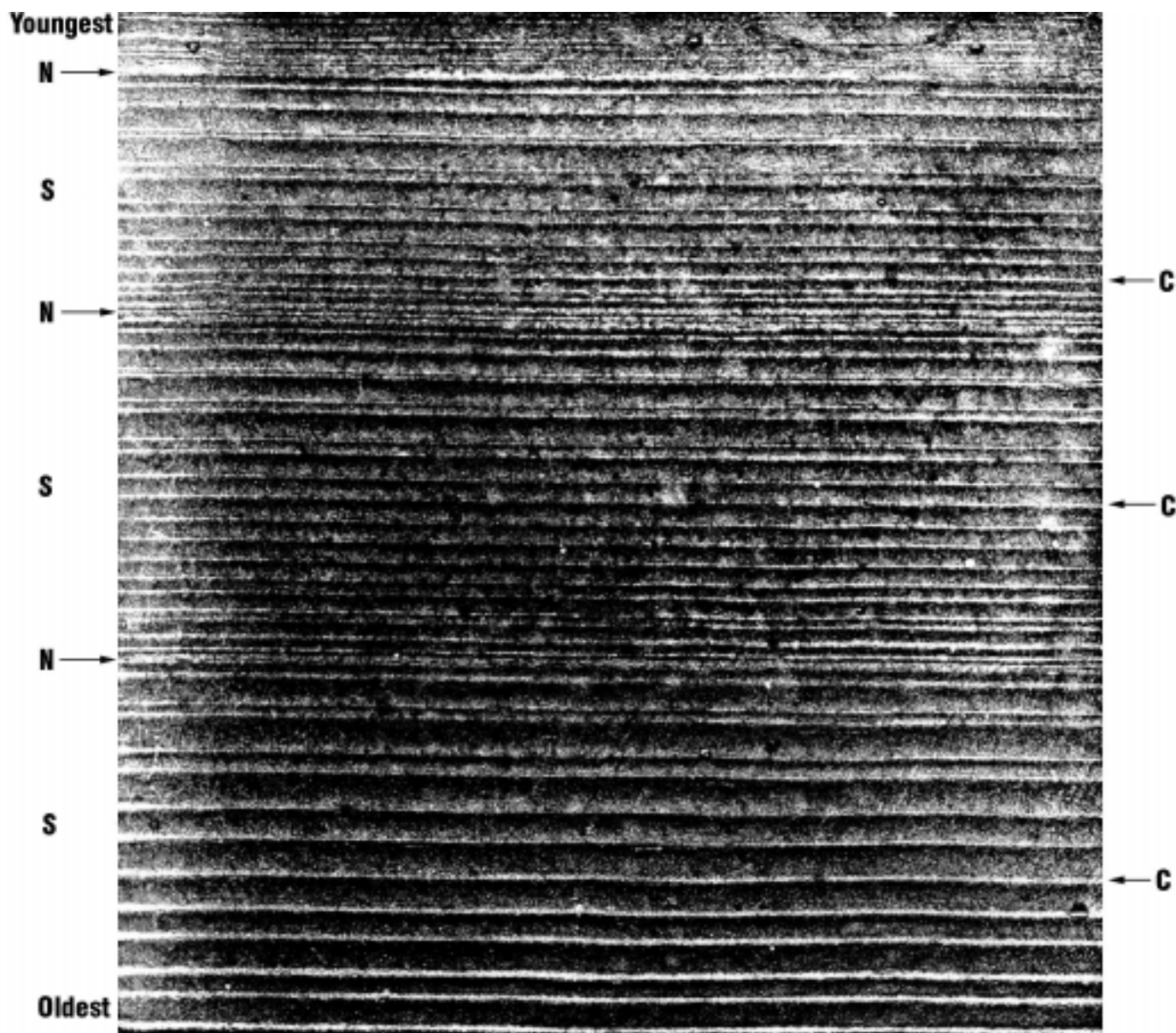
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*Jan Evans of Greenfield Middle School tried this lesson with her students and provided the following comments:*

1. Students shared various experiences they have had with tides—establishing low and high tides, etc., since we are, after all, midwesterners and don't encounter tides on a daily basis. We also worked on tidal terminology such as neap and spring tides.
2. We looked carefully at the sample you sent and I presented the idea that the layers were created by tidal deposits. I suggested that we could look for patterns in the width of the deposits and compare them with present-day tidal data.
3. Our school district is into the 4MAT system that requires a variety of methods of teaching for all kinds of learners. One activity I came up with was to place a large piece of paper on the wall with measurements. Students were then given stickers and we went through a month of tidal data, sticking dots in consecutive order to see a pattern. One student even made wave effects as students went forward to place their dot on the paper. They understood the idea easily.
4. Before measuring the widths we discussed how a scientist might take the data, as I found I was distracted by various things as I was measuring the layers myself. They decided to number each layer and have the same person measure to prevent the variable presented when two or three are measuring (at least at this age).
5. Students then entered the data into a spreadsheet and created graphs both from the whetstone and the tidal data I gave them. We learned a great deal about entering data such as using consecutive heights for high tide rather than being more random about it. They were able to see the relationship between the shape of the graphs throughout a month and the whetstone graph.

### Enlarged scanned image of surface of tidal rhythmite core (instructor's copy)



**N = Neap Tide**

**S = Spring Tide**

**C = Crossover**

**Enlarged scanned image of surface of tidal rhythmite core**

