Name _____ Period _____ Date _____

VARVES: DATING SEDIMENTARY STRATA

INTRODUCTION: Most of our knowledge about earlier life forms on Earth comes from fossils left in sedimentary rock. Sedimentary rocks are formed in layers, with the more recent sediments lying on top of older sediments. This is called "relative dating." Scientists can also now obtain fairly accurate numerical age measurements of other types of rock by radioactive dating and other methods. Methods like radioisotope dating which measures the decay rates of radioactive elements and their relative abundance in some rock specimens, as well as dendrochronology (tree ring dating, used to calibrate carbon 14 radioisotope dating), are considered "absolute dating" because a numerical value is determined (e.g. 1280 AD $\pm$ 50 years). In this investigation we will measure sedimentation rates derived from varved shales of the Green River Formation, ancient playa lake deposits about 40 million years old.

The Green River Formation is a shale deposit of preglacial laminated sediments averaging about 600 meters thick and covering about 25,000 square miles. Found in Colorado, Wyoming, and Utah, a large part of these sediments appear to be annual sedimentation cycles, called "varves." Unlike most modern varved deposits, the Green River varves are very thinly layered; and each layer consists of two laminae, one of which contains considerably more carboneous matter than the other. The layers generally occur in alternating light and dark pairs. In a typical pair one layer is thicker, coarser grained, and rich in calcium carbonate, while the other layer is thinner, finer grained, and rich in organic material. The conclusion that each light/dark pair (a "varve") represents a year's worth of deposits is supported by numerous facts, one of which is that the annual varves fluctuate in thickness in a cycle corresponding to the sunspot cycle.

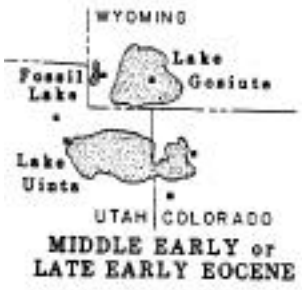


image from Grande, L., 1984

The rock sample that you have been asked to study is actually the compressed sediments from the bottom of this ancient dried up lake formation. This shale billet is only a very tiny portion of the whole deposit.

PURPOSE: To estimate sedimentation rates and infer total age for sediments of the Green River Formation in Wyoming, and from this extrapolate a minimum age of the Earth.

MATERIALS: per group of 2 (check to be sure that you have all necessary materials before you begin)

___ binocular dissecting microscope, 30x mini-scope, or low power (40x) compound microscope

___ piece of polished shale billet ___ small metric ruler ___ calculator (optional)

PROCEDURE:

___ 1. Examine the shale billet. What is the total thickness of your sample? _____mm (Be sure to measure from the bottom layer to the top layer. Remember that you are measuring the span of the actual thin lined bands on your sample, like measuring the thickness of a stack of papers.)

___ 2. Predict the total **number** of tiny little dark bands that run horizontally through your shale billet.

_____ estimated total

___ 3. Examine your shale specimen (with exposed varved layers facing up) with a 30x-40x microscope, illuminating it only from above. Place the metric ruler on the shale billet with the mm ruler markings parallel to the varve layers. Position the ruler so that you can count the number of varves (count the dark bands only) in a typical 1mm portion. _____ varves per millimeter.

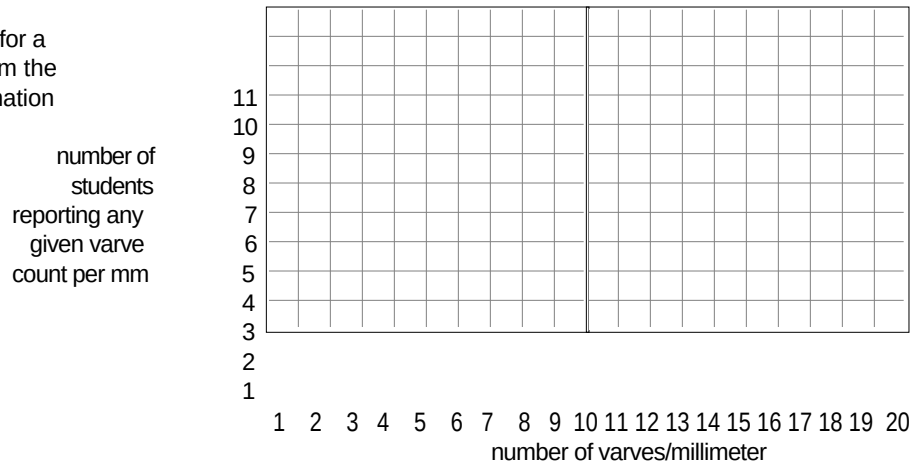
___ 4. Each member of the group is to determine the actual **total** number of varves for the specimen. This can be determined by taking the answer from #1 above and multiplying it by #3 above.

_____ actual total varves in sample.

___ 5. When instructed by your teacher, report your individual varve count per millimeter in step #3. Each student will report their individual varve count per millimeter in order to create the histogram located on the next page.

DATA AND RESULTS: Fill in the histogram below by blackening one square for **each** varve count from each student.

Graph #1: Histogram of student **varve counts per millimeter** for a piece of shale from the Green River Formation



DISCUSSION: (Show all calculations.)

1. How thick is one **average year's** deposit on the bottom of this ancient dried up lake?

2. Although the layers are not perfectly smooth, why is it impossible that any layers would ***cross over*** into other layers.

3. Using this shale billet as a model of deposition rates, how long would it take for "mother nature" to deposit a set of layered sediments 1 meter thick?

4. The Green River deposits average 600 meters thick. Calculate how long this lake (actually 3 different lakes in this region) was in existence before it permanently dried up.

5. Predict 2 kinds of evidence that would lead scientists to conclude that these layered sediments were formed at the bottom of an ancient freshwater lake.

6. What conditions caused the formation of varves in this ancient lake bottom? (Where do these very fine sediments come from?)

7. How does this lab demonstrate the principles of absolute and relative dating?

8. Knowing that the dark bands contain relatively higher concentrations of organic material (microscopic algae,etc.), what do the occasional, very thick dark bands suggest?

9. Looking at the **class data** on the histogram determine the **mean**, **mode**, and **median** for varves/mm.