ES202 Geologic Time Lab Key (Updated Feb. 4, 2021)

Your task is to complete portions of Lab 8 in your lab manual (AGI 10th Ed.). Part1. Short Answer. Read the lab materials on p. 209-214 and define the following terms and concepts / answer the questions.

1. Discuss the difference between relative age dating and absolute age dating, as pertaining to the geologic rock record. Relative age dating simply describes the age of something relative to other things. So a rock layer that has layers above and below it is older than the layers above it and younger than the layers below it. Absolute age dating describes the age of something in exact units, like years. It is more specific than relative age dating. For example, one rock layer could be 425 million years old.

2. Law of Original Horizontality – Sedimentary layers (strata) and lava flows were originally deposited as relatively horizontal sheets.

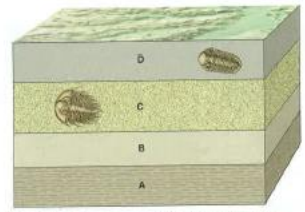


FIGURE 8.2 Law of superposition in horizontal strata.

3. Law of Lateral Continuity – Lava flows and strata extend laterally in all directions until they thin to nothing (pinch out) or reach the edge of their basin of deposition.

4. Law of Superposition – In an undisturbed sequence of strata or lava flows, the oldest layer is at the bottom of the sequence and the youngest is at the top.

5. Law of Inclusions – Any piece of rock (clast) that has become included in another rock or body of sediment must be older than the rock or sediment into which it has been incorporated.

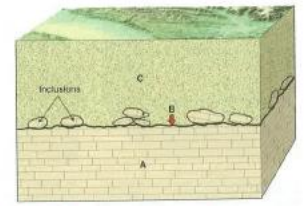


FIGURE 8.3 Inclusions on a disconformity. These strata

6. Law of Cross-Cutting Relations – Any feature that cuts across a rock or body of sediment must be younger than the rock or sediment that it cuts across.

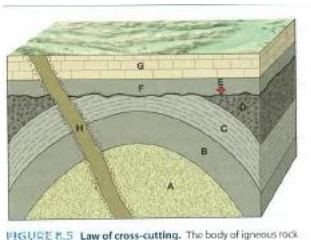


FIGURE 8.5 Law of cross-cutting. The body of igneous rock

7. Unconformity – A surface that represents a gap in the geologic record that formed wherever layers were not deposited for a time or else layers were removed by erosion.

8. Angular Unconformity – An unconformity between two sets of strata that are not parallel to one another.

9. Disconformity – An unconformity between parallel strata or lava flows.

10. Nonconformity – An unconformity with sedimentary rock overlying much older crystalline igneous or metamorphic rock.

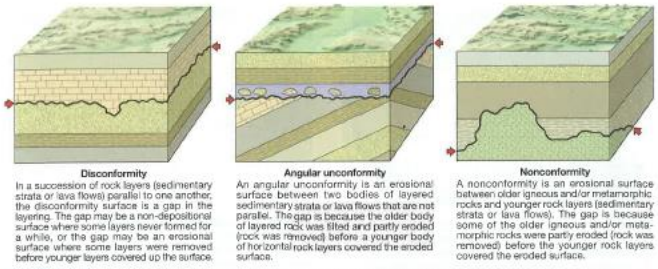


FIGURE 8.1 Three kinds of unconformities. Unconformities are surfaces that represent gaps (missing layers) in the geologic record; analogous to a gap (place where pages are missing) in a book. Red arrows point to the unconformity surface (bold black line) in each block diagram.

11. Isotope – a variety of any given element from the periodic chart that has the same number or protons (defining the element) but a different number of neutrons. Each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; in particular, a radioactive form of an element.

12. Parent vs. Daughter A **daughter isotope** is the product which remains after an original **isotope** has undergone radioactive decay. The original **isotope** is termed the **parent isotope**. A **daughter isotope** is also known as a **daughter** product, **daughter** nuclide, decay product, or radio-**daughter**.

13. Half-Life **Half-life**, in radioactivity, the interval of time required for one-half of the atomic nuclei of a radioactive sample to decay (change spontaneously into other nuclear species by emitting particles and energy), or, equivalently, the time interval required for the number of disintegrations per second of a radioactive material to decrease by one-half.

14. What is the daughter product and half life of Carbon 14? Nitrogen 14 5730 years

15. What is the daughter product and half life of Uranium 235? Lead 207 713 m.y.

16. Can C-14 be used to numerically date materials that are 10 m.y. old? Why or why not? False. C-14 half-life is too fast of a decay rate for materials that old. C-14 age dating is only good for materials going back to 40,000 years to 70,000 years before present.

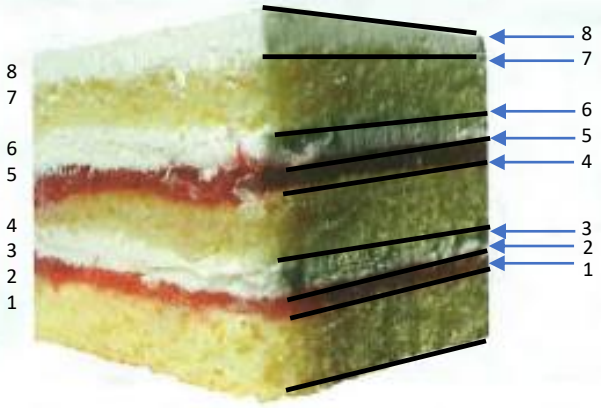
Part 2. Lab Activities. Complete the following lab questions / activities.
Activity 8.1 p. 208 Basics of Relative Age Dating
Activity 8.2 p. 208 Geologic Cross-Sections and Relative Age Dating
Activity 8.4 p. 222 Absolute Age Dating

ACTIVITY 8.1 Geologic Inquiry for Relative Age Dating

Name: _____ **Course/Section:** _____ **Date:** _____

A. Analyze this block of layer cake. Each side of the block of cake is a vertical **cross section** of the layers. Also notice the surfaces between the layers, where two different layers touch each other. Geologists refer to surfaces between layers or other bodies of rock as **contacts**.

1. Think about the process used to construct the layer cake, from making and *depositing* (laying down) the first layer to making and depositing the last layer. On the left edge of the cake, number the layers to show the sequence of steps in which they were deposited to make the layer cake from 1 (first step) to n (the number of the last step).
2. Using a pen, draw lines on the layer cake to mark all of the contacts between layers. Then place arrows along the right edge of the cake that point to each contact. Label each arrow (contact) to show its relative age from 1 (the time when the first contact was created; the oldest contact) to "n" (the number corresponding to the last time a contact was created; the youngest contact).



B. The picture below is an outcrop about 5 meters thick near Sedona, Arizona. The red rock is an ancient body of soil. The brown layer in which grass is rooted is modern soil. The blocky brown-gray rock with wide fractures (cracks) is an ancient lava flow (basalt, a volcanic rock). This outcrop is a natural geologic cross section of rock layers, analogous to the cake.

1. Which layer is the oldest? How do you know?

Red soil is oldest, on bottom, law of superposition

2. Using a pen, draw a line on the picture that marks the exact position of:
   a. the contact between the red ancient soil and the lava flow.
   b. the exact contact between the top of the lava flow and the base of the darker brown modern soil in which grass is growing.
3. Notice the **fractures** (cracks) that cut across the lava flow layer. Are they older or younger than the lava flow? How do you know?

Fractures younger than lava flow,
Law of cross-cutting relations

4. Notice that *clasts* (broken pieces) of the lava flow are included in the brown soil. Are they older or younger than the brown soil? How do you know?

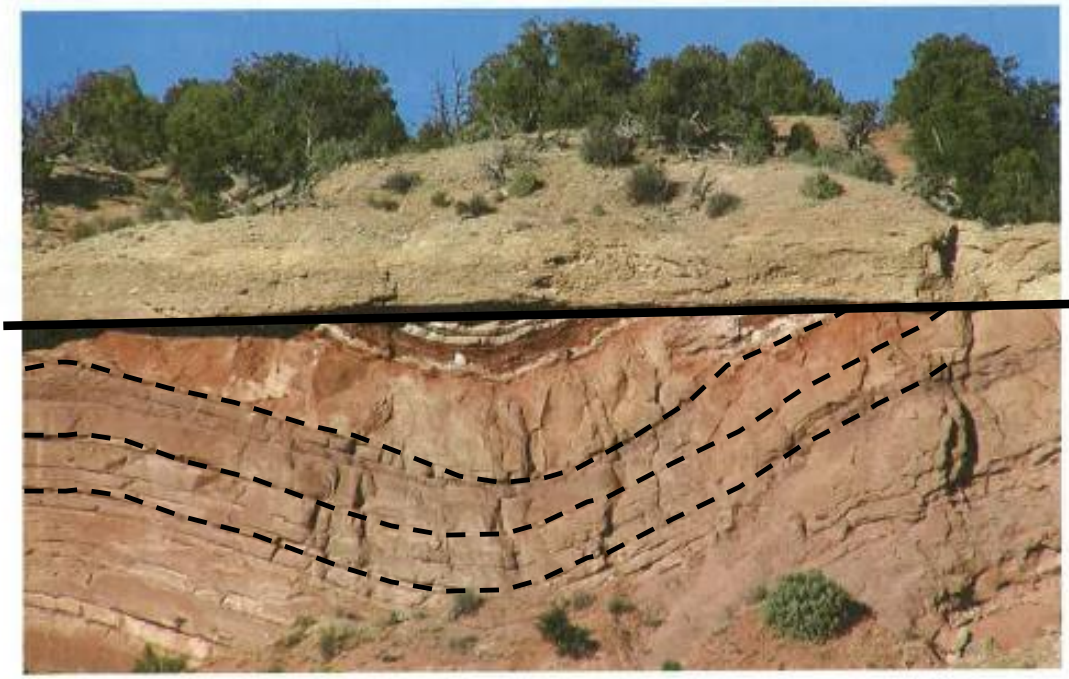
Lava flow is older than brown soil,
Law of Inclusions and Superposition

Brown Soil

Lava Flow

Red Soil

C. Analyze this outcrop, photographed by geologist, Thomas McGuire. It is another natural geologic cross section with red sandstone layers on the bottom and a yellow conglomerate (gravel) rock layer on top. Notice that the red rock layers are not horizontal. They are bent up on the left and right, and down in the middle, as wave-like **folds** (like a crumpled rug).



1. Using a pen, trace two of the contacts between layers of the red sandstone as well as you can. Assuming that the red sandstone layers were originally horizontal, what may have caused them to be folded in this way?

Sandstone deposited in horizontal layers, followed by tectonic
Compression and folding of layers into syncline (Law of original horizontality)

2. On both sides of the picture, use an arrow to label the exact location of the contact between the red sandstone and the horizontal yellow conglomerate above it. This surface is an **unconformity**—a surface (contact) representing erosion of layers or a break in deposition of layers, like a place where pages are missing from a book. Something happened at the time represented by the surface, but no rock layer remains as a record of the event. What sequence of events may have happened to form the unconformity?

Sandstone deposited in horizontal layers, followed by tectonic
Compression and folding of layers into syncline, followed by erosion of unconformity surface, with
Final deposition of yellow conglomerate on top in horizontal layer (unfolded)

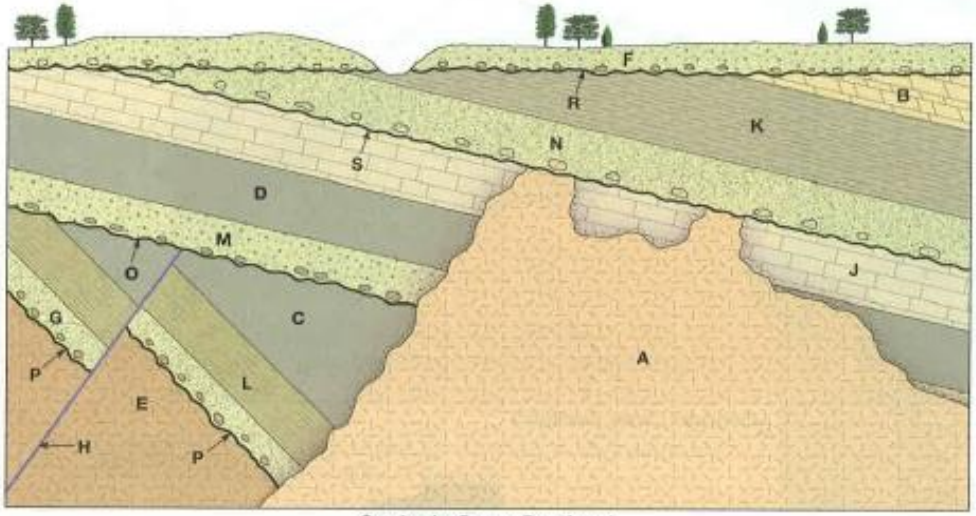
D. **REFLECT & DISCUSS** In all of your work above, you had to figure out the relative ages (from oldest to youngest) of rock layers, fractures, folds, and clasts included in soil. Based on your work, write down three rules that a geologist could follow to tell the relative ages of rock layers, fractures, clasts, and folds in geologic cross sections.

Law of Superposition
Law of Original Horizontality
Law of Cross-Cutting Relations

ACTIVITY 8.2 Determining Sequence of Events in Geologic Cross Sections

Name: _____ **Course/Section:** _____ **Date:** _____

A. Review the legend of symbols at the bottom of the page. On the lines provided for each cross section, write letters to indicate the sequence of events from oldest (first in the sequence of events) to youngest (last in the sequence of events). Refer to FIGURES 8.1–8.9 and the laws of relative age dating (page 209 as needed).



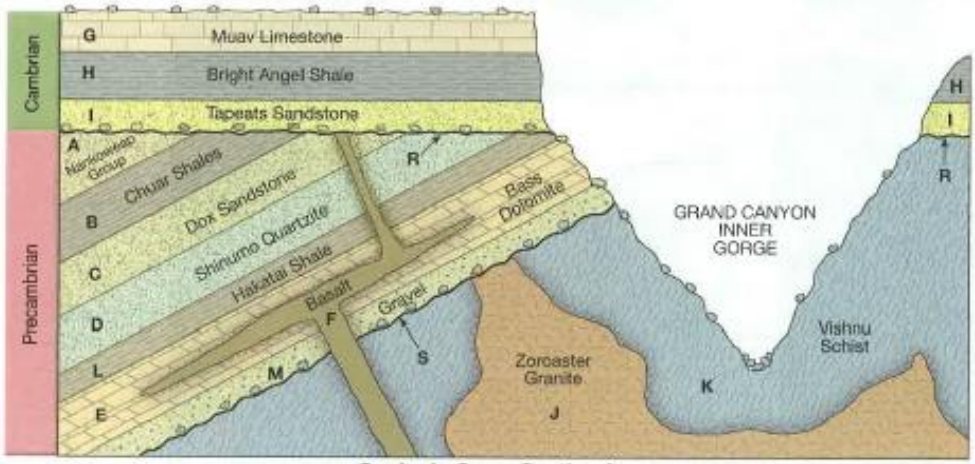
Geologic Cross Section 1

Youngest _____

Figure 8.9

_____ **F** (youngest, occurred last)
_____ **R**
_____ **B**
_____ **K**
_____ **N**
_____ **S**
_____ **A**
_____ **J**
_____ **D**
_____ **M**
_____ **O**
_____ **H**
_____ **C**
_____ **L**
_____ **G**
_____ **P**
Oldest _____ **E** (oldest, occurred first)

Answer Cross Section 1



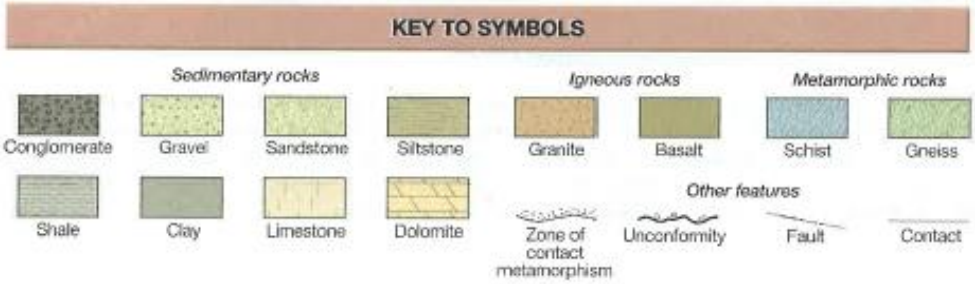
Geologic Cross Section 2

Youngest _____

Figure 8.10

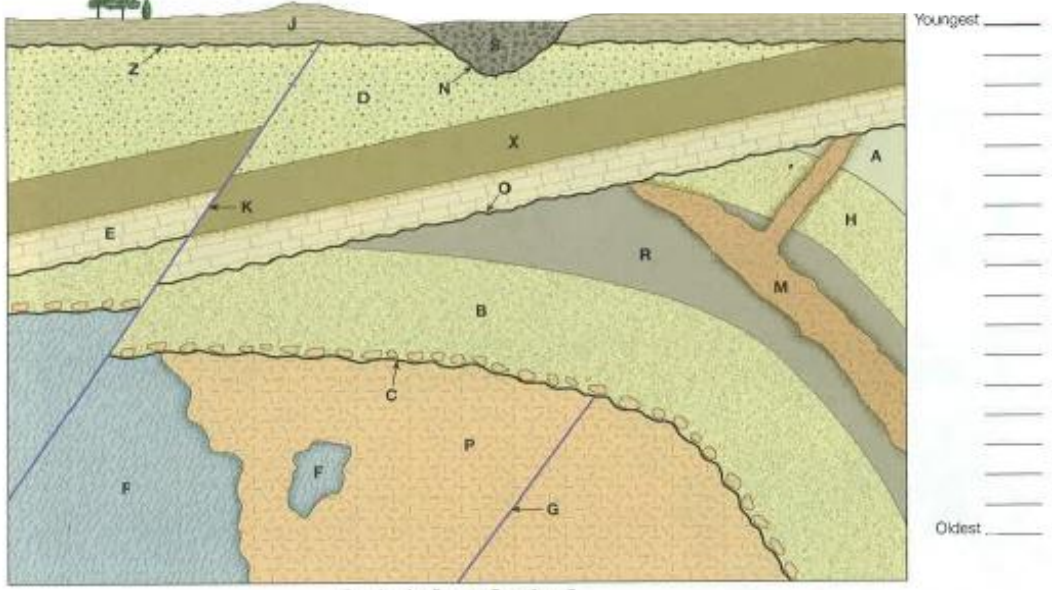
_____ **G** (youngest, occurred last)
_____ **H**
_____ **I**
_____ **R**
_____ **A**
_____ **B**
_____ **C**
_____ **D**
_____ **L**
_____ **F** (occurred anytime after **C but before R**
_____ **E**
_____ **M**
_____ **S**
Oldest _____ **J**
K (oldest, occurred first)

Answer Cross Section 2

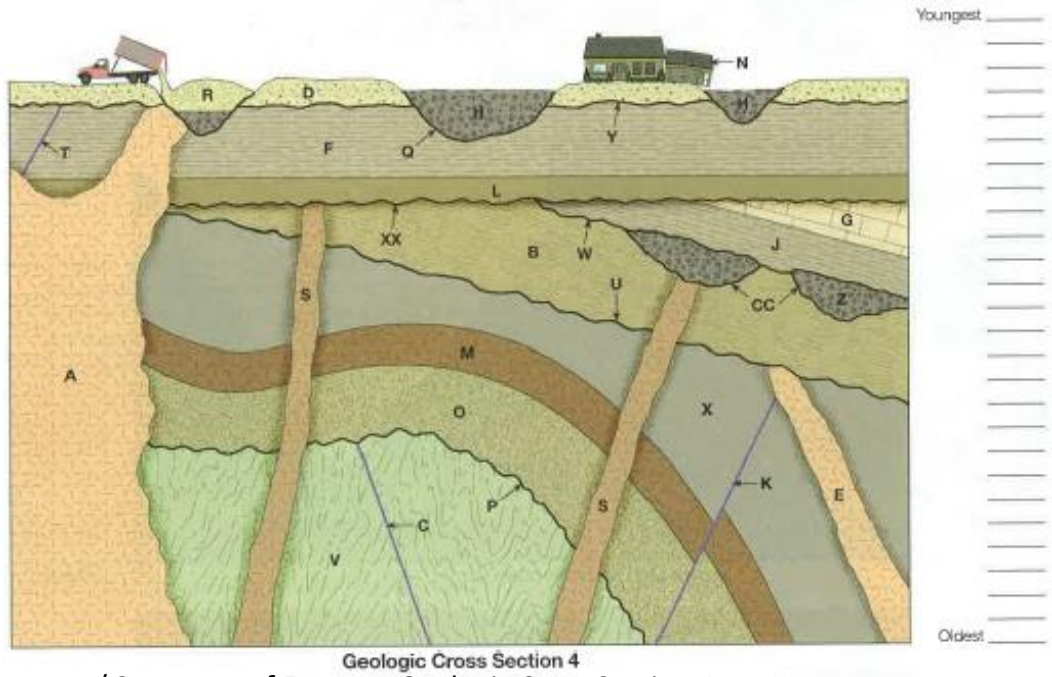


Answer / Sequence of Events
Geologic Cross Section 3

For Fig. 8.11, Oldest to Youngest: F (parts of F included in P, so it came first), P (part of P included in B, so it came before B), G (doesn't cut layer B), B, R, M (doesn't intrude layer H), H, A, E, X, D, K (doesn't cut J or S), J, S.



Geologic Cross Section 3



Geologic Cross Section 4

Answer / Sequence of Events – Geologic Cross Section 4

For Fig. 8.12, Oldest to Youngest: V, C, O, M, X, K, E, B, S, Z, J, G, L, F, T, A, D, H, P, N (I interpret that N occurred during faulting of P. Since the garage is dipping into the river channel where H has formed, H must have formed before faulting P occurred), R.

ACTIVITY 8.4 Absolute Dating of Rocks and Fossils

Name: _____ **Course/Section:** _____ **Date:** _____

A. A solidified lava flow containing zircon mineral crystals is present in a sequence of rock layers that are exposed in a hillside. A mass spectrometer analysis was used to count the atoms of uranium-235 and lead-207 isotopes in zircon samples from the lava flow. The analysis revealed that 71% of the atoms were uranium-235, and 29% of the atoms were lead-207. Refer to FIGURE 8.11 to help you answer the following questions.

1. About how many half-lives of the uranium-235 to lead-207 decay pair have elapsed in the zircon crystals? ___

2. What is the absolute age of the lava flow based on its zircon crystals? Show your calculations.

1. 1/2 of a half life (0.50 half-life) has elapsed.
2. 0.50 x 713,000,000 yr = 356,500,000 yr (about 357 million years old)
3. The lava flow must be less than or equal to the age of the zircon crystals (357 million years old).
4. The rocks beneath the lava flow are older than the lava flow, so they are more than 357 million years old.

3. What is the age of the rock layers above the lava flow? _____

4. What is the age of the rock layers beneath the lava flow? _____

B. Astronomers think that Earth probably formed at the same time as all of the other rocky materials in our solar system, including the oldest meteorites. The oldest meteorites ever found on Earth contain nearly equal amounts of both uranium-238 and lead-206. Based on FIGURE 8.11, what is Earth's age? Explain your reasoning.

50% of the parent has decayed, so one half-life of 4.5 billion years has elapsed. Based on this logic, the Earth is about 4.5 billion years old.

C. If you assume that the global amount of radiocarbon (formed by cosmic-ray bombardment of atoms in the upper atmosphere and then dissolved in rain and seawater) is constant, then decaying carbon-14 is continuously replaced in organisms while they are alive. However, when an organism dies, the amount of its carbon-14 decreases as it decays to nitrogen-14.

1. The carbon in a buried peat bed has about 6% of the carbon-14 of modern shells. What is the age of the peat bed? Explain.

94% of the parent (C-14) has decayed (because only 6% remains), so about 4 half-lives of 5730 years have elapsed. So the peat must be about 22,920 yr old.

2. In sampling the peat bed, you must be careful to avoid any young plant roots or old limestone. Why?

Younger plant roots would contaminate the peat with more C-14 and make it seem younger, while older limestone would contaminate the peat with more N-14 and make it seem older.

D. Zircon ($ZrSiO_4$) forms in magma and lava as it cools into igneous rock. It is also useful for absolute age dating (FIGURE 8.11).

1. If you walk on a modern New Jersey beach, then you will walk on some zircon sand grains. Yet if you determine the absolute age of the zircons, it does not indicate a modern age (zero years) for the beach. Why?

No, the zircon crystals are weathered from older igneous rocks. The zircon crystals did not form at the same time as the sand deposit; they are older than the sand deposit.

2. Suggest a rule that geologists should follow when they date rocks based on the radiometric ages of crystals inside the rocks.

The radiometric age of a crystal in a rock is about the same age as the rock only if it formed at about the same time as the rock (and has not been re-heated or isotopically contaminated, as in Question 10b above).

E. **REFLECT & DISCUSS** An "authentic dinosaur bone" is being offered for sale on the Internet. The seller claims that he had it analyzed by scientists who confirmed that it is a dinosaur bone and used carbon dating to determine that it is 400 million years old. Discuss the sellers claims with a partner or in a small group. Should you be suspicious of this bone's authenticity? Explain. (See FIGURES 8.10, 8.11).

False C-14 Age Dating is only good for materials less than 80 t.y. old, would not apply to 400 m.y. old bones