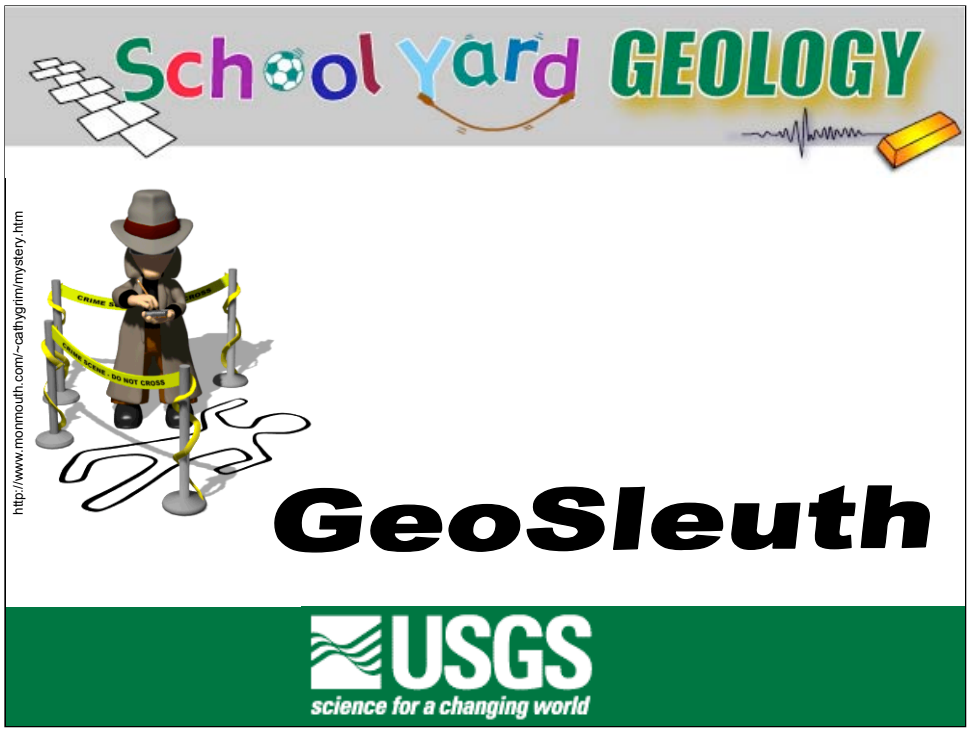
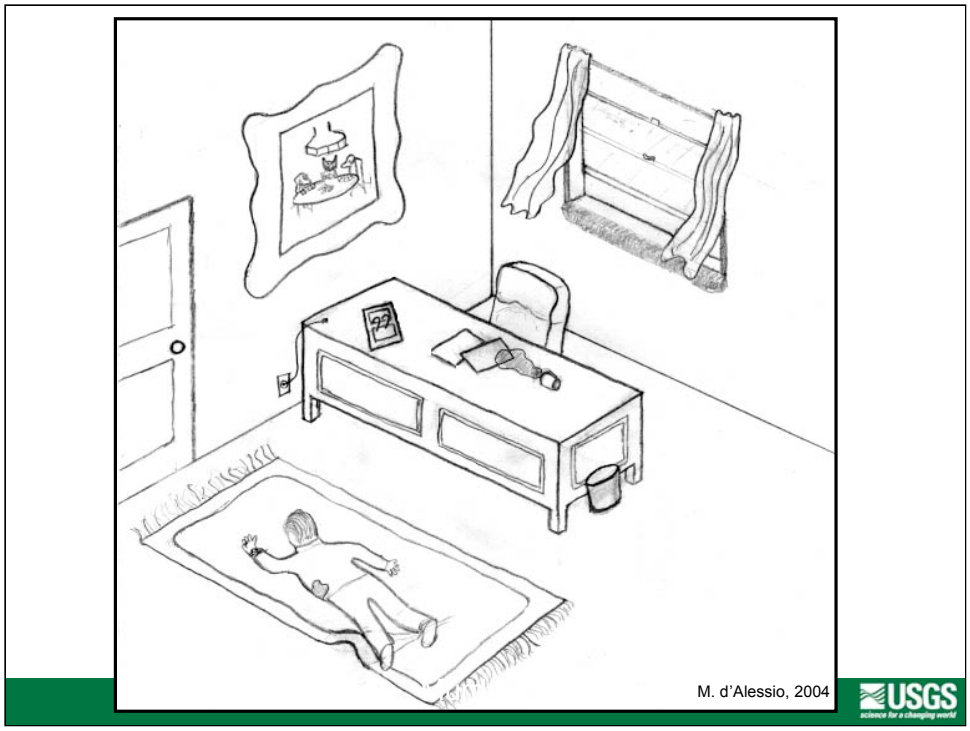


I used this exercise to begin the very first lecture of the semester in an introductory geology course for non-majors. More specifically, the course was taught at the community college level in a program inside San Quentin State Prison.Originally, we were apprehensive about teaching a murder mystery to students who may have committed a murder themselves. However, the students became very interested and excited in the exercise, enthusiastically participating. Once we established a list of agreed upon observations, they began arguing back and forth about theories and their interpretation of the evidence. The exercise was an overwhelming success. Depending upon the age level of your students, a murder mystery may or may not be appropriate. Either way, don't glorify the violence. In fact, one possible scenario is that the man is not dead, but just spilled coffee, tripped and fell.



I did the exercise in the following order:

1 Have students look at the photo for 1 minute silently by themselves.

2 Ask students to list **observations** about the image. Write them down on the board as students give them. Be very clear about the difference between observations and interpretation and don't write any interpretations on the board.

3 When you have collected all the observations, ask the class if everyone agrees with these observations.

4 Now the fun begins. Ask for students to volunteer their **interpretation** about the sequence of events that happened.

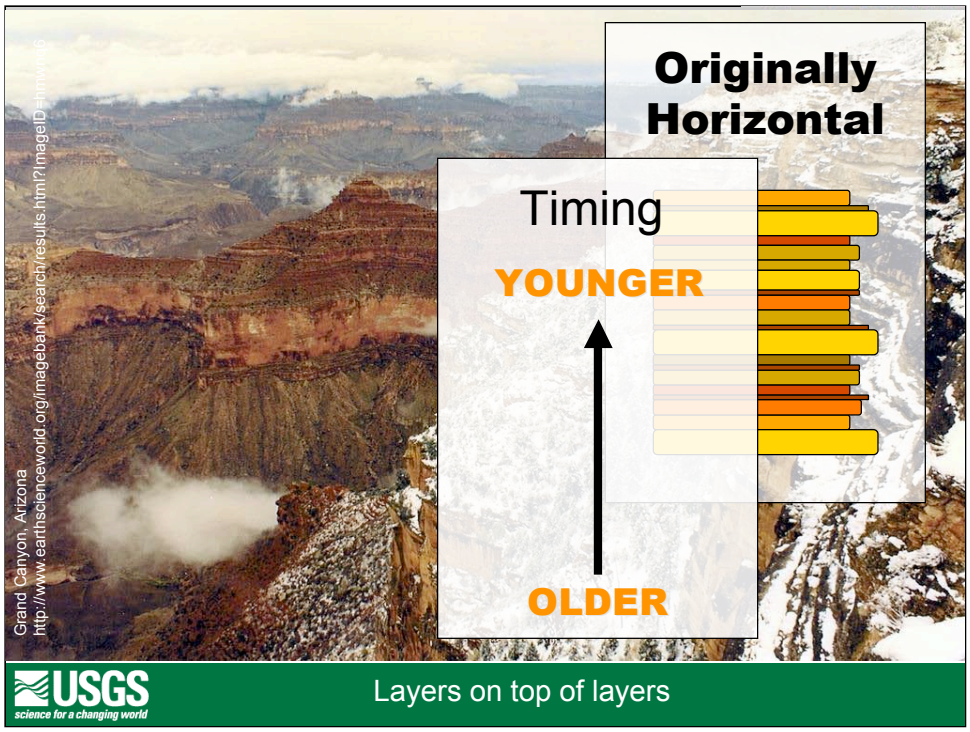
5 Let chaos reign for a few minutes as students argue competing theories.

6 Summarize the different interpretations, highlighting the geologic principles that each theory depends upon (shown below).

7 Show the geologic images from the Powerpoint presentation.

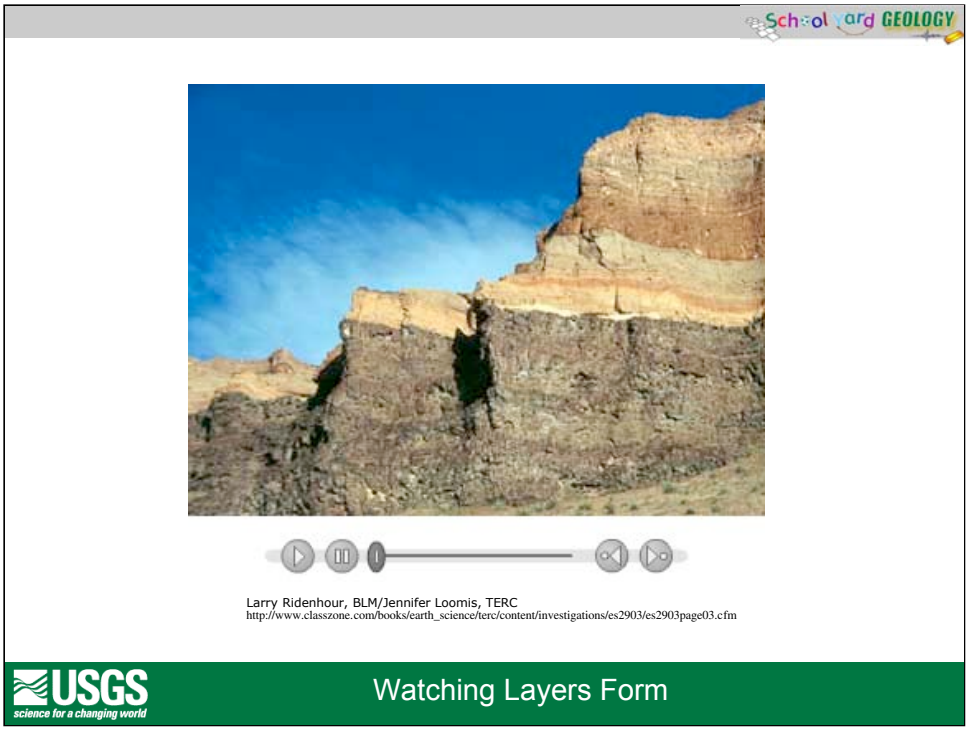
8 Put the murder mystery image up and go over the geologic principles again.

9 End class without giving them an answer about what really happened.

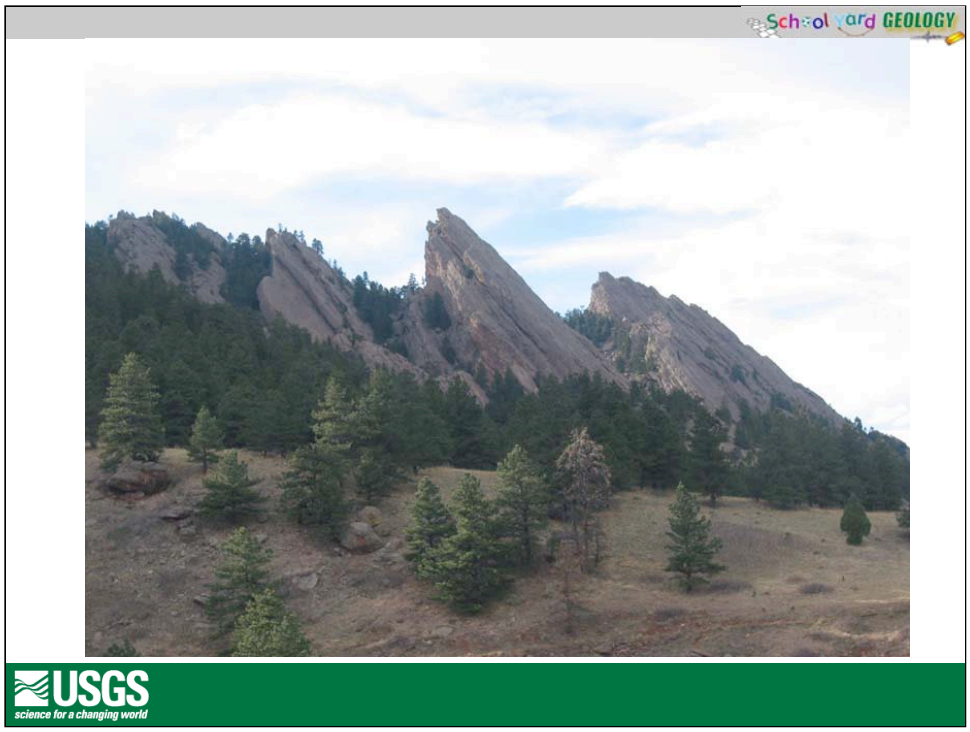


There are two principles that we learn from the man on the carpet, and that show up here in the Grand Canyon. When layers of rock are deposited, they usually start out flat (horizontal). This is because they often form under water where individual grains of sediment settle down to the bottom of the ocean, lake, or stream. Settling leads to horizontal layers. In the murder mystery, the carpet is also placed down originally horizontal.

We can also tell about the timing of a sequence of events. The man in the murder mystery is on top of the rug, so he had to fall AFTER the rug was placed on the ground (otherwise, someone would have had to slide the rug underneath the body, which is totally unrealistic). The same is true of layers of sediment. The oldest layers are on the bottom, and younger, newer layers get added on top of what is already there.



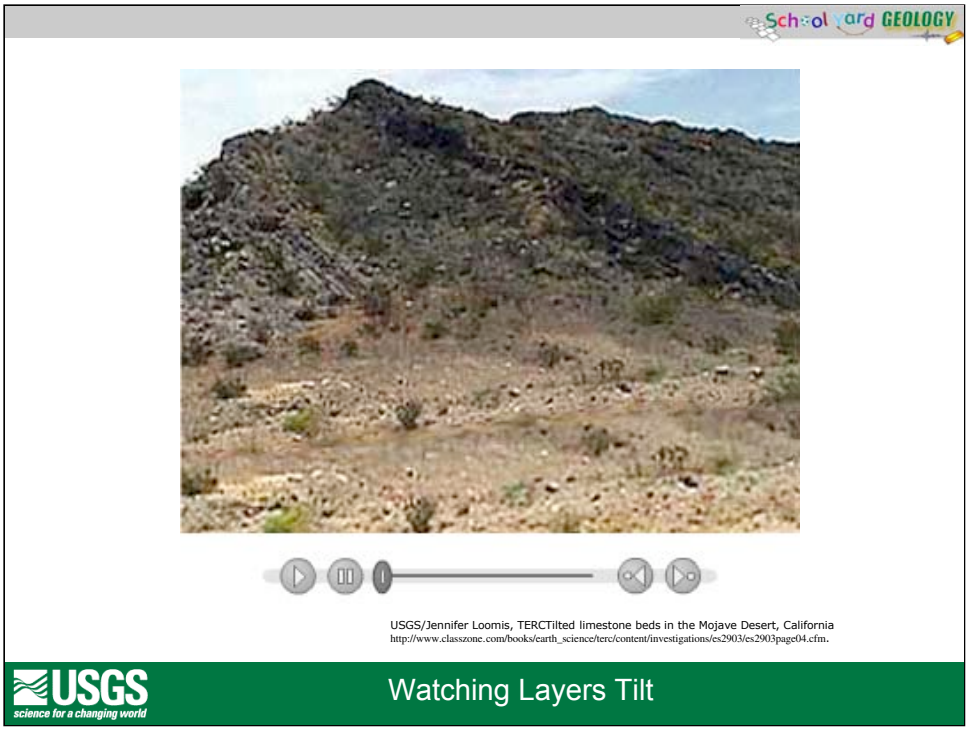
Here is a brief movie showing the deposition of layers of sediment. Note that they are rarely perfectly flat, but pretty darn close.



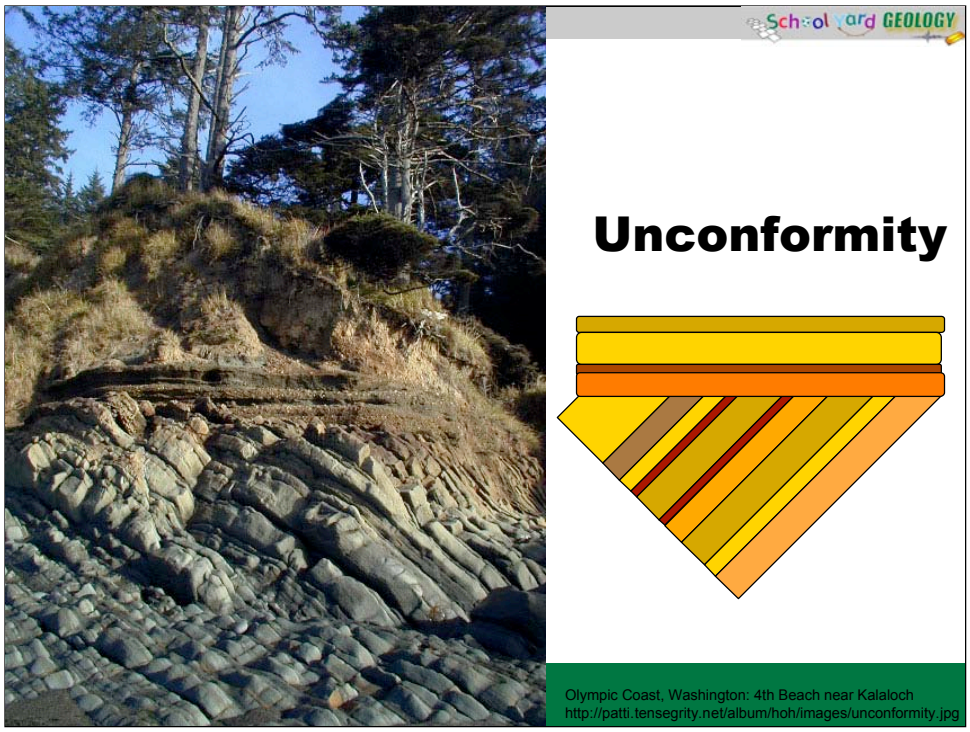
What happened here?

These are tilted layers. When we discover layers that are no longer horizontal, we know that something must have happened. They started out flat, or else they wouldn't form such nice layers. Then, at a later time, they must have gotten tilted. Again, we can discover the sequence of events from looking at the shapes and positions of the layers.

(Optional: Ask students which are the oldest rocks in the photo. They are the ones on the left side. The youngest rocks are on top of those, at the back right.)



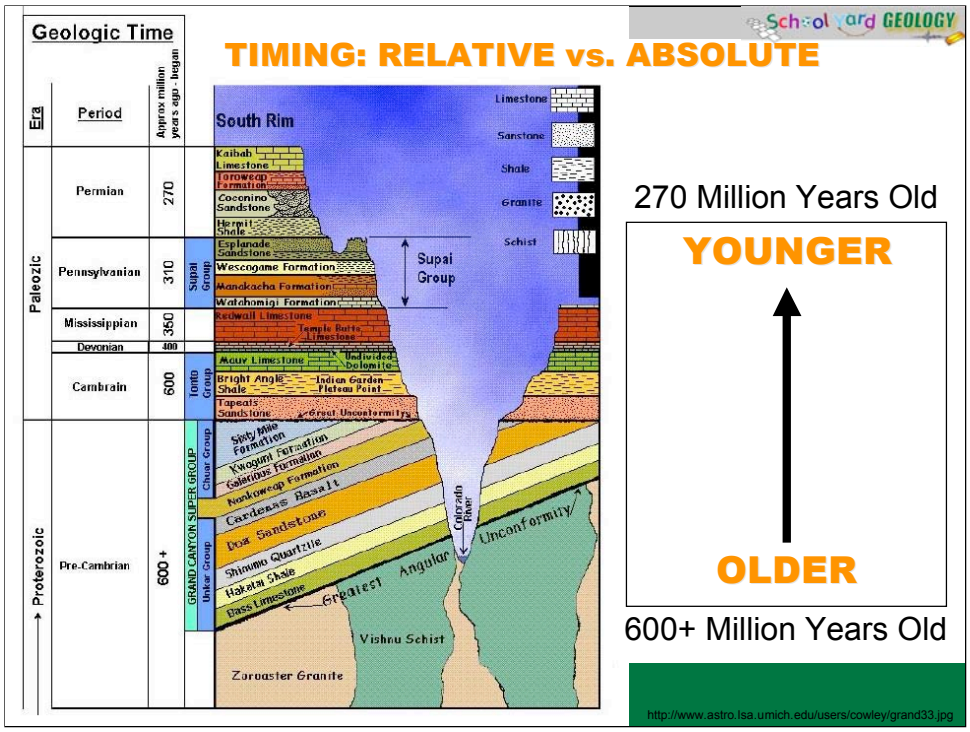
Here is a movie showing how sometimes layers get tilted.



Optional (can be skipped for younger kids): Sometimes, layers give an indication of many different events. First, there was a set of layers laid down flat. Then, they got tilted, like the flatirons in a previous photo. Over time, the tips of the layers got eroded down into a new, flat surface. Then, another set of flat layers got deposited on top.

This feature is called an “unconformity” because one set of layers does not fit in with the tilting of the other set of layers (don’t ‘conform’).

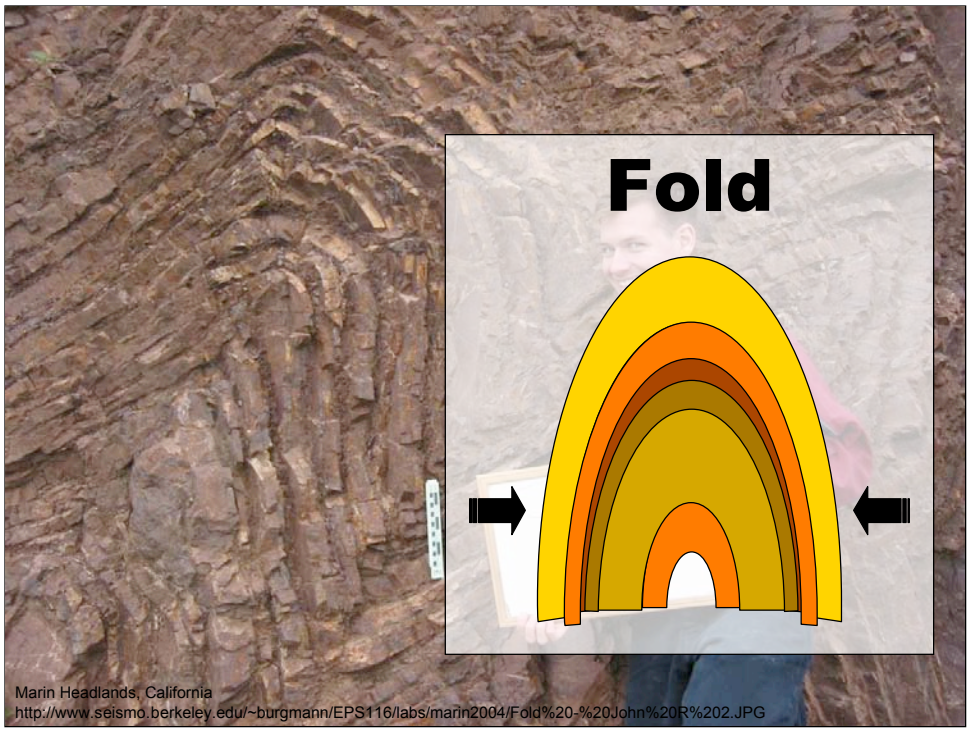
Advanced topic: Erosion and deposition don’t happen in the same place at the same time. Either you are building up layers or eroding them away. Because of the erosion that happens during part of the sequence of events leading up to an unconformity, there are no rocks that are deposited during that time. So, if you were to date each layer in this sequence, you would find that there was a big gap where no rocks were deposited. Something is missing! But because there is an unconformity, you know that it must be missing. The missing telephone in the murder mystery is an analog to an unconformity. You know that there had to be something there before, and an event must have removed it. So sometimes the absence of evidence is itself evidence of an event!



Here is a picture from the Grand Canyon showing different layers and an unconformity. You can tell which rocks are older because the oldest rocks are on the bottom. We call this “relative dating” because it describes the relationship between the ages and positions of different layers.

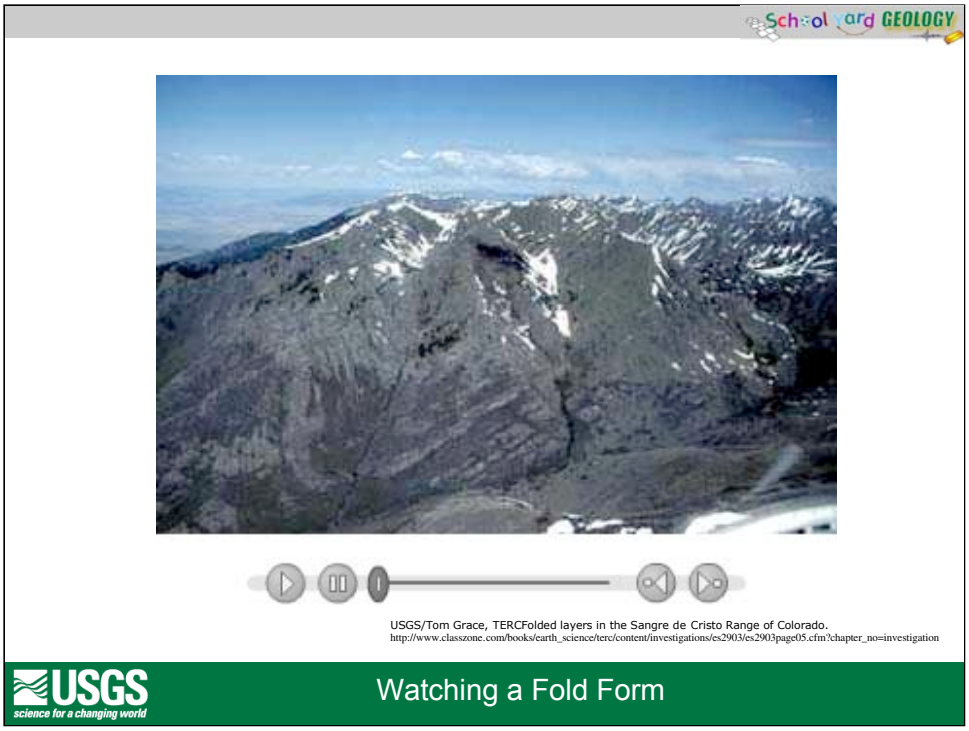
Another way geologists can tell about a sequence of events is by using radiometric dating. You’ve probably heard of carbon-14 dating, but there are all sorts of elements that radioactively decay over time. Carbon is not very abundant in most rocks, so we can’t use carbon-14 dating. Instead, most rock ages are determined using the decay of Uranium, or sometimes other elements. These radiometric clocks, when properly calibrated, tell us the age in years of a given layer of rock. Oldest layers are still on the bottom, but now we know exactly HOW old.

In the murder mystery, there are two examples of absolute dating. What are they? (Wrist watch on dead body and calendar open on desk). Geologist can read the layers of rock almost as easily as a person could read the pages of a calendar.

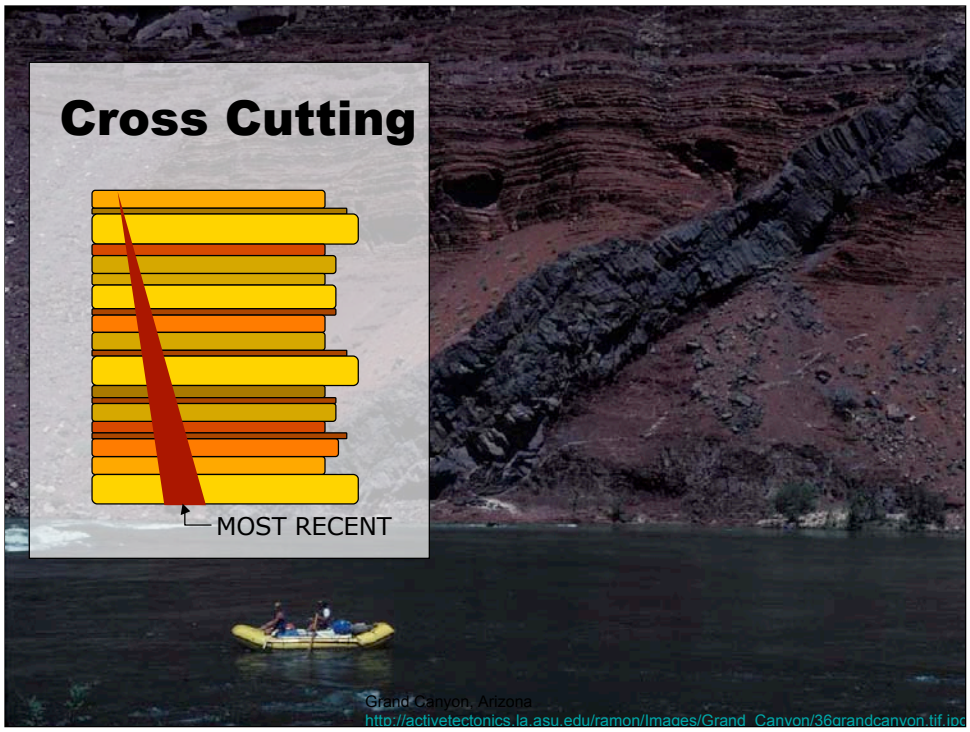


Layers start out flat, but sometimes they can get deformed by tectonic or volcanic stress. When that happens, we call the feature a fold. Folds are usually evidence of compression (but not always).

The murder mystery has a fold in it. Can you find it? (Carpet). Here, there was a deformation event. When did it happen? Before or after the rug was laid down? (AFTER! You can't fold something that isn't there!).



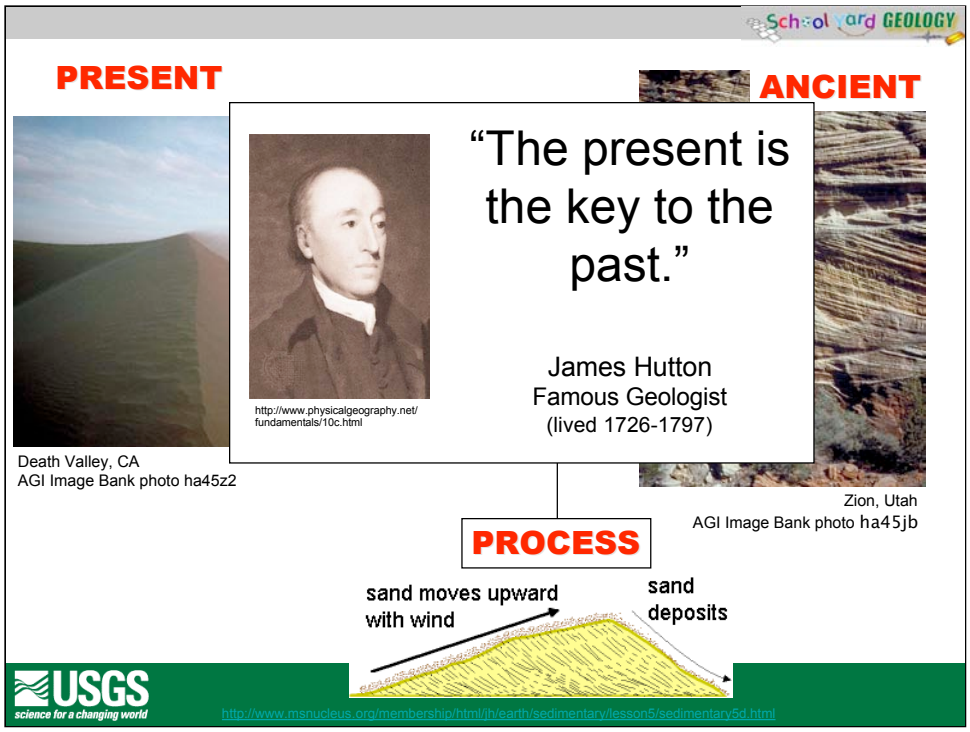
Here is a movie showing the sequence of events that leads up to a fold: 1) Deposition of flat layer, 2) Deformation of that flat layer caused by a continental collision. You can still identify the oldest rocks as the ones at the bottom and the youngest rocks are always on top.



Sometimes, layers get cut by something else. Here, the reddish-brown layers were deposited flat. Then, the dark layer cut across all the other layers. It is younger, because you can't cut layers until they have all been deposited. This dark object was originally molten magma that was squeezed into the layers as it fought its way towards the surface. It eventually solidified, forming what you see here.

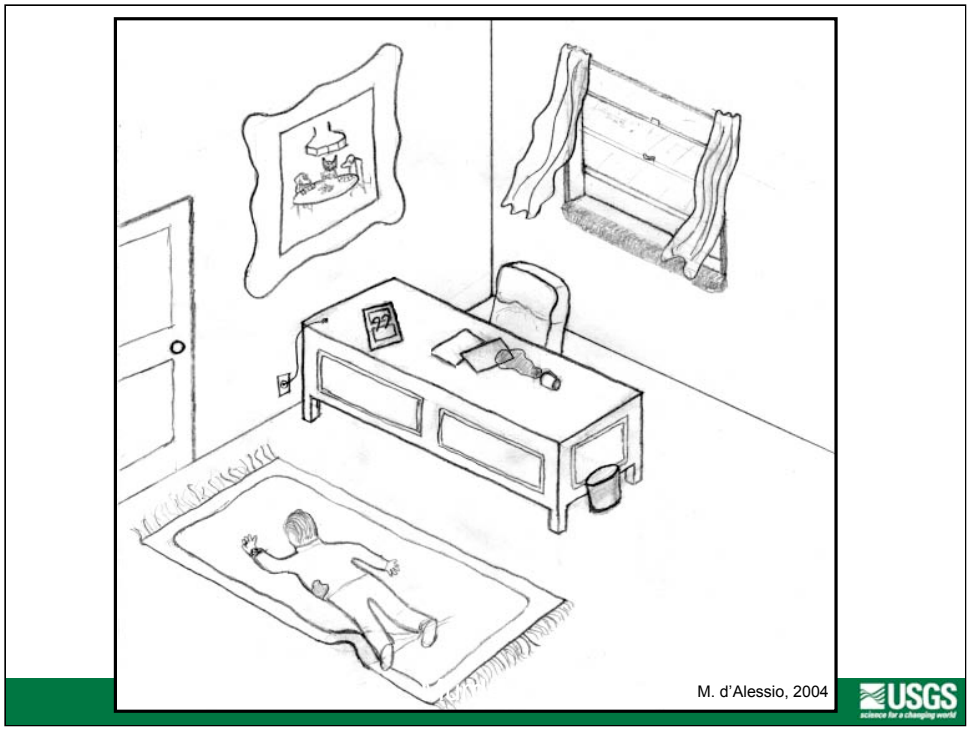
In the murder mystery, there is an example of cross-cutting relations. Where is it? (Coffee spilled across the papers). The papers were there before the coffee spilled.

Optional: The last geologic event in this picture was the carving of the Grand Canyon by the Colorado river. It cuts right through all the other rocks, so it must have happened AFTER they were deposited.



Sometimes, we can use our knowledge of physical laws and processes from today to figure out what happened in the past. The sand dune on the left is being shaped by the wind today. Sand dunes are an example where you form layers that are not always horizontal. The rocks with the wispy layers on the right are ancient sand dunes, and you can see a bunch of different layers. By watching sand dunes form, we can see how they develop layers. We can use this knowledge of the PROCESS of sand dune growth to learn about ancient wind patterns. Because the layers on the right are in all different directions, we can learn that the wind direction must have changed over the years when these rocks were deposited.

The murder mystery also has an indication of wind direction. The curtains tell you which way the wind is blowing. How about the cup? Do you think it blew over in the wind? Why or why not? (probably not, because if it did, it would have blown in a different direction).



The power of this exercise is that it exposes students to the main goals of geology and even some of the fundamental principles in a setting that they can understand. Solving the detective story introduces students to both OBSERVATIONAL skills and the fundamental principals of Geology. Geology is a lot like detective work.You use common sense and some basic fundamental principles. These principles are often introduced at the beginning of a first year geology class. Here, I introduce them in a non-geologic context and then show images of how they apply geologically.

For example, you might find the some of the following observations that lead to a discussion of important geologic concepts:

- Wrinkled Rug = **Original Horizontality** Plus Deformation (fold)
- Man on top of rug on top of floor = **Superposition**
- Coffee spilled onto papers = **Cross-cutting relations**
- Missing telephone = **Unconformity** (we know something used to be there)
- Broken wristwatch & Calendar = **Absolute dating** of events
- Coffee spilled on shirt gives us **relative timing** of coffee and shirt, but nothing about the relative timing of coffee spilling and murder.
- Spilled Coffee not due to open window because the direction of coffee spill is not consistent with the wind direction. = Inferences based on **Physical Processes** and the Laws of Physics