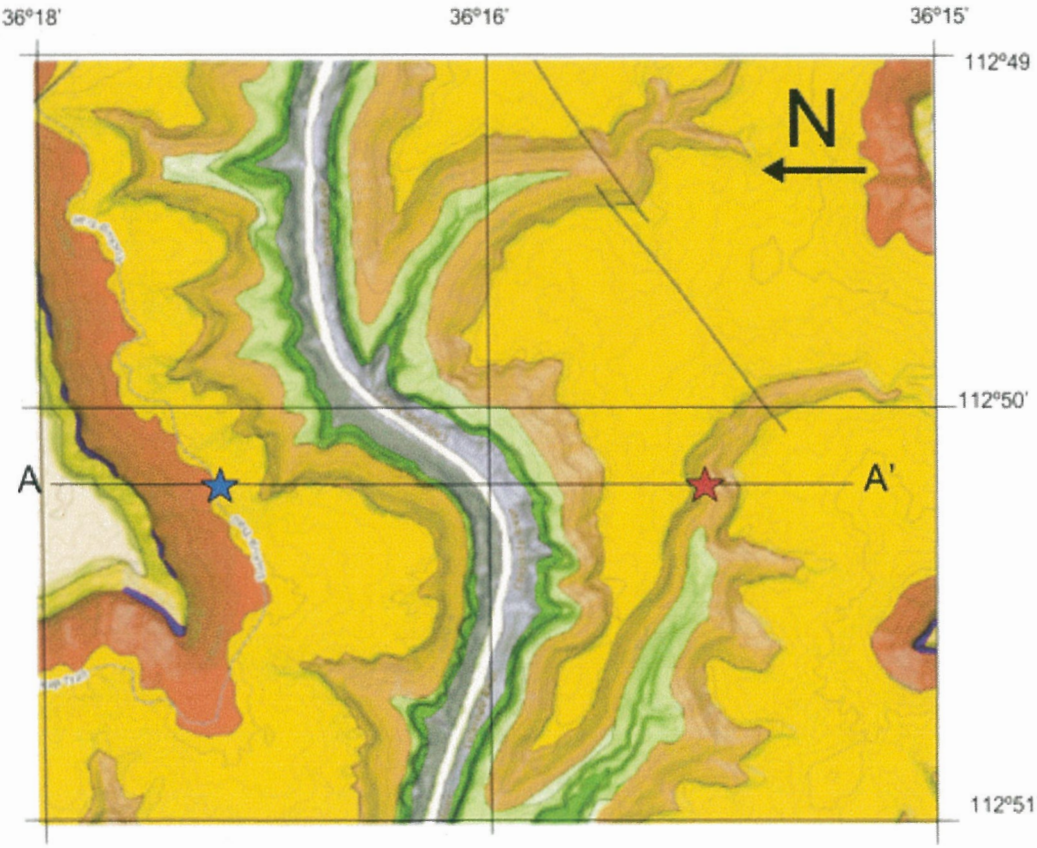
**Answer key reflecting students thinking in 3D but sketching horizontal layers**

**Grand Canyon Cross Section Lab** **Name** Horizontal

**Part 1: Predictive Sketch**

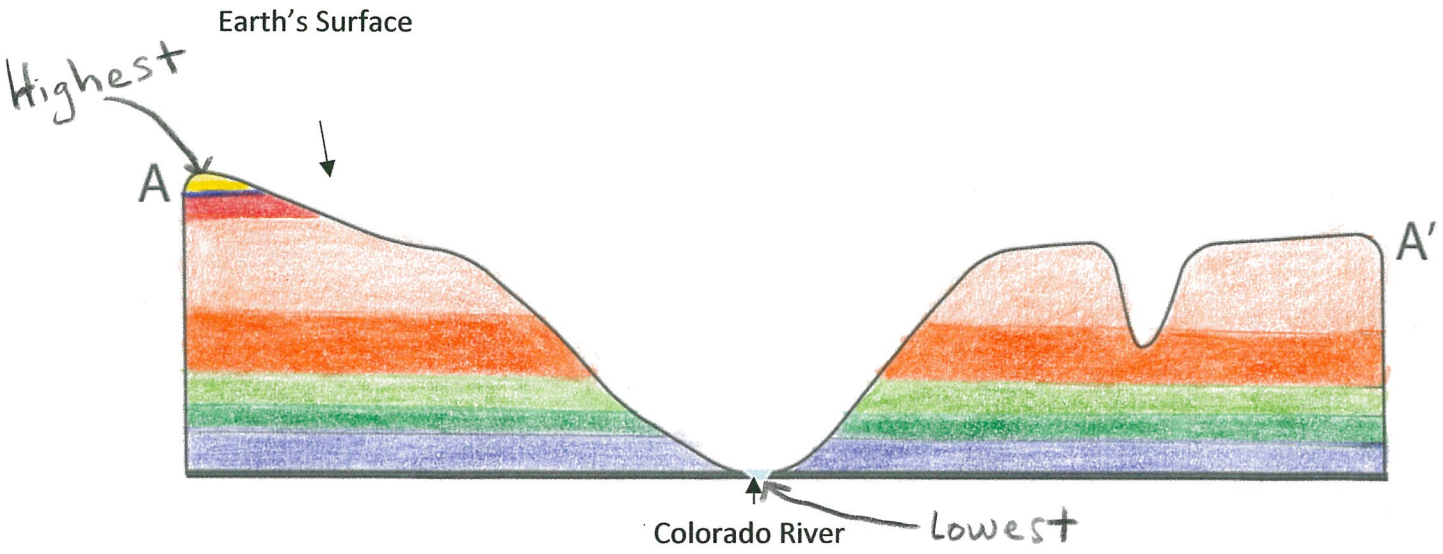
Local gossip says there's gold somewhere in the area displayed in the map below, so Raheem, Hank, and Bev, a team of hopeful geologists are going to look.

Our geologists determine their first step is to make a cross section based on the map so they can make predictions to help them create hypotheses to help them find the gold that is the talk of the town. Remember, a cross section is a vertical slice through the earth that shows the types of rocks and the order of the rock layers as you drill deeper into the Earth. After hours in the library collecting information that others have shared and talking to the locals, they find this region is where gold would most likely found. They have marked up the map with the information they know. This includes geologic layers, topographic lines, or contour lines, and A-A' which is a more specific area to look. The two stars are the core samples they collect.




| Key | |
|---|---|
| **Color** | **Rock Type** |
| | Kaibab Formation |
| | Toroweap Formation |
| | Coconino Sandstone |
| | Hermit Formation |
| | Esplanade Sandstone |
| | Supai Group |
| | Redwall Limestone |
| | Temple Butte Formation |
| | Mauv Limestone |

In the space provided at the top of the next page, use colored pencils to sketch what you think the cross-section of the whole line A-A' looks like underneath the surface on both sides of the Colorado River. Remember, cross sections are created by taking a slice out of the earth, to see the layers we can see well from the surface, as if it were a layer cake. Try to match the colors to the key on the left side of the map as closely as possible and provide a key for your colors next to this key.




Mark the highest point on the cross section and the map, along the cross-section line A-A'.

See image.

Mark the lowest point on the cross section and the map, along the cross-section line A-A'.

See image.

How did you decide where to put the layers?

I took a perspective from inside the canyon looking east at the imaginary cross section and included all the layers that the cross section line A-A' runs through.

Compare your cross section to Raheem and Bev's cross sections. How is it similar to Raheem's cross section? And Bev's? How is it different from theirs?

The layers in my cross section are more distinct than Raheem's. It is more like Bev's whose cross section has neat lines between the layers.

**Part 2: Core Sample Data**

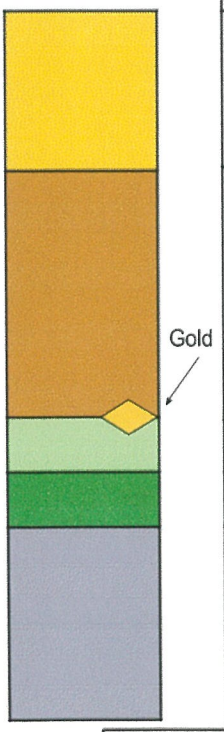
Their second step is to drill and collect core samples from the places they have identified as possibly having gold deposits. They have found fairly strong evidence that gold will be found around either of these two locations and marked by a blue and a red star on the map. Unfortunately, they have no idea how deep the gold might be! Their funding only allows them to drill as deep as the river, so they are hopeful it will be in these rocks.

Remember core samples provide us with the exact order of the rock layers below the surface, geologist drill vertical holes into the ground, bring up a cylinder, or core, of rock to examine.

They take the core samples and head back to the lab to analyze them. On the way back, Bev starts to grow skeptical that they found gold. Given the geology of the area, she claims, we wouldn't really find gold deposits. There hasn't been the type of hydrothermal activity here that there has been in other places in Arizona. While Raheem and Hank agree with her reasoning, they are still very hopeful that maybe there were processes that occurred here to deposit gold. They think about the geology of the area and build a model while the samples are prepared for tests. The next day Hank gets into the lab the early to have a close look at the core. The samples are still being analyzed but he looks at the rocks more closely. He calls a meeting and tells the team he thinks he has found the gold. He marked where believes the gold to be on his PowerPoint recreation of the core sample that he shows Bev ad Raheem. In his excitement, Hank forgot to make a new cross-section that includes these core samples. After the meeting, Raheem and Bev take the new data home to revise their cross sections. Like Raheem and Bev, revise your core sample using the new data.

The core samples are shown below: the layers of rock under the surface at these specific locations marked on the map. Core Sample 1 (left) is represented by a blue star in the map on the first page, the location of Core Sample 2 (right) along the cross-section is represented by a red star in the map on the first page. The depth and layer thickness data are shown in the table next to each core sample

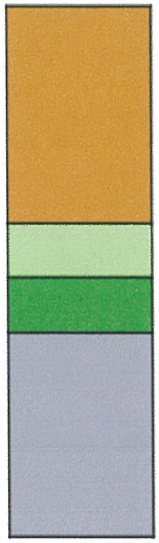
**Core Sample 1 (blue star)**




| Rock Layer | Approximate Thickness (m) | Approximate Depth (m) |
|---|---|---|
| Esplanade Sandstone | 150 | 150 |
| Supai Group | 250 | 400 |
| Redwall Limestone | 50 | 450 |
| Temple Butte Formation | 50 | 500 |
| Mauv Limestone | 200 | 700 |

Elevation at top of sample: 1200 m
Latitude and Longitude: 36°17'49.45" N, 112° 50'10.21" W

**Core Sample 2 (red star)**

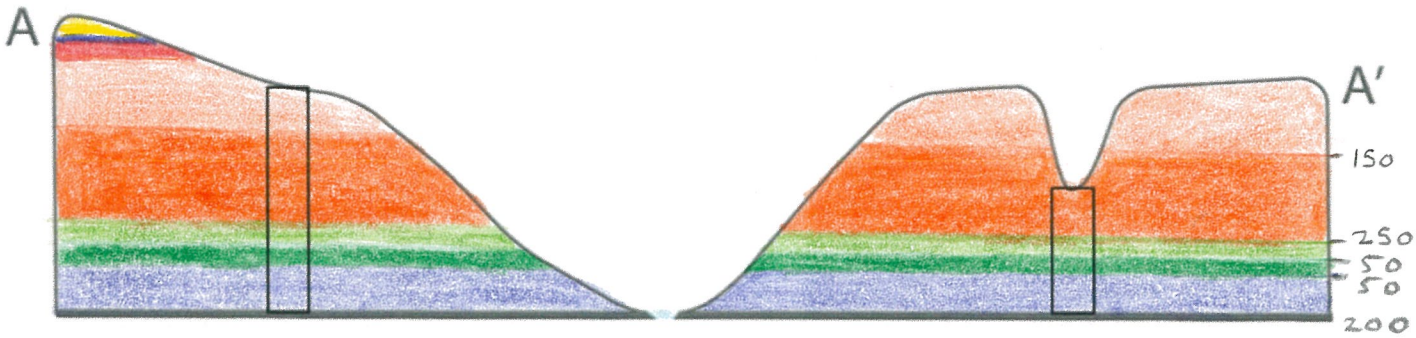


| Rock Layer | Approximate Thickness (m) | Approximate Depth (m) |
|---|---|---|
| Supai Group | 200 | 200 |
| Redwall Limestone | 50 | 250 |
| Temple Butte Formation | 50 | 300 |
| Mauv Limestone | 200 | 500 |

Elevation at top of sample: 1000 m
Latitude and Longitude: 36°15'53.75" N, 112°50'14.98" W

**Core Sample 1 (blue star)**

**Core Sample 2 (red star)**




How did this new data make you change your sketch?

It helped me line up the layers better and make my cross section reflect the true thickness of the layers relative to each other.

Does your cross section look like Raheem and Bev's new cross sections? If not, what is different?

Yes, they both show the layers as more distinct, like my and Bev's original cross section.

With this information in mind, propose 2 locations on the map to look for more gold. Mark the spots on the map and explain your reasoning.

I would look for gold under the land on either side of the core that gold was found in over the cross section. If it is here, it is likely close to where we think we have found it.

Often, to get a better idea of how the layers look over a large space, our geologists draw in the layers they do not see. With a pen or pencil connect the lines across the empty canyon in the cross-section space above to more clearly see where the layers used to be. Color this space to represent the rocks that are now eroded away.

Does this change how you would draw your sketch? If so, what would you change?

It helps me view the layers how they originally were, but it does not change how I view the layers.

Excitedly they wait for the results, which take a few days. Bev looks thoughtfully at her modified cross section and again starts to grow skeptical that they found gold. Given the geology of the area they really probably won't find gold deposits. While Raheem and Hank still agree with her reasoning, they are very hopeful. They think about the geology of the area and build a model while the samples are prepared for tests.

**Part 3: Play-doh Model**

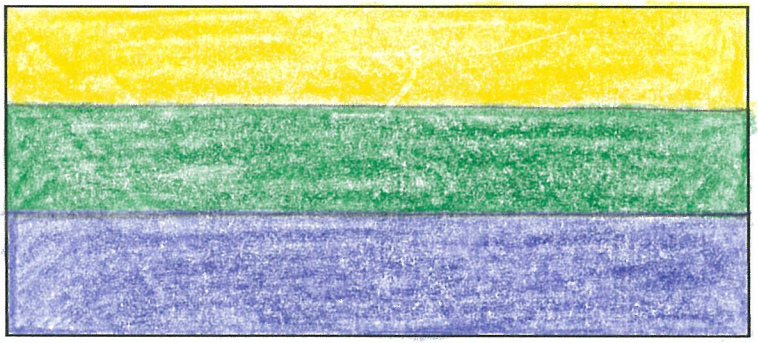
Before we get into creating the model, we have to consider the land: What process makes the canyon land form? And how does it do that?

No idea!

To look at the results of the erosion that created the Grand Canyon a little deeper (pun intended!) we're going follow the following steps to make a play-doh model of layers exposed by hundreds of thousands of years of erosion.

**Step 1**: Using the different color play-doh provided, create a model of the layers in the Grand Canyon. Match the color of the play-doh to the color of the layers as best you can and lay the Play-Doh down like a layer cake in the order the rock layers are deposited. Making a cube, match the thickness of your play-doh model to thickness of the rock layers the best you can.

In the space below, sketch what a cross section of the layers would look like if we cut a slice through the play-doh model like we cut a slice through through the Grand Canyon in Part 1.



**Step 2**: Using floss, or a similar tool, slice your play-doh model in half.

Looking at the side exposed by the cut you made, how is this similar to your predicted sketch?

It shows the layers I expected to see.

How is it different?

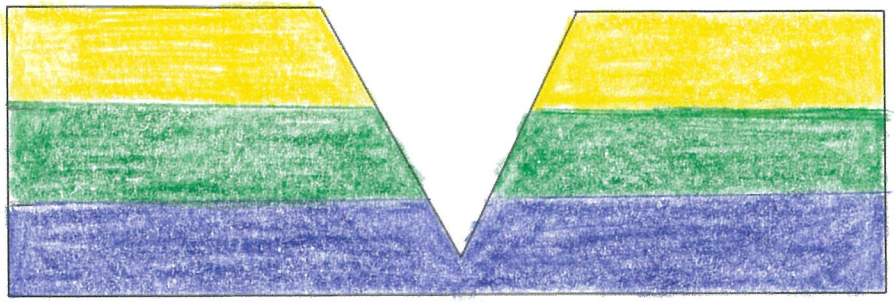
It is not as clean cut as I thought but I can see each layer.

What would you do differently if you sketched it again?

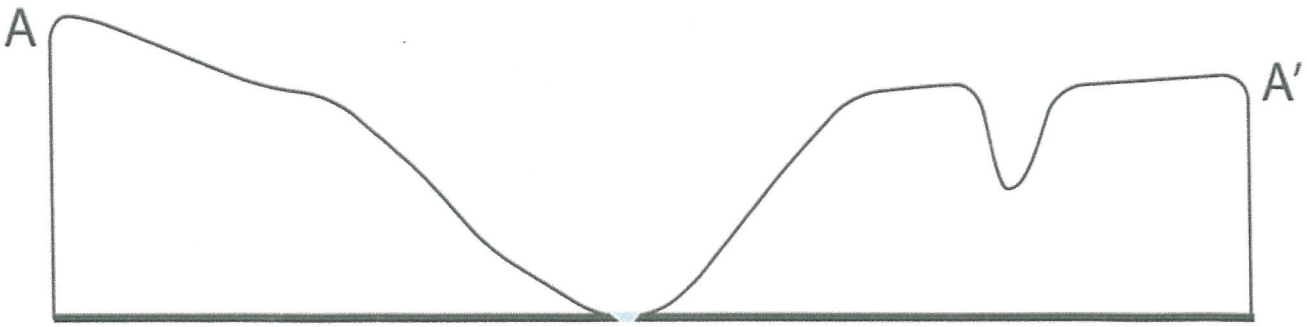
Maybe I would include more messiness to reflect what I see in the real model.

**Step 3**: Take floss or a similar tool and slice the Play-Doh structure at angles that will create a "V" shape at approximately the same location as the Grand Canyon cross section shows a "V" shape. The "V" shape created in the Play-Doh is similar to the pattern of erosion caused by a river, like the Colorado River, cutting into the layers of rock over hundreds of thousands of years.

After making a "V" shape in the play-doh model, turn to the next page and sketch the cross section in the space provided that is similar to how you sketched the Grand Canyon. Imagine you take a slice out of the play-doh model showing how the layers on both sides of the canyon would look if you took a slice out of the model.



Compare the Grand Canyon cross-section sketch and the Play-doh model with the "V" shape cut out.




What is similar?

They both have a large part of the middle cut out.

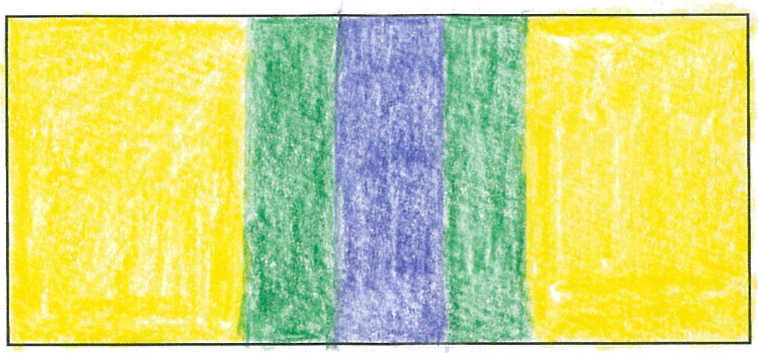
What is different?

The play-doh model is more rigid and the Grand Canyon cross section is rounder and has a dip on the right side which the play doh model does not have.

How does it compare to Hank, Raheem, and Bev's models?

It looks very similar.

**Step 4**: Look at the Play-doh model from a bird's eye view. From above looking down on your model, sketch what you see in the space provided below.



Look back at the map on page 1.

What features do you see on the map that are similar to your sketch of the Play-Doh?

The pattern of layers mirroring on either side of the river is similar to the pattern of colors of play doh on either side of the "V" shape.

What features do you see on the map that are different to your sketch of the Play-Doh?

The map is a larger perspective and other parts of the layers showin in the map are wiggly as you follow them up (east) or down (west).

How is the 2D map representing the 3D surface of the Grand Canyon?

It shows the 2D surface of a body of rock that has depth and is in/takes up 3D space.

**Part 4: Comparing Processes: River Erosion vs. Gold Intrusions**

Results are in! The samples tested did not contain gold. They turned out to be particularly yellowish samples from the Redwall Limestone. This result just goes to show that color isn't the best indicator for rock type!

So why didn't they find gold? We saw in Part 3 how this area is formed, and that river erosion occurs, but that doesn't explain why they didn't find gold. How is gold made? Where is it usually found?

First, let's look at a real picture of the Grand Canyon to see what they saw when they visited the canyon. Then, we'll explore how gold is made.

**A**

Look at the image of both sides of the Grand Canyon below.

What do you notice about the image? How do they compare to your sketches? What is similar? What is different?

I notice the layers and a river at the base. The walls are steep and a little vegetation lines the river.
In the image and my sketch the layers are oriented horizontally and while it looks like less colors of layers, if you look closely, you can see many little layers in each rock layer (bed).

**B**

The Law of Original Horizontality states that the rock layers we see today were originally deposited horizontally and any deformation must have occurred at a later point in the rock forming process.

How does the Law of Original Horizontality apply to the cross sections you have drawn?

All of the layers in the Grand Canyon and my sketch were deposited horizontally as we see them and later a river started to run through and has cut down the layers creating the canyon over time.

How can this be used to explain the pattern you're seeing in the Grand Canyon?

I see a pattern of horizontal layers and some are different colors. It explains why the layers are horizontal and dictates that the river cut into the canyon later, after the layers were deposited and lithified (became rock).

**C**

So why didn't they find gold? We saw in Part 3 how this area is formed by river erosion, but that doesn't explain why they didn't find gold.

How do you think gold is made in the Earth?

Not sure.

After examining the explanations you found in your research, revise your explanation of how gold is made. Use pictures to explain your ideas as well as words.

In some places, gold happens to be in a solution that is forced into the crust from deep in the Earth. The water or liquid in the solution evaporates or leaves for one reason or another and the gold in the solution is deposited on the surface of the crack created in the bed rock.