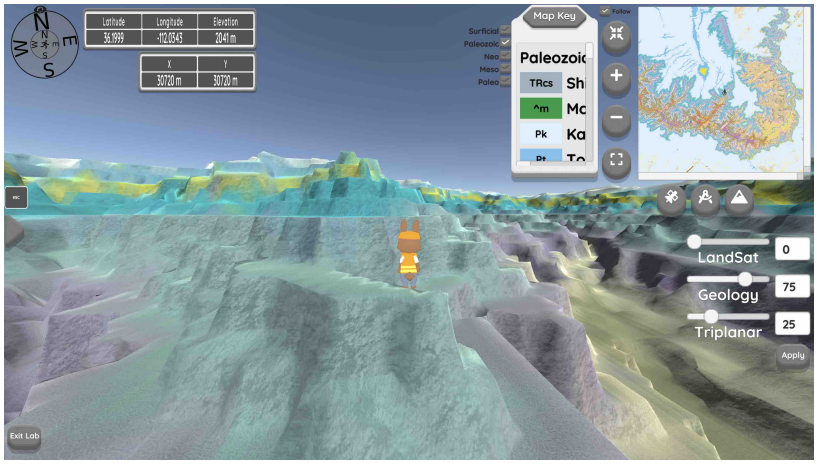
Grand Canyon Geomorphology: Tutorial

This is a preview of the published version of the quiz

Started: May 18 at 4:41pm

Quiz Instructions



This tutorial starts with questions about the information displayed in the geovisualization, ranging from geological units to the sorts of geographical coordinates, elevation and distance information displayed in the data boxes in the upper left. The idea of this first sequence of questions is to make you more familiar with the information at your disposal in the geovisualization.

The tutorial also has mixed in a series of helicopter flights where to help you orient yourself to this amazing mixture of topography and geology.

The questions should be quite easy. The idea is a tutorial and an orientation, and you get 7 tries to earn 100%. So relax, learn and enjoy.

Question 1

0.5 pts

In the Fast Travel menu, travel to 35.9713. -112.3166. What are the X-Y coordinates in meters from the southwest corner? [X being meters east of the origin and & being meters north of the origin]

You are welcome to try to walk the avatar to the far southwestern corner (you cannot walk off the edge of this world).

- X 10 Y 10
- X 232 Y 6035

Question 2

0.5 pts

QUESTION: In Fast Travel enter latitude 36.0570 and longitude -111.8389 and go to this location. Write down the X coordinate that the avatar is standing on. You can see the coordinates underneath the elevation.

You will be using "Fast Travel" a lot if you want to do the lab quickly.

- First - you open the menu using the arrow on the left side of the geoviz.

- Second - you click on Fast Travel
- Third - you enter the coordinates
- Fourth - click on the fast travel paper airplane icon and go

WARNING: **There is a giant pool of questions and answers ... literally hundreds of questions in the pool.** *We are doing this giant pool in order to encourage students to actually go through this tutorial. In our experience, we know that students who skip the tutorial ... end up spending a lot more time being frustrated than those who go through all of these questions.*

- ◯ 39515
- ◯ 38555
- ◯ 30750
- ◯ 51827

Question 3

0.75 pts

Now Fast Travel back to the starting point of the game (36.2000 -112.0350), and what are the X-Y coordinates and how many meters is this from the southwest corner? (remember, the X-Y coordinates for the southwest corner are 0,0)

You get to use a formula you probably learned in middle school, the formulae for the hypotenuse of a triangle. You are welcome to use any website you want, such as simply searching google (which pops up with solving for the hypotenuse) such as this one: **https://www.omnicalculator.com/math/hypotenuse (https://www.omnicalculator.com/math/hypotenuse)** You just enter the Y coordinate as one variable and the X coordinate as the other variable) and the online calculator will solve for the distance in meters from the southwest corner to the starting point for the game in meters.	Hypotenuse  In geometry, a hypotenuse is the longest side of a right-angled triangle, the side opposite the right angle. The length of the hypotenuse can be found using the Pythagorean theorem, which states that the square of the length of the hypotenuse equals the sum of the squares of the lengths of the other two sides. Pythagorean theorem $a^2 + b^2 = c^2$ a = side of right triangle b = side of right triangle c = hypotenuse

We are not torturing you with a reminder of middle school without reason! You will need to calculate distances later in this lab, and so we just wanted you to know how easy this is. Just enter (the length of X, same as a) and 30720 (the length of Y, same as b).

The hypotenuse calculator will solve for C, the length of the hypotenuse, or the real distance in meters from the origin (southwest corner) to the location in the game.

- ◯ X: 2991, Y: 57722, hypotenuse: 12582 m
- ◯ X 30645, Y 30735, hypotenuse 43445 m

Question 4

0.5 pts

Examine the three slide bars on the lower right in the geovisualization. Try sliding the Landsat bar to the right at 100%, with geology and triplanar at zero. Then push apply. What data are displayed?

- ◯ Landsat satellite data that approximates the visual image someone would see from orbit
- ◯ Landsat satellite data displays the geologic layers

Question 5

0.5 pts

Now, shift the geology bar to 100, with Landsat and Triplanar at zero. What data are being displayed?

Note: The triplanar layer is for aesthetics. You can shift the bars to whatever combination you like the best. Our focused group liked Geology 75, Triplanar 25 for understanding the topography-rock connection.

- ◯ The geological mapping done by the U.S. Geological Survey wrapped on the digital elevation data obtained from Space Shuttle radar.
- ◯ The geological mapping showed satellite data

Question 6

0.5 pts

QUESTION: In Fast Travel enter latitude 36.1547 and longitude -112.2314, and go to this location. Write down the color of the geological unit pixel that the avatar is standing on. What is it? [Select the closest answer, even if you think the color description is slightly off.]

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- Third - you enter the coordinates
- Fourth - click on the fast travel paper airplane icon and go

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- ◯ light blue
- ◯ olive green
- ◯ yellow
- ◯ purple

Question 7

0.5 pts

QUESTION: In Fast Travel enter latitude 36.2969 and longitude -112.0930, and go to this location. Write down the elevation that the avatar is standing on in meters. What is it? [Select the closest answer, even if you think the color description is slightly off.]

You will be using "Fast Travel" a lot if you want to do the lab quickly.

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- Second - you click on Fast Travel
- Third - you enter the coordinates
- Fourth - click on the fast travel paper airplane icon and go

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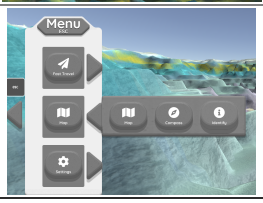
- 2611
- 1800
- 3777
- 1859

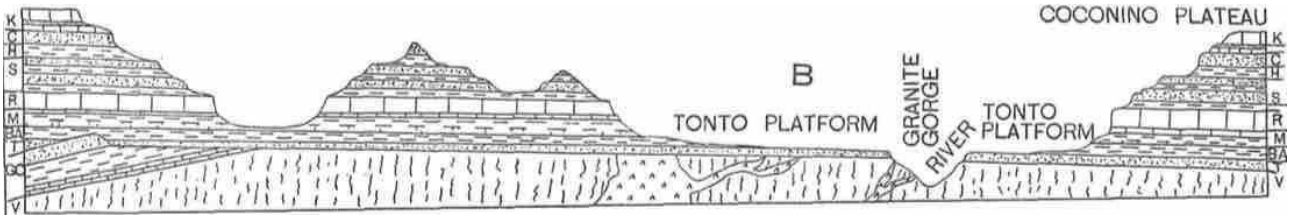
Question 8

0.5 pts

The geology units in the Grand Canyon region exist in five broad age categories. These are the categories that are displayed in the geology Map Key. If you click on all the buttons, you'll see all of the geological units displayed in the key	
If the Map Key annoys you, it is very easy to remove it. Just click on the arrow (left side) to open up the menu, then map, and then identify.	

Surficial - being materials like river sediment and landslide deposits that are geologically recent (last million years or so). They are not really something you will see in this lab. They are too small for the most part.

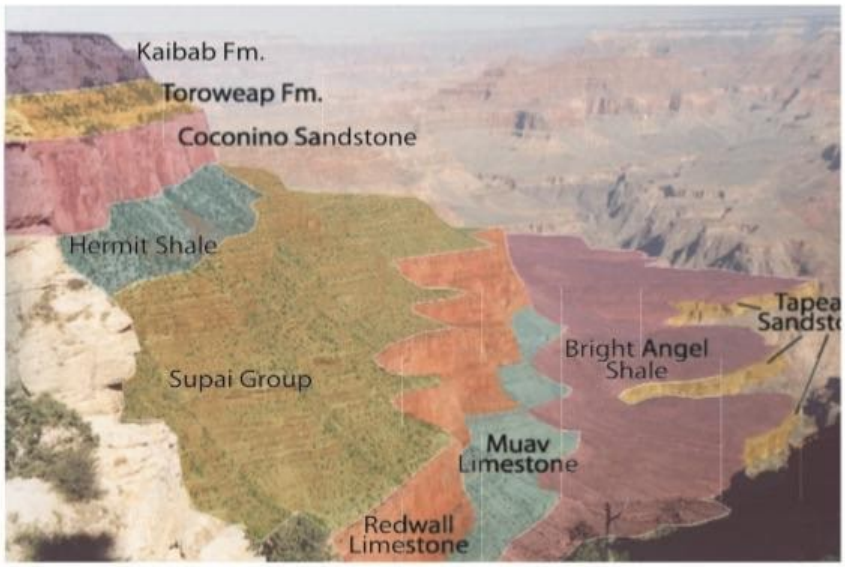
Proterozoic (**Neo**proterozoic, **Meso**proterozoic, **Paleo**proterozoic) - these are extremely old (hundreds of millions to billions of years old) and complex rocks that are found down in the deepest parts of the Grand Canyon - in the inner gorge (granite gorge). These very old rocks are underneath everything, but you only see them down in the inner.



Paleozoic - these are the horizontal layers that dominate the Grand Canyon region. They are the focus of this lab. The Paleozoic Era is the period of time from about 250 million years ago (The Kaibab Limestone at the top is about 270 million years old) to about 540 million years ago (at the bottom, the Tapeats Sandstone).

These are the most important Paleozoic rock units you will see and come to understand in this lab:

A)



The Paleozoic layers. *A) The different sedimentary layers that were deposited are highlighted. In order of deposition, from the bottom up, the layers you can easily see from the rim are the Tapeats Sandstone, Bright Angel Shale, Muav Limestone (these first three are together known as the Tonto Group), Redwall Limestone, Supai Group, Hermit Formation, Coconino Sandstone, Toroweap Formation, and Kaibab Formation. B) The table breifly describes identifying characteristics of each of these Paleozoic sedimentary layers.* Note: The Temple Butte and Surprise Canyon Formations are not included in these diagrams because they are difficult to view from the rim.

B)

Rock layer	Thickness	Shape	Depositional Environment	How to identify from the canyon rim
Kaibab Formation	300 to 400 feet (92 to 122 m)	cliff	Shallow marine, beach-like, and intertidal zone	At top of canyon, not much vegetation
Toroweap Formation	200 to 300 feet (61 to 92 m)	slope	Shallow marine, intertidal zone, and eolian desert	Small, vegetated slope between cliffs of Coconino and Kaibab
Coconino Sandstone	400 feet (122 m)	cliff	Eolian sand dunes	Bath tub ring of canyon, distinct beige color with cross-bedding
Hermit Formation	300 feet (92 m)	slope	Shallow marine, lagoon, fluvial, and eolian	Dark red-orange slope
Supai Group	1000 feet (305 m)	slope; small cliffs	Shallow marine, lagoon, fluvial, and eolian	Thin, red-orange step-like layers
Redwall Limestone	500 feet (153 m)	cliff	Shallow marine	Thick red to beige colored layer; many caves
Muav Limestone	up to 450 feet (137 m)	cliff	Shallow marine, occasional intertidal zone	A thick limestone, at base of Redwall Limestone
Bright Angel Shale	up to 340 feet (104 m)	slope	Intertidal zone and shallow marine	Very gentle slope, often has greenish tint
Tapeats Sandstone	0 to 200 feet (0 to 61 m)	cliff	Fluvial, beach-like and shallow marine	Looks like a stack of pancakes or graham cracker with bites in it

Unfortunately, the colors displayed in the game (those employed by the U.S. Geological Survey) do not match this graphic produced by the National Park Service (from a booklet used to train rangers).

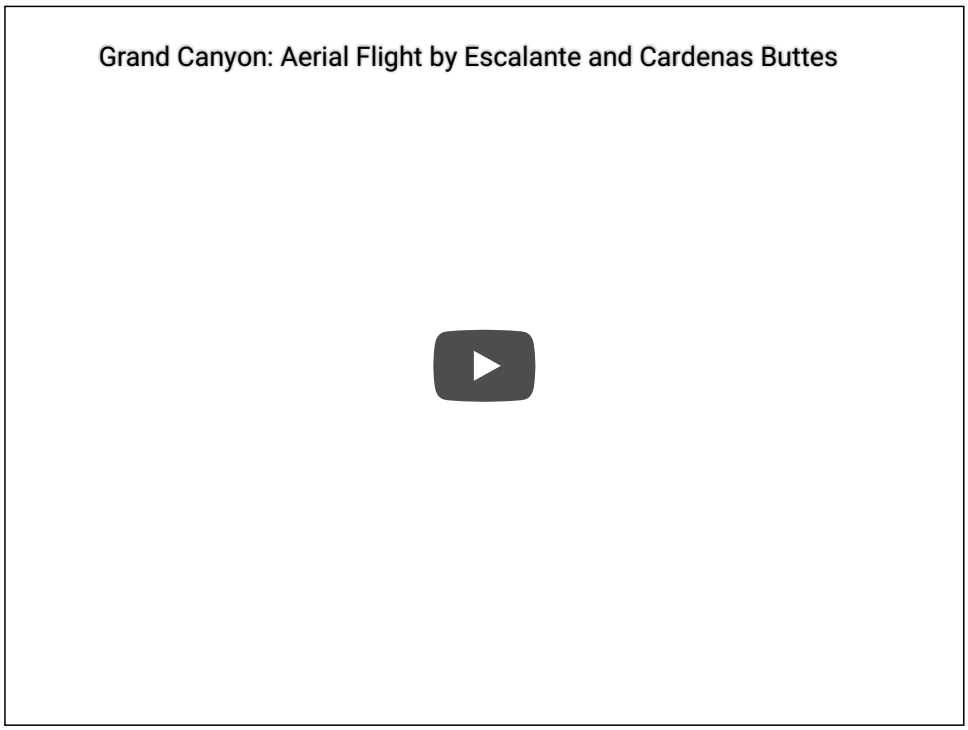
QUESTION: What geological era dominates the rocks you will see in the Grand Canyon?

- ◯ Neoproterozoic
- ◯ Surficial
- ◯ Paleozoic
- ◯ Paleoproterozoic

Question 9

0.5 pts

This is the video shown in the overview to this lab.



In the geovisualization, please

Fast travel via air lift (helicopter) between these two locations:

START: 36.0156 - 111.8724

END: 36.0841 -111.8551

Enter the coordinates for latitude and longitude, and then hit the paper plane icon. You will be taken to the spot you see identified in the inset map on the South Rim.

This location is near Desert View – a famous viewpoint that many people visit on the South Rim, because it's the first view if you enter the Grand Canyon from the east.

Once you are at this place, then you need to enter the end coordinates of the helicopter flight. You are setting yourself up to have a virtual fly over of the Grand Canyon geology & topography. Thus enter these **END coordinates: 36.0841 -111.8551**

Then, change the Air Speed to maximum (most students like it at top speed) and also check Scale Speed box. You can fiddle with what you like best. Lastly, click air lift. When you are in the air (virtually), you can change the camera angle to look around. Some students take a series of screenshots to review the flight and what they see.

WHAT TO LOOK AT AS THE HELICOPTER FLIES: Open the color key for the Paleozoic formations (topic of the previous question). You don't have to focus on the names of the formation, but just their sequence from the rim down into the canyon. Focus on the color sequence in the key and in the game. Notice that the bottom of the Grand Canyon has the color that is the same as the bottom of the Paleozoic sequence. Notice that the top of the Grand Canyon has the light blue color of the Kaibab formation (near the top of the Paleozoic sequence.

QUESTION: Using the information from the previous question, what answer best describes the ages of the Paleozoic formations you are seeing in the virtual helicopter ride?

- ◯ The top layer (Kaibab Formation) is the youngest of the Paleozoic formations in the Grand Canyon, and the formations get progressively older as the helicopter flies deeper into the canyon.
- ◯ The top layer (Kaibab Formation) is the oldest of the Paleozoic formations in the Grand Canyon, and the formations get progressively younger as the helicopter flies deeper into the canyon.

Question 10

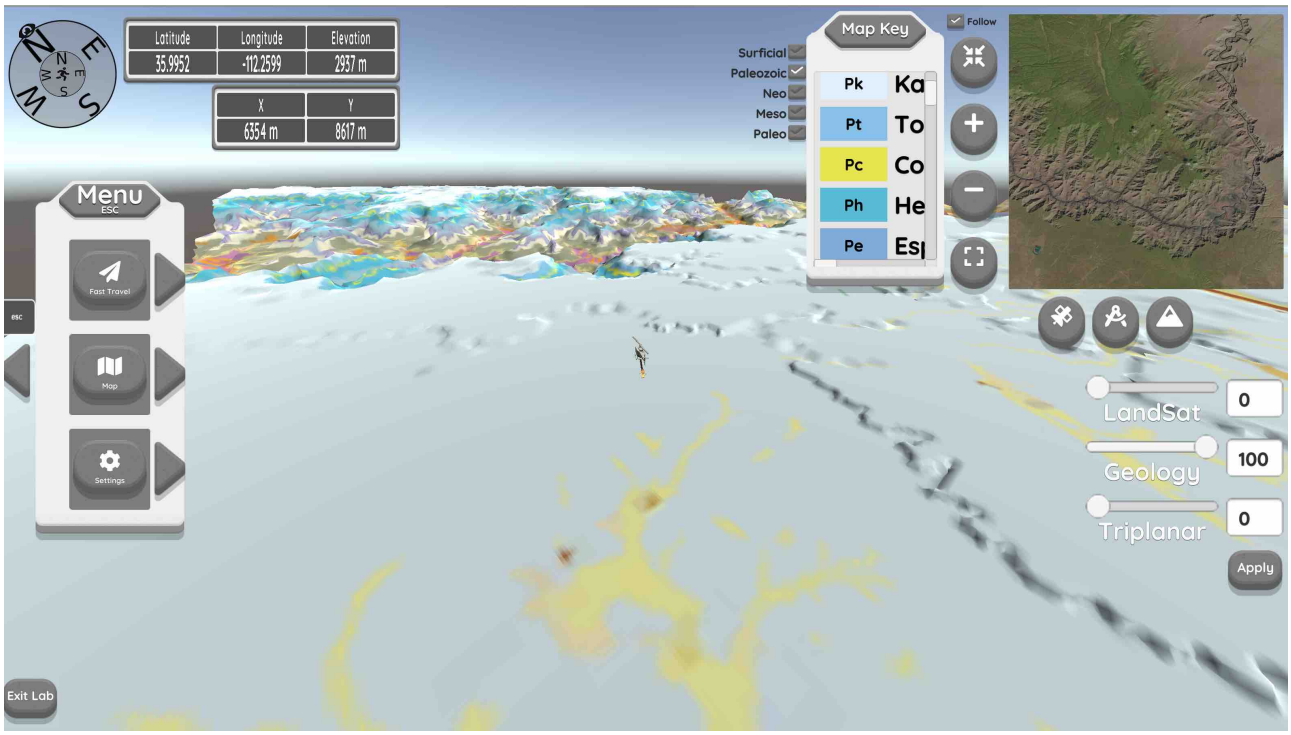
0.5 pts

This question asks you to take a virtual helicopter tour from the southwest corner of the visualizations to the North Rim of the Grand Canyon.

START: 35.9440 -112.2882

And program in the end before you hit Helicopter (remember, fast and click the Scale Speed box) END: 36.2482 -112.1201

QUESTION: What type of landscape dominates the scenery for the start and also at the end of the helicopter ride? HINT: That light blue color is called the Kaibab Limestone (Pk as the geologists would name it, P for Paleozoic and k for Kaibab). Its the name given to the Kaibab Plateau on the north side of the Grand Canyon.



- Canyon country
- Plateau (raised and flat) country

Question 11

0.25 pts

Marble Canyon is the section of the geovisualization that runs from the northeastern portion to the confluence of the Colorado and Little Colorado rivers. There's no marble! The name came from John Wesley Powell who knew there was no marble! But he thought the limestone is so pretty and polished that it looks like marble. The Marble Canyon of the geovisualization is eroded entirely into the Paleozoic strata (strata is the name for the layers of sedimentary rock).

Please take a virtual helicopter tour in the geovisualization with the starting point almost on the edge of the game (36.4732 -111.8493). You hit fast travel to go to this spot.

Then, you go to Fast Travel menu again, and (a) enter 36.3079 -111.8757, (b) slide the air speed bar all the way to the right, (c) click on scale speed), and then (d) click on the helicopter icon. We recommend you move the camera angle back up high to get a good view. Please spin the camera around to look forward and backward.

QUESTION Part 1: What is the best description for the channel of the Colorado River through marble canyon (the terms in the fluvial lecture for channel type are meandering, braided, and straight)? Part 2: Do you see any super obvious connection between anything you see in the geology information and this channel type pattern?

- ◯ The river has a meandering channel, without a clear connection to any aspect of the geology
- ◯ Do not put down this answer. It will be scored wrong. But please understand that this meandering pattern is a mystery that needs an explanation. Meandering patterns exist in big flat floodplains, like the Mississippi River. To see such a channel pattern cut into a canyon means that the Colorado River DID ONCE have this meandering channel on a big flat floodplain. Then, something happened to make the river incise (cut down) into this ancient floodplain.

Question 12

0.25 pts

There are ancient faults in the rocks of the Grand Canyon. These faults started in the Proterozoic (before 500 million years ago), and they were re-activated about 50-80 million years ago when the landscape of the region was uplifted (along with the Rocky Mountains).

The most famous of these faults is the Bright Angel Fault. One of the hiking routes between the rims basically follows this fault.

Also, Bright Angel Creek is a canyon that follows this fault. This creek started forming when the Colorado River started to flow 4.8 million years ago. As the Colorado River incised (eroded down) to form the Grand Canyon, so did Bright Angel Creek. That is the way that tributaries work. When the main stream erodes down, tributaries follow in turn. Also, the headwaters of tributaries continue to "headward erode" up into the plateau as the Colorado keeps incising. This is called "headward extension".

To answer this question, you need to take a virtual helicopter tour that gives you a birds-eye view of the Bright Angel Trail (South Rim to the Colorado) and the Kaibab Trail (Colorado to the North Rim). Basically - your helicopter route is just to the side of the Bright Angel Fault.

START: 36.0579 -112.1479

END: 36.2468 -112.0146

QUESTION Part 1: What is the best description for the channel of Bright Angel Creek (the terms in the fluvial lecture for channel type are meandering, braided, and straight)? Part 2: Do you see any super obvious connection between anything you see in the geology information in the helicopter trip and this channel type pattern?

- ◯ Straight and there's nothing clear in the geology that I can see
- ◯ **Do not select this answer, but please read on.** There is certainly a fault present. But even experienced geologists cannot discern the the presence of the Bright Angel Fault through this geological map. The rock types do show an "offset" -- due to the faulting -- where movement between 50-80 million years pushed the west side up a little bit (compared to the east side). But this is too subtle to show up in the mapping of the U.S. Geological Survey.

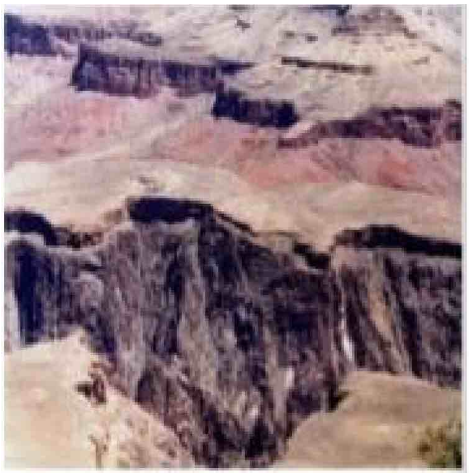
  The broader point of what you are reading is that tributary streams of the Colorado (like Bright Angel Creek) do "take advantage" of weaknesses created by faulting. Faulting crushes rocks. Crushed rocks erode faster, and so a tributary will form by "headward extension" up into a fault zone of crushed rocks. However, **the Colorado River does not take advantage of the faults it encounters**. This behavior indicates that the Colorado River did not form by headward extension (eating upstream). It formed by a different process -- you will explore later.

Question 13

0.25 pts

The inner gorge (a section of which is the famous granite gorge) of the Grand Canyon has a different geology and shape than the rest of the Grand Canyon. In real helicopter shots, you can see the flat-lying Paleozoic sedimentary rocks above the inner gorge. The inner gorge itself has very steep slopes and is made up of a mix of very old (billions of years) metamorphic and igneous (a lot of granite) rocks. A very famous spot is "Vulcan's Throne" on the right. Its a volcanic eruption of a basalt lava flow that is 1.2 million years old. Look at how the dark black basalt lava flows down the side of the inner gorge. This means that the incising (eroding) of this part of the Grand Canyon had already taken place.

- Think about it. This means that the Colorado River had incised (cut down) to almost the current level of the river by about 1.2 years.
- Later in the lab, you'll learn that the Colorado River originated about 4.8 million years ago. So if you subtract ... 4.8-1.2= about 3.6. The incision (downcutting) of the Colorado River took about 3.6 million years (give or take a few hundred thousand)

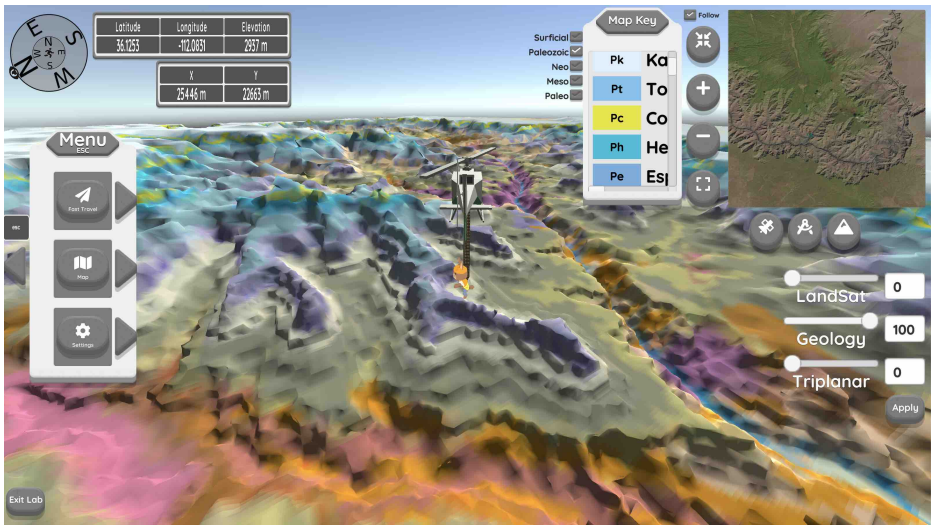


To answer this question and think about the implications of the Colorado River eroding down (incising) over a period of about 3.6 million years -- go for a helicopter flight.

START: 36.2204 -112.2424

END: 36.0121 -111.8937

Its worth the effort. You will see views like this:



Where you can see the inner gorge and its narrow steep canyon, and then full downward erosion of the Colorado River in such a short period of time (of 3.6 million years). Then, also think about the width of the Grand Canyon in this helicopter flight.

QUESTION Part 1: Just based on the visual impression of this helicopter flight alone, what appears to be the longer dimension (a greater distance): the downcutting (incision) of the Colorado River or the width (rim to rim) of the Grand Canyon?

Question Part 2: Just based on visual impression, what appears to be longer (greater distance), the height or width of the inner gorge?

- ◯ The rim-to-rim width is much greater than the depth of the Grand Canyon, but the Inner Gorge's depth and width appear roughly similar.
- ◯ **DO NOT SELECT THIS ANSWER.** And so this begs the question: what role does rock type play in the erosion of the canyon? A lot! The Grand Canyon is a spectacular laboratory for how rock type can influence slope steepness. Look at the stair-stepped nature of the topography in the helicopter views and how they correspond to rock type. You'll figure this out in the lab!

  And this begs another question: since everybody thinks that the Grand Canyon was made by erosion downward by the Colorado River -- do you think that the Colorado River did all of that canyon widening? No. Definitely no. Canyon widening is bit from Colorado River erosion. All the Colorado River does is the same thing as the sewer pipes where you live: it carries away ... hmmm... how to put it delicately ... the products of erosion. If the Colorado River did not carry away the products of canyon-widening erosion, the Grand Canyon would fill up. That's not the case, so the Colorado River is a very effective sewer system in removing everything thrown into it.

Not saved Submit Quiz