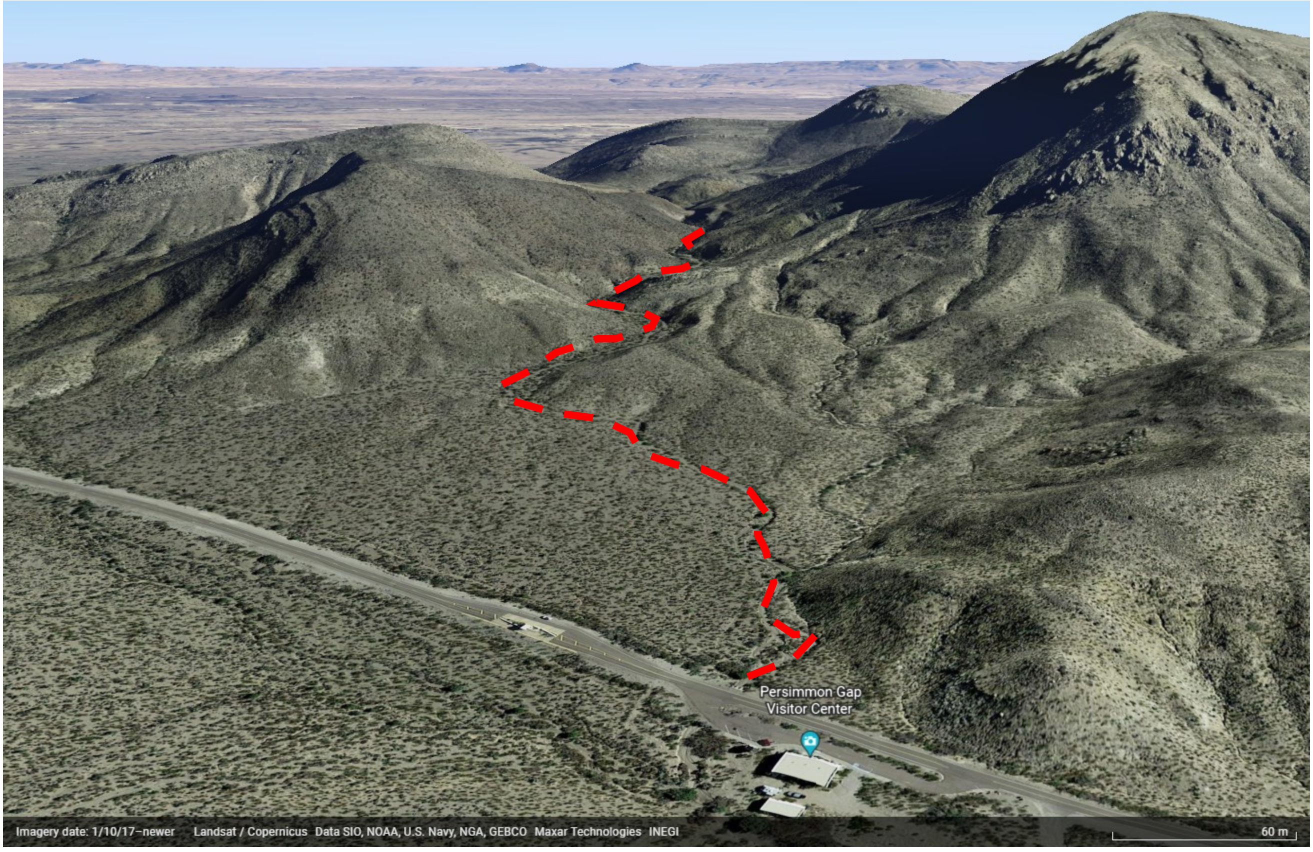
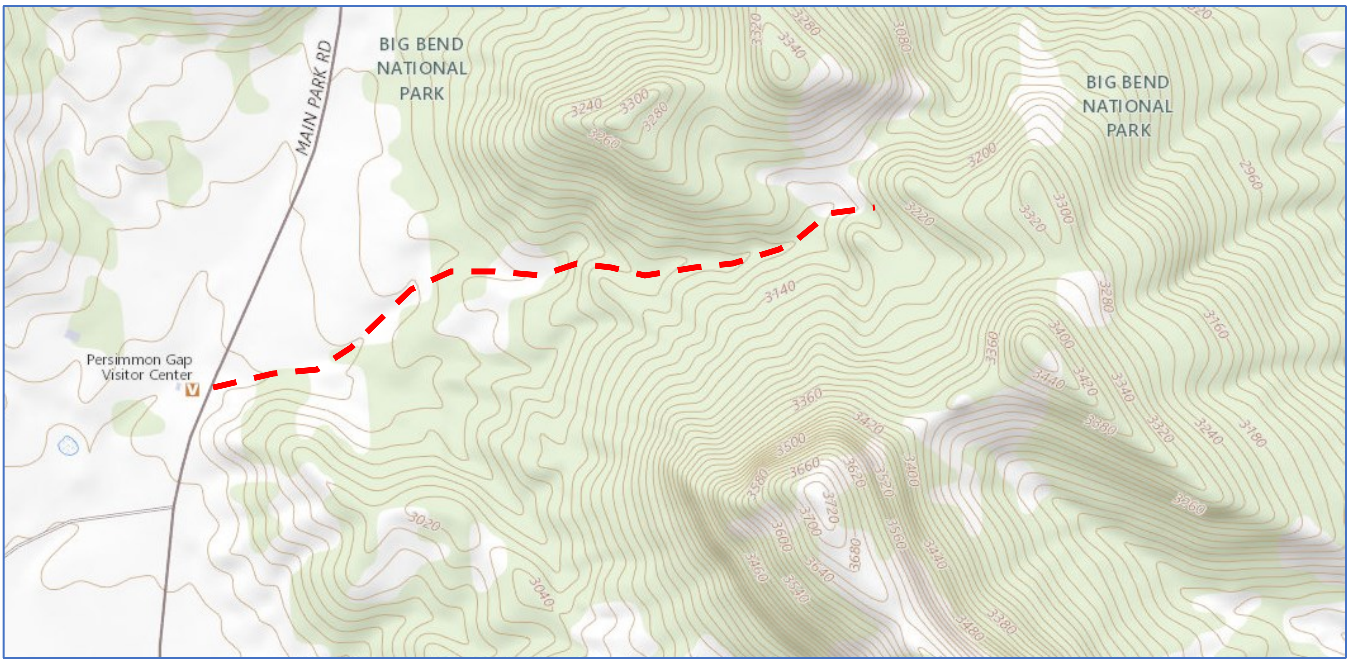


Persimmon Gap Field Trip – Big Bend National Park

Big Bend National Park is a geologic wonderland where you can take several easy hikes to see great rocks. One of the best is right when you arrive on U.S. Highway 385 at the Persimmon Gap Visitor Center. Hiking here sets the stage for understanding how the amazing scenery of Big Bend formed because this is one of the only places you can see the oldest rocks in the park. Rocks along the trail tell the story of about 500 million years of earth history; a story that involves ancient oceans, dry lands and crashing continents. Here you can see what is inside the mountains and why they rise above the surrounding plains while taking a (mostly) leisurely hike.



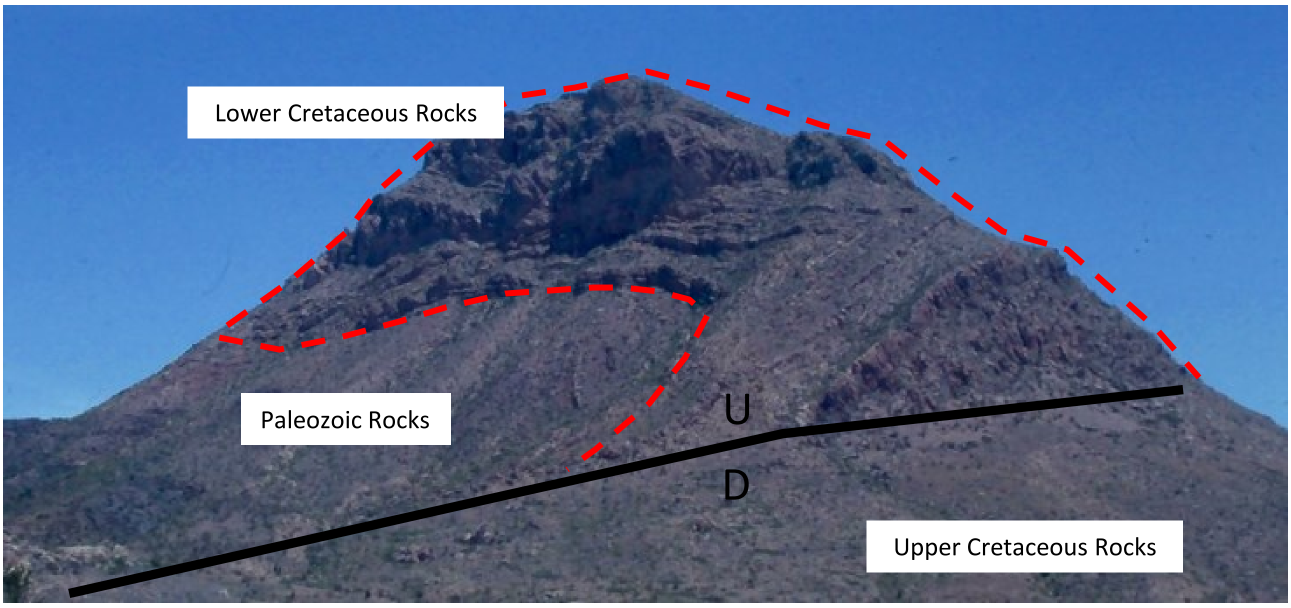
The trail is not well-marked because it begins in the arroyo directly across the highway from the visitor center. Soon (in about 375 feet) you will want to take a fork to the left to follow the longer arroyo. In about one-half mile you will leave the arroyo and follow an obvious trail that climbs a ridge. The climb is short but steep so care must be taken not to slip and fall. From there on, you will see more rock outcrops and about a half mile later the trail ends in a spot where the surrounding ridges close in to form a small bowl. The trail is not a loop so you will retrace your steps to get back.

Geology of Persimmon Mountain

The thing you notice before you even begin the hike is Persimmon Mountain, the high peak on the south wall of the valley that contains the arroyo,. It has a very interesting pattern of layers so let's make some basic observations.

First, the top and right side of the mountain have hard rocks that make a series of small cliffs. Just below the "cliffy" rocks at the top there are thinner layers of hard rock separated by areas of soil. This is the outcrop pattern made when a pile of hard rocks like sandstone or limestone formed between layers of soft rocks such as shale. The "cliffy" rocks are limestone without and shale.

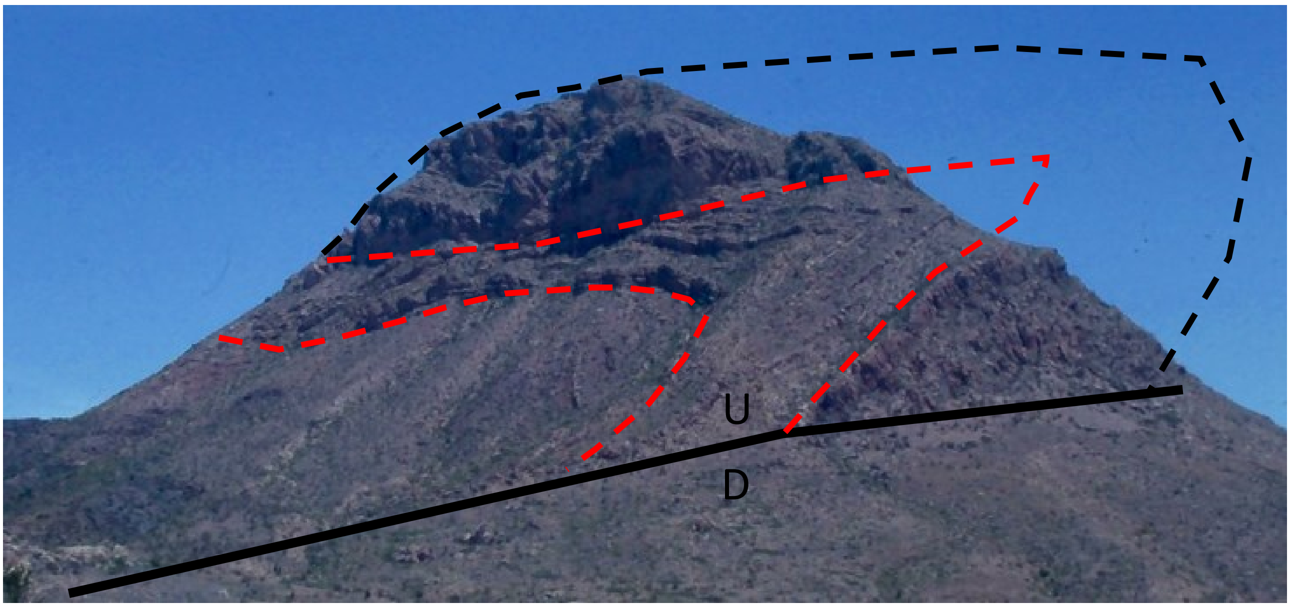
Now that we have talked about how to recognize hard and soft rocks, you will notice that most of the the mountain is made of what appears to be soft rock. There are two areas dominated by hard rocks, the top and part of the right side. To make the discussion easier, look at the picture below for the names of these rocks.



The Paleozoic rocks are the oldest in Big Bend. Geologists use the term Paleozoic to describe the rocks that formed between about 540 and 250 million years ago. The rocks in this part of the mountain are extremely broken and their layers are chaotic as a result so rather than talk about the individual geologic formation names, it's easier to just call them Paleozoic. The rocks that you will see along the trail were formed between about 485 and 325 million years ago.

Cretaceous rocks form much of the scenery of Big Bend. They formed between about 145 and 66 million years ago as a shallow sea flooded over southwestern North America. The earlier part, the Lower Cretaceous, is mostly limestone that formed in shallow, clear ocean water. The later Upper part has some limestone, but it also contains a lot of claystone and sandstone that formed as dry land replaced the sea. The famous dinosaurs of Big Bend lived during the Upper Cretaceous.

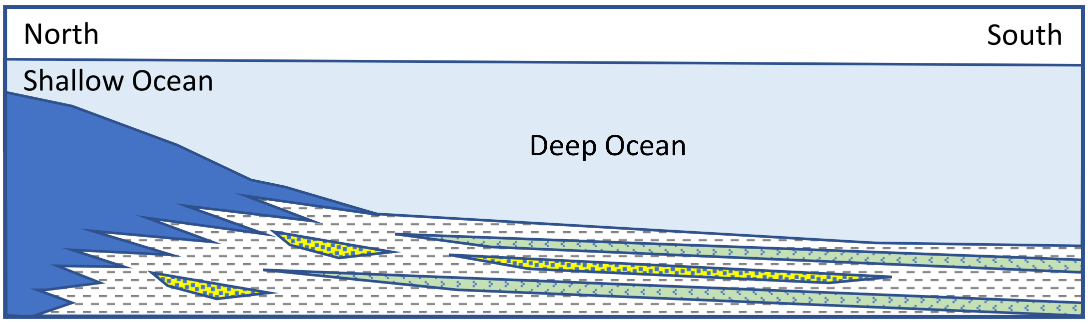
The Lower Cretaceous rocks here are part of the Glen Rose formation. A formation is a formally-defined rock unit corresponding to a specific time interval. What can we observe about the Glen Rose? We already noted how it has alternating hard and soft rocks at the base and cliff-forming rocks at the top. This pattern show the classic upward change from sandstone and shale to limestone that happens as a rising sea crosses onto the land. As the shore moves onto the land, the old rivers that supplied clay and sand are flooded by clear ocean water and limestone forms. The top of Persimmon Mountain looks like a normal change from sandstone and shale up into limestone, but what about the right edge of the mountain?



If you look at the thin beds in the softer part of the Glen Rose and trace them from left to right, they appear to bend over and continue down toward the base of the mountain. This is no optical illusion; they are actually bent in the shape of a sideways V. The black line shows how the two pieces of the harder part of the Glen Rose were connected before erosion removed that part of the mountain. All the Glen Rose in the right side of the mountain has been bent over and is upside down in what geologists call an overturned fold. How did this happen?

Folds form in a variety of ways that usually, but not always, involve squashing the rocks by plate tectonic forces. In this case, the squashing was caused by plate tectonic forces that squeezed Persimmon Gap from southwest to northeast until the rocks broke to form faults. We recognize the black line above as a fault because we see older rocks on top of younger rocks, Lower on Upper Cretaceous in this case. Geologists use the letter U to indicate the side of the fault that went up and D for the down-dropped side. As the fault formed, the Glen Rose went up as the Lower Cretaceous went down thereby creating a drag force that bent the beds over until they were upside down.

If this sounds confusing, that's good because it means you are trying to understand something that is complex, and you are paying attention. To try to make this mountain easier to understand, I made a series of drawings that start at the beginning of the story.



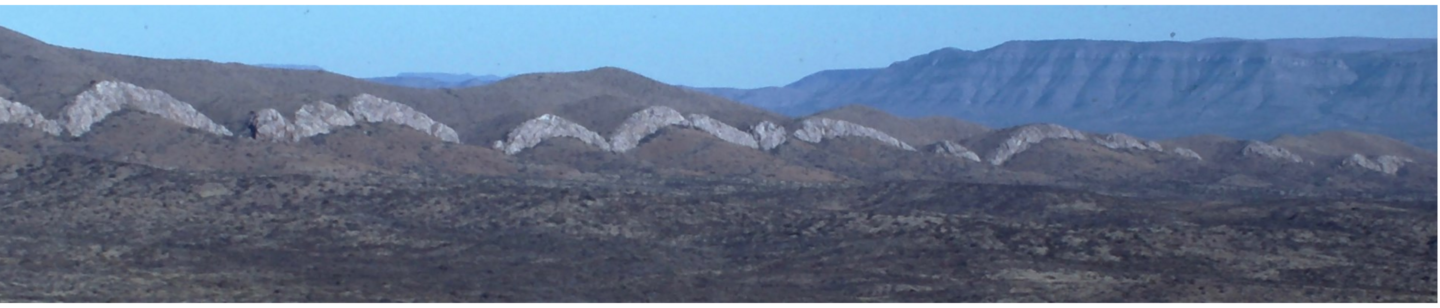
The first drawing covers hundreds of miles and Persimmon Gap was on the south end under the deep ocean south of the southern edge of the Paleozoic continent. For hundreds of miles south of the old shoreline, there was a shallow sea where thick limestones formed (blue). Many of those limestones are oil and gas reservoirs in the Permian Basin. The rocks formed in the deep ocean are very different than those. There are some limestones there but they usually are black instead of white or grey. There is also a lot of clay in the deep ocean so thick shales form (white with black dashes). Chert (green) is another deep ocean rock that almost all silica from the bodies of plankton. Sometimes chert is also called flint. Sandstones also formed in the deep ocean.

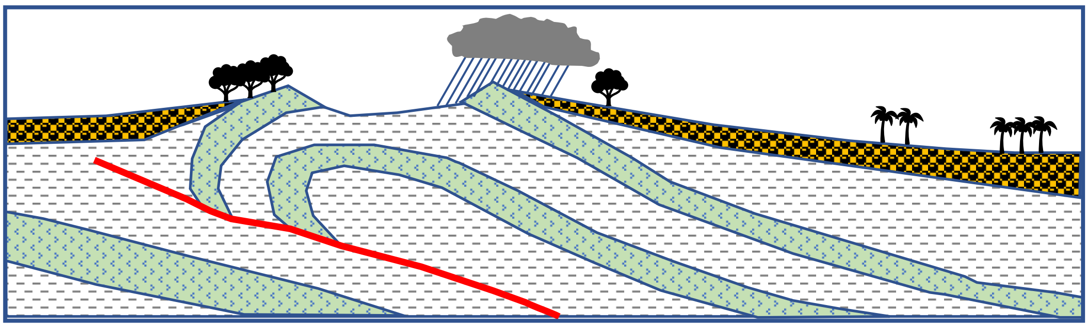
When a stack of deep ocean rocks are squeezed by plate tectonic forces, they form numerous folds and faults that end up looking like the folds in a rug if you push it from one end. This is because the hard limestone, sandstone and chert layers are surrounded by so much soft, squishy shale. Just north of Persimmon Gap there is an area where the Paleozoic rocks were squeezed from about 325 to 295 million years ago. This area, the Marathon Basin, look like a squashed rug on the aerial photo below.

You probably drove across the area in this Google Earth image on highway 385 to get to Persimmon Gap from Marathon. The lines that look like folds in a rug are made by a chert layer called the Caballos Novaculite. Novaculite is just another word for chert. You will see the Caballos on the hike. These folds formed when pieces of South America collided with the southern edge of North America.

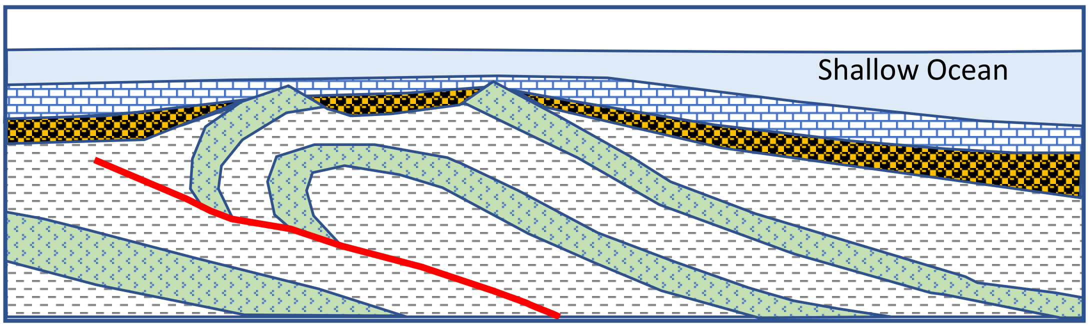
This Google Earth image shows the white layers of folded chert at Fort Pena Colorado Park (5.2 miles southwest of Marathon). On the right is a photo I took in 1979 that shows the tilted Caballos Novaculite forming one side of one of the folds. The tops of the folds are usually eroded away because that's where the bending is most intense. The rock gets so broken there that erosion happens faster. The photo below is from the highway 385 picnic area 10.2 miles south of Marathon. It shows a chert ridge in the foreground where the beds have been tilted to be almost vertical and a second chert ridge on the skyline that looks nearly horizontal. These are the two sides of the fold, and the top is missing.

The photo below shows another ridge of chert near the picnic area to give you an idea of how long these features can be.

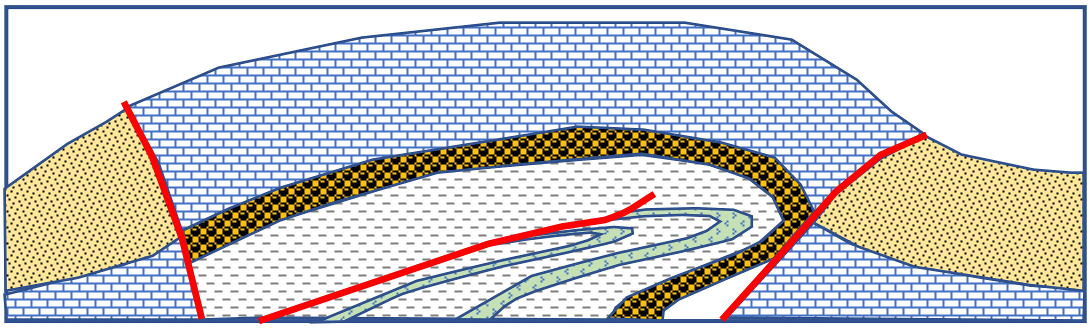




Now that we have looked at the chert ridges of the Marathon Basin, let's talk about how they formed. The deep ocean rocks were squeezed from the south and southeast by plate tectonic forces and folds were formed like you might see in a rug. In fact, the folds got so tight that they broke, and faults formed (red). This deformation caused the rocks to be uplifted out of the ocean to form mountains on dry land. Rivers began to erode the mountains and deposit sand, gravel, and clay that became sandstone, conglomerate and shale (orange).

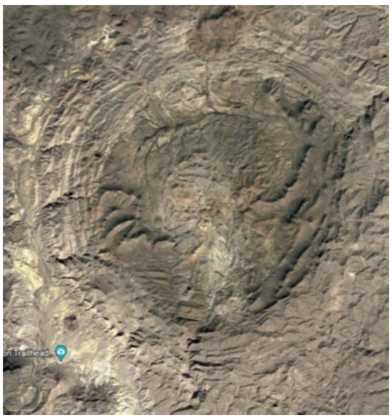


The next major event recorded in the rocks is the expansion of the Early Cretaceous sea over the land that resulted in deposition of the Lower Cretaceous Glen Rose limestones.



Limestone continued to form in Big Bend until the shoreline moved in from the north bringing with it the sediments that formed the Upper Cretaceous sandstone and shale. About 65 million years ago, plate tectonic forces again impacted Big Bend; this time producing a squeeze directed from the southwest. This squeeze created the faults that pushed the Glen Rose up over the Upper Cretaceous as Persimmon Mountain was uplifted. The Caballos Novaculite and the other Paleozoic rocks were folded for a second time to produce a chaotic arrangement of layers.

Persimmon Gap is a unique place because these two plate tectonic events mainly affected different edges of the continent. The older event was part of the time of mountain building that ran along the eastern and southern edges that resulted in the formation of the Appalachian Mountains in the eastern US and the Ouachita Mountains of Oklahoma and Arkansas. The later plate tectonic deformation is associated with the west edge of the continent and the Rocky Mountains. Persimmon Gap is unique because the two events overlap there. The only other place where you can see the overlap is in the Solitario of Big Bend Ranch State Park pictured in the Google Earth image below.

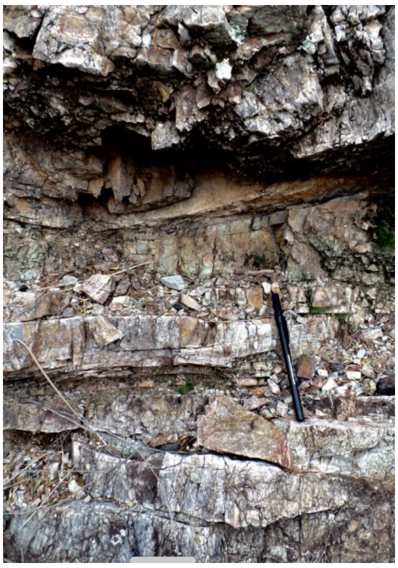


The Solitario is a huge, deeply eroded dome that formed when igneous rock pushed up from below. The outer ring is the Glen Rose formation pushed up on end; the beds are nearly vertical. The white patch in the lower center is part of the igneous rock and the chaotic folded ridges on either side are the Paleozoic rocks that were folded twice. You can see highly folded ridges of Caballos Novaculite just to the left of the white patch. For more info on the Solitario see "Geology of Big Bend Ranch State Park, Texas" by C. D. Henry (Bureau of Economic Geology Guidebook 28, 1998).

Rocks Along The Trail

There are a couple of places where you will want to take a closer at the rocks along the trail. Just after you climb the steep part of the trail, you will see this outcrop of Caballos Novaculite on the left.

When the chert formed, it would have been in horizontal layers. You can clearly see that they are highly tilted here as a result of being folded twice. In fact, I don't know if they are upright or upside down.



These pictures show how these rocks have been crushed by the repeated folding. Whenever you see and outcrop of Caballos Novaculite you usually see at least some of these cracks that geologists call fractures. This is the most highly-fractured Caballos I have ever seen.

The most common color of the Caballos is white but there are many others as you can see. These are very cool rocks but remember, collecting rocks in the national park is unlawful. Leave them for others to see. You can collect some Caballos on the roadside at the highway 385 picnic area mentioned above. There are also some roadcuts between the picnic area and Marathon, but they require caution because of the high-speed traffic.

At the end of the trail, you will find the sandstone and conglomerate at the base of the Glen Rose that formed as the Paleozoic mountains were eroded. Conglomerate is like sandstone, but it has gravel pieces as well as sand. You can see that the gravel grains are fragments of many kinds of rocks. This is because the rivers that carried the gravel flowed over a complicated landscape of mountains with a variety of different rocks.

You will notice that these beds are tilted. They would have been horizontal originally. If you look back to Persimmon Mountain, you will see that the slope of these beds continues right up to the peak as part of the fold shown in the diagram above.

You will also observe that these layers are not badly broken or chaotically-arranged. They are in much better shape than the Caballos layers. That's because they were only folded once and, at this location, the folding was not as extreme as what you see on the west side of the mountain. If you would like to know more about this area, I highly recommend "Big Bend Vistas" by William MacLeod.