‘I have been working on the Railroad’ Dike and thinking about Deep Time

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A long linear igneous dike holds up Railroad Mountain located between Roswell and Elida, New Mexico. How and when did it form? What happened afterward? The rocks tell us a story that could not have happened in a few thousand years. It occurred over Deep Time.

Figure 1. A long linear igneous dike holds up Railroad Mountain located between Roswell and Elida, New Mexico.

Plain language summary:

Using the Railroad Dike, an igneous intrusion that is exposed in Eastern New Mexico and the other rocks exposed there, we can demonstrate that the processes active when they were formed are like those taking place today. While some rates may have varied from modern ones, they demonstrate that these rocks did not form over the last roughly 4000 years as interpreted by Young Earth Creation (YEC) writers. We see evidence of discontinuous ephemeral stream deposits that were intruded by hot magma resulting in an igneous dike. Following this, there was extensive erosion of hard rocks, including the igneous rock that forms the Railroad Dike. This was followed by another period of stream deposition, again by rivers that flowed intermittently mostly. Then there was a long period when a caliche paleosol was deposited in semi-arid to sub-humid climate over a very broad area. Later, the area was covered by wind-blown sands that formed dunes and by more ephemeral streams and playa lake deposits. Some of these include evidence of humans and mammoths and then younger Paleoindian cultures. They are all consistent with God creating the Earth and preparing it for man over deep time, but do not fit the interpretation of a recent creation or global flood deposition.

Set the stage… why is it important?

Every rock has a story, but in some places it takes a fair amount of effort to be able to read the story. It is not like it comes in English or any other typical human language. Some people come to most of the Earth's rocks with the built-in assumption that they are about

***Figure 2**. Google Earth images of the Railroad Mountain Dike.*

4,000 years old and were laid down by Noah's flood. Most geologists disagree. In this article, we will look at one particular geologic feature and try to let the rocks tell their story. We will describe one long thin hill, referred to as the "Railroad Mountain. It is a straight, 30-mile-long feature that is the remains of an igneous feature known as a dike. (**Figure 1 and Figure 2**). Hence, I will call the rocks that make it up as the "Railroad Dike". It is located in eastern New Mexico, not far from the city of Roswell. (No, it was not put here by aliens.) The dike was once molten rock though it is not directly associated with any volcano. It formed beneath the surface of the Earth and has now been exposed because most of the surrounding rock has been eroded away. What we have today can tell us a lot about how and when these rocks formed.

Field trip

As a child, one of the fun things to do was to go looking for Indian arrowheads. I grew up on the high plains in eastern New Mexico and Indian arrowheads were not really rare there. Unfortunately, I wasn't great at finding them, perhaps because I was easily distracted by other interesting rocks. A leader of a boy's organization in our church, a wonderful man named Denver Askew took some of us out looking for arrowheads occasionally and one day he took us to visit the Railroad Mountain. That sounded really cool. We were having a great time climbing over the hill, but not finding any Indian artifacts. After a while a lady rode up on horseback. She told us in fairly colorful language to get off of her land. Our leader hadn't got permission, but, particularly in those days, few objected to boys hunting for arrowheads. One of the few happened to be this lady. We left. That was about 60 years ago.

The next time I visited the Railroad Mountain was in March of 2025. My wife and I were staying nearby and I decided that this was the time to revisit this notable location. This time I wasn't looking for arrowheads. I wanted to see if there were clues as to how and when this hill formed. I wanted to learn about its history. How could such a strange feature have formed.

Basic geologic description

What is a dike? How do they form? Igneous magma is hot molten rock down deep in the earth. Most people are familiar with the expression of magma that reaches the surface of the earth at volcanos and often flows out as lava flows. However, in some places molten magma gets injected into fractures in pre-existing rock in the subsurface, where it cools and solidifies, forming features called "dikes". A dike can be vertical, as in the example in

Figure 3 or it can be at any other non-horizontal angle. (If it were horizontal or parallel with the bedding, it would be known as a "sill".) The Railroad Mountain Dike is such a feature. It is about 30 miles (50 km) long, 100 – 150 feet (30-45m) wide and up to 80 feet (25 m) high (Constantopoulos 2024). The east and west ends are highly eroded and show little topographic expression.

The dike is composed of a black igneous rock. In hand sample, it is called a gabbro. This is a general term but recent detailed descriptions refer it by other names such as an "alkali olivine diabase (Constantopoulos 2024), a more technical term. (**Figure 4**). Some dikes are intruded with large amounts of aqueous fluids, producing extensive mineralization including in places mineral ores. This dike intruded without a lot of water, limiting the amount of associated mineralization. Cores have been cut into the dike and surrounding rock looking for mineral deposits but nothing significant has been found. This explains why there is just a very small alteration zone around the dike, almost as thin as in the small dike shown in Figure 3.

The story of this feature includes not just the igneous portion, but the rock that it was intruded into and what followed its emplacement. In this case, the rock that we have direct evidence being intruded is the Triassic **Santa Rosa Sandstone** (**Figure 5**). The Triassic is the earliest period in the Mesozoic Era, the time of the dinosaurs, and in fact dinosaur bones have been found in the Santa Rosa Formation and its equivalent formation in Texas (Heckert, Lucas, and Sullivan 2000; Lehman and Chatterjee 2005). The formation consists of red shales and sandstones with no indications of marine fossils or marine deposition. The sandstones are discontinuous, often wedge shaped bodies. Today, similar sediments form in terrestrial environments with small rivers and lakes.

Figure 4
Unweathered diabase from the Railroad Dike.

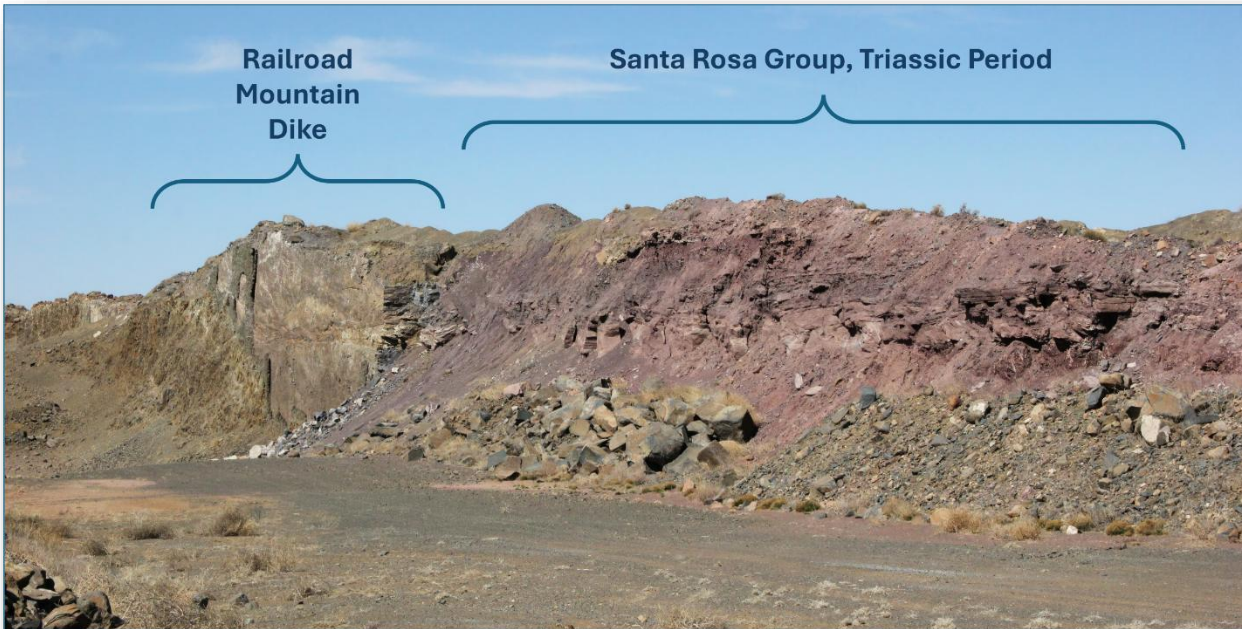


Figure 5. *Photo of one of two places where the dike material has been mined for road gravel. The excavation took place along the dike, such that the quarry wall runs roughly parallel to the dike. The dark red sandstones come close to the dike but there are just a few meters of alteration.*

What do we know about what happened after the dike intruded into the sediments? One thing that is clear is that a lot of erosion took place. Dikes intrude below the Earth's surface and yet today this dike forms a hill. The initial top of this dike and much of the rock that was originally above and adjacent to the dike is gone We know that Cretaceous marine sands are found in eastern New Mexico not far east of the dike and probably they originally covered this area as well. They were presumably eroded away in the intervening time. (Kues 1986) Where did they go? The sands and mud eroded from this area headed for the Gulf of Mexico, one of the largest accumulations of sediment on Earth, but some probably didn't make it that far and were laid down in fluvial deposits along the way.

The next rock that we do have is the **Ogallala Formation**, although even it has now been eroded away over much of the area. The base of the Ogallala Formation is an erosional unconformity that in this area separates sands and shales deposited in the Miocene epoch of the Neogene period from the sands and shales of the Triassic period. Sands of the Ogallala Formation are a very important aquifer in the Texas Panhandle and eastern New Mexico. They were deposited in a large fluvial system that carried sediments from the Rocky Mountains. In eastern New Mexico, the Pecos River captured the rivers that fed the Ogallala sands in the Llano Estacado region and left them cut off. In the Railroad Dike area, very little sand was deposited because it was away from the main rivers.

The top of the Ogallala Formation is a distinctive limestone known as a caliche, a soil horizon that in this case is ancient and hence known as a paleosol. Locally it is known as the "caprock" and it tops the broad plateau, the Llano Estacado, that is the size of the state of Indiana (Llano Estacado in New Mexico and Texas Vs. YEC and Flood Geology). (**Figure 6**). This paleosol extends northward all the way across Nebraska and originally extended much farther westward and eastward. Today the Llano Estacado only covers the eastern part of the Railroad Dike, not the portions with the most relief. However, caliche can be found on the dike where the dike has been deeply weathered. It cannot be tied directly to the Ogallala caliche, but even if it is separate, it formed the same way. More on this later.

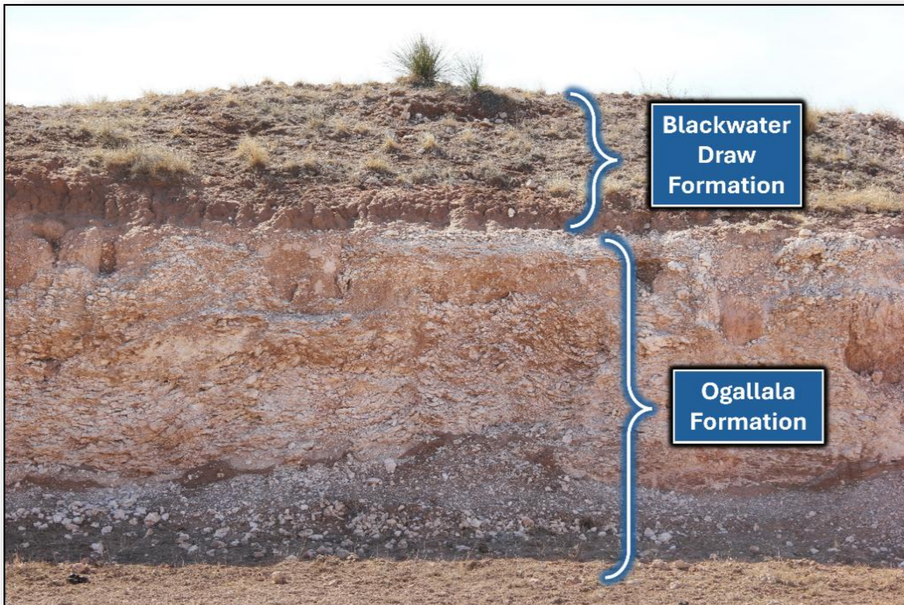


Figure 6. *Exposure of the upper caprock caliche in the Ogallala formation and the Blackwater Draw Formation. The exposure is in a pit where caliche was mined for road gravel. It is located 1.5 miles north of the Railroad Dike and 4.5 miles northeast of the exposures that I visited.*

Above the Ogallala Formation is the Pleistocene **Blackwater Draw Formation (Figure 7)**. It is composed of fine sands, silts and clays. These were deposited as sand dunes, just like modern active dunes in the area today, and as fine-grained sediments in areas which contained small rivers, springs and playa lakes. Younger units are famous for mammoth bones and many Paleoindian artifacts, including distinctive points known as "Clovis Points". Thus we can tell when mankind entered the scene in this area.

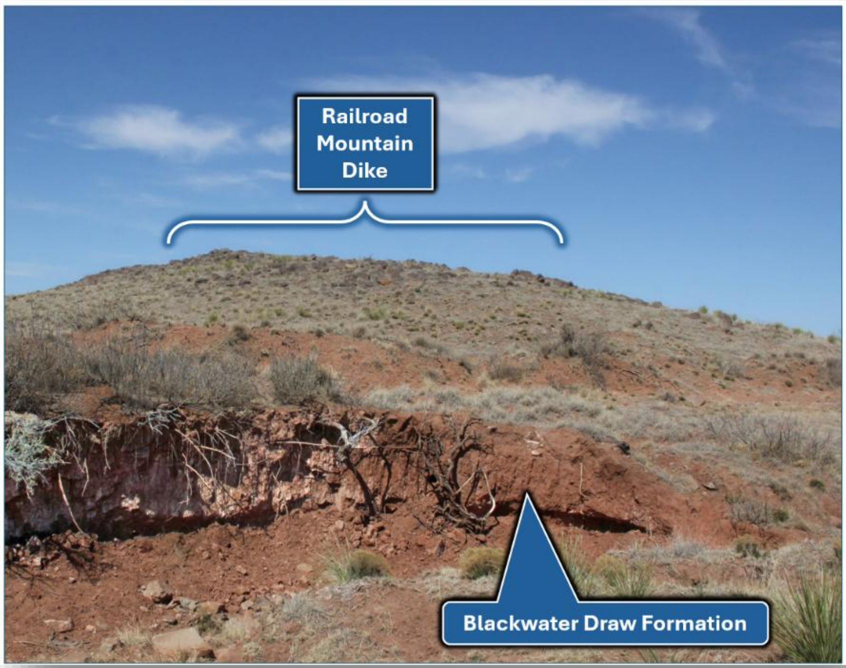


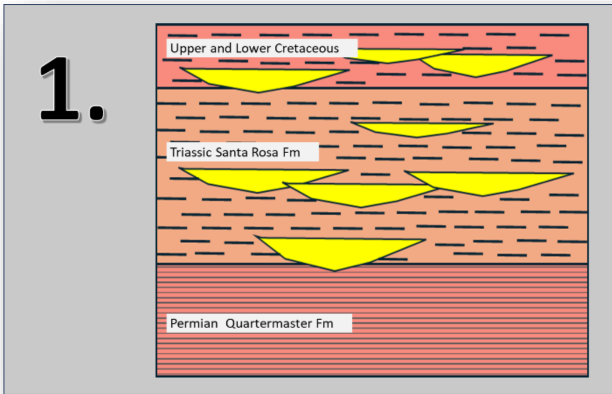
Figure 7 *Blackwater Draw Formation on the flank of the Railroad Dike*

History and Timing

So far what I have done is largely describe the rocks. Now let's start looking more at what they tell us about how they were formed and how much time was involved. This might be compared to reporting how long it takes to make a book. There might be several ways to answer this and it might be difficult to be precise for any one particular book. Even so, some limits can be reasonably made. In a holistic sense, you might start with growing trees, cutting them down, converting them into pulp and making paper. Maybe you would even include the time to build the printing presses. Once you begin printing, particularly in a modern system, a relatively short time might be involved but if you really include all of the preparation steps, we can be certain that years are involved. You still would find it difficult to say how much time it took to generate one particular book, but using a bit of research, you could provide reasonable estimates.

Similarly, it is not possible to be precise about much of the rock record. We can however make estimates and can sometimes be confident that more time was involved than some people claim. I will use a set of schematic drawings to illustrate five stages that are demonstrated here. Recognize that there are older sedimentary rocks below those illustrated that tell a much longer story. Borrowing from the book analogy, they might be like including the very real time that it took to mine the ore that was eventually smelted and allowed the computer and printing equipment to be constructed and used to print the book.

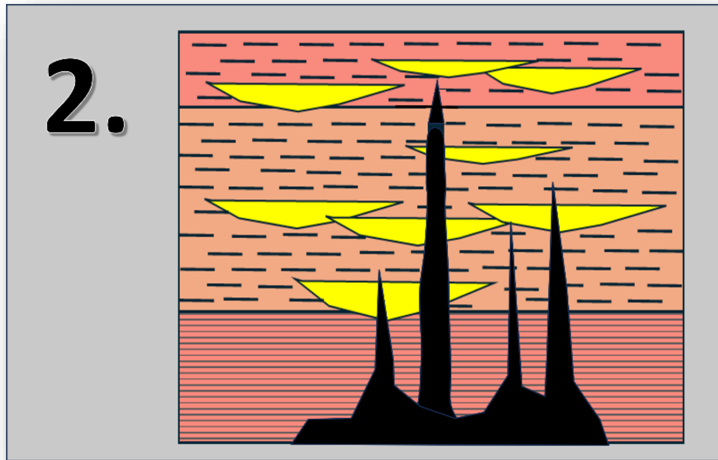
Stage 1 **Figure 8**



In stage one, a series of sedimentary rocks were laid down. In the book analogy, the trees were grown. The figure includes three formations deposited in three different geologic periods. The contacts between the formations are erosional unconformities that in some areas are quite angular. These unconformities indicate that significant time elapsed while some sediment was eroded away before the next unit was laid down. The Triassic Santa Rosa Formation as described earlier includes sandstone bodies with internal sedimentary structures and external body shapes that tell us that they were deposited by streams that meandered over a low-relief surface. (Lucas, Heckert, and Hunt 2001; Gratzer 2016; Gregory 1972; Fritz 1991; Lehman and Chatterjee 2005). There also are shales that contain dinosaur fossils, desiccation cracks, and flow direction indicators that tell a story of ancient streams and lakes.

Conventional geologic dating would tell us that these rocks were laid down over the course of 150 million years. This would allow for many river systems and their associated systems to have laid down sediments and for long erosional breaks between the formations. Leading "flood geology" interpretations all demand these units to have formed over the course of a few weeks at most, either late in the flood (AIG) or near the mid-flood (ICR) (see **Figure 19** at the end**).** Catastrophic flood deposits would have formed far more chaotic deposits than these. Comparing ancient river systems to the flood interpretation is a subject for another article.

Stage 2 **Figure 9**



The sediments were buried and that burial caused them to heat up and harden. Loose sands and soft shales were changed to rock through a process known as lithification. The weight of overlying sediments compacted them. This combined with the heat to cause minerals to be deposited between grains. This lithification was not a local feature just around the dike, but it affected a large region. In general, the deeper that a rock is buried, the more lithification occurs and in this case, these particular rocks were probably at the deepest that they have ever been when the next event occurred.

Enter the Railroad Dike as hot molten magma. Fractures may have already begun to form as the rocks responded to regional tectonic forces that impacted the entire region. Whether through existing fractures or ones created by the pressure of intruding magma, the hot magma rose through the sediments along parallel fractures. One of those magma-injected fractures became the Railroad Dike, a single planar feature that is at least 30 miles long at the surface. Soft muds and sands just do not allow the propagation of fractures for long distances, particularly as linear features. We don't see other indications that the sediments were soft at the time. One example that is missing is peperite, an igneous rock made up of combinations of igneous and sedimentary rock that hardened together (McLean, Brown, and Rawcliffe 2016). The rocks are telling us that the soft sediments as they were originally laid down had already hardened before the dike injected into them.[1]

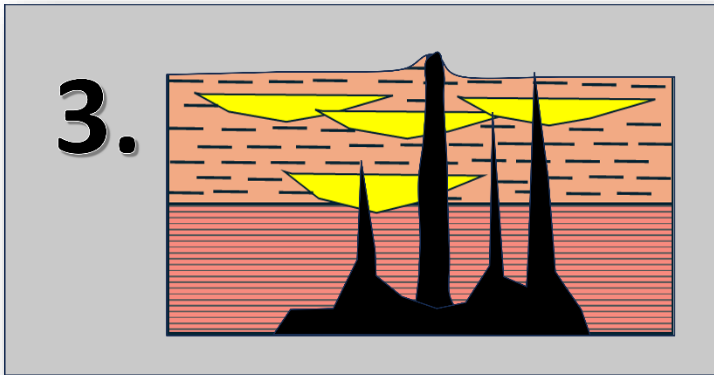
[1] Andrew Snelling has argued that folds in the Tonto Group in the Grand Canyon developed while the sediments were still unlithified and soft. (Snelling 2021). Together with my co-author, Dr. Kennen Tillman, we have demonstrated that the rocks tell us that these folds had associated fracturing that tell us that the rocks were folded after they were lithified. (Mitchell and Tillman 2024a)

There are other known dikes in the overall area that are parallel to the Railroad Dike and they were probably formed at around the same time (Aldrich Jr., Chapin, and Laughlin 1986). There also may be other dikes near the Railroad Dike, but if so, they are still below the surface as shown in the sketch in Figure 9. The main magma chamber was probably much deeper. Magma that cools to form diabase would have been at least 1000°C to 1200°C (1830°F to 2190°F) as it rose along the fracture. It would have been at least a few hundred meters, if not a few kilometers below the surface. Over time, it cooled and solidified. The size of the crystals tell us that it didn't cool very quickly, such as in lava that cools rapidly on the surface, precluding the growth of larger crystals. It is difficult to calculate how long the magma would have taken to solidify without knowing how deep the source body was, what the temperature of the surrounding rock was, and other such factors that we don't know. (Snelling 1991) One might expect that it cooled over a few thousand years but that is not really a significant amount of time compared to the other times involved here.

How long ago was the dike intruded into the sediments? According to flood geology, these are about 4300 years old. Conventional geology makes them far older. In 2024, Constantopoulos had two samples tested yielding ages of 27.66 ± 0.03 Ma. This is consistent with earlier analysis in 1986, when Aldrich dated the dike as 27.9 million years old (Aldrich Jr., Chapin, and Laughlin 1986). Aldrich provides dates for 47 dikes across New Mexico as part of a larger study. Dates range between 0.8 my and 44 my, forming groups that help us to understand how the rocks responded to the formation of a down-faulted feature known as the Rio Grande Rift.

YEC explain the consistent pattern of radiometric dates found through the earth's rocks to have been the result of accelerated decay that occurred during creation week and during Noah's flood (Vardiman, Snelling, and Chaffin 2000). If that were the case, this would mean that all of these dikes would have formed late in Noah's flood. That would certainly be challenging to explain.

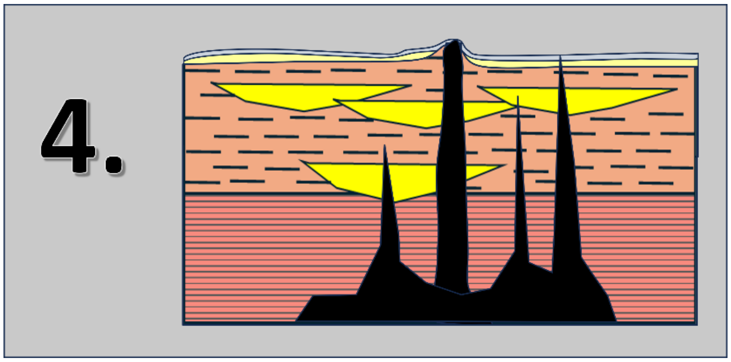
Stage 3 **Figure 10**



By the end of stage 3, a lot had changed. Much sediment from Stage 1 was eroded away, plus the upper portion of the dike. We can't tell exactly how much material is missing. The crystals that can be seen with the naked eye in the diabase dike material suggest that it was thousands of feet. The base of the overlying Ogallala reflects active river dissection. We should not be surprised that long missing gaps are found in any local rock record. When we have modern streams covering ancient rocks, the result is a major gap.

How long would it have taken to remove this rock? This is not difficult to fit in the timeframes of standard geological dating, given the 80 million years of missing time indicated by the radiometric dates, but flood geology must find this challenging. In their interpretations this occurred either late in the flood or after the flood. One cannot call on raging rains or tsunamis late in the flood. Normal erosion cannot remove so much rock in a few days or even a few years. Notice that in the illustration, the dike stands above the surrounding rock. It would have been more resistant to erosion than the surrounding rocks just as it is today. The erosion that removed so much material probably involved many stages of deposition and erosion but the end result was to take out the Cretaceous and part of the Triassic rocks that were there.

Stage 4 **Figure 11**



In stage 4, we see renewed deposition of sediments in the region. Immediately as the ancestral Rocky Mountains rose up, they began to erode away, shedding sands and gravel east of them, including across eastern New Mexico. Sands and gravels were laid down along ephemeral streams that flowed in low areas such as along the paleo-Brazos River near today's Portales and Clovis, New Mexico. The river deposits contain well-rounded gravels of rocks eroded out of the Rockies. Clearly these were hard rocks, rounded by stream transport just like we find today. These include petrified wood and Cretaceous rocks, clearly demonstrating that they were hard rock when they were sitting in the ancient stream beds. It is significant that these were already eroded out of hard rocks that had to have already lithified before the Miocene epoch. This is problematic for flood geology interpretations. **Figure 12** shows one of the many fine sections of the Ogallala described by Dr. Thomas Gustavson (Gustavson 1995). It shows many phases of deposition and soil formation.

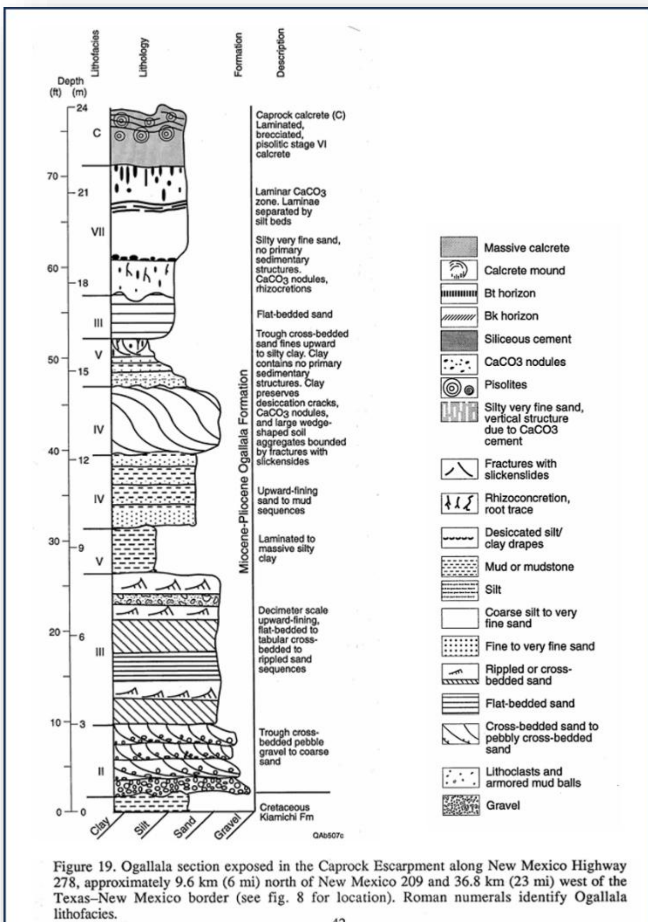


Figure 19. Ogallala section exposed in the Caprock Escarpment along New Mexico Highway 278, approximately 9.6 km (6 mi) north of New Mexico 209 and 36.8 km (23 mi) west of the Texas–New Mexico border (see fig. 8 for location). Roman numerals identify Ogallala lithofacies.

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***Figure 12**. Measured section profile from the Ogallala*

Freshwater mollusk and snail fossils are common, along with pollen from grasses, flowers and trees that probably lived along ephemeral ponds and streams (Leonard and Frye 1978). We don't find dinosaur tracks, but mammal tracks, including those from camels and large cats, have been found less than 20 miles north of the Railroad Dike in the Ogallala. (Williamson and Lucas 1996). Bones and teeth are found in the Ogallala in other areas, including those from squirrels, ground squirrels, mice, dogs, fox, wolverines, saber-tooth tigers, rhinoceros, horse and bear. (Dalquest 1983)

A key feature of the Ogallala is the presence of many paleosols of various types. Well-developed soils take thousands of years to form. The paleosols include root tubules with associated features and silt-filled mudcracks that formed as the sediments dried out. One key soil type found is the caliche soils. Rainwater leaches calcium from soils and in humid regions, the calcium is carried out of the area. In areas where caliche develops, there is enough rainfall to move the calcium down, but not enough to carry it out of the system. The calcium reacts to form calcium carbonate in the form of coatings and eventually concentrates into caliche. Calcite coatings can form quickly, but layers of caliche covering broader areas would have taken thousands of years to develop.

Another part of the Ogallala is the fine to medium grained sand with trough cross-beds. These are interpreted as wind-blown (eolian) deposits from ancient sand dunes. These are just like those of modern dunes in the area.

YEC geologist, Dr. Tim Clarey of the Institute for Creation Research (ICR) proposes that the Ogallala was laid down as a blanket sand in the final stages of Noah's flood. (Clarey 2020) Apparently this was based on the fact that the sand is widespread and on his limited examination of the Ogallala Formation in the Palo Duro Canyon area. The characteristics discussed here and in many geologic articles suggest that this is about as far from being a blanket sand as one could get. The basal sands were deposited by braided fluvial systems that were controlled by the topography of the erosional surface below them. Complex environments controlled the sediments immediately above this sand that included many soils and sand dunes. The soils are consistent with climates that were subarid to subhumid. The diverse flora and fauna suggest that it was somewhat like a modern savannah such as exists in Africa today.

To cap it off is the capstone made of caliche (also called calcrete) in the upper Ogallala extending across the Llano Estacado and northward up through Nebraska. The caliche at the top of the Ogallala is one of the most extensive caliche deposits in the world. Bachman and Machete (1977) described six stages of calcrete (caliche) development showing how it advanced over time. The more advanced stages took thousands of years to form. All stages are preserved in the upper Ogallala caprock. **Figure 13** shows examples of the Stage 6 caliche development from 25 miles northeast of the Railroad Dike where I examined it. These rocks tell us that there were many different times when the caliches were exposed,

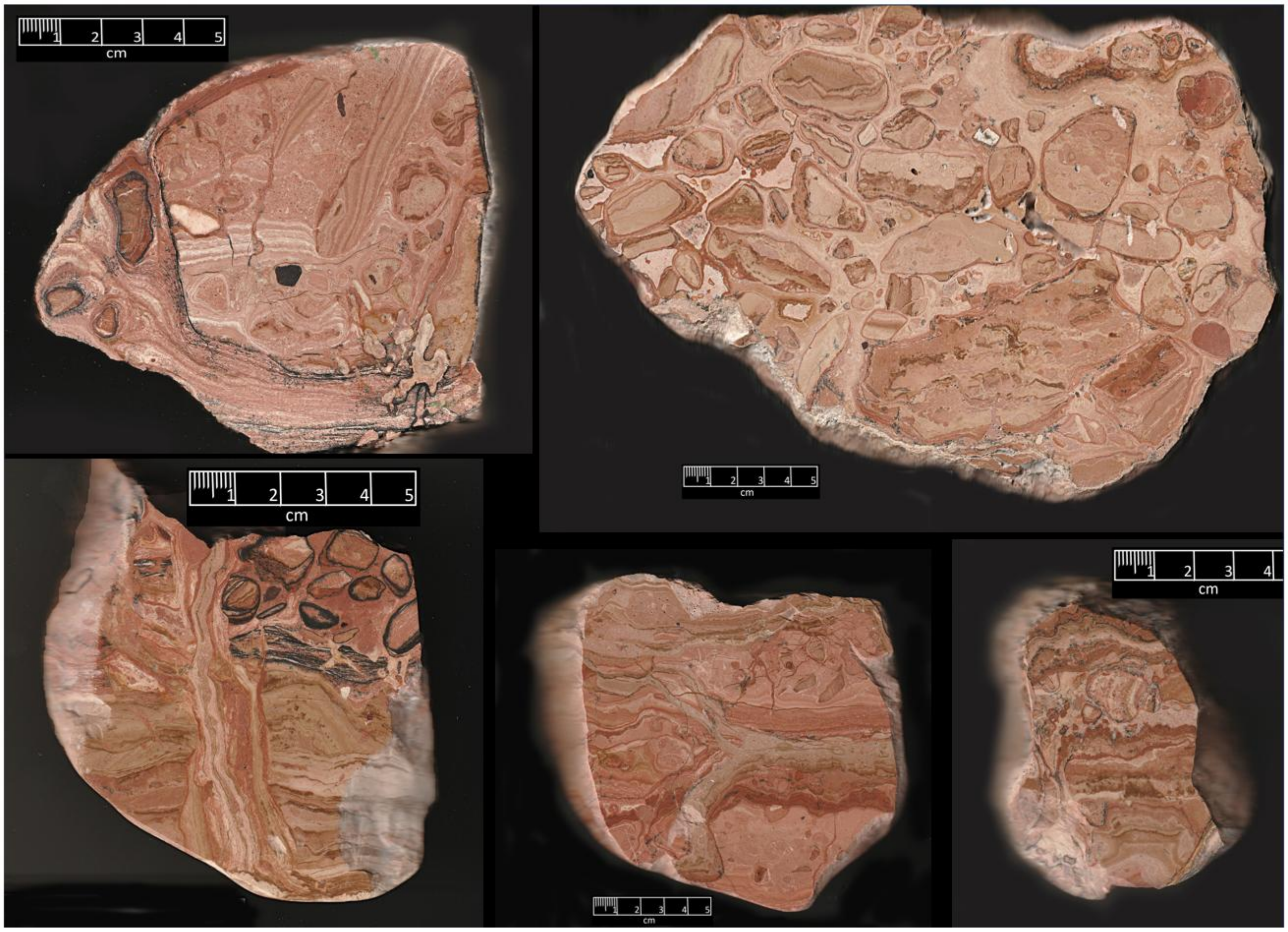


Figure 13. Caliche from near Elida, New Mexico. These have been polished, showing how hardened this ancient soil has become. Notice that each piece shows several phases of brecciation, pisolite formation, re-healing and often banding. All reflect phase 6 calcification.

reburied, broken up, healed and re-healed. Gustavson (1995) wrote, "This calcrete represents at least several hundred thousand years of landscape stability."

As noted earlier, the Ogallala caliche is not found over the Railroad dike, at least where I examined it, but there is evidence of calcite mineralization as Stage 1 calichification. Heavily weathered portions along the crest of the dike are preserved today. (**Figures 14 - 16**). Over time, water seeped into fractures in the dike. It did two things. Seeping down the fractures the water came in contact with the diabase and the igneous rock began to gradually break down through a process called "hydrolysis". This changed the minerals. Calcium from overlying soils and from the breakdown of the mineral plagioclase in the diabase deposited as calcite in the fractures and coated rocks.

As the diabase weathered, the fluids altered the material deeper and deeper, leaving smaller and smaller rounded portions of the original rock. The process is called spheroidal

Figure 14. *Caliche coatings and associated calcite filled fractures extending down into weathered dolerite, Railroad Dike, N.M.*

Figure 15*. Close-up of fracture showing calcite extending down into the dolerite.*

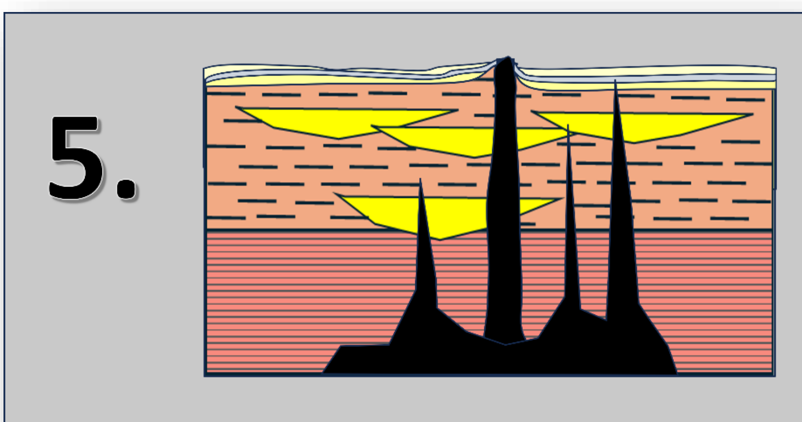
Figure 16. *Spherulitic weathered dolerite.*

weathering. How long does it take for spheroidal weathering to form features like those in Figure 16? We know that it is affected by factors like the mineralogy of the dike, the spacing of the fractures, the climate and temperature history of the region. The rocks tell us that they were deeply weathered, but it would take more work and perhaps even new technology to let them tell us more specifically what the rate of weathering was and this portion of the history here.

An analogy is available that helps. Working on basalts on the Réunion Island in the Indian Ocean, Dr. Christelle Claude and her coauthors documented spheroidal weathering that took place over 293,000 years. I doubt that many YEC would interpret the lavas that she studied as having been deposited during Noah's flood. If they would say that these were post-flood, then they would have been well after the pulse of accelerated radioactive decay that they hypothesize took place during Noah's flood. The basalts would have had similar chemistry but were located in an area with a very humid and warm climate suggesting faster weathering. Perhaps there were humid periods in the Railroad Dike's history, but today, it is much dryer and over much of the time they have been exposed it was at least as dry as today (13 inches (330 mm) of rain per year).

The Ogallala rocks haven't given us any precise dates, but they have told us about processes that acted over long periods of time.

Stage 5 **Figure 17.**



In stage 5, we see deposition of more recent sediments. The base of these more recent sediments is another erosional unconformity. If you look at what has been deposited in Eastern New Mexico over the last 100 years, it includes sand dunes and deposits from small ephemeral streams and playa lakes. That has been true for a long time. The Ogallala Formation was covered with sediments laid down by the same processes as are active today. The lower ones are named the Blackwater Draw Formation. These were laid down in the Pleistocene Epoch. Radiometric dating and infrared stimulated luminescence (IRSL) tell us that the ancient sand dunes and associated deposits were laid down over a period of about 1.4 million years. (Holliday 1989; Hall and Goble 2020). Regardless of the exact duration of the overall unit, it is significant that there are stacked paleosols identified, each of which represents several thousand years of development. (Haynes 1995; Holliday 1989; 1997; Baird 2015)

For this article, I haven't added a separate phase to reflect the later Holocene deposits. In many cases, these represent another phase of the same type of deposition: sand dunes separated by paleosols. Ancient ephemeral streams washed through valleys that were set up by the braided rivers and ephemeral streams of the Ogallala. Just like in modern settings, wildlife followed the water. Paleoindians followed the water and the game. Springs and streams in what is now eastern New Mexico and the Panhandle of Texas provided hunting and camping grounds. Distinct cultures are identified by the style of their points and their stratigraphic order is clearly documented. (**Figure 18).** In the modern world technology changes rapidly. Not so in the ancient world. Clovis points are recognized over much of North America and were apparently used from about 11,500 to 10,900 BCE. Anthropologists debate whether Clovis man at the original Blackwater Draw site, were hunting mammoth or scavenging meals provided by mammoths that died.

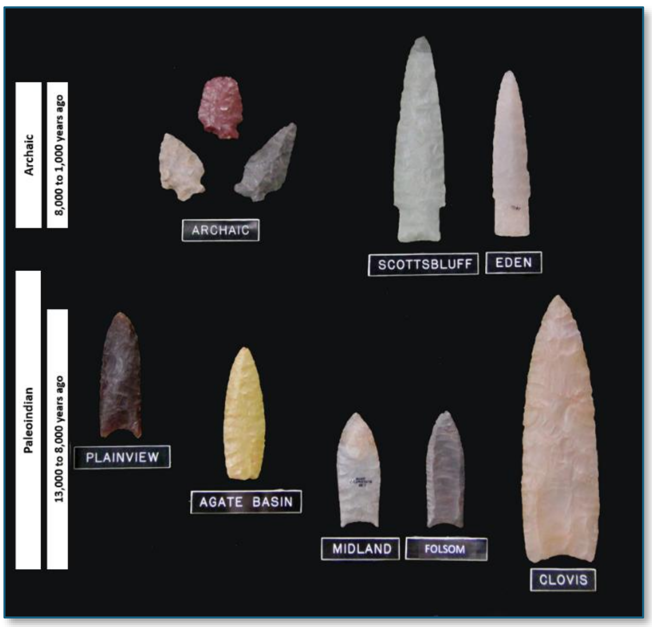


Figure 18. Arrowheads from Blackwater Draw and nearby sites representing different cultures. Blackwater Draw Museum, Eastern New Mexico University, Portales, NM.

Discussion

How does this fit with YEC flood geology models? Most geologists consider the rocks and softer overlying sediments in the Railroad Mountain Dike area to have been deposited over "deep time", a multimillion year timeframe. YEC flood geologists propose that these rocks formed over approximately 4000 years. The observations here can easily be interpreted over deep time, but can they fit into a timeframe that is six orders of magnitude less? **Figure 19** (at the end) shows how the most popular YEC models would need to fit the rocks into their timelines. Both models shown would interpret the Santa Rosa Formation and the igneous material of the Railroad Dike to have formed during the "receding phase" of Noah's flood. It is important to recognize that in these flood geology proposals, deposition of each unit during Noah's flood had to occur over a matter of days or weeks. For instance, one would estimate, based on Dr. Clarey's book, that the Santa Rosa Formation was deposited over about 10 days. If it took significantly longer but still within the year of Noah's flood, then that would simply mean that the other units had to have been deposited all the more quickly. He would place this within the "bad to worse" portion of the rising flood. He says that "runaway subduction" was taking place, such that the tectonic plates were moving at meters per second and sedimentation was driven by major tsunamis.

Dr. Snelling's proposal would have the Triassic deposits formed as sediments were carried by floodwaters that were rapidly returning to somewhere in the earth. Processes would have been very rapid in either proposal. This is very different than what we saw in the Santa Rosa Formation. The shales and sands were laid down in terrestrial settings. The sands were bodies along ephemeral streams that flowed after occasional storms, not major rivers.

The sands and muds of the Santa Rosa Formation were lithified with burial. Straight fractures as long as the Railroad Dike support the interpretation that the Santa Rosa was well lithified before the Dike intruded the rocks. The YEC interpretations don't really have time for that. The rocks needed burial to lithify and when did that occur? The molten magma moved up the fracture quickly, and may have even cooled relatively quickly. However, eroding the rock took time. We can't be sure how much rock was eroded and is now missing, but if we estimate that it is hundreds of feet, including some of the cooled dike material, then hundreds of thousands of years would be minimal

As described earlier, Dr. Clarey interprets the Ogallala sands as part of a rapidly deposited blanket sand. Clarey wrote:

> *"Secular scientists claim these are deposits from rivers, but a receding mega-flood explanation better fits the broad extent of the Ogallala. How else can a blanket sand*

layer spread across thousands of square miles with no evidence of river channelization? And localized post-Flood catastrophism cannot explain the massive extent of this deposit either, just like isolated regional processes cannot explain the huge deposit of the Whopper Sand in the deep Gulf of Mexico."

As documented in my article, Llano Estacado in New Mexico and Texas Vs. YEC and Flood Geology, the evidence of river channelization is obvious with a bit of research or field work. Clarey has not discussed the extensive caliche deposit that cap the Ogallala Formation. Surely this should not be considered part of the flood. If it is recognized that paleosols of caliche are inconsistent with flood deposition, then this should also apply to the many caliches recognized in deeper units, such as in the Permian.

What if the caprock caliche is interpreted to have formed in the post-flood period within the YEC ages? Think about the processes that YEC often invoke as having occurred. Some claim that the post-flood world was characterized by high rain, at least initially. Andrew Snelling wrote:

> *The high precipitation rates in the early centuries after the Flood would have produced a greater volume of run-off water, which would have meant corresponding rates of both erosion and sedimentation. Such heavy rainfall concurrently over large areas would have resulted in peak flows of the water over the earth's surface, eroding sediments and strata in a planar fashion, rather than being channeled into streams.* (Snelling 2009)

Massive amounts of runoff and downcutting do not take place in meandering streams such as are found here. Most YEC also consider the flood waters to have been hot. Snelling wrote, "*By the time the Flood waters had settled into the post-Flood ocean basins, they had accumulated enough heat to make the ocean waters as much as 200C or more warmer than today's ocean waters.*" (Snelling 2009) That is incredible. Certainly all of the ocean life would have been killed. There would have been clear indications of such temperatures through all of the flood sediments and afterward.

Most flood geology authors recognize that the Earth experienced at least one ice age after the flood. There are several creative explanations to orchestrate what the drivers were and what the results were. The interpretation of peak flows of water predicted for the period immediately after the flood would seem to clearly rule out caliche formation. If the climate was far dryer after the initial period as some suggest, then this would again make it difficult for the stable "subarid to dry subhumid" conditions, similar to those of today, that occurred while the extensive caliche formed. Of course, the most difficult part to overcome is just how to form thick caliche in the very limited time available. Even if one were to ignore the consistent radiocarbon dating for the Paleoindian cultures, there just isn't enough time for the number of caliches to form, let alone the thick caprock caliche. Deeply weathered diabase with spherulitic weathering also testifies to deep time.

Much work has been done to characterize the climates associated with the dunes that overlie the Blackwater Draw formation, both to study the Paleoindian cultures and to study climate change over the last 12,000 years. (Holliday 2001; Hall and Goble 2006). Climate change is not new. Early on I used the illustration of making a book, and noted that how long it would take depends on how much one includes in "making the book". How long did it take to make the sand dunes? The accumulations of sand began largely a few thousand years ago with some beginning 4000 years ago, about the time of Abraham.

However where did the sand come from? A reasonable hypothesis would be that it originally comes from quartz that was in ancient granites. As these weathered, the quartz was mechanically broken down into fragments that become the sand grains in sandstones. Granite can contain as much as 25 percent quartz or more, but the average granitic rock that supplies the quartz grains to the sandstones contains only 10 percent quartz. That means to make a sandstone formation that is 100 feet thick requires the weathering and mechanical breakdown of a thickness of 1,000 feet of granitic rock. That amount of weathering cannot happen in 4,000 years. The weathering of granite tombstones with dates of lettering on their surfaces shows that such weathering is only at thicknesses of less than thousandths of an inch per year. (Lorence Collins, personal communication)

In most cases, quartz grains from granite would have been deposited in older sediments, including the Ogallala and Blackwater Draw formations that were later eroded. Multiple phases of deposition, burial and erosion winnowed out the shale and allowed the sands to be concentrated. Winds would have blown these in from the west and concentrated them into dunes. The entire holistic history of even the recent sand dunes would have been very long.

Conclusions

Let's begin with the evidence recognized that points to the rocks here being formed over the last 4000 years. That would be appropriate in order to weigh the options. Unfortunately, I have not identified any such evidence. If we just let the observations from the rocks tell us their story, nothing tells us that they were formed rapidly or by any other processes than those we see today. We see features that indicate streams that flowed intermittently. We see a dike that intruded through them, only to be partly eroded away. We see paleosols that each took thousands of years to form. Noah's flood happened, but there is nothing here to suggest that it was responsible for any of these rocks.

Appendix: Stratigraphic Columns

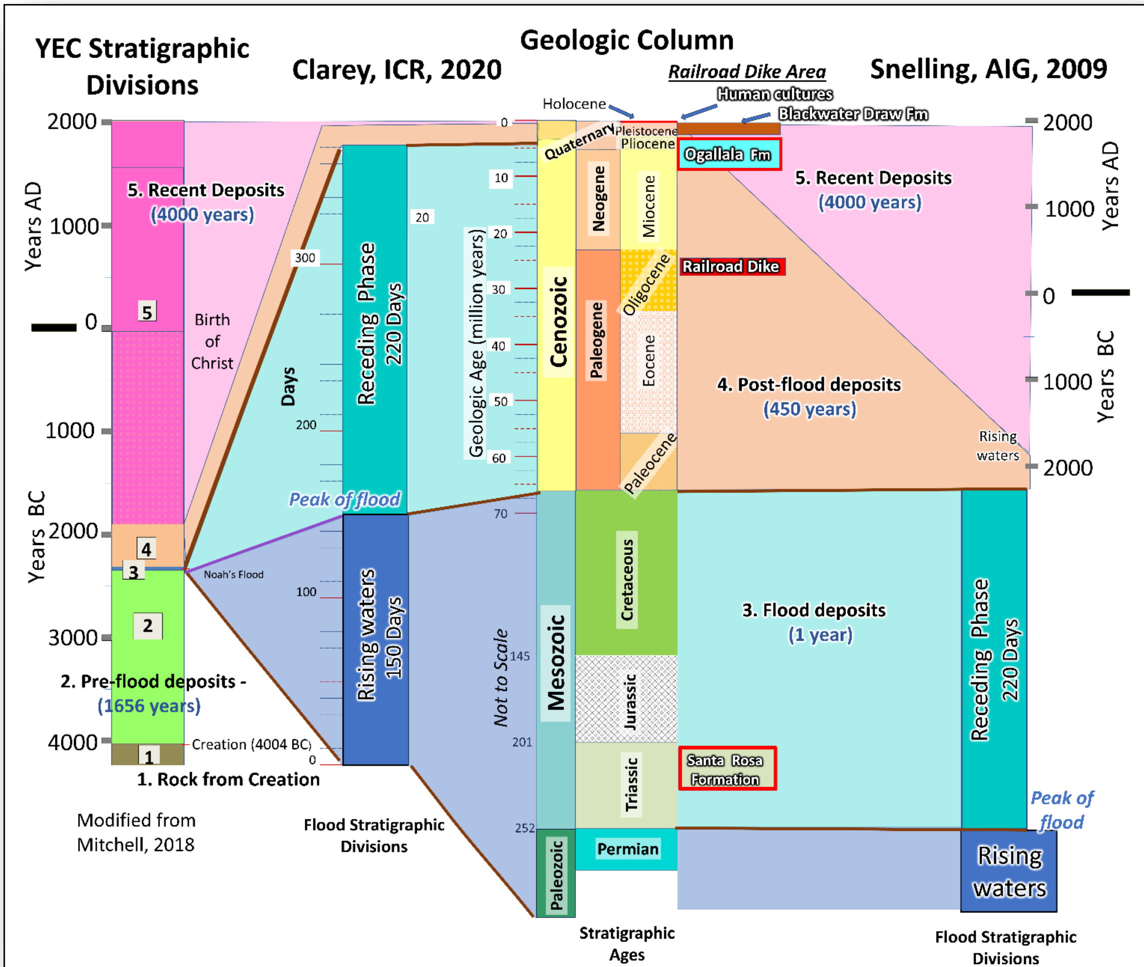


***Figure 19**. Modified from Mitchell and Tillman, 2023*

YEC with any significant geologic training have recognized that the "Geologic Column" used by geologists over the last 200 years is a valid summary of thousands of observations, providing a framework to use to understand older vs. younger rocks. YEC have proposed different correlations of the relationship between the geologic column vs. their interpretations of the Earth's history. Two are shown in Figure 19. (Mitchell and Tillman 2024b) The first column on the left in this figure shows the events that YEC recognize in the Earth's history that have geologic implications. The 3rd column shows the geologic column with the Eras, Periods and Epochs in the relative order that they are found around the world. Only the upper part of the column is shown, in order to expand the portion important in this article. The Cenozoic Era portion is scaled as accepted by modern geology. The Mesozoic and Paleozoic Eras are not scaled. The second and forth columns show interpretations as published by two leading YEC organizations. Notice that they are very different. The rocks discussed in this article are labeled next to the geologic column. Using this figure, one can estimate how long flood geologist are claiming it took to deposit various formations.

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