Issue #2: Deformation – folding and faulting of hard rocks

Assertions:

1. Sediments were lithified with burial.

2. After lithification, the rocks were folded.

3. Lithified rocks cannot be folded over a few thousand years.

4. Therefore rocks that were lithified before folding were folded over deep time.

Key assumptions:

a) It is possible to recognize when rock was hardened early. (Stream pebbles from older rocks provided as evidence.}

b) Hardened rock cannot be folded quickly (as assumed by YEC authors as well)

Discussion

We find examples throughout the geologic record and the world of solid rocks that were deposited as horizontal or near horizontal beds but today are folded. While some were folded while they were relatively soft and pliable (soft sediment deformation), in many places sediments and igneous rocks were hardened before being folded. We see hard rocks being actively folded today, albeit very slowly. We will look at the rates of tectonic plate movement in Issue 11, where we will see Arabian Peninsula folding, faulting and crumpling solid rocks to form the Zagros Mountains. GPS shows that the Peninsula is moving at a high rate of 19mm per year. During the last ice age, continental glaciers covered large areas in North America, Europe and Asia. The weight of the ice depressed the crust and as the glaciers retreated, the crust began to rise. GPS measurements show that parts of Sweden are coming up by up to 11 mm per year. Both are cases of solid rocks that are being both folded and faulted at slow rates today.

Dr Andrew Snelling (2009) stated, "*When solid, hard rock is bent (or folded) it invariably fractures and breaks because it is brittle*" but that is only true for short times such as the few thousand years permitted in YE models. From my book,

> *"All solid and liquid substances have varying degrees of strength but will deform or flow given enough time. The measure of a materials resistance to flow is viscosity. Water flows easily and therefore has a low viscosity. Honey flows much more slowly and therefore has a higher viscosity. Tar is very viscous but over time it will flow as well. We can measure properties such as density, size, weight, and time and find that they are proportional to the viscosity of a material. M. King Hubbert (1903–1989) wrote a classic article in 1945 where he demonstrated that over millions of years, the viscosity of rocks allows them to easily flow. He was able to demonstrate that by just using properties that he could measure, the rate at which sediments deform was entirely consistent with the folding over geological time. He concluded, "Without the necessity of any special hypotheses of strength much less than, or of fluidity much greater than, that of the crystalline rocks of the earth's surface, the behavior of the earth as a whole in geologic time must*

be very similar to that of the ordinary viscous fluids and extremely soft muds of our everyday experience" (Hubbert 1945)." (Mitchell, 2018)

The tendency of a rock to behave ductilely, folding rather than faulting is impacted by lithology, temperature, geopressure, tectonic pressure, fluid content and **TIME**. Hotter rocks flow more easily just as hot wax is easier to fold (less viscous) than cold wax. It is possible today to measure the viscosity of rocks and we can confirm that over geologic time ranges, any rock will flow, and this viscosity is even more important that tectonic stress such as from plate movement. In rocks, we find an entire continuum from totally soft sediment folding and slumping to post-lithification folding to brittle faulting. Certainly, many rocks were buried deeply and lithified by that burial, yet have been subsequently folded.

When lithified rock is deformed quickly, as Snelling reports, it does deform by brittle mechanisms such as fracturing and cataclasis (pulverization). Slower deformation allows the rock to change in shape ductilely such as with folds. What happens in lithified rocks to allow them to fold? Structural geologic studies have identified a number of processes that act on such rocks. Studies have shown that grains can slide past one another (grain boundary sliding), have sliding within mineral crystal lattice (dislocation creep), change grains diffusive mass transfer processes or dynamic recrystallization. Studies of thin sections (rocks ground thin enough to be studied using special petrographic microscopes) allow the processes to be identified and to tell a range of temperatures and conditions under which the rocks were deformed.

In the Figures 1 to 6, I will show in a series of images and explanations, using a geologic cross-section to show an example of the folding and deformation in West Texas. The deformation shown reflects a long history. While this cross-section is from a publication, I helped build a very similar cross-section in some detail in my first job as geologist in 1978 while working this area in Monahans, Texas. I find the folding and the relationships that it shows impossible to reconcile with either flood geology or a Young Earth.

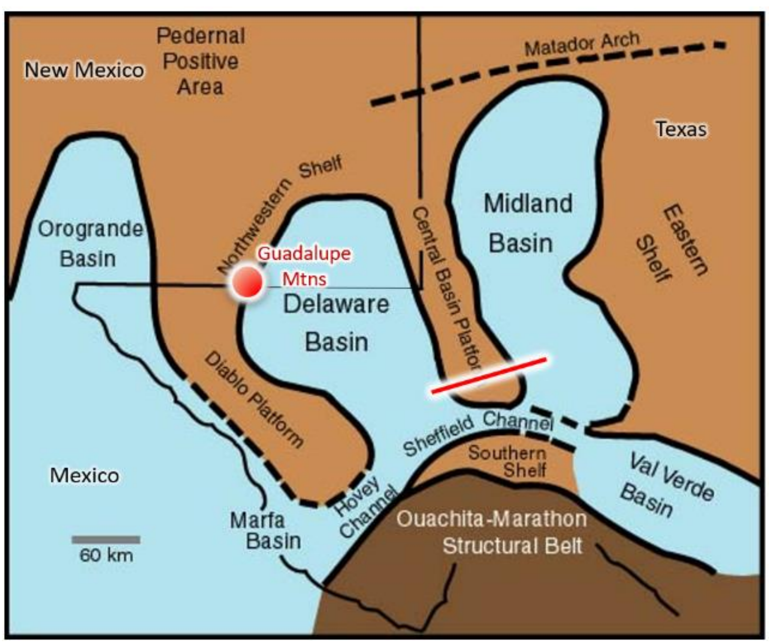

Figure 1. I will show a cross-section or profile across where the red line is drawn on the map. The map shows major geologic features in the area as present in the Permian Period. The Central Basin Platform was an exposed high area that separated the Delaware Basin from the Midland Basin. Later I will also show an exhibit from the Ouachita-Marathon structural basin to the south.

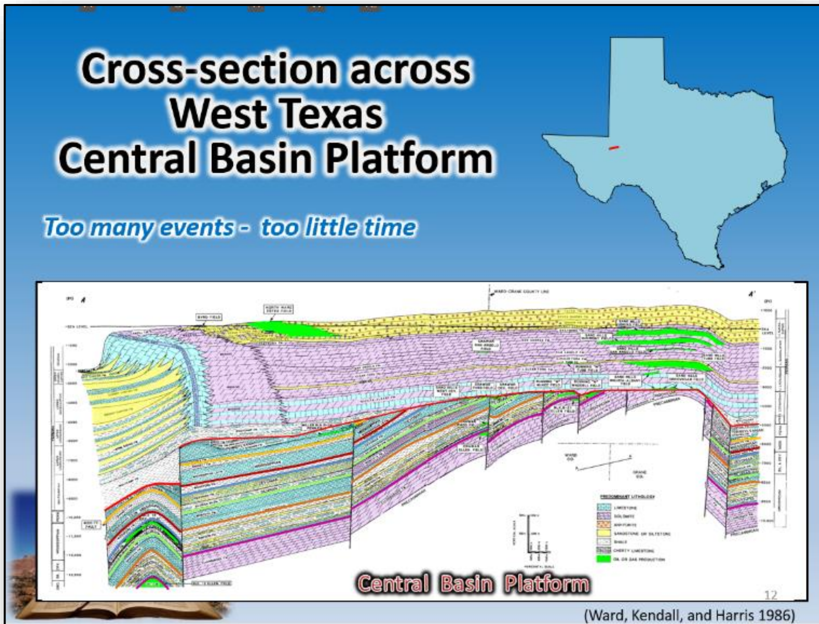

Figure 2. A cross-section drawn to show what it looked like at the end of the Permian Period: All of the colored units represent layered rock of different lithologies. The green areas are major oil fields. YEC authors all assign the entire sequence to have been formed during various stages of Noah's flood.

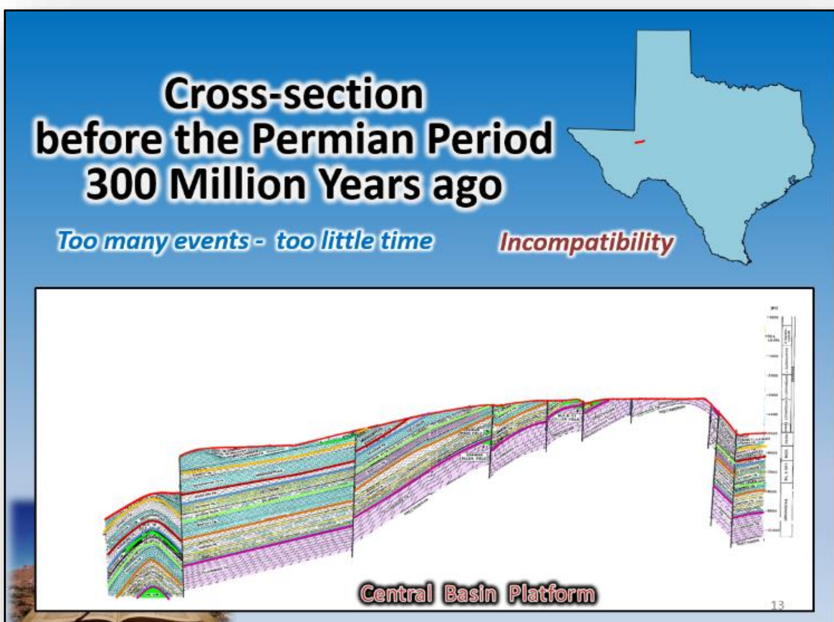

Figure 3. If we look at the portion of the cross-section below the major erosional surface (known as an unconformity), we see what the profile would have looked like in the past. The folding took place in the geologic period known as the Pennsylvanian, conventionally dated as 300 million years ago. Each of the various layers were laid down horizontally. They were buried deeply and over the course of time, turned into hard rock. The rocks were folded and faulted and uplifted.

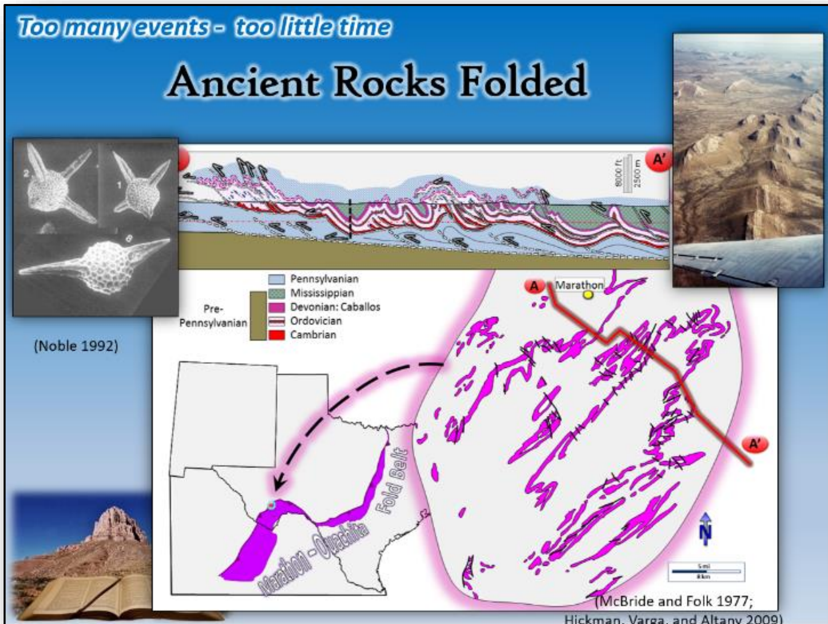

Figure 4. A map and structural reconstruction through the Marathon fold belt: The purple on the inset map represents near vertical beds of Caballos Novaculite from near Marathon, Texas. These are the remnants of faulted and tightly folded beds. Novaculite is a quartz rock that is often made into whetstones. These white chert beds formed lime muds with many siliceous sponge spicules and radiolarian fossils such as are shown in the upper left. It was lithified before the folding and thrusting, making it the strongest rock that controlled the folding and thrust faulting. It is possible to find cobbles of earlier Cambrian rocks in some of the later rocks that are folded. Pressure solution features known as styolites are common, reflecting post-lithification dissolution of hardened novaculite before the folding. (Cox and Whitford-Stark, 1987)

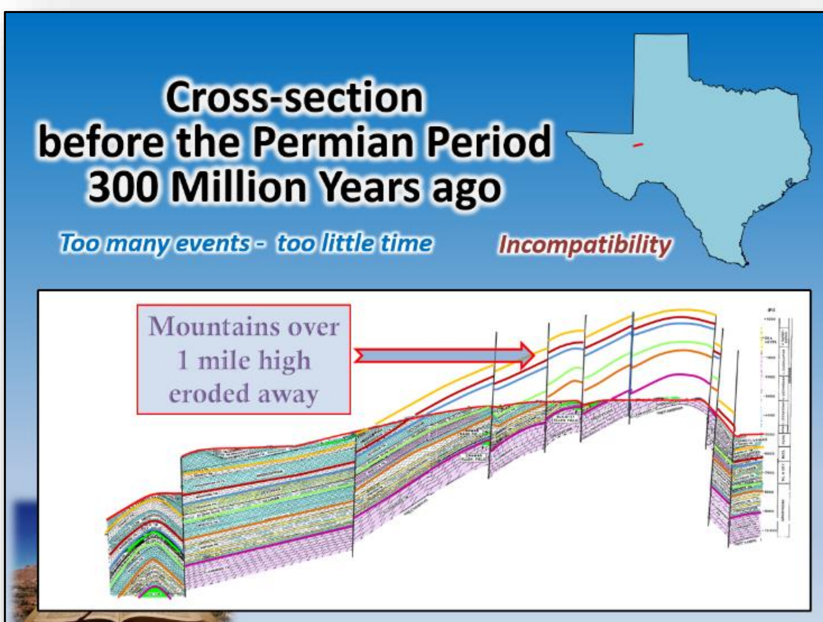

Figure 5. Profile now showing the major section that was eroded away before the Permian rocks were deposited over the highly eroded portions: Along the erosional surface, ancient stream gravels have been cored that had rounded pebbles and cobbles of the Devonian cherts, demonstrating that they were lithified before the erosion. Streams have been mapped to locate the gravels as reservoirs for oil fields.

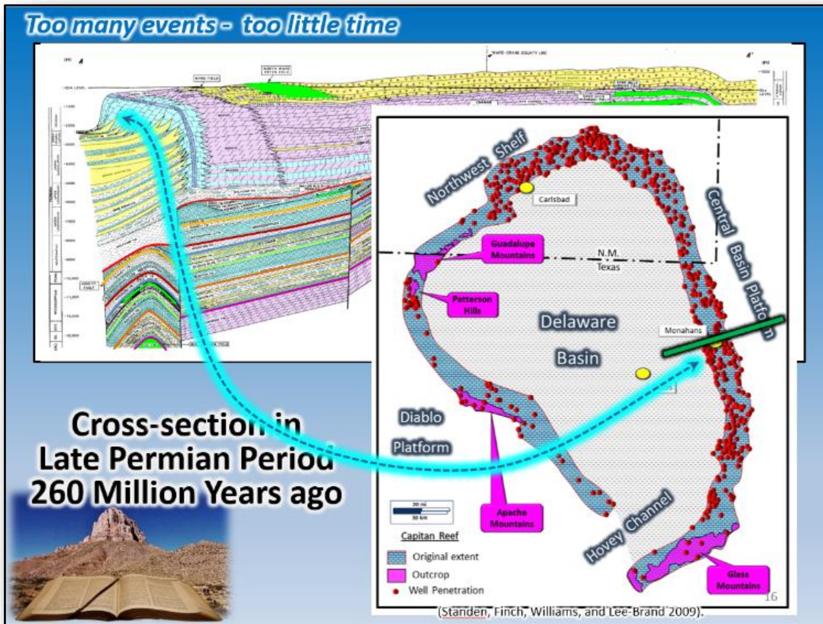

Figure 6. The Permian rocks were deposited over the old eroded mountains and the basins on either side. We find wonderful deepwater sand deposits in the basins, classic reefs such as were described in an earlier post. Behind the reefs and in the surrounding shelfs are arid sabkha (salt flats) and tidal deposits.

One more example from the Permian basin. Once again, we see rocks that were lithified into real rocks that were folded and faulted in complex ways. In this case the underlying basement rocks were also folded. If the YEC model is that Precambrian granites and metamorphic rock were created mature, then they were certainly lithified at creation and before the Pennsylvanian folding. No YEC so far propose that the granites and metamorphic rock of basement were soft and pliable during the flood.

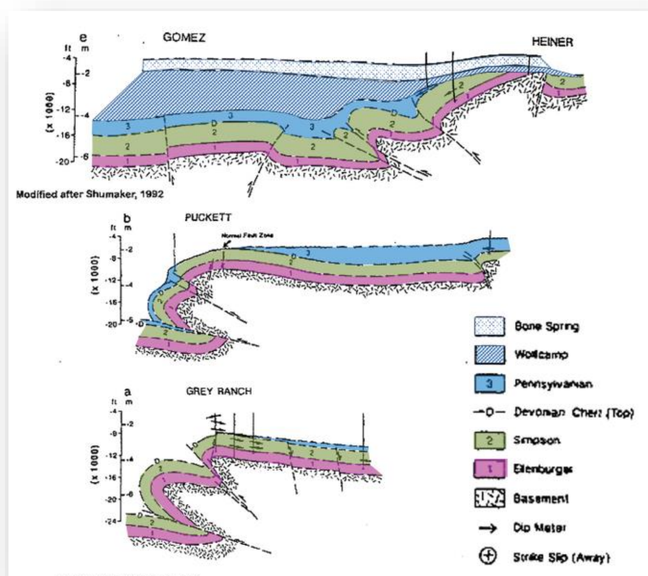

Figure 7. Structural cross-sections through three oil fields along the CBP showing the basement-involved reverse fault movements that developed during the Pennsylvanian structural event. Notice that the Precambrian basement (black & white pattern) is involved and faulted. (Hoak, et al, 2009)

YEC explanations:

Andrew Snelling makes the case that, even when moving at slow rates, folded rocks are not as highly faulted as they would need to be if they had been lithified at the time of the folding. He gives the example of folding of the Tapeats Sandstone in Arizona (Snelling 2009; Snelling 2009) I asked a colleague who is an expert structural geologist, Kenneth Fowler to look at Snelling's example. He explained that when a stack of relatively thin-bedded units is folded, most of the movement is between the beds, a process known as flexural slip. This is similar to the folding of a deck of cards or a phone book. The cards slip past one another, without actually permanently deforming the cards. Thin shales at the bedding planes don't slip perfectly and there are space considerations, so there are small fractures evident even in Snelling's pictures of the Tapeats example. Such folds are entirely consistent with a slow deformation rate. Even so, if these lithified rocks were shortened and deformed over a period of a few hundred or thousand years as demanded by the YEC model, even flexural slip would not keep them from shattering. Snelling shows drawings that suggest that the Tapeats simply drapes over the Precambrian metamorphic rocks and granites, suggesting that the folding of the Precambrian was older, perhaps from creation week. In fact, the crystalline basement was folded along with the later rocks, and all of the strain taken up in fracturing, as one would expect in slow tectonic movements. The Geologic Society of America volume, Laramide Basement Deformation in the Rocky Mountain Foreland of the Western United States, (GSA Special Papers 280, 1993) is devoted to this topic.

The YEC have a particular problem with rocks deposited during or after the flood, buried deeply and then folded. They want lithification and diagenetic changes to happen very quickly, but want to do all of the folding while the rock was soft. Explanations remain inadequate.

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