Sediment transport and deposition: evidence for rapid rates and large-scale transport

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PhD in evolutionary biology, from Cornell University, 1970. I later retrained in geology, and have been teaching at LLU since 1969. I have taught classes in mammalogy, vertebrate paleontology, animal behavior, and Philosophy of science and origins, I have published 8 books, and conducted research resulting in over 45 published research papers.

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Abstract: The conventional, materialistic understanding of geology assumes that most rock formations formed slowly and gradually (uniformitarianism), by the same slow geological processes we observe in the modern world, and also assumes that the radiometric time scale gives accurate ages in years for these rock formations. In research on ancient rock formations, some of us have found it more productive to leave all those assumptions aside, and just ask: How did this happen? How long did it take? We define several different hypotheses for these rocks, covering a wide range of possibilities, including some we don't like. Then, in our original research, this multiple working hypothesis approach improves our chances of thinking how to test between the hypotheses. This approach has consistently led to interpretations of the rocks that are more consistent with the geological field evidence, and also more consistent with a biblical understanding of earth history.

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Introduction

Standard geology theory, accepted by most of the world, maintains that the portion of the geological record containing almost all multicellular fossils (the Phanerozoic: Cambrian to Recent) has formed over a time span of 541 million years. During that time just about all geological formations are assumed to have been deposited by the same slow geological processes that happen today, or are feasible in the modern world. We see some local catastrophes now, and there were some in the past, but they are believed to have been the exceptions. The geological community does not accept the biblical accounts of a global flood or a time scale of a few thousand years. As with the other issues discussed in this series of papers, the scientific confidence in this story of millions of years of evolution and slow geological processes raises doubts among Christians – doubts that the Bible account could be trusted.

Do we have a response to that? This paper will begin an evaluation of that scientific confidence, and discuss significant evidence that challenges those firmly held assumptions.

Worldviews and the geological evidence

We all have a worldview, whether we think about it or not. A worldview is the sum of how we see the world. It answers basic questions like where we came from, why we are here, where we are going, and how we interpret what we see around us. Here is an outline of two dominant worldviews in modern society.

Secular worldview (materialism, or naturalism):

Foundation of the worldview has two pillars:

1. Time: hundreds of millions of years. No creation.
2. Catastrophe: limited catastrophes. No global catastrophe. Uniformitarianism – geological processes were only like modern processes.

Short age biblical worldview:

Foundation also has two pillars:

1. Time: only thousands of years since creation.
2. Catastrophe: a global geological catastrophe.
   After that event, geological processes more like modern processes.

This paper will address item number 2, the question of catastrophe, versus gradual geological processes. The next paper will deal with item 1 – geological time in relation to the evidence. There is some overlap as we discuss these two issues, but our primary topic now is the rate of geological processes. The secular, or materialistic worldview is based on the conclusion that all geological processes proceed at the rates that we observe in the modern world. Some geological catastrophes do occur, but they are minor and are the exceptions. The geological processes that we mostly see now are rivers, streams, and local flash floods gradually modifying the landscape. We have never seen a flood or other catastrophe on a continental or global scale. Geologists claim that what we see now is how it has always been: there never was a global flood.

There are at least two ways to respond. One is to assume this evidence is conclusive, and accept whatever it leads to. This is certainly the easiest way. But have we given adequate thought to where this leads? Is that prediction correct? That is the more important question. In recent centuries, as a materialistic philosophy was developing, was there sufficient geological understanding to assure that it was the evidence that was leading the philosophers, or was it the growing trend toward materialistic thinking running ahead of the evidence, and determining how evidence would be interpreted?

Lyell's uniformitarian thinking flew in the face of the evidence at that time for geological catastrophism, and it is wise to consider whether materialism and uniformitarianism has become an *assumption* – an assumption that is accepted without careful and critical evaluation. We will discuss evidence that challenges the uniformitarian assumption.

Examples of large-scale geological processes and events

First of all, for the non-geologists, here are some basic geology terms relevant to our examples.

Deposition: flowing water carries sediment and deposits it in layers and formations.
Erosion: more flowing water erodes the sediment and carries part of it away, leaving the landscape as we see it today.
Lithification or cementation: various processes cement the sediment into rock.

A diagram of the geological column is at the end of this document – **Appendix 1**.

Conventional, secular, geology theory argues that ancient geological processes and events must be explained by processes seen or feasible in the modern world. However, according to the short age biblical worldview, many ancient events were quite different – more rapid, catastrophic, and on a much larger scale. Which of these two options seems like a better explanation for the thousands of square kilometers of sandstone in Fig. 1?

Figure 1

Figure 1. The Navajo Sandstone was deposited as a flat-topped layer several hundred meters thick, covering an area of hundreds of thousands of square kilometers. Later, water erosion removed it from all of the area to the left of the middle of this photo (also no doubt, thousands of square kilometers). Photograph by the author.

Modern processes that deposit sediment (mud, sand, gravel, etc.) include, for example, streams, rivers, ocean currents, and flash floods. Sedimentary rock formations, are believed to have formed by this process, but how can that be, when most often they are persistent layers that cover very large areas. Consider the formations seen in the walls of the Grand Canyon (Fig. 2). They are mostly persistent from one end of the canyon to the other, and far beyond. Processes we see today depositing sediments include rivers as seen in Fig. 3. Rivers of any size erode and deposit sediments in a fairly constricted channel. Even the Mississippi River has been flowing through centuries in its channel, and it has wondered back and forth over a flood plain that usually is several kilometers wide, but it still does remain in its channel, or close to it. Even ocean currents carrying sediment from our shores are complex and not widespread on the scale seen in ancient rock formations.

Figure 2

Figure 2. The Grand Canyon in Arizona, USA. Photograph by the author.

A rock formation is a unit of rock that continuously covers an identifiable geographical area, and has a sufficiently consistent geological content to be named as a formation. The Coconino Sandstone and the Navajo Sandstone, for example, are consistent bodies of cross-bedded sand, each limited to a specific geographical area. Many geological formations like those seen in Fig. 4 are surprisingly uniform over thousands or even hundreds of thousands of square kilometers. The examples I am using here are not unusual formations, but are fairly typical of rock formations in the Paleozoic and Mesozoic (lower ~ two thirds of the geological column). Modern processes do not operate on such a widespread scale, or anything approaching it. Many of these formations can only be explained by continental-scale processes. An extreme example is the Jurassic Morrison Formation, which extends from Canada almost to Mexico.

Figure 3

Figure 3. Left – a river eroding within its channel, as is typical. Right – the Mississippi River has a flood plain several kilometers wide. It still normally remains within its established channel, and does not spread over thousands of square kilometers. Left – photograph by the author. Right – public domain image.

Figure 4

Figure 4. Typical rock formations that cover enormously large areas. Top: Navajo SS covering over 380,000 sq. km. Lower: Maps of the distribution of some widespread rock formations. Left – Jurassic Morrison Fm, - 1.5 million sq. km. Middle – Cretaceous Dakota Fm. - 815,000 sq. km. Right - Triassic Shinarump Conglomerate - 260,000 sq. km. Top – photograph by the author. Diagrams by Ariel Roth.

Fig. 5 is a summary of these concepts for a thoroughly studied area – the Rocky Mountain region in western North America. This drawing portrays the rock formations over an area about 200 miles (320 km.) across. It is what we would see if a trench was cut into the earth in this entire region, revealing a cross section of the earth's upper crust. Section A is what the section would have looked like near the end of the Mesozoic. The Paleozoic and Mesozoic formations were typically flat and covering huge areas. Near the end of the Mesozoic the Rocky Mountains began to fold, as pictured in B, and new, Cenozoic sediment layers filled the resulting basins. By the end of the Cenozoic (modern times) more erosion had further shaped the land, and modern sedimentary deposits were formed by rivers and other modern processes. Notice how tiny those modern sediments are, compared to all the enormous and broad earlier rock formations.

Figure 5

Figure 5. Cross-section views of the Rocky Mountain region in western North America, at three different times in geological history beginning with A. Explanation in text. Diagram by the author, from Brand and Chadwick 2016.

Looking beyond North America

The widespread, persistent geological deposits we are discussing are not just in North America. Many unique geological deposits circle the globe or a major part of it! A British geologist, Derek Ager, traveled widely, making a point of comparing the geological record over the globe. In his book *The Nature of the Stratigraphical Record*, Ager examines this phenomenon of widespread deposits (Ager 1981). He discourages readers from thinking that he would support ideas of creation or a biblical flood, but he recognizes that "there are some very curious features about the fossil record" (p. 20). I suggest that refusing to recognize the possibility that this evidence is consistent with a global catastrophe is an arbitrary assumption that is difficult to justify. Here is a summary, listing several examples of the type of evidence he presents.

Upper Cretaceous chalk with a unique selection of fossils and minerals (White cliffs of Dover) - along the Black Sea, in France, Germany, Scandinavia, Ireland, Germany, Poland, Bulgaria, Georgia, Egypt, Israel, southern United States and in western Australia.

Quartzite (coarse metamorphosed sandstone) – base of the Cambrian at most locations, worldwide, followed by orthoquartzite, then sandstones, marine shales, and thin limestones.

Devonian red sandstones – Canada, Ireland, through western Europe, Russia.

Mississippian Redwall Limestone and matching limestones – western USA, across North America, Europe, Asia.

Pennsylvanian coal with similar characteristics and fossils – eastern USA, Texas, Britain, Ireland, all the way to Russia.

Triassic characteristic sets of deposits called "red beds" – across USA, Mexico, South America, across Europe, and China.

Why are these deposits, with their unique characteristics, so widespread, with each one limited to just one part of the geological column? Why, for example, would a geological deposit in Australia match what is happening at the same time in Europe (chalk at White Cliffs of Dover), instead of being a unique Australian event, controlled by the environment in Australia? And these examples are just the beginning of a prominent feature of the geological record. We will now focus in on some specific formations.

Triassic Moenkopi formation

In Utah and several nearby states (USA) is the Triassic Moenkopi Formation. – the first formation above the Paleozoic formations in the Grand Canyon. It is composed of mudstone, sandstone, and siltstone, believed to have been deposited in various environments, including tidal flats, slow-moving rivers, and flood plains. These are not environments expected to include individual thin layers extending for many kilometers. However, a colleague and I have been involved in intensive research on the Moenkopi Formation along the Utah/Arizona border. Much of this formation forms cliffs that are difficult to reach, so part of our research was based on about 6,000 aerial photographs taken from a helicopter, across 100 miles (160 km) of these cliffs. This allowed detailed study of the brown mudstone layers near the top of the formation (Fig. 6). By comparison of several hundred enlarged photographs we found that many individual meter-scale layers could be traced for 10-14 kilometers. Many of these layers could still be traced in the next hills, a few km away. Also, the same type of layers in a national park 218 km away from our study area are indistinguishable from them. This is too far to trace individual layers, but the series of mudstone layers have exactly the same characteristics, indicating a matching depositional process and environment.

A more detailed study done in the same area along the Utah/Arizona border, on accessible outcrops that could be reached and studied on the ground revealed that even a series of very detailed fine layers continued unchanged for over 100 kilometers. This type of continuity of layers, including specific sets of fine layers, for such long distances is completely unexpected in this type of rock formation. Modern geological processes, which uniformitarian geology theory expects to be the norm, could not produce this result. The evidence indicates geological processes on a far larger scale of size, and probably a much shorter time scale. Our research over four decades convinces us that this type of research can be done on many rock formations, with similar results.

Figure 6

Figure 6. The contact between the Moenkopi Formation (brown) and the overlying Shinarump Conglomerate (whitish). Photograph by the author.

How do you form a continental-scale staircase?

In Utah, Arizona, and Colorado, western USA, is s striking geological feature, a staircase on a scale of hundreds of kilometers. It is called the Grand Staircase, for good reason, and is part of the Grand Staircase, Escalante National Monument. Fig. 7 is a drawing of the lower series of steps, going north from central Arizona to southern Utah, and in Fig. 8 are photographs that verify the reality of its staircase features (Brand 2018)

Figure 7

Figure 7. A drawing of the Grand Staircase. Artwork by Doug Oliver, from Brand and Chadwick 2016.

Figure 8

Figure 8. Photos that verify the staircase nature of the Grand Staircase. The labeled cliffs are the same as in Fig. 7. Each step of the staircase is a cliff, dropping down from the flat, kilometers wide top of the step (arrows). The staircase actually continues through several Cenozoic formations in central and northern Utah. From Brand 2018.

As indicated by the dotted lines in Fig. 7, geologists who have studied this feature think that the respective rock formations seen in the steps originally continued all the way down to at least central Arizona. These formations were eroded away as the individual vertical faces of the steps (also called scarps) retreated to the north, a process called scarp retreat. Fig. 9 shows what is meant by scarp retreat. Fig. 10 is a map of a portion of these scarps, or cliffs.

Figure 9

Figure 9. The process of scarp retreat, with three cliffs moving back, “upstream,” through time, as seen in the lower diagram. From Brand 2018.

Figure 10

Figure 10. A vertical view of a small portion of the Grand Staircase cliffs (black lines). North is up in the map. North-south distance is 50 km. From Brand 2018.

As far as I can determine from the geological literature, no geologists have seriously asked how a staircase like this could form. One paper discusses the staircase, but assumes that it happened by processes we observe today (Schmidt 1989). It then uses the radiometric time scale to estimate how many million years it took for the scarps to retreat. The modern analogue of scarp retreat would be individual rock falls, as happens occasionally today in places like Yosemite National Park (USA). A common view is that this process, one rock fall at a time, could result in scarp retreat over millions of years. That, of course, is an unsupported assumption, which would probably be impossible to test.

A more significant difficulty with this uniformitarian explanation of the Grand Staircase comes from a look at the staircase in its broader geological context. Along with the occasional rock falls there would have to be fluvial (by flowing water) activity – rivers and streams moving back and forth and eroding away sediment from in front of each cliff, allowing the cliffs to remain, one above another. That process could occur, to a certain extent, if there was enough time.

However, that apparently would not work in this case. Rivers erode valleys or canyons, with a bank or cliff on each side, not just on one side (Fig. 11). The Grand Staircase does not have a matching staircase on the other side of the valley. It drops down to the south, and where it ends in central Arizona there is a flat valley floor that goes on to the south through Arizona. How could this situation result from geological processes that we have ever observed? It appears that the only explanation that could form the Grand Staircase is a massive, catastrophic flow of water from above the staircase, moving across this whole region of thousands of square kilometers, eroding back the rocks from south to north, and carrying the sediment to the ocean. This process does happen, and can be observed on a small scale. It is called headword erosion, with water flowing across an area and beginning to cut gullies at the lower end of the area. The gullies enlarge and erosion continues to lengthen them, cutting back toward the source of the water. This is consistent with what could happen in a global flood, but is not compatible with uniformitarian processes and the radiometric time scale.

Figure 11

Figure 11. A river can erode a canyon or a broad valley, but there is always a bank on both sides of the river. From Brand 2018.

Paraconformities and missing geological time

As we experience life, time continues with no end, and no pauses in which time ceases to pass. As time proceeds with no breaks, things around us change. Weeds grow, we grow older, and if enough time passes, old buildings decay and fall apart. If time stopped for a while, it seems that the old buildings would stop decaying, leaving no evidence of the passing of time. Can this ever happen with geological processes?

If a ground surface is exposed, “decay” processes steadily proceed. That ground surface will be altered by erosion that carves ditches, gullies, canyons, or at least irregular surfaces. Trees grow and their roots penetrate farther into the soil. Animals dig tunnels or dens into the ground, and worms tunnel through the soil, and all this activity gradually destroys any evidence of layers in the soil. This is called bioturbation, and in the modern world bioturbation reworks the soil surprisingly fast. Unless time stops, these processes will continue to proceed, eliminating evidence of the orderly layers of sediment that were originally laid down.

There are many places where one rock formation sits on top of another formation. In relation to many of these contacts there is discussion about whether significant geologic time passed before the lower formation was covered by the layer just above it. Dating processes or other evidence seems to indicate that the lower layer remained undisturbed for several million years, or 50 or 80 million years, or even up to 150 million years (Roth 1998, p. 222-230), before it was covered. If that were true that a lot of time passed without any new layers covering the lower layer, what types of evidence would we expect to find at that contact? If that time did pass, with no upper layer protecting the lower layer, there should be abundant evidence in the lower layer, of processes like bioturbation, tree root growth, erosion etc. The longer was the passing of time, the more of such evidence should be seen at the contact, but in any case, there should be considerable evidence of that type. Those contacts with presumed passage of time but no evidence of disturbance to document that time, are called paraconformities.

Are there other possibilities? It could be suggested that there were disturbances, but the disturbed surface was smoothed off by some erosion process, removing evidence of bioturbation and other disturbances. That could happen, but at the bottom of the eroded off layer there should still be evidence of older episodes of bioturbation, "tree-turbation", or other soil disturbances. As time moves on, these processes do not stop and wait for another layer of sediment to be deposited. We will discuss this more in another paper, but for now, just recognize that whatever happens, there should be evidence of whether the expected bioturbation processes occurred or didn't occur.

At many of these paraconformities the layer below the contact has no bioturbation or others of the expected disturbances that passing time should bring. That situation is at times referred to as "missing time." That is a confusing term, because time is not really missing. What is missing is the expected evidence for that time.

The contact between the Moenkopi Formation and the overlying Shinarump Conglomerate (Fig. 6) is one of those paraconformities, with "missing time." The geological age of the top of the Moenkopi and the bottom of the Shinarump Conglomerate is not accurately known, but various authors estimate the "missing time" at 10-30 million years. It does not matter much which estimate is correct, because even five million years (or much less) should have left abundant bioturbation or other evidence, but there is virtually no such evidence. There is geological evidence that the upper Moenkopi was still soft when it was covered by the much coarser Shinarump Conglomerate. The "missing time" at the Moenkopi/Shinarump contact is not based on evidence. It is based on the assumption that the geological time scale is correct. Many other paraconformities are just like this, and some are supposedly missing up to 150 million years, with no convincing evidence to support that.

The hypothesis that best fits the evidence is the hypotheses that the geological time scale is seriously wrong, and there was essentially no time passing at these paraconformities.

Conclusion

We would all like to know the answers to these geological puzzles. I have presented my best answers, but you will have to decide if you agree, or still wish for more evidence. With these issues, we all have a significant handicap, in comparison with other areas of science. In study of ancient history – geological or paleontological history – we cannot observe the ancient events we wish to study. I don't have a working time machine, and nobody I know has one. We have not seen, and cannot see these events. We can only observe what happens in our modern world, and make guesses about how similar this is to what happened thousands of years ago.

Some of us are fortunate enough to spend our life seeking to find the best answers we can, from the rocks. What I can tell you is that in several decades of this research, we have found that careful research, seeking not to support our favorite hypotheses, but to ask hard questions and test competing hypotheses against each other brings better answers (Brand 2023a, 2023b)). This process has consistently supported the idea that biblical insight brings out evidence and explanations missed by others, and convinces us that God knows vastly more about geological history than we will ever know. Other papers in this sequence, and in other sources further explore this concept.

Why do other geologists not see it this way? The possible answers we are willing to consider will be strongly influenced by the assumptions we are strongly committed to. Commitment to a secular worldview is not compatible with considering the possibility that the biblical worldview could be correct. In contrast to that perspective, though I believe the short-age biblical worldview is correct, I don't feel the need to be able to defend it against what science says. If the biblical insights were false, that would be God's problem, not mine. Truth will take care of itself.

If a friend gives you a map to hidden treasure, will you search for the treasure? It probably will depend on how much confidence you have in that friend. Those of us who have confidence in God's biblical map of earth history, find that when we can use that map to study the rocks and fossils, it opens up new discoveries that we would not have found without that map.

There is an abundance of written material, videos, and other material that can be helpful in encouraging our fellow Christians to take God's Word seriously (and literally). The written papers in this published series are a beginning, and there is a wealth of additional material, described in the separate document called *Origins Resources*.

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Appendix 1. The geological column and typical fossils in each portion of the column.

Appendix 2 – figures

Figure 1

Figure 2

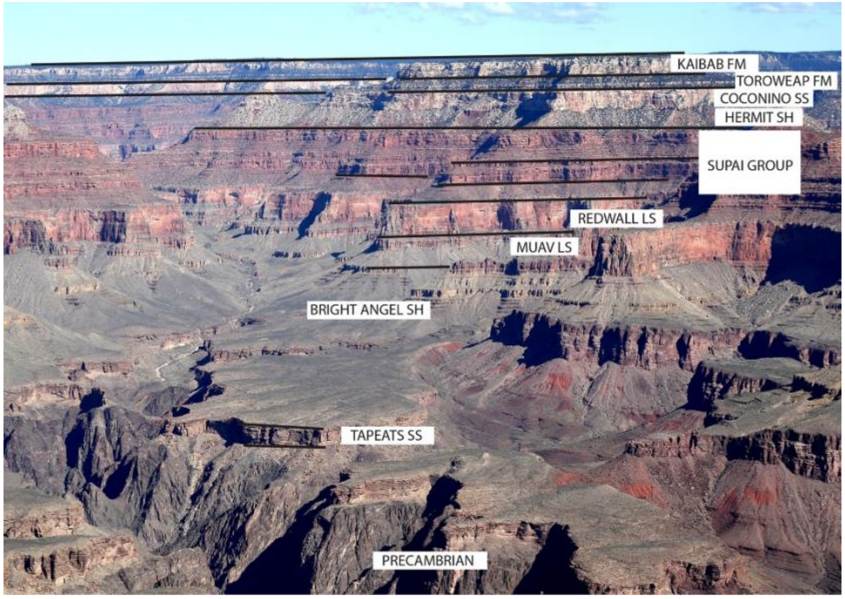

KAIBAB FM
TOROWEAP FM
COCONINO SS
HERMIT SH
SUPAI GROUP
REDWALL LS
MUAV LS
BRIGHT ANGEL SH
TAPEATS SS
PRECAMBRIAN

Figure 3

Figure 4

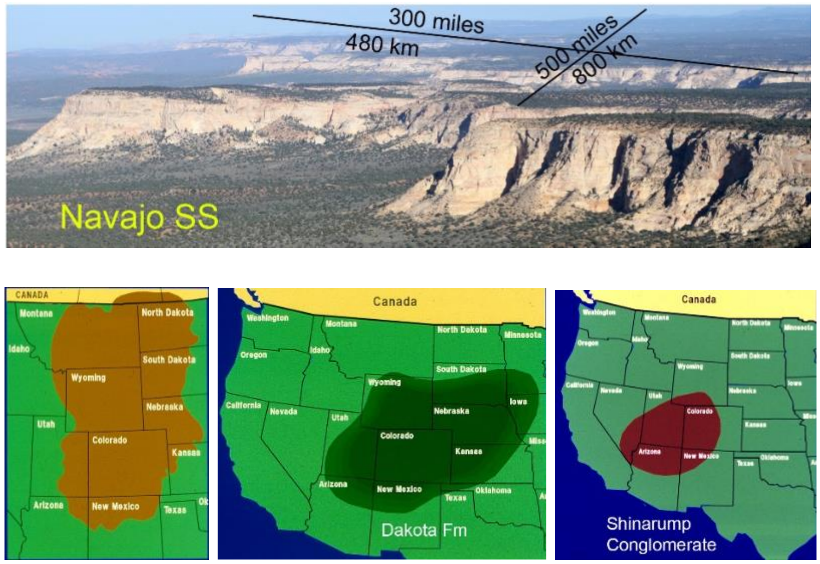
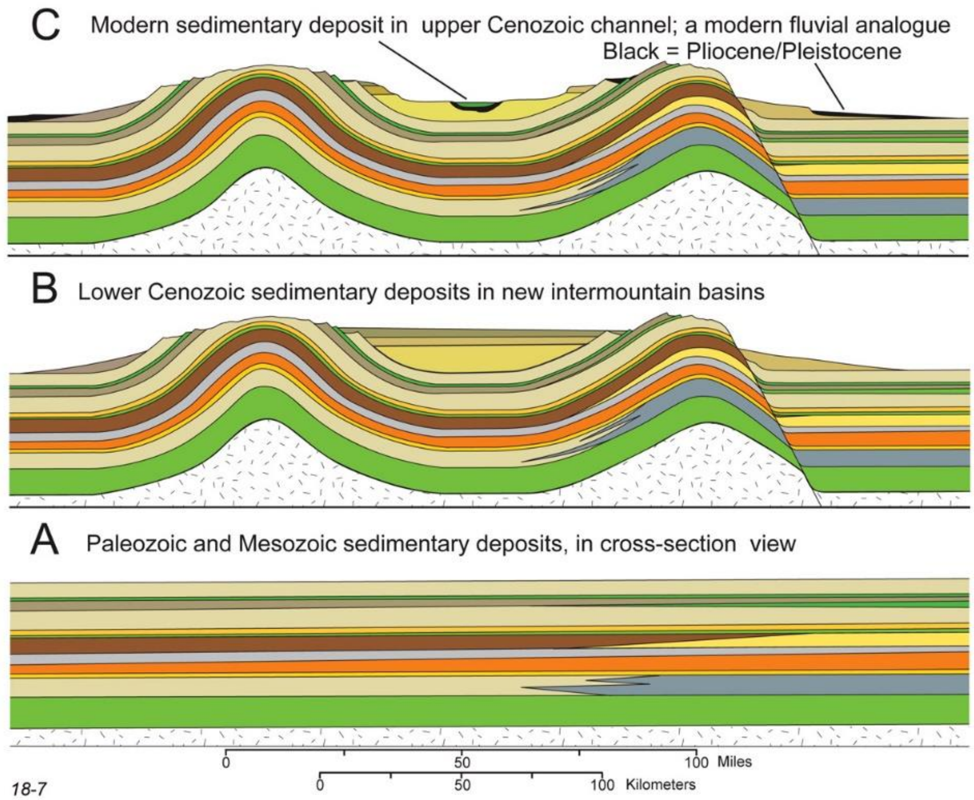

300 miles
480 km
500 miles
800 km
Navajo SS
Canada
Dakota Fm
Shinarump
Conglomerate

Figure 5



C Modern sedimentary deposit in upper Cenozoic channel; a modern fluvial analogue
Black = Pliocene/Pleistocene
B Lower Cenozoic sedimentary deposits in new intermountain basins
A Paleozoic and Mesozoic sedimentary deposits, in cross-section view
0
50
100 Miles
0
50
100 Kilometers
18-7

Figure 6

Figure 7

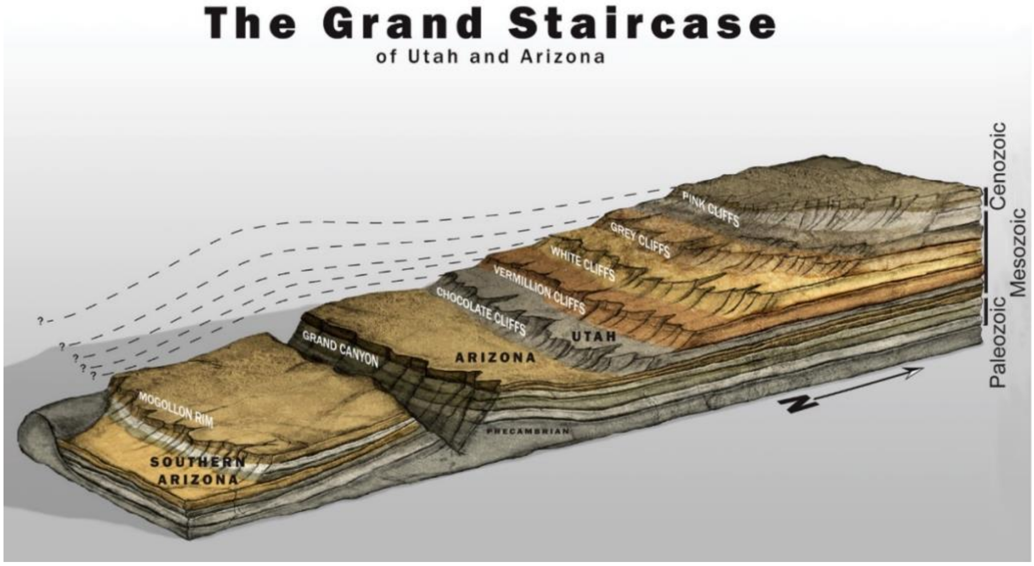
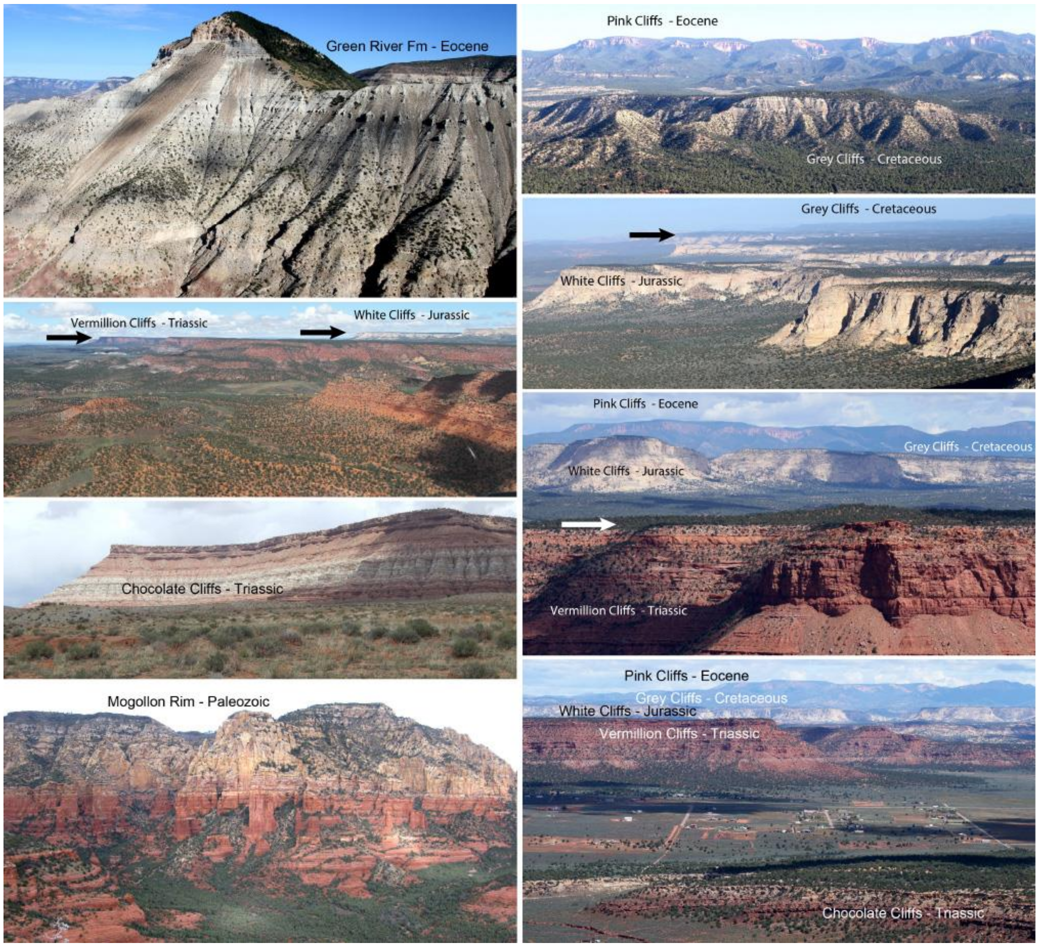

The Grand Staircase
of Utah and Arizona
PINK CLIFFS
GREY CLIFFS
WHITE CLIFFS
VERMILLION CLIFFS
CHOCOLATE CLIFFS
UTAH
GRAND CANYON
ARIZONA
MOGOLLON RIM
SOUTHERN
ARIZONA
PRECAMBRIAN
N
Cenozoic
Mesozoic
Paleozoic

Figure 8



Green River Fm - Eocene
Vermillion Cliffs - Triassic
White Cliffs - Jurassic
Chocolate Cliffs - Triassic
Mogollon Rim - Paleozoic
Pink Cliffs - Eocene
Grey Cliffs - Cretaceous
Grey Cliffs - Cretaceous
White Cliffs - Jurassic
Pink Cliffs - Eocene
Grey Cliffs - Cretaceous
White Cliffs - Jurassic
Vermillion Cliffs - Triassic
Pink Cliffs - Eocene
Grey Cliffs - Cretaceous
White Cliffs - Jurassic
Vermillion Cliffs - Triassic
Chocolate Cliffs - Triassic

Figure 9

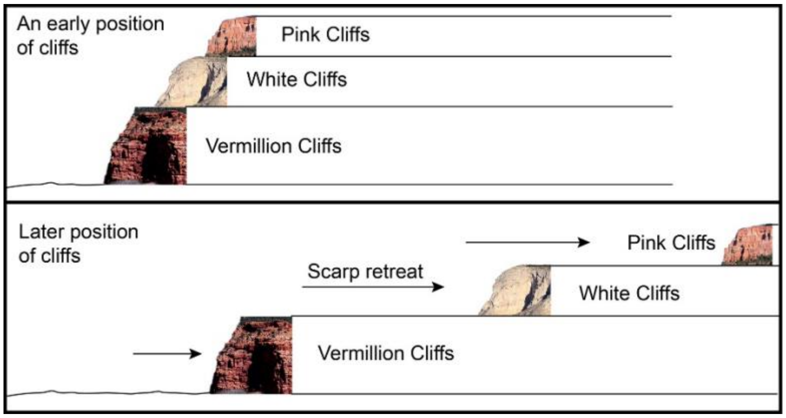

An early position of cliffs
Pink Cliffs
White Cliffs
Vermillion Cliffs
Later position of cliffs
Pink Cliffs
Scarp retreat
White Cliffs
Vermillion Cliffs

Figure 10

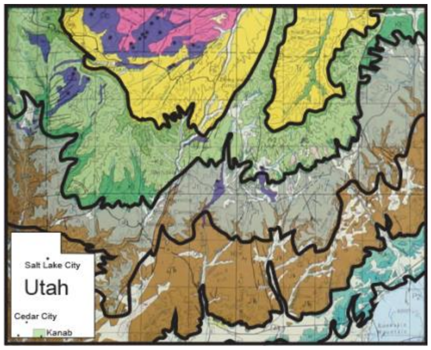
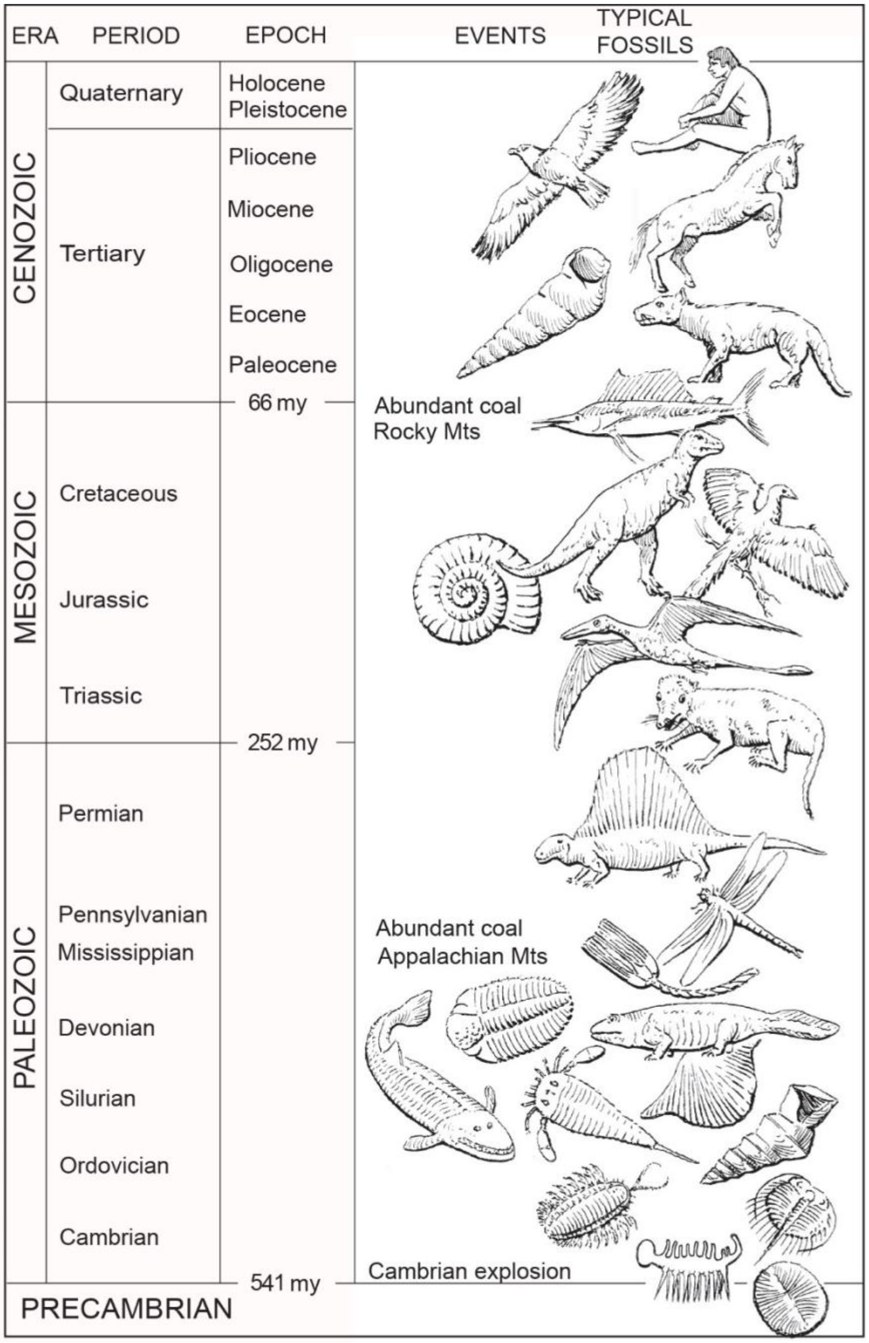


Figure 11

Appendix 1



The geological record, with some typical fossils to illustrate differences in the fossils found in different parts of the fossil record. Dates in millions of years, as understood in the standard geological time scale. Modified from Brand and Chadwick, 2016, Faith, Reason and Earth History.