A Texas-Sized Challenge to Young Earth Creation and Flood Geology

A Christian Geologist Looks for Answers

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Introduction

I was the little boy that was always banging on rocks and carrying them home, much to the chagrin of my mother. I worked hard to identify them and learn all that I could about them, so it was not hard to choose geology as my major when it came time for college. Not long after starting my geology studies, a good friend who was also my Bible teacher at church loaned me a book that he suggested that I read. It was *The Genesis Flood* by John Whitcomb (b. 1924) and Henry Morris (1918–2006). I was keen to read about apologetics, the systematic defense of the Christian faith, and I was excited at the promise of an explanation for how to relate the Bible to geology. Unfortunately, the explanations for the geologic record just did not seem credible to me. I gave my friend back his book and decided that understanding the geology of Noah's flood would have to wait. That was forty years ago. I completed two degrees in geology and have recently retired from working as a petroleum geologist around the world for thirty-seven years. I have also continued to read and study Christian apologetics and remain convinced that Christianity is true scientifically, historically, and experientially.

I have had many discussions with both Christians and non-Christians about geology, the age of the earth and the Bible. The discussions included many with people who interpret the Bible to demand that the earth is far younger than geologists date it to be. The book *The Genesis Flood* that I read as an undergraduate and as well as other books, many written because of its influence, invoke Noah's flood to explain much of the rock record. Many non-geologists find the arguments presented impressive and are easily persuaded to accept them. Does the Bible teach that the earth is six to ten thousand years old? Do the rocks really tell us that the earth is much older?

Perhaps this is the old one-watch-two-watches problem. You see, a man with one watch knows what time it is, but a man with two watches is never sure. Do the Bible and science represent contradictory timepieces that tell us when the earth was made and what its early history was like? These particular "watches" do provide some challenges. Both require interpretation in order to decipher the ages that they tell us. This book represents my attempt to look at both of these "watches" and see what they tell us about the age of the earth and in particular, the explanation proposed that the geologic record resulted largely from Noah's flood.

The proposal of a miraculous flood explanation involves a set of assumptions and many predictions that follow from these assumptions. We will discuss the assumptions and consequences. Using

a single event to explain the thick sedimentary deposits around the world is certainly a dramatic interpretation. If we are to accept such a dramatic explanation, then the proponents must present a convincing case that the physical evidence in the rocks fits the explanation. The proponents claim that normal geologic explanations are not possible. If we are looking at two watches, it might be difficult to know which is correct if they are five minutes apart. However, if two watches are six hours different, then it will not be so hard. If one "watch" says that the earth is billions of years old and the other says that it is less than ten thousand years ago, then the evidence should easily be good enough to tell which is more correct. If one "watch" says that most of the sedimentary rocks were formed over the course of one year and the other says that they were deposited over many millions of years, then it should be possible to study the evidence and determine if one or both of them is very wrong. Logically, they could both be wrong, but they cannot both be true.

Evaluating the "flood geology" claims does involve looking in some detail at geology. It might be nice if that the answers could all be covered in a two-minute sound bite, but that really is not adequate here. Our family has a book named *All about God* that is 220 pages long. It is pretty amazing that all we can know about God is in this short book. Definitely the book leaves out a lot of details. A quick check of Amazon.com shows a sixty-four-page book titled *All about Rocks*. Admittedly, the knowledge of rocks is a smaller subject than the Almighty God, but I am more than skeptical that the book really covers it all. In this case, I can only scratch the surface of either geology or the biblical issues in this book. Perhaps some will say that more detailed data should have been presented, but others will undoubtedly wish for far less. I want to take the young earth claims seriously and try to address them in sufficient detail. Every subject touched on here has had multiple volumes written about it. However, this book is not written as a technical report and is aimed at non-geologists with some interest in science and willingness to look at the evidence. Every field has its own terminology and geology is no exception. Just as reading a cookbook or a book on insurance can be difficult for those of us that are not knowledgeable in these fields, this terminology can be daunting. A glossary will be provided in the back that I hope will be helpful.

This book is written primarily for Christians who are interested in relating faith and science. I hope it will be helpful for understanding problems with many of the "flood geology" claims. I recognize that many Christians already have strong opinions and have decided what they believe about the flood and geology. If they are convinced that the Bible demands a young earth and that Noah's global flood accounts for the rocks, then reading this or any other book is unlikely to change their mind. I do hope that some have a new recognition that Christians can believe the earth is old and do so without denying the faith. Non-Christians may well be interested and find it useful to learn that many Christians have no difficulty in accepting the age of the earth as recognized by science. The non-Christian should recognize that Christians have a wide variety of ideas about these issues and that many Christians try to honestly look at all the scientific and biblical data to understand God and how He has acted through time. The Christian faith rests on Jesus, his identity, his sacrifice, and his resurrection, not on our interpretation of Genesis. Rejecting Christianity because some Christians hold an invalid view of science seems to me to be a pretty weak argument.

Science and the Bible both provide very important answers to questions about our world and our lives. The illustration has been given of a person who sees a kettle and asks why the water is boiling. A scientist might give the answer, "The heat source beneath the kettle is supplying energy that is exciting the atoms within liquid water. It raised their energy level so that once the vapor pressure of the liquid was equal to the pressure exerted by the surrounding environmental pressure, bubbles began to nucleate along surfaces at an increasing rate." This scientific explanation might be exactly true, but it would only explain the mechanism, not necessarily the cause. Another explanation that might be given is, "I am making a cup of tea. Would you like one?" If we know that both speakers are truthful, then both explanations can be equally true. Both can be very useful, but for different things. So it is with science and the Bible. Science provides much information about mechanisms used by God, but it simply cannot address many other areas that are also true and important. That is not to say that they are unrelated. Biblical truth and science both touch the reality that we live in. Ultimately, they cannot say contradictory things and both be true. It is a journey to interpret both realms and try to understand how they relate. Considering the boiling water illustration, it may have been useful to know the scientific explanation, but if you do not understand the second, you might be missing a good cup of tea and a welcome discussion. In life, if the Bible is true, then missing its message would mean missing a close personal relationship with God in this life and much more for eternity.

The first part of this book will assess how "flood geology" fits the geologic record using one specific region, one part of the world as an example. Originally that was all that the book was planned to cover. Then I realized that it would not be fair to stop there. It is always easier to criticize an interpretation than to present one's own interpretation and risk being rejected. I suspect that no one reached the conclusion that the earth is less than ten thousand years old or that a massive flood caused most of the sedimentary rock deposition starting from scientific evidence and then later found out that this agreed with the Bible. The major questions for most Christians involve understanding how to interpret the biblical accounts in relation to science. The next part of the book will examine some of the key questions in this area and possible answers. These sections should be treated a bit more tentatively. I am clearly not trained in theology, anthropology, or biology and so there are inherent dangers in delving into these areas. I have tried to use reputable sources but undoubtedly have missed many. Scientists are accustomed to varying opinions on the interpretation of scientific data. That is part of what makes it interesting. Christians should also be familiar with widely varying opinions given the number of Christian denominations there are and the number of translations of the Bible we have. As humans, we are fallible but by God's grace, Christians can still fellowship together in spite of disagreements about issues. It is not that the issues that Christians disagree about are unimportant but that the importance of loving one another is of even greater importance. Hopefully this exam- ination of the biblical issues will promote more discussion and generate new ideas. I pray that it will not promote greater disunity among brothers and sisters in Christ.

Part I

Evaluating “Flood Geology”

1 Geology and Creationism

The apostle Paul had a challenge when he accepted an invitation to speak to the great philosophers of Athens. The book of Acts records that "they took him and brought him to a meeting of the Areopagus" (Acts 17:19 NIV). It may not have been voluntary, but Paul saw this as a great opportunity, a chance to present Christ to a new group that needed to know Him. His listeners would have included the intelligentsia of the day. These sophisticated people probably knew some things about the Jews and their peculiar ideas, but Paul had to assume that they understood nothing about God. Paul knew God on so many levels. He knew God intellectually with his detailed training in the Old Testament, having set under the great Hebrew teacher, Gamaliel (Acts 22:3). Paul met Jesus initially in a totally unique encounter and also had spent time learning from those who had physically walked with Jesus while He was on earth. How should Paul begin to introduce the Greeks to this one who he knew so deeply and intimately? He connected to his listeners by first pointing out the Greek statue to the "Unknown God." Then he used that reference to introduce God in the most basic way. He explained how God is connected to all of creation. Arguably there is no more fundamental way to describe the Christian God than as the creator. The recognition of the Christian God as the creator of the universe resonates deeply in man. It answers basic questions about where we come from and why we are here. It is one reason why Christianity is found in so many cultures around the world. It is true that science has delivered a virtual nuclear explosion of information about creation. The key identity of God as cre- ator has never been more relevant. Christians have a great opportunity to introduce people to God and help them to have a relationship with the majestic Creator whose creation is far beyond what man could have even imagined a hundred years ago.

Christians all agree that God created the universe and humans. It might be simpler if Christians agreed and all shared a common understanding of how God created and how to interpret the Bible in this area. The reality is that Christians have many varied ideas about creation. Not that this situation is unique. Christians disagree about many things. Some of the disagreements divide along denominational lines but disagreements, about creation cross those boundaries. Christians have been forced to decide how to react to the avalanche of data and the interpretations provided by science. Much

of the new information supported scripture and its interpretation. Archaeological discoveries have provided us a much more complete picture of biblical times. Some of the data did not fit in so painlessly. Some challenged cherished interpretations of scriptures. The ideas of Copernicus and Galileo challenged the accepted interpretation of the Bible. Eventually it was recognized that not only were the early ideas about the stars and planets wrong but the earlier Bible interpretation as well. It wasn't that the Bible was wrong. It just was not addressing the questions it was being asked.

Prior to the late 1700s, most western thinkers accepted the concept that the earth was about six thousand years old (Young and Stearley 2008; Gillispie 1951). After all, Genesis was their only reasonable timepiece and with only one "watch," they assumed that they were reading it correctly. Of course, if you thought you were looking at a clock, but it was really a compass, you might be very wrong about the time. Watches and compasses can look a lot alike, but they serve very different purposes. If you want to know the time of day, the compass will not help you. However, if you are lost and need to know what direction to go in life, then perhaps the compass is a more useful instrument. The Bible overall and Genesis in particular are certainly a compass for guiding life, but how much it was ever intended to be a timepiece for early earth history is open for interpretation.

Geology had the distinction of being the first science where the discoveries ran against the accepted age of the earth. Does the age matter? Truth matters. One particular resource that geology provides for all of science is a timeline, a means to tell what order ancient events took place in and what was happening at the same time in other places. This timeline should help to understand the history of how God has worked in our world. When prosecuting attorneys bring a defendant to trial for murder, one of the basic parts of their case is a timeline for the crime that shows how the crime was committed and demonstrates that the accused had opportunity to commit the crime. If God is responsible for the creation of the world and man, the geologic timeline of earth's history cannot help but affect the way we understand God's activity. It should be consistent with a creator's motives and methods.

At first, as the earth was studied, geology also seemed to fit nicely with the expectations of the model. Early naturalists found marine fossils in the rocks up on mountains. That fit with the expectation that Noah's flood covered the mountains. Early "natural philosophers" as scientists were called, accepted the flood view, not so much because of their religious zeal as because it was the accepted view of their time. Then the story got more and more complicated. Rocks were often interpreted as deposits from Noah's flood covered by post-flood deposits, but when the rock units were mapped over broad areas, the interpretations did not fit. What seemed to make perfect sense in one area was just the opposite in another area. The "flood deposits" could not be consistently interpreted to have been deposited by a single flood. Early geologist George Cuvier (1769–1832) proposed that there were many floods and hence Noah's flood was just one of them, perhaps the largest. As rocks were studied in more detail, it was not long before it began to be apparent that the rock layers had taken far more time to form than was allowed by the traditional view of biblical history. Some write that scientists believe that the earth is old only because of radiometric dating (commonly cited as carbon-14 dating) and that this is used because the scientists are trying to bolster the theory of evolution. It is worth noting that geologists had already recognized the evidence for the great antiquity of the earth before Charles Darwin was even born or radioactivity was discovered, let alone radiometric dating

considered.[1] Louis de Buffon (1707–1788) published that the earth was seventy-five thousand years old based on the assumption that it was cooling from a molten beginning (Wicander and Monroe 2007). Several such proposals were made long before *The Origin of the Species* was published in 1859 with quite a range of estimates. Evolution would have been inconceivable with a few thousand years of history but is hardly proven by the longer time frame. Evolution, particularly macro-evolution, is an entirely separate issue and largely beyond the scope of this book.

Over the last three hundred years, Christians have discussed and debated how the geological interpretation is to be addressed. Today, Christian interpretations of the biblical account of creation are quite varied but can somewhat be divided into three basic views with a variety of nuances within each group. The basic views are

1. young earth creationists (YECs),
2. old earth creationists (OECs),
3. theistic evolutionists (TEs).

All the groups recognize God as the creator and are thus in sharp contrast to any who use naturalistic explanations that try to take God out of the equation. The disagreement between the three positions is in how God chose to create. Strong opinions are the rule, not the exception. It is interesting that conservative and evangelical Christians holding to each of the views are common. It is also probably safe to say that Christians in the more liberal churches are more likely to accept TE than either of the other two ideas. All these ideas have developed over time and parts of that history are important to the evaluation here. These will be covered in more detail as those topics come up.

The first of these, the YEC position is that the Bible teaches that God created the earth in six twenty-four-hour days about six thousand years ago. They believe that this is the only way that the Bible can be interpreted and that trumps any scientific interpretation. However, leading proponents of this view claim that the scientific evidence, when correctly interpreted, is consistent with this interpretation. The "young earth" claims conflict with mainstream scientific ideas from a variety of fields such as physics, astronomy, and geology. The implications, if this is correct, are wide ranging in science. This different understanding of the natural universe if true, impacts everyone in many ways. YEC proponents are typically convinced than any other interpretation of the scripture will do irreparable damage to Christian doctrine. This possibility will be considered in more detail in the second part of this book.

The second, the OEC position, is sometimes called "progressive creationism." I could have used the PC acronym but that has already been taken a couple of ways. Those holding this view believe that God created the world but chose to use the long time periods scientifically recognized. There are many ideas about how He went about this but the key point is that He was active in the creation process. Those holding this view try to honor scripture and scientific data, believing that, as with many

[1] Davis Young and Ralph Stearley present an excellent account of how geologists came to accept the concept that the earth is ancient, including the Christian faith of many of those involved in the development of the concept (Young and Stearley 2008).

YEC proponents, that when the data are all interpreted correctly, there will be no conflict between scripture and the information found in nature.

Lastly, TE believers consider God to be the primary cause of the universe and of life but largely accept the explanations given by science as the secondary causes, the methods that God chose to use. Both OEC and TE adherents accept the more conventional scientific data that yield an age for the earth of approximately 4.6 billion years. Both recognize that life has changed over the history of the earth. Both recognize God as the primary cause for that change. TE believe that God chose to work through Darwinian evolution to bring about that change. Some would prefer to refer to this method as "evolutionary creationism" (Alexander 2008). That is to say that God used natural selection and mutation as the methods to bring about all the forms of life that we have today, including man. Here is how one proponent chose to define this view:

> I will call it the fully gifted creation perspective—a vision that recognizes the entire universe as a creation that has, by God's unbounded generosity and unfathomable creativity, been given all of the capabilities of self-organization and transformation necessary to make something as humanly incomprehensible as unbroken evolutionary development. (Van Till 1999)

If we want to decide which if any of these is credible to believe, then we must delve into both the biblical and scientific evidence. All the views claim to honor both scripture and scientific data, but yet they view them differently. YEC views can be distinguished from the others by their claims regarding the age of the earth and their unique interpretations of geology. This book will address these claims in some detail. TE believers typically interpret the Genesis accounts as less literal than the others and so can perhaps be distinguished on that basis. Most do not believe that there was a literal Adam and Eve from whom all other people are descended. The OEC position views the Designer's hand as having had a more active role than typically interpreted by TE believers although there are many ideas about how that looked. Differences in the OEC and TE interpretations involve the methods that God chose to use. While geology does provide information about life's history on earth, questions about the mechanisms that acted involve the study of biology as well. Hence this book will address distinguishing these views less although the second portion of this book will look at options that are considered.

Recognizing a valid timeline from the geologic record is vital to evaluating YEC claims. Are we talking about ten thousand years or billions of years? Christian geologists must be actively involved in examining the evidence for both claims. Non-Christian geologists can address the technical case for the age of the earth but Christian geologists need to help other Christians to understand data in our areas of expertise and help develop ways to integrate the data that will stand up under examination. Many geologists are hesitant to respond to the vocal YEC. Some may fear a backlash from Christian friends and ministers who consider the age of the earth to be a critical test of orthodoxy. Few geologists know ancient Hebrew or are trained in theology or in many of the other relevant disciplines, and this may cause them to hesitate to speak on this topic. Nevertheless, the geologic data is key and if it is to be fairly considered, geologic knowledge and interpretation skills are important in the process. I can

highly recommend two books that have recently come out by Christian geologists that also address this topic: *Deep Time in Genesis: A Christian Geologist Joins the Debate* by Steven Webb (Webb 2016) and *The Grand Canyon: Monument to an Ancient Earth* by Gregg Davidson and ten other geologists (Hill et al. 2016). Evaluating the different viewpoints involves putting together information from many different sources, evaluating very different interpretations and assessing the confidence in them. This sounds a lot like a petroleum geologist examining prospects to drill for oil that have been proposed by different companies. Maybe such experience will be helpful in this investigation as well.

In this first section of the book, the focus will be on examining what the YEC interpretation predicts about the rock record versus what is actually found. YEC often claim that the geologic record is badly misinterpreted by the conventional geologists who claim that rocks represent millions of years of history. Does the education and training to become a geologist forge a strong bias in them so that they find the earth to be old because that is what they are trained to find? This author is a geologist and a Christian. I became aware of many of the arguments presented by proponents of "flood geology" at the same time I was studying geology in school. I have worked in petroleum geology for over thirty-five years in many different geographic areas and have come to know the sedimentary rock record in a number of areas very well. Working for major companies has given me the opportunity to examine data and see detailed work from every continent except Antarctica. Such training and experience does form biases, but that is part of gaining knowledge. Consider the opposite side. Does the fact that a Christian has spent years of attending Sunday school and churches where the days of creation were considered twenty-four hours long mean that they are intrinsically unable to look fairly at the evidence any other way? There are people in both positions who have not and will not look at the merits of the case for and against "flood geology" or an ancient earth. However, those who want can choose to examine and decide the strength of the evidence regardless of their prior biases.

There are many articles and books from the young earth perspective. While their quality and depth varies, over time there have been changes in what might be considered the best or most serious presentations. Almost without exception, they assail more conventional geological positions by making broad statements and then often use for evidence what from my perspective, are small side issues. In many cases, it is not particularly difficult to defend the geologic understanding of such details or to disprove explanations that they provide, but the YEC generally fail to address what I see as the bigger issues. Examples of evidence presented to "prove" a young earth include strange claims such as a buried whale, [2] too little shale on the abyssal ocean floor, [3] human tracks and dinosaur tracks

[2] Buried Whale—The claim is twofold. First, they say that normal geologic processes couldn't bury and preserve a whale and second the whale is oriented as though it were standing vertically on its tail (Ackerman 1986). The claim fails on both counts. The first point assumes that since rock layers take millions of years to form, the whole carcass would have been decomposed before the rock could be laid down. Geologists all recognize that many rocks are deposited quickly and secondly decomposition requires oxygen and in some settings that just is not available. As for the standing on its tail, it so happens that all of the beds are tilted now. The whale lay quite flat on the bottom after death (South 1995–1997).

[3] Too little shale—An often-referenced article by Larry Vardiman (b. 1943) takes a few data points collected for the Ocean Drilling Program (ODP) from locations that were obviously chosen for their thin Tertiary section. (Vardiman 1996) He claimed that too little sediment has accumulated there for the time claimed by geologists. This assumes

together (this will be discussed later in more detail) or too little dust on the moon.[4] Many times, the original proponents of the various arguments have long abandoned them, but like urban legends, the original claims keep resurfacing.

The case presented by young earth creationists has changed through the years and some understanding of the history of "flood geology" helps to understand the arguments presented.[5] The term *creationist* has come to be understood to imply a "young earth" and the "flood geology" theory. Often the media portrays creationists as simple and backward but that is not fair. Most do not have geologic training and thus some errors in this area are understandable. However, today some argue their case with more sophistication and are very skilled in presenting their viewpoint. Their ideas and arguments have had to change as support for the age of the earth as developed by scientists has come from more and more different independent directions.

Remember that a "young earth" explanation for the earth's age was largely universally accepted, at least in the western world up until the 1700s. As geology to began discover that the earth was much older, these new ideas about an old earth were not immediately accepted even by the scientists or "natural philosophers" of the day. Over time, most Christians came to peace with it. When Charles Darwin (1809–1882) came out with *The Origin of the Species*, again many Christians challenged evolution and some attacked geology as if it were a coconspirator. Once again, over time, Christians largely came to peace with the age of the earth, though evolution has remained contentious. Many leading geologists were outspoken Christians. It seemed that science and faith could work together. This changed however. Modern YEC creationism can largely be traced to a Seventh-Day Adventist, George McCready Price (1870–1963); (Numbers 1993). Although Price claimed to be a geologist, this was not on the basis of formal training or occupational experience. I found his 1913 book *The Fundamentals of Geology and Bearings on the Doctrine of a Literal Creation* to be an entertaining read, given when it was written. It is an account from someone without access to much of the support for the things he attacked and it was written before the explosion of learning that has taken place since, particularly in the last fifty years (Price 1913). He was widely read at the time and even quoted often by William Jennings Bryan in the famous Scopes evolution trial. Few geologists took his work seriously.

We will look further at Price's basic arguments, but it is important to recognize that these basic arguments were presented again with more supporting material in 1961 by John Whitcomb (b 1924) and Henry Morris (1918–2006). (Whitcomb and Morris 1961). Their book *The Genesis Flood* is widely recognized to have single-handedly led to the modern revival in YEC creationism. Henry Morris earned a PhD in hydraulic engineering and was a respected professor in his field. His PhD and technical analysis of geology persuaded many that "flood geology" was plausible science

essentially a uniform deposition of sediment, no processes that remove or dissolve sediment and calculates through many equations, how much should be there. These assumptions are flawed.

4 Claim by Henry Morris has basically been withdrawn by original proponents but continues to be presented as fact in later books and Web sites (Snelling and Rush 1996).

5 Ronald Numbers book *The Creationist* provides a detailed account of the history of the modern creationist movement (Numbers 1993).

and provided the long-awaited answer to evolution. He went on to help form the Creation Research Society and the Institute for Creation Research (ICR) in Dallas, Texas. *The Genesis Flood* continues to be influential and quoted in YEC literature. Thus it will here be considered one of the most important sources to consider in analyzing the case for "flood geology." This book will also draw heavily on ICR, Answers in Genesis (AIG) led by Australian Ken Ham (b. 1951), and the Biblical Creation Society (BCS) from Great Britain for YEC interpretations of geology. Not many members of these groups are geologists but there are a few, including several with PhDs. Prominent examples are Dr. Steven Austin (b. 1948) and Dr. Andrew Snelling (b. 1952). This book will draw on their papers and others to represent more recent "flood geology" positions. More recent authors such as these have commonly abandoned many of the arguments presented by Price or Whitcomb and Morris. Their geologic understanding is admittedly greater, and they present many examples, if very selective ones. It can be confusing and it is difficult for any geologist to be familiar with the details in all the areas that they cover in order to follow the logic and rebut every argument. Donald Wise's paper "Creationism's Geologic Time Scale" is a good example of a prominent secular geologist's response to their arguments (Wise 1998).

This book will examine many of the claims made by the advocates of the YEC timeline and "flood geology." The cases for a young earth and that most of the geologic record formed during Noah's flood run sharply against most of the field of geology as understood by the vast majority of geologists today. They do not simply claim that the Bible teaches that the earth is young but that the scientific evidence also shows that the earth is recent. This involves many detailed claims, but this book will try to demonstrate that their explanations just cannot explain large parts of the rock record. If the earth is in fact millions or billions of years old, then the YEC attacks are misguided and should be demonstrably in error. The body of work that supports the understanding that geologists have built over the last three hundred years is very large. It is not surprising that making a case that all of this work is predominantly wrong is not easy. Here is an analogy that may help to illustrate the problem. Imagine a young man who goes to California and sees there the giant tree there known as General Sherman. Seeing the way the branches block the sun, the young man is offended by the way it blocks *his* view of the sun. The young man is full of zeal and eagerly attacks the tree, vowing to use the wood to build an altar to the sun. However, for all of his enthusiasm, he is a bit limited in effective tools. The only tool available is a small saw designed for detailed scroll work known as a coping saw. It has a thin narrow blade about eight inches (20 cm) long. It is over one hundred feet (30 m) around the General Sherman tree and the diameter at the base is thirty-six feet (11 m) in diameter. Nevertheless, he eagerly attacks every day for a few minutes, and occasionally, he succeeds in cutting off a piece of bark. Each day, he declares that the tree is conquered. A good suggestion might be for him to back up and take a good look at the whole tree. He might then appreciate that the small points that he cut off were not hurting the tree and really did not change the tree's existence. He might also want to consider whether or not the sun actually wanted the tree cut down to begin with so that he could build an altar. This is perhaps a bit ridiculous as an example, but indeed, it may be that the geologic record is true and though there are details that will need adjustment, if it is in large part true, the attacking and misconstruing details will not change that. It also may be that the Son

can use the truth in other ways, for His own purposes and it doesn't need to be torn down. Similarly, I will try to show that the YEC explanations of the rock record are just not viable and fail for multiple reasons. The closer one examines the YEC's explanations, his coping saw, the more one realizes that the record just does not match the proposed explanation. The more conventional explanation might not seem as dramatic as an instantaneous creation and a massive global flood, but it does seem to be consistent in general with the way God chooses to act most of the time. If that is the case, then perhaps it is our task to understand what this teaches us about God rather than to tear it down.

There are many ways to study the age of the earth and evaluate the proposal that a global flood formed portions of the rock record. One way might be to put together a comprehensive study of all of the scientific evidence for the age of the earth. Dr. G. Brent Dalrymple has written *The Age of the Earth*, an excellent book that does just that (Dalrymple 1991). Dalrymple's analysis includes geology, astronomy, and cosmology. This book goes thoroughly into the way radioactive elements have been used to put together a consistent picture for the age of the earth. While this method is great for the overall age of the earth, it does not answer all the questions regarding a global flood. Another way might be to go through all the YEC literature and examine each and every claim of support for their theories. If one could refute all these claims, presumably we could agree that the theory would have to be rejected. This book will take a different tact. I will try to take one part of the world, the region of Texas, New Mexico, and northern Mexico where there is a tremendous amount of well-documented data and see how the "flood geology" theory fits to just this one area. To be clear, I am not questioning that the earth was created or even that Noah's flood occurred. The first section of this book is dealing with the interpretation of the age of the earth and the claim that most of the earth's sedimentary cover resulted from theGenesis flood. This part will look at what "flood geology" specifically predicts and how these predictions compare to the rock record. The second part of the book will be different. Here we will look into the Bible and consider if it tells a history that does not fit the scientific data recognized today. Here we will look at creation in the Bible and Noah's flood.

The geologist's understanding of earth history is admittedly a work in progress. It has been developing since the 1700s, and it has been challenged many times. How solid is this interpretation? The geologic strata or layers of rock must be explained in some fashion. If geologists are wrong, then what are the alternatives? YECs try to explain the geologic record by one of three means or by a combination of them:

(1) Noah's flood caused much of the rock record,
(2) rates of rock deposition and formation were much faster than understood by geologists,
(3) the earth was created with the appearance of being old.

The last explanation is really a theological issue, but the first two can be tested by examining the rocks. The last will be addressed using the scripture.

We will deal with the first two explanations using the geological evidence, but it is important to recognize that the YEC position is driven by the belief that the Bible is the only truly reliable source of truth and that all other sources of information must be interpreted in the light of it. That means

that the biblical interpretation always trumps the geological data. In many cases, there is no possible scientific evidence that would impact their view on this subject. This author also believes that the Bible is absolutely true and provides the critical foundation on which to build our lives. It is absolutely clear how to interpret the Bible about many things. Many people do not accept the Bible but often it is not because they cannot understand what the Bible is saying. Mark Twain is quoted as having said, "It ain't those parts of the Bible that I can't understand that bother me, it is the parts that I do understand." It is also a fact that sincere Christian believers disagree about how to interpret other parts of the Bible.

The YEC position reflects a strong belief that there is one very clear way to interpret the biblical account of creation and the Genesis account of Noah's flood. This interpretation leads to a number of the typical common beliefs or tenets of YE creationism that have geologic implications and these will be evaluated. Each tenet is based on an interpretation of scripture that may be internally consistent but is not the only viable option, at least in the opinion of many Christian biblical scholars. I believe that there are valid scriptural answers or at least options for each of these tenets and these will be discussed in more detail in the book's second part. For the moment, it is important to recognize that these beliefs lead to very clear implications of what we should find in the rocks that we find on the earth. This is good news for examining the different positions on creation. Clear positions are much easier to assess than fuzzy ones. The first step will be to understand just what the YE model of geology must look like and then describe what we actually observe in the rocks and then compare and evaluate which position is viable.

2 Comparing Assumptions

Basic tenets of YE creationism with geologic implications

The YEC position is based on the assumption that the Bible is the inerrant Word of God. Many other Christians agree. The YEC interpretation of the Bible with respect to creation holds that several distinct tenets are proven by the Bible. A geologist cannot "prove" when light first appeared or when man began to wear clothes, though the Bible does address these questions and the YE position is clear about them. Not much testing these types of tenets. There are places where the YE interpretation of creation in the Bible does impact the record in the rocks and we can examine these. Here are some examples:

1. Creation took place over six twenty-four-hour days

   The YE interpretation of the length of the creation days is based on a simple direct reading of Genesis 1. There is no denying that the text is easily read in this fashion, though the validity of this interpretation has long been debated. Augustine of Hippo (354–430) believed that earth and the whole universe were created by God instantly, but the days were God's explanation for man. The geologic implication of creation over 144 hours (six days) is that the creation week would appear instantaneous in the rock record. There would be no separating day 2 versus day 6. No scientific dating tool has that type of resolution. Perhaps there would be some sort of sudden change, but it would be hard to know what to look for, especially given the second tenet below.

2. Earth created mature and complete.

   Many Christians point out that if God spoke the universe into existence, then it appeared as a finished product. Just as Adam was apparently created instantly as an adult with an implied childhood, so the world could have been created mature. Thus there would be a difference between maturity and actual age. Many, if not all, YECs consider the apparent maturity of pre-fossiliferous rocks not to be an issue. A "mature" earth might appear to have had many of the same processes active that are active today. Early scriptural geologist, Granville Penn 1761–1844 put it this way:

   > *Primitive formations were made "in correspondence with the laws which [God] was then about to establish" anticipation of effects and appearances which were thenceforward to be produced only by the operations of those laws. (summarized from "A Comparative Estimate of the Mineral and Mosaical Geologies*," 1822; Young D. 1995)

   Examples that are given include volcanic activity and stream activity. Such a hypothesis, of course cannot be proven or disproven using scientific means.

3. Life created on day 3 for plants and day 5 for animals. (No life prior to that.)
4. No death prior to Adam's sin (the Fall)

   These two tenets indicate that all strata with fossils must be considered to have been deposited after Adam's sin in the Garden of Eden. All fossiliferous rocks were thus formed after creation week and are not part of the "created mature" story. Although we are not told how old Adam was when he sinned, the text states that he was 130 years old when Seth was born, so the time span was not too large. That leaves very little time for rock deposition after creation week, before fossils could have been deposited. This is really important because it means that we can recognize rocks that the YEC must ascribe to after creation. While it is not useful to think in terms of the passage of time for rocks that might have been "created mature," we should expect that those after the appearance of life developed over actual time. It becomes useful to think about how much time was involved, depending on the processes that were active.

5. Animal life was created vegetarian and began to eat meat as a result of the fall.

   This means that any rock with fossils had to have been laid down after Adam's fall. With no animal death before the fall, this meant that in order to eat, all the animals would have been herbivores. This means that all adaptations that are clearly for carnivores or predatory forms or even eating insects must have developed as a result of the Fall. Some YEC do not extend the lack of death to insects or lower lifeforms but it is unclear why that would be, given their demands from the biblical text. When we see fossils of carnivores, those animals would have lived, not just after Adam's sin, but after animals evolved from that initial state into genetically and physically different beasts. The evolution rate for the plant-eating animals becoming carnivores must have been incredible. Imagine all the adaptations that would have been involved to end up with a shark or tiger after the flood.

6. No rain before the flood

   Rain prints and evidence of rainfall are common in the rock record. This YEC tenet demands that all of these were deposited during or after the flood. The pre-flood earth is viewed as not having the marvelous water cycle that we have today. Presumably rock deposited before fossils entered the scene could include rain prints because of the "mature" creation. Apparently if rain was not part of the original plan for the earth, then God anticipated it as a part of what the mature earth would be like. Scheven points out that the lack of rain implies little erosion compared to today (Scheven 1990).

7. Noah's flood was global

   The biblical narrative describes a miracle with no parallel since. Over the years, many rock formations and characteristics have been attributed to Noah's flood. A global flood means that the resulting deposits would all be stratigraphically related. There should be a synchronous surface below the flood deposits though the waters might have eroded into older sediments of other ages. Geologists refer to such a surface as an ***unconformity****.*[6] *This unconformity would always have sediments and rocks from before the flood below it and rocks from the flood or younger above it. The rocks deposited by the flood should be consistent with having been laid down very quickly by water. Some claim that the flood period had dramatic volcanism, but surely the dominant process would have been deposition from water. The top of the flood deposits should be of a uniform age except where it was eroded later. Some interpret different processes for different parts of the flood, but there does not seem to be a consensus about this.*

8. The date of creation is indicated by the genealogies of the Old Testament.

   Bishop Ussher, a scholar and head of the church in Ireland declared in 1650 that creation took place Sunday, 23 October 4004 BC and this date is accepted, at least approximately by most YEC authors (Humphreys, Austin, Baumgardner, and Snelling 2011; Vardiman 1996; MacArthur 2001; Whitcomb and Morris 1961; McIntosh 1997; Rosevear 1986; Huse 1983). Some YEC authors have noted variations in generations given in the Bible and consider that gaps are possible in the genealogies (MacArthur 2001; Whitcomb and Morris 1961). Few report believing that such gaps would allow for significantly larger amounts of time. Typically, the oldest proposed dates would place creation no older than 10,000 BC. This is critical to their interpretation of much scientific data. Any data that suggests an older date must be explained as errant or misinterpreted.

[6] Every field has a vocabulary and geology is no different. Words in this font will be further defined in the attached glossary.

Basic standard geologic assumptions

Just as the YEC position comes from assumptions, there are assumptions that this book uses as well. Initially, setting aside the theological arguments, I will try to answer the question: is the geological rock record consistent with the YE tenets above and the consequences that come from them? This comes down to simple questions, such as, could most of the sedimentary record have been deposited during a single global flood? The assumptions used to test such proposals need to be simple and supportable. Science claims to start with and hold to simple presumptions. "Understanding Science 101" reports that "science operates on the assumptions that natural causes explain natural phenomena, that evidence from the natural world can inform us about those causes, and that these causes are consistent" (Understanding Science, n.d.). Science normally does not try to defend the presumption of using only natural causes but it is important to understand that it is there. Appealing to only natural explanations as a working method is called methodological naturalism (Scott 2009). It works well for most questions and certainly in day-to-day geology. It allows for the type of rigorous investigation that has worked well in science and is tested daily in practical tests, such as in petroleum geology. I do not know any scientist, Christian or not, who considers proposing a miracle as an explanation in their daily work. Some scientists do go beyond this to philosophical naturalism, the atheistic view that natural explanations really are all that exist. Somehow, they have enough faith to trust that these are adequate to explain the universe and life. If one starts with naturalism as an assumption, then of course YEC "flood geology" fails but that really proves nothing. Such an assumption is not really adequate for ultimate questions about origins. In any discussion of ultimate origins, philosophical naturalism would be starting with the conclusion as one of the assumptions. The goal in this document is to be able to use a few simple defendable presumptions but not ones that already determine the result. Here is a list of basic geological assumptions and a brief basis for each.

1. The earth's rocks were not created in a form designed to deliberately deceive us.

   One reason modern science flourished in the western world is because of a Christian heritage that believed that God created a good universe. Its order and reason are derived from its Creator. Just as He is truth, Christians trust His revelation of Himself in creation to be true. As a geologist, here is one of my favorite passages: "For the LORD *is a great God, and a great King above all gods. In his hand are the depths of the earth; the heights of the mountains are his also. The sea is his, for he made it, and his hands formed the dry land" (Ps. 95:3–5).*

   Geology is His creation. It reflects Him. Certainly, many societies have worked on different assumptions with capricious gods that were not trustworthy. The scientific assumption that natural causes explain natural phenomena is not the only possibility but in this case, when founded on the character of God, it makes scientific endeavor potentially worthwhile. The God of Truth (Isa. 65:16) is the maker of heaven and earth and He is faithful forever (Ps. 146:6). God does not create things mature in order to deceive man.

2. Basic order of sediment deposition is real and can be discerned

This is a basic task for the branch of geology called stratigraphy, *the study of sedimentary rock layers and how they formed. Geologists are all taught the* "law of superposition" *that basically states that sedimentary rocks are laid down as horizontal or sub-horizontal layers referred to as BEDS with the oldest on the bottom. Geologists are not the only ones to use this "stratigraphic filing system" to locate things. Just go into a teenager's room. Where are the oldest papers? However, the teenager may suddenly go into the room and disrupt the stratigraphy in a frantic search for a missing paper. Similarly, geologists recognize that later events such as faulting and folding may disrupt the order of sediments as well. In some cases, it can even make it difficult to recognize which side of the strata was up originally, but geologists have identified many means to work this out. Fortunately, it is normally possible to go to areas where the rocks have not been deformed and work out the basic stratigraphic order. This order is commonly referred to as the "stratigraphic framework" because it gives the basic timeline for understanding the order in which sediment deposition and other events took place. Once the basic stratigraphic framework is developed in the simpler areas, it can be carried into more complex areas. This is really important. If we can work out the order of deposition, then we can have meaningful discussions about the processes and time involved. If the order were just random or so complex that it cannot be discerned, such work would be fruitless. George McCready Price, Whitcomb and Morris, and several other early authors did not accept geologist's ability to discern this order of rock formation. More recently, several major YEC authors (Garner 2011; Garton 1991; Scheven 1993; Snelling; 2009) have written publications accepting the basic global stratigraphic order recognized by geologists, even though they don't agree with the absolute ages involved. Even now, others, typically those with little time spent understanding geology, write as though the geologic framework were useless. Some will accept the order where it fits their model for the flood and then conveniently reject it when it does not conform.*

The geologist's stratigraphic filing system provides a "relative time scale." It is relative, in that we can tell what is older and younger but it does not tell us by itself how much older in years. That requires something else, some sort of clock or calendar to provide absolute ages. If you ask a geologist how old a rock is in years, the age you get will be based on radiometric dating. Radiometric dating was invented in 1905 by Rutherford (USGS, n.d.), long after the major geologic ages were defined and in world-wide use. Most geologists seldom actually date rocks radiometrically. We are typically far more concerned about their relative age and are satisfied with dates worked out globally for the age of various units. The International Commission on Stratigraphy works very hard to define the absolute age of units in years and there are often small adjustments as better data becomes available (International Commission on Stratigraphy 2013). The dates that they have developed are consistent with the rates of geologic activity that we see today. It is an almost universal YEC position that radiometric dates are flawed. Measurements of ages in millions of years do not fit well with a creation ten thousand years ago or less. Many articles have been written questioning the assumptions that support the method-

ology but it is clear that the YEC objections are driven by their belief in the YEC tenet 8 from above, not from the scientific demands.

For the purposes of this book, part one will not use radiometric dating as the basis for the age of rock units. Here, we will try to constrain rates and time frames as best we can, without this technique. This is not to say that the author does not accept radiometric dating. I am quite comfortable using radiometric dates where good data is available. This technique is quite independent of other geologic methods and provides an independent support for the antiquity of the earth. Part two will use radiometric dates with respect to early man. After all, the physics behind radiometric dating is very solid and if the YEC dating is not a factor, then it can be used to study this important time period. See Appendix: Radiometric Dating for more on radiometric dating.

3. Fossils represent dead plants and animals (not fakes).

This follows from the first assumption but in early days was not believed. When fossils began to be found of creatures that were clearly different than those living today, some rejected them as artifacts, not remains of things once living. Assuming that they do represent evidence of ancient life is key in assessing YEC tenets 2–5. If God created a "mature" universe that included fossils that really were never alive, then there would be no point to addressing the questions at all. He also could just as well have created the universe last week, along with all of our collective memories. It would be within His might but deceptive and that would be against His character.[7] *God does not lie! (Titus 1:2, Deut. 32:4)*

4. We can identify the processes by which sedimentary rocks were deposited.

If we can learn nothing about how a rock was formed, then the game is over. The assumption here is that it is possible by systematically studying rocks in their setting to learn about how they were formed. Much time will be spent in this book trying to apply this assumption to specific

[7] This comment from James Montgomery Boice's Genesis commentary, is helpful (Boice 1982, 1998): "What about Science? There is one last point. The possibility of doing science in our day or any other day is undergirded by the assumption of certain laws of nature, operating in the past and continuing to operate on into the future. But according to the creationists, those laws were not operating or else were entirely different during the period of creation itself, and therefore any scientific investigation of creation is both impossible and illegitimate. Is that what our knowledge of God's ways leads us to expect? Are we given minds that can reason, only to be told that at the point of creation the data they perceive and the basis on which they would reason are an illusion? If so, it is the end of science, at least in this area and it may be the end of other thinking also.

If the earth and the universe look old when they actually are not, why should any of our observations be trusted? True, the Bible tells us much, and it can be trusted. But the Bible does not tell us everything. It does not even tell me that I exist. Perhaps I do not. Perhaps appearances in this area too are deceiving. Taken to its extreme, the idea of "apparent age" (or "apparent" anything) leads to skepticism, and we are not to be skeptics. We are to know and know we know—by the word of God and by that limited but nevertheless extensive and extremely wonderful revelation of God in nature, perceived and understood by reason."

rocks. The geologic branch of sedimentology involves the detailed study of the processes by which sedimentary rocks were deposited. Depositional processes that are active today have been studied extensively. Why do we care how sediments are laid down today? James Hutton (1726–1797) is credited with explaining the logic by saying "the present is the key to the past." Today we might modify this slightly to say "the present is a key to the past." We recognize that some processes that were active in the past just cannot be observed today. Until we have another asteroid impact, we will not be able to physically observe all the processes involved. That said, the processes related to asteroid impact would be expected to be physical processes, many of which are just like those we see every day. They would just be working at different rates and scales than the normal processes. The same would be expected for much of what would have happened during a global catastrophic flood. For example, one would expect fast moving water to cause erosion and slow water to allow sediment to settle.

Can geologists actually be confident that they have correctly identified the processes that caused particular rocks to be formed? In order to build the case for this assumption, I will begin by pointing out some that are pretty unambiguous. The evidence used comes at all scales, from microscopic to packages that cover large areas. First, some individual features are diagnostic such as coal beds with tree roots still in place, ***reefs*** *with the reef forming animals still in place, algal mats (stromatolites), carbonate banks comprised of grains known as ooids that formed by rolling around on a beach. We also recognize rock types that form today in dry arid environments such as the Arabian Desert such as "spiderweb anhydrite" that clearly formed in the past as they do today. An example of this will be shown later and in due course, we will look at other examples of individual features as they are relevant.*

Features in some sedimentary rocks are very distinctive and tell us a great deal about the conditions in which they were deposited. This setting or "environment of deposition" can be identified.

While some rocks have clearly diagnostic features, it is also true that for many individual layers or beds of rocks, there are no unique features and the features that we do observe could have formed in many settings. It takes a bit more detective work to work out an understanding of how these were deposited. While there may be many options for how one isolated rock or a bed was deposited, often understanding the rock's formation requires the geologist to step back and look at the bigger picture. In geologic terminology, the setting in which a sedimentary bed was deposited is known as its "environment of deposition" (EoD). For one layer, taken by itself, it may be difficult to decide how it formed but if you know what kinds of rocks were deposited at approximately the same time over a region, you can have a better chance to choose the right EoD option. I would argue that it is normally possible for the geologist to work out this context or EoD and to understand how sedimentary rocks were deposited and what the setting was like.

Working out the depositional context for rocks is in this sense similar to trying to understand one sentence out of a book. It is very important to look at the context where the sentence comes from. The Bible is the best example ever for this. If we can place the rock into context, then we can understand the significance of other clues. For the moment, let me give one example of a key clue that helps to provide the context to determine the EoD. To use the biblical analogy, this might be like knowing whether a verse comes from the Old or New Testament. For sediments, we often start to determine the environment of deposition for a set of strata by first locating a particular point in a basin known as the depositional shelf edge (Figure 1). This is a hinge point that provides a key piece of context to use in deciphering the way sediment was deposited. Over time, as sediment fills an area, this hinge point shifts and changes in style but it can be identified confidently using several datasets and criteria.

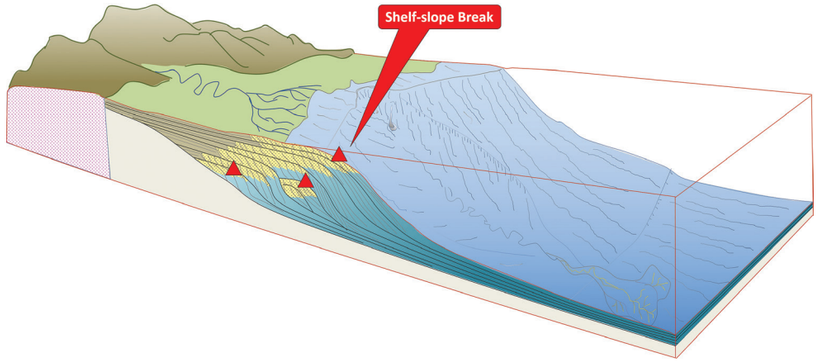


Figure 1. The three-dimensional model above shows the bathymetric features recognized in basins around the world that control the sedimentary processes that occur. The shelf-slope break is highlighted with a red triangle. Basinward of this point, sediments are no longer impacted by wave action but move into deeper water by gravity flow down the slope toward the basin floor or abyssal plain. Shelfward of this point, the sediments were deposited in river and shallow water environments.

For the moment, I want to discuss this shelf break, both as an example of a feature that often can be readily identified and also use it to introduce reflection seismic data, a dataset that is very important in understanding larger features and relationships in geology. ***Seismic*** *data is acquired by generating a sound wave that is sent into the subsurface using a sound source. Many source types are used, ranging from dynamite to large air guns towed behind ships offshore. The sound goes down into the earth and the energy bounces off rock layers and then is recorded by a set of receivers at the surface. Modern computers are able to process these recordings to give an image of the layers under the surface. Not many years ago, such data were printed as long paper sections, but now they are examined on computer screens. Geoscientists learned to identify the depositional shelf edge on seismic profiles and to use that information to place sediments in*

context. The geometries observed on the seismic lines at the depositional shelf edge show a distinctive change in dip, an inflection point in many settings (Figure 1). Sediments on either side of that inflection point show consistent evidence of having been deposited in different environments and water depths and by different processes. We observe the inflection point best on very high-quality lines that image the modern shelf breaks around the world and also in large outcrops such as in west Texas and Utah, where we can walk or climb right up to the rocks and examine them. We recognize the direction that sediment came from, and we recognize processes on this landward side of the shelf edge that include ***subaerial*** *processes such as* ***fluvial*** *(river) processes and various processes that we find today acting on beaches and in areas affected by waves and storms on the depositional shelf. Every rock on the landward side is consistent with shallow water or subaerial deposition. On the basinward side of the shelf edge, the subaerial and shelf processes were clearly absent. The main processes recognized there are those that were driven by gravity acting on sediments as they collapsed along the depositional slope into the deeper water. The deposition is interpreted to have been very sporadic and we have examples where such deposition was triggered by sudden events such as storms or earthquakes. Sandstones deposited in these settings often were deposited in thin sinuous meandering bodies (Figure 2). We see the same type of channel deposits in basins today.*

We can understand the general processes and settings with high confidence in most cases. While our ability to recognize ancient environments is an assumption for this book, it is quite important and many examples will be shown to support it.

What is the point of this discussion? We can use our knowledge of depositional systems from today, from models and from outcrop studies around the world to determine how sedimentary rocks were laid down We can understand the general processes and settings with high confidence in most cases. While our ability to recognize ancient environments is an assumption for this book, it is quite important and many examples will be shown to support it.

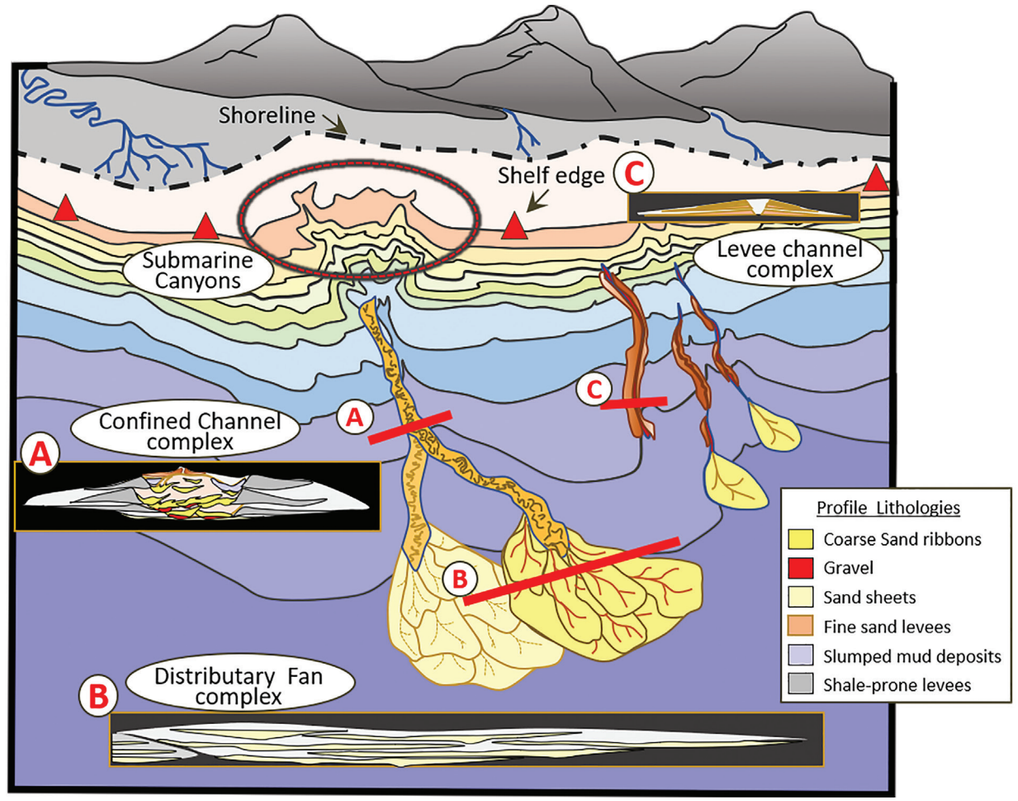


Figure 2 This schematic model shows many depositional features recognized in deepwater settings. It is based on many seismic examples and outcrops. Many examples are in the literature such as an excellent model and discussion at the SEPM Society for Sedimentary Geology Stratigraphy Web (http://www.sepmstrata.org/page.aspx?pageid=1). Rivers formed deltas at the shelf edge and when it collapsed, plumes of mud and sand known as turbidity currents moved down the floor of the basin. Deepwater turbidity currents carried sand and gravel that deposited when the currents decelerated. Seismic images often show the deepwater channels in elaborate detail. Great examples can be found at the Virtual Seismic Atlas (http://see-atlas.leeds.ac.uk:8080/home.jsp). Perhaps the best examples come from West Africa, but the Gulf of Mexico has many examples as well. Unfortunately most of these are proprietary to the companies that own the seismic data. Sites like the Virtual Seismic Atlas make them available, though including them in this book has not been possible.

5. There are some limits to the rates that are reasonable for deposition and other geologic processes.

Many YEC authors point out that while geologist claim that rock formations take millions of years to form, sediments can actually be deposited very quickly (Whitcomb and Morris 1961; McIntosh 1997; Huse 1983; MacArthur 2001; Caldwell 2005; Snelling; 2009). They do not take into account the difference between an average time versus the time ofdeposition of indi- vidual beds at individual locations. It is a bit like the difference between an average income and the individual income. If one were to take the area where Bill Gates lives, you would be correct in saying that the average income is extremely high. However, the income of most of the individuals in the area is far below that of Bill Gates. Geologists recognize that individual beds
can be deposited very quickly. When we see tidal deposits, we believe that the individual layers were deposited in one tidal cycle. We recognize deposits in deepwater environments where thick deposits known as turbidites can be deposited in a matter of minutes to hours. Deposits in Spain described as "megaturbidites" can be up to 656 feet (200 m) thick (Seguret, Labaume, and Madariaga 1984). These are interpreted to have been caused by seismic events (earthquakes) that happened sporadically there. Abrupt erosional and deposition events such as these took place many times in the geologic record.[8]

We also see depositional packages that imply much longer time frames. It is difficult to quantify how much time has passed without some sort of clock and as pointed out earlier, here we will not rely on radiometric dating. In many cases, it is apparent that the same processes that we see taking place today in modern environments formed the ancient rocks. In such cases, it often then becomes difficult to make a case for extremely different rates. As we look at the sedimentary layers and the processes by which they were formed, we can think about what things would have needed to be like for vastly different rates to have taken place and whether there is any reason to believe that the world was really like that. Think about sediment deposition along rivers and in deltas. We know and have documented recent rates of river sediment deposition. We have measured how fast deltas form for various river types. If we were to postulate that these same processes deposited sediment vastly faster, that would dictate that the rivers were much, much larger. Such rivers ought to be recognizable in the sediments. The interpretation of large amounts of rock as being the result of a single flood that took place over one year demands extremely high rates of deposition. We should be able to recognize processes that would deposit sediment to rapidly.

[8] Michael Garton (1991) actually tried to calculate the amount of time it took from a YEC perspective for various cliff faces in England to have been deposited during the flood. Average times per bed such as he calculates in some settings might work. He falls into the average time pitfall. He says, "A rate of about 1/5th of a millimetre per year (and frequently much slower) is often quoted in literature (e.g., Alego and Wilkinson 1988; House 1989, p. 4) showing that such slow rates are accepted by the geological community." He misses the point that the authors made. Even so, Garton's questioning the lack of deposition in one place for long periods of time should be addressed.

3 YEC Geologic Column

If the YEC mode of geologic history is true, then all the rocks in the world were formed in one of five time intervals. If this is correct, then you drill a hole anywhere in the world, and if no sections are missing from erosion or lack of deposition, then these five intervals should be present in the same order everywhere. These time divisions form a geologic column predicted by the YEC model (Figure 3). It is possible to describe these divisions in terms of their geologic characteristics so that they should be recognizable. This can be compared to the rocks that we find in nature. Geologists, particularly those of us known as stratigraphers, will typically begin to describe a column of rocks from the earliest to the latest, and so that is how this column will be described.

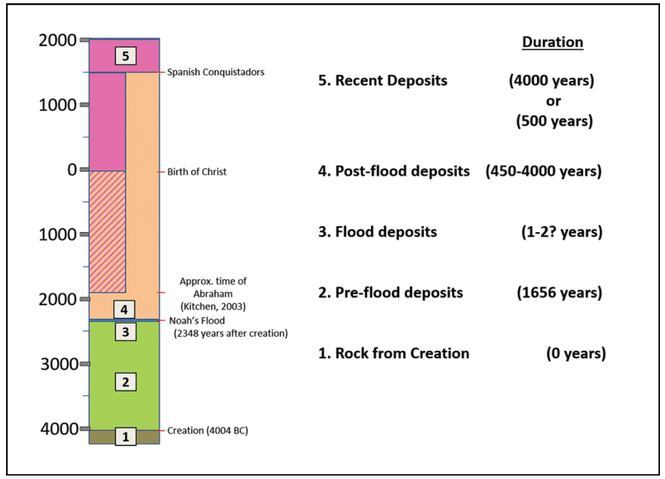


Figure 3 The units in the diagram can be used to characterize the YEC model for the earth's geologic history. Unit 1 represents rocks created during creation week. Creation here is taken as Bishop Ussher's date of 4004 BC. Unit 2 represents rocks formed between creation and Noah's flood. Unit 3

represents deposits formed during and soon after Noah's flood. Unit 4 represents deposits between the flood and the oldest point when there is general agreement on the stratigraphic age of sediments. For most places, this can be considered the time of Abraham, though with respect to the study area, some might hesitate to agree until later times, such as around the birth of Christ or even the time of the Spanish Conquistadors in 1519 AD. Unit 5 represents deposits that can be dated to historical times. This period provides a way of calibrating how fast normal geologic processes move.

Unit 1 Rock from Creation

Duration: 0 Year

The YE reading of the first day of creation in Genesis 1 has the mature earth appearing essentially instantaneously. Most YEC authors do not try to describe geologic events in terms that might be used to subdivide rocks from the separate six twenty-four-hour days of creation week in their model. Andrew Snelling proposed a series of geological events linked to the seven creation days of Genesis 1 (Snelling 2009). Such proposals are untestable because no one is likely to ever be able to prove age dates that are twenty-four hours apart. One might interpret a series of rocks to fit Snelling's proposal in different locations, but proving that they were the same events, deposited on the same days in another location would be impossible. Apparent rates of deposition would be meaningless. The assumption that the earth was created mature means that the rocks might appear to be very old, even though they were just created a few thousand years ago. Radioametric dating will not be of any use for rocks in this unit. Dates might be random or ordered but would prove nothing in these rocks. Austin et al. 1994 state,

> We believe that there was a significant thickness of all types of sediment already available on the earth by the time of the flood. We have three reasons for this position:
>
> 1. biologically optimum terrestrial and marine environments would require that at least a small amount of sediment of each type had been created in the Creation week;
> 2. Archean (probable pre-Flood) and Proterozoic sediments contain substantial quantities of all types of sediments; and
> 3. it may not be possible to derive all the Flood sediments from igneous and/or metamorphic precursors by physical and chemical processes in the course of a single, year-long Flood.

How would we be able to distinguish rocks created mature from those that formed after creation? The answer is in the basic tenet that life was created during creation week after the earth itself.

Sedimentary rocks that include fossils should date to after the creation week. Using the YE model, rocks older than the first fossils would largely be assumed to have been created with an apparent age. Any rock that is non-fossiliferous and stratigraphically older than the oldest rocks known to hold fossils could be considered Unit 1.

Unit 2 Pre-Flood Rocks

Duration: 1,656 years

Fossiliferous sediments as the YE predict overlie older rocks that are non-fossiliferous. How would we recognize the end of creation week in the rocks? The assumption of created mature might mean that there would be an erosional surface or unconformity at the top of creation week section. It also might just appear as business as usual except for the appearance of life. The Genesis account specif- ically names seed-bearing plants, trees, giant sea creatures, birds and mammals including man. A six twenty-four-hour-day creation process would appear as a single event in the rock record and so one
should see all the various kinds of animals that have ever lived from the earliest stratigraphic level. Adam and Eve would have been created on day six in Eden, presumably in the Middle East and thus signs of man might only be found there. That might be used to explain the lack of evidence for them in other parts of the world. The earliest levels might not include carnivores. Somehow, an amazing rate of evolution is proposed to have taken place after Adam's sin and the fall, as animals adapted beautifully to a balanced ecosystem that includes carnivores.

The YEC assumption that the first rainfall came with the flood means that no rain prints should be present in this section. Scheven described the impact of no rain as follows:

> Another important difference between the pre-Flood conditions on earth and the present concerns the water cycle. The statement that God had not yet caused it to rain upon the earth (Genesis 2:5) is valid until the announcement of His intention to cause it to rain (Genesis 6:4). Instead, the pre-Flood earth was watered from below. "Now a river went out of Eden to water the garden, and from there it parted and became four riverheads" (Genesis 2:10), encompassing whole countries. At this stage, we will dwell on one aspect only.
>
> If there was no rain before the Flood then there was no erosion that could have washed sand etc. into the seas. Consequently, there was no deposition of any kind. This being so, no geological work can have been accomplished between the Fall and the outbreak of the Flood: neither erosion, nor deposition, nor volcanism (as we shall see), nor mountain-building activities, nor, of course, any entombment and lithification of fossils can have taken place. (Scheven 1990)

Rivers, even if fed from some sort of subterranean source from below, would have caused some erosion and deposition. The amount would depend on the material being eroded and the size of the rivers. The normal geologic processes and depositional environments that we see today reflect basic physical laws that all agree have acted since creation. Loose sands are turned to sandstone by the weight of burial and chemical processes that together are known as the process of ***lithification***. Pre-flood sediments should have undergone lithification just as all sediments do today. There is no reason to

expect global continuous miracles, so rates should have been similar to today. We would expect lithified rocks to behave through their history in predictable ways. If enough stress were applied, such rocks would have had to change in shape. This is known as deformation. We find deformed rocks commonly in the rock record. We find rocks that are deformed by folding and others that are faulted (Figure 4). Both YE proponents and conventional geologists recognize that solid lithified rock cannot be folded in a few thousand years. With from six thousand to a maximum of twenty thousand years since creation week available to deform rocks, we can say something about how these rocks would have been deformed. If lithified solid hard rocks are to be folded, this demands very long timeframes. Just as warm rubber will bend easily, very cold rubber is said to be *brittle* and will break when force is applied to it. Brittle lithified rocks would have deformed by faulting as opposed to folding. In the YEC model, if rocks were created as "mature" lithified rocks, these would only have been deformed by faulting because no time would have been available for folding them. Any folding of these or later sediments had to have taken place while the sediments were soft, by a process known as *soft sediment deformation*. We will look at this issue in more detail later using both examples and theoretical studies and experiments.

I said that we will not use radiometric dating to evaluate the YEC model, but one really would expect that all carbon fossils and igneous rocks formed during this period should really date from the period of 2500–4000 BC or something perhaps slightly older. It is really hard to understand why this would not be the general rule for the rocks formed during this period. Rocks that were "created mature" might have any range of dates, but it is hard to understand dates of millions of years from younger rocks.

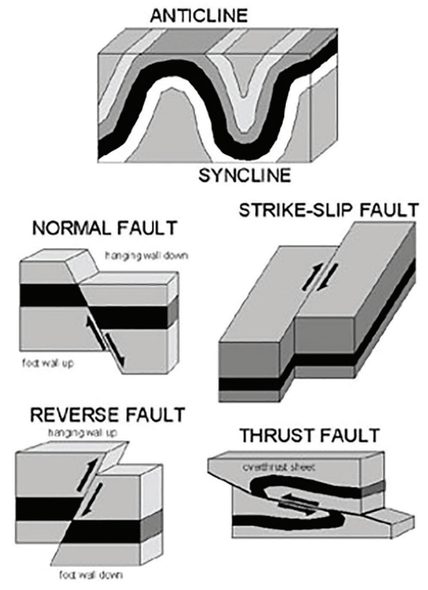


Figure 4 Drawing of basic types of folds and faults (Wikipedia)

Unit 3 Flood Deposits

Duration: One to a few years

Unit 3 consists of deposits that resulted from Noah's flood, including strata formed during and soon after what Genesis describes as a totally unique event. Christians interpret this scripture in a number of ways that range from a dominantly natural event timed by God to a dominantly miraculous event. A miracle in this sense would have been an event in which God deliberately set aside the natural laws to intervene, wholly or in part, with no physical or natural cause. How would such a miraculous event appear in the geologic record? Miracles have been described as being somewhat like a pebble thrown in water. Immediately and physically nearby, the ripples are large and evident, but as one moves away, both in time and distance, the ripples get smaller. For instance, when Jesus brought Lazarus back from the dead, the miraculous event was instant and dramatic. Afterward, the normal laws of nature resumed and Lazarus eventually succumbed to normal processes and died.

> A catastrophic global flood should have left deposits that were very distinct from normal sediments.

Miracles associated with the flood would have been brief but followed by processes acting with the normal physical laws. The geologic impact of the flood over the area it covered would have been abrupt and dramatic. If it was global as all YEC agree that it was, then the dramatic geologic impact would have been global, synchronous (stratigraphically occurring at the same time) and dramatic. Whatever the effects, the record of such a global event should be unique in the record. It definitely would not have been business as usual.

"Flood geology" texts have many interpretations of what processes were included and what the deposits might look like. These include

1. tremendous erosion from rainfall (Whitcomb and Morris 1961; Snelling 2009),
2. enlarged ocean basins (Whitcomb and Morris 1961; Snelling 2009),
3. volcanic and seismic upheavals causing tsunamis (Whitcomb and Morris 1961; McIntosh 1997; Austin et al. 1994; Snelling 2009),
4. mountain building (Whitcomb and Morris 1961; McIntosh 1997; Snelling 2009),
5. plate tectonic movements (Austin et al. 1994; Baumgardner 1994; Snelling 2009),
6. large-scale formation of fossils (Whitcomb and Morris 1961; Huse 1983; Snelling 2009),
7. fossils *hydrodynamically sorted* (sorted by size and density with the biggest and densest on the bottom overall; Whitcomb and Morris 1961; Snelling 2009),
8. vertebrates higher because of their greater mobility (Whitcomb and Morris 1961; Snelling 2009),

9. large-scale buckling and folding of soft sediment (Whitcomb and Morris 1961),
10. large deposits of coal from floating concentrations of organic debris (Whitcomb and Morris 1961; McIntosh 1997; Huse 1983; Snelling 2009),
11. floating forests becoming coal (Scheven 1990),
12. sediments deposited by catastrophic processes (Whitcomb and Morris 1961; McIntosh 1997; Snelling 2009),
13. "slabs of oceanic crust broke loose and *subducted* [pulled down under other slabs] along thousands of kilometers of pre-Flood continental margins" (Austin et al. 1994),
14. "substantial modifications to the thickness of the pre-Flood crust" (Austin et al. 1994),
15. precipitation of salts, anhydrite, and carbonates (Austin et al. 1994),
16. large-scale transportation of ocean sediments onto the continents (Austin et al. 1994).

What kind of basic stratigraphic relationships would one expect to result from a global flood where the water raised and fell in one year? The first stage would have been the rising flood waters. What kind of stratigraphy results from a rapid rise in sea level? Geologists interpret sea level to have risen repeatedly through time, and we have generated scale models to help understand what happened. However, compared to normal processes, the rise associated with the biblical flood would have been geologically instantaneous. The deposits that we generate today in models with rapid rises in the water level include beaches and deltas that move landward as the water rises. Such deposits take years to develop. In a rapid flood like the YEC flood, we would not expect to see the normal backstepping of environments because of the pace. Normal processes could not adjust to changes at such a pace.

The forty days and nights of rain would have produced erosion but perhaps more significant would have been the erosion that should have occurred during the dramatic dropping of sea level, as the seas returned to their normal position. One would expect an unconformity in the areas exposed and one might expect to find a large wedge of sediment that was deposited during this fall in sea level. We know what normal storm deposits and sediments from sea level drops look like. Deposits are typically chaotic. Sudden collapses would have led to stacks of sediments deposited by gravity in bodies of water known as debris flow deposits (*debrites*) and *turbidites*. Sediment deposited like this have distinctive characteristics that are readily recognizable. Such sediments are formed today when sediment on the continental shelf collapses and moves down the slope to a lower final resting place. The scale of such deposits from the YEC flood would certainly be larger in aerial extent if not necessarily in thickness. On today's ocean floor, turbidite deposition is organized into large fan-shaped systems known as deepwater fans (Figure 2). Organization of such deposits typically takes time. Channels, whether onshore or in deep ocean settings usually develop ***levee*** systems and channels that are ***sinuous*** and ***meander***. These types of features are observed to change through time, and this development implies significant time, well beyond one year.

Before we began to send satellites into space, there were all kinds of speculations about what the surface of Mars was like. Once we had satellite photos and landed rovers, we found there it was different in ways that we could not have predicted. Similarly, we would not be able to predict all the

features from a global flood such as in the Genesis account. Such a large, unique event would look different from the smaller floods that we analyze from historical times, at least in some respects. Even so, some things just logically would not be part of a global flood deposit. Finding one of them would be like finding an MP3 player in an "ancient rock." You would immediately know that the rock was not really ancient. Similarly, regardless of what else went on during the flood, it is hard to imagine large deserts or glaciers or normal swamps. If we recognize and can clearly identify features in a portion of the rock record that are patently inconsistent with a large flood, then we can rule out those portions as being part of Unit 3 as described by "flood geology." Here are examples of characteristics that cannot be part of this unit, most of which will be discussed in greater detail later:

1. No deposits that would be indicative of arid environments. Examples would be *playa* or *sabkha* deposits or *subaerial* dunes or indicators of desert environments. A global flood would be anything but arid.
2. No paleosols. Soils do not develop in one year, let alone during a flood.
3. No subaerial footprints. Tracks from animals walking around on land in a flood would be hard to justify. One might suggest that the base of flood deposit might have tracks from animals escaping, but certainly not out of the later deposits.
4. No subaerial volcanics. One could certainly speculate that lava flows could have taken place beneath the flood, but such lavas would have formed as "pillow lavas." Water-born deposits would be associated (Figure 5)
5. No thick *bioherms* or reefs. Such calcareous accumulations of organic debris take much longer than one year to form.
6. No other lifeforms preserved in growth form. Trees in growth position could not have grown there over less than one year.
7. No rain prints unless somehow preserved from the earliest days of the flood itself.
8. No shallow *tidal deposits*. Stacks of tidal deposits such as we find today on beaches and other near shore deposits are not consistent with global catastrophic processes.
9. No glacial deposits. Glaciers would have either melted or at least stopped growing during a global flood.
10. No lacustrine (lake) deposits. A global flood would have covered any lakes that existed before it.
11. No swamp or marsh deposits. Swamp and marshes deposits would not be part of a global flood.
12. No major changes in the type of lifeforms. If all the animals were on the ark, then all modern animal types were alive from the start of the flood. Fossil forms should be randomly distributed throughout.
13. No restricted marine deposits. Such deposits form when a basin is isolated from open oceans. During a global flood, such restrictions would not have happened.

In fact, logically all that would have to happen would be for geologists to show is one feature or bed or even aset of beds that took over one year to form and the "flood geology" theory collapses, at least for rocks in that stratigraphic unit. As with the earlier period, this report will not base its conclusions on radioactive dating, but one should expect a pretty random pattern of dates from sedimentary flood deposits. However, if volcanic rocks were formed during the period, I see no reason why they would not give dates consistent with 4,500 years ago, if the samples are good. Plant remains certainly should give carbon14 (^{14}C) dates of that age.

If geologists show one feature or bed or set of beds that took over one year to form, then the "flood geology" theory collapses, at least for rocks in that stratigraphic unit.

Some authors suggest that in the period shortly after the flood, conditions were very unstable. This would have been somewhat transitional, but Genesis indicates that once Noah left the ark, there were trees and perhaps even a fairly normal setting. Maybe the argument could be made that deposits from the end of the flood were eroded away during this transition period.

Figure 5 Basalts deposited under water are distinct and recognizable. The left photo shows pillow lavas forming on the ocean floor today (National Oceanic and Atmospheric Administration 2002). The right photo shows ancient pillow lavas from New Zealand (reproduced by permission of Nicolas C. Barth [Barth 2011]). One would expect if the ancient volcanics were all deposited under flood waters, many such pillow lava deposits should be found.

Unit 4 Post-Flood Deposits

450 to 4000 years

Many of us remember the reports of the massive earthquake and tsunami that hit Indonesia on December 26, 2004. Those there experienced a catastrophe that forever changed normal for them. Even so, from the standpoint of nature, normal processes resumed fairly quickly. Rivers ran, tides resumed, and nature went on. Following a global catastrophe such as the Genesis flood, waters would have receded, and at some point, the system also would have stabilized. Rocks formed after the waters stabilized are known as Unit 4 in this stratigraphic column. Normal deposition would have taken place as well as normal volcanic eruptions and earthquakes. Eventually we would come to a level where there will be a general consensus about the age of strata regardless of one's view of Genesis. We will look at how we might recognize such a level in different settings. Such a layer or stratigraphic level, though somewhat arbitrary is defined for this analysis to represent the top of the unit 4 post-flood deposits. The depositional processes and rates that were active during the deposition of unit 4 would presumably have been generally much like what we have today. No tremendous changes or miraculous events that would have affected global geology are described in the Bible. Any postulated accelerated erosion or such associated with the immediate aftermath of the flood should be included in the unit 3 flood deposits as considered here.

> If normal processes resumed after the flood, then normal rates and processes should account for all rocks after the flood.

The time included in this unit is given as a range because of the potential difficulty in agreeing on the stratigraphic level where we can all agree on the age. Even these younger rocks don't necessarily come with ages written on them. Unless we find something like a coin with a date stamp, there is some ambiguity. Even so, that degree of precision probably isn't necessary for our purposes here. If we were talking about the Middle East, we could consider dates for the pyramids as archaeologically agreed on units. Accepted dates for the early periods of the Egyptian dynasties begin 3000 to 3400 BC. Abraham is typically dated to 1900 to 2000 BC by most biblical scholars (Kitchen 2003).

Whitcomb and Morris proposed a date of 2167 BC for Abraham's birth but that is older than most modern scholars accept (Whitcomb and Morris 1961). Matt McClellan summarizes the views in his document "Abraham and the Chronology of Ancient Mesopotamia" (McClellan 2012). Most would agree that we can confidently date archaeological material as being from that general time and identify the associated strata from that period. Thus we can understand in general terms how much sediment was deposited since then and how the land has been shaped.

In this report, the study area from Texas, New Mexico, and northern Mexico will be used. There can be some uncertainty in dating things in Texas without radiometric carbon-14 dating, though the same principles and general rates should apply. When can we agree that the recent period begins

in Texas? We will look at this in more detail later, but we know that five hundred years ago when the Spanish Conquistadors arrived, the landscape and coastlines were very much like they are today. Most would agree that that was also true at the time of Christ, two thousand years ago. The same general modern landscape would have been present in America just as we know it was in Europe, northern Africa, the Middle East, India, and China where written records exist. It really would be hard to explain why it would have been much different at least back to the time of Abraham in 1900–2000 BC.

Dating events in this time period can be a challenge without using carbon-14, but there are other means. Consider dendrochronology or tree rings. The oldest living trees in America go back 5062 years[9] (Rocky Mountain Tree-Ring Research, n.d.). Dendrochronology provides calibration for 12,400 years (Reimer et al.). If there is a case that large changes in landscape have taken place in the last four thousand years in North America, then the onus must be on the YEC to demonstrate this.

If unit 4 deposits are a set of sediments overlying the flood deposits, deposited at normal rates and by normal processes, what else might we expect? Flora and faunal remains should be essentially uniform throughout. Some have suggested that some of the creatures on the ark might have found the brave new world pretty uncomfortable. Even if some creatures died out, surely all the life existing today should have been there since the start. That means that modern forms of plants and animals should be found throughout the rock record from this period.

[9] Before this oldest tree started growing over 5000 years ago, a lot of geologic events had taken place. It is worth considering the history and all that is recorded there before this tree even sprouted. This tree is in the White Mountains in eastern California. The mountain range includes Paleozoic sediments that range from Cambrian through Devonian in age. (Nelson, Hall, and Ernst 1991) These rocks include classic Cambrian deposits with the wonderful explosion of life and the some of the earliest reef deposits known. They include tidal deposits and mudcracks in rock that was deposited as sand, buried and lithified into sandstone and metamorphosed into quartzite. The rock was involved in three phases of mountain building. In the Jurassic, granitic plutons were formed. During the Cenozoic, the region was uplifted and eroded deeply and many volcanic eruptions took place. Then the area was uplifted again in the late Cenozoic with much folding and faulting. Then 5,062 years ago, one of the oldest of the trees that they have dated so far began growing. This all would seem to demonstrate tremendous amounts of time before the tree even started growing.

Unit 5 Recent Deposits

Zero to 4000 years

The youngest section is obviously the one we know the most about. Geologists know tremendous amounts about the packages that have been deposited during recent times in many environments. We have studied the depositional processes and rates in hundreds of settings. We know the flora and fauna and the environments in which they live and how their remains can at times be preserved. Using the old world as an analog, we have historical records from many, many sources to provide further calibration. Sediments from this interval, while typically thin when compared to the rest of the rock record are important as a basis of known to compare to. They are the most confident calibration that we have.

We can say that in general, using Abraham's period as a beginning, we know what four thousand years of normal processes look like. This will help to understand the unit 4 deposits.

4 Evaluation Dataset: Texas (and New Mexico and Northern Mexico)

The next step is to compare the YEC predictions to the rock record. We could do that in many parts of the world. An interesting comparison would be to take the UK, where the study of geology began. Another possibility would be to take a part of the Middle East, where the Bible was written and human history extends back such a long way.

Several YEC authors try to make the case that the Grand Canyon area in Arizona can be made to support their case. Unfortunately, I have not personally worked the geology in any of these areas in enough detail to be comfortable writing about them. Again, I would highly recommend the book *The Grand Canyon: Monument to an Ancient Earth* to understand the Grand Canyon story. Even so, I believe that the area that I have chosen gives an even more complete comparison, plus it is an area where I have worked extensively. The area chosen is sizable, including the states of Texas and New Mexico, part of northern Mexico and the western Gulf of Mexico out to the Sigsbee escarpment, approximately 180 miles (300 kilometers) offshore. A few examples will draw on the surrounding area but most will be taken from this study area. In interpreting the Bible, there are dangers in basing too much theology on one isolated verse. In science, there can be dangers that come from trying to study a small dataset or a small area and extrapolating those data to make global, large scale conclusions. One has to ask, is the area is really representative? The area chosen here should be large enough to avoid that danger. The area includes over two million square miles (greater than three million kilometers square). It is true that there are great examples from other areas, but this area is exceptional from many standpoints. YEC authors, for some reason, often claim that you cannot go to any one location and find the complete stratigraphic column of the geologic rock record there (Austin 2012; Huse 1983; Whitcomb and Morris 1961). If earth history does include over four billion years and a complex interaction of tectonics and sedimentation, then it should be impossible for any one site to have a complete record. This study area, when considered as a whole has one of the most complete records in the world with a tremendous amount of data of many, many different types. Figures 6 to 9 show the area, using standard geological names for the

age of the strata. The maps are colorful and can seem strange to the non-geologist. The geologist can use them to see much about the history of the area. The maps are colored by strata names that tie back to European strata where the global geologic stratigraphic column originated. Each major unit has a "type section" in Europe where it was first defined. The linkage back to those strata is based on fossils. A later section will talk more about fossils themselves. This section of this book will consider this study area alone, and so in that sense, these are just names for strata. The ***correlation*** of these strata to others around the world is a bigger topic than needs to be covered here. We can evaluate "flood geology" using just the strata here, so the relationship to other areas is not important.

It is time to discuss a bit of geologic terminology. Geologists distinguish between talking about a set of strata, the rocks themselves, versus talking about the time that it took for them to be deposited. Over this area, we can talk about a particular time during which the rocks were laid down, regardless of its length in years and we all know what strata are involved. Just as we all divide up time into weeks, days, hours, and minutes, geologists divide up the time that strata represent into eons, eras, periods, and epochs as shown in Figures 7 and 10. Geologists and the YEC may differ on how much time is involved, but one can still use the same name for the time involved. For instance, if we are talking about a set of strata that we call the Cretaceous strata, we would call them the Cretaceous ***system***. That system of strata took some amount of time to be deposited. Regardless of its actual length, the geologist would refer to that time as a *period*. This is really useful terminology in this discussion because we can talk about the time of the Cretaceous Period and we all know that we mean the period of time when the same rocks were formed. The strata themselves are divided into eonothem, erathem, systems, and series. In describing the geology in the study area, the physical distribution of the strata, this terminology allows us to discuss particular rocks, regardless of how the rocks correlate to other parts of the world. In this area, the order and relative age of the rocks is really well understood and rock from almost every geologic period is well represented. New Mexico, West Texas, and central Texas have good exposures of the older rocks, known as the Precambrian. The rocks overlying them, the Phanerozoic eonothem strata extend over most of the area, including New Mexico, Mexico, and Texas out to the middle of the Gulf of Mexico. In southeastern New Mexico and West Texas, rock deposited during the first era of the Phanerozoic, the Paleozoic strata filled up what was a major basin. These are demonstrably physically overlain by the next erathem, the Mesozoic strata, thus proving that the Mesozoic strata are all younger than the Paleozoic. The next erathem, the Cenozoic strata are easily demonstrated to physically overlay the Mesozoic and so are younger yet. The whole stratigraphic column is represented, from the Precambrian to the present. The order of deposition for all the strata is really clear.

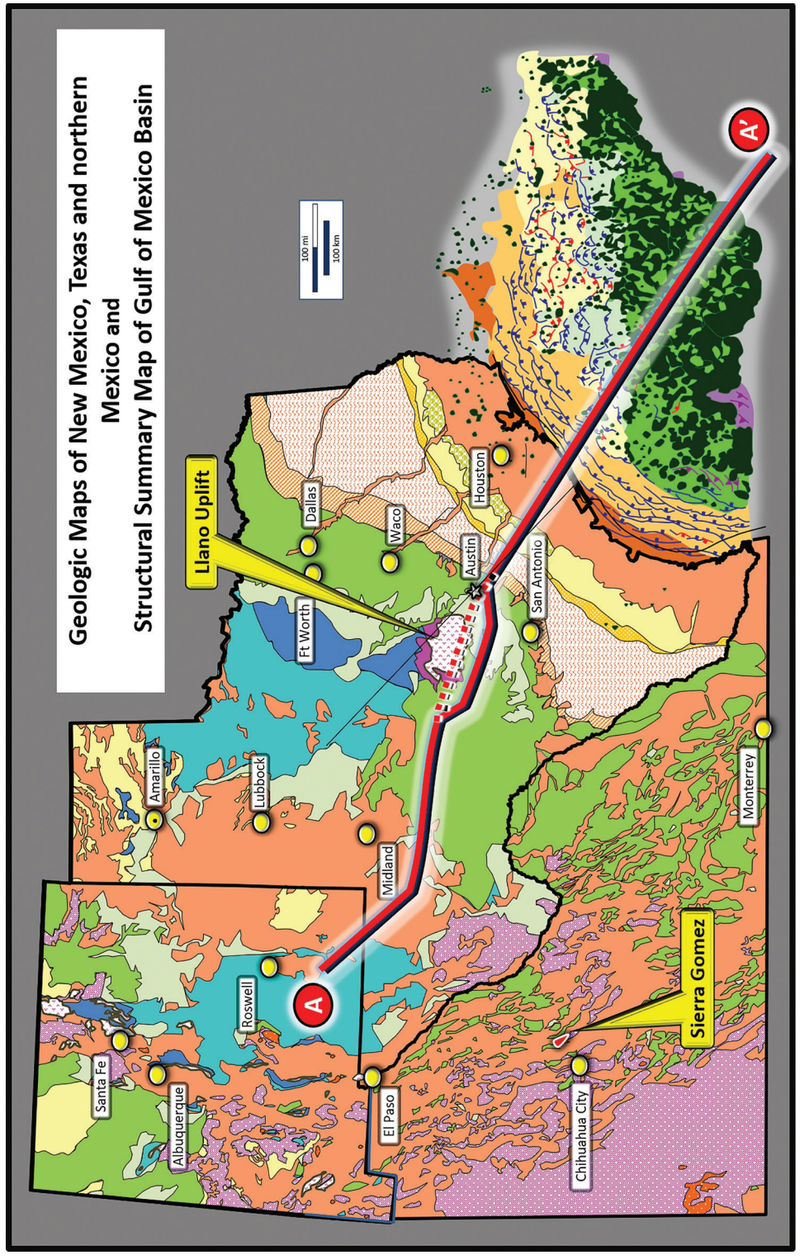


Figure 6 Geologic maps for New Mexico, Texas, and northern Mexico show the surface geology over the onshore area. Offshore, the map shows the structural provinces from that area. The location from the A-A' profile is shown in the solid red line. The dotted red line shows the location of two of the source profiles used in the construction of A-A'. The profile was drawn around the area to emphasize the clear way the Cretaceous overlies the Paleozoic section (Texas BEG 1992; NM 1965); Diegel et al. 1995).

Explanation for Geologic Maps and Cross-sections

Onshore

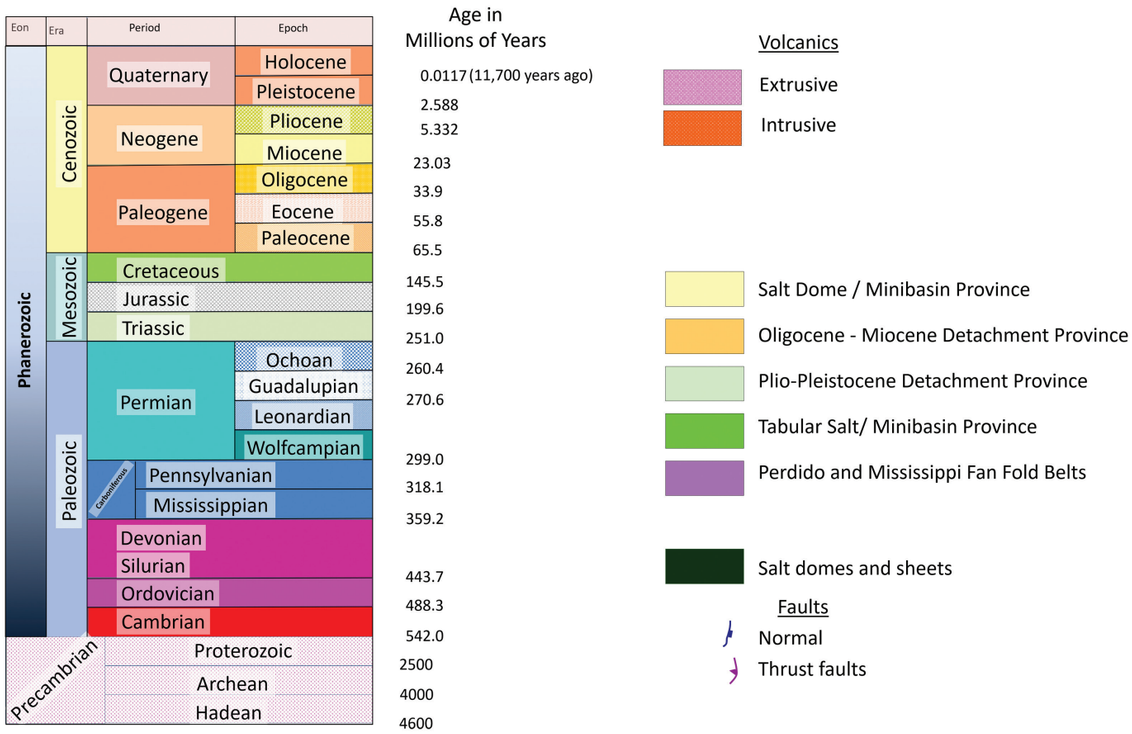


Figure 7 Explanation for geologic maps

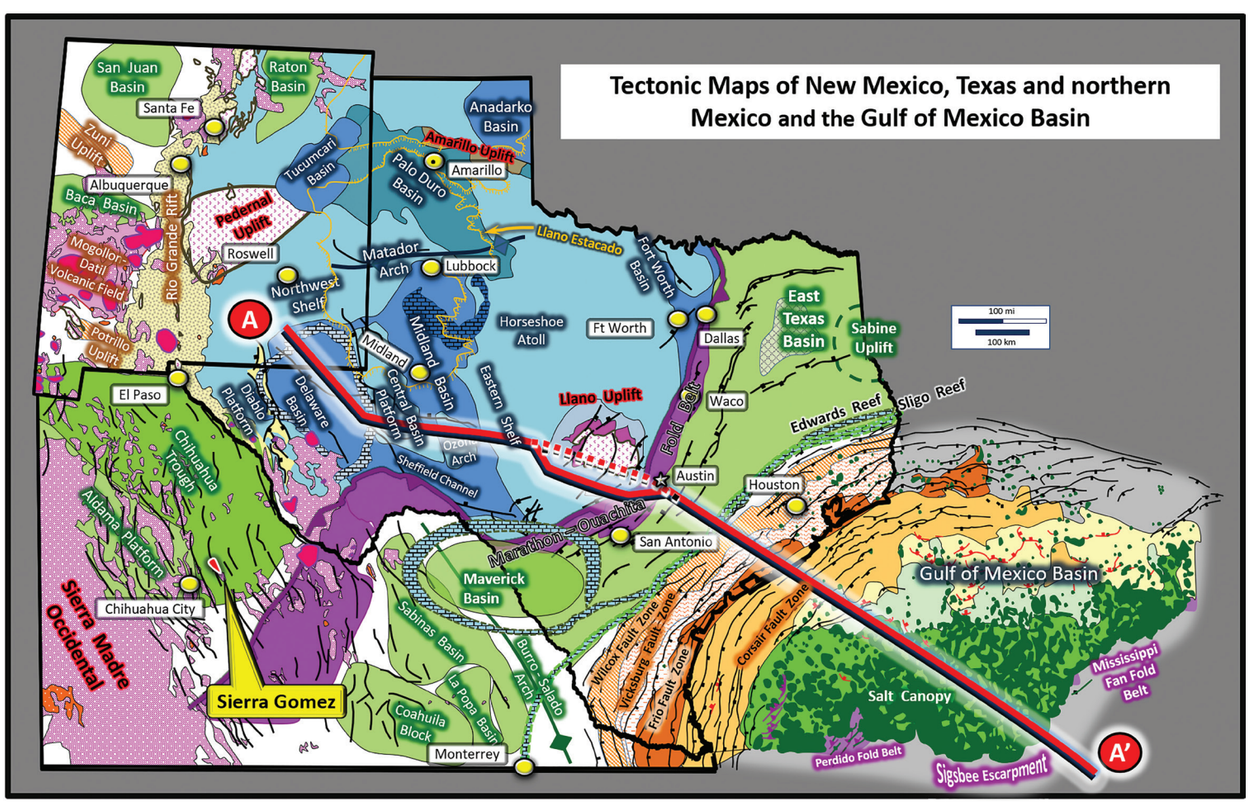


Figure 8 Tectonic maps for New Mexico, Texas, and northern Mexico show the large structural features like basins and largest faults. The location from the A-A' profile is shown in the solid red line. The dotted red line shows the location of two of the source profiles used in the construction of A-A'. (BEG 1997; NM 1965; Diegel et al. 1995; Henry and Aranda-Gomez 2000; Goldhammer 1999).

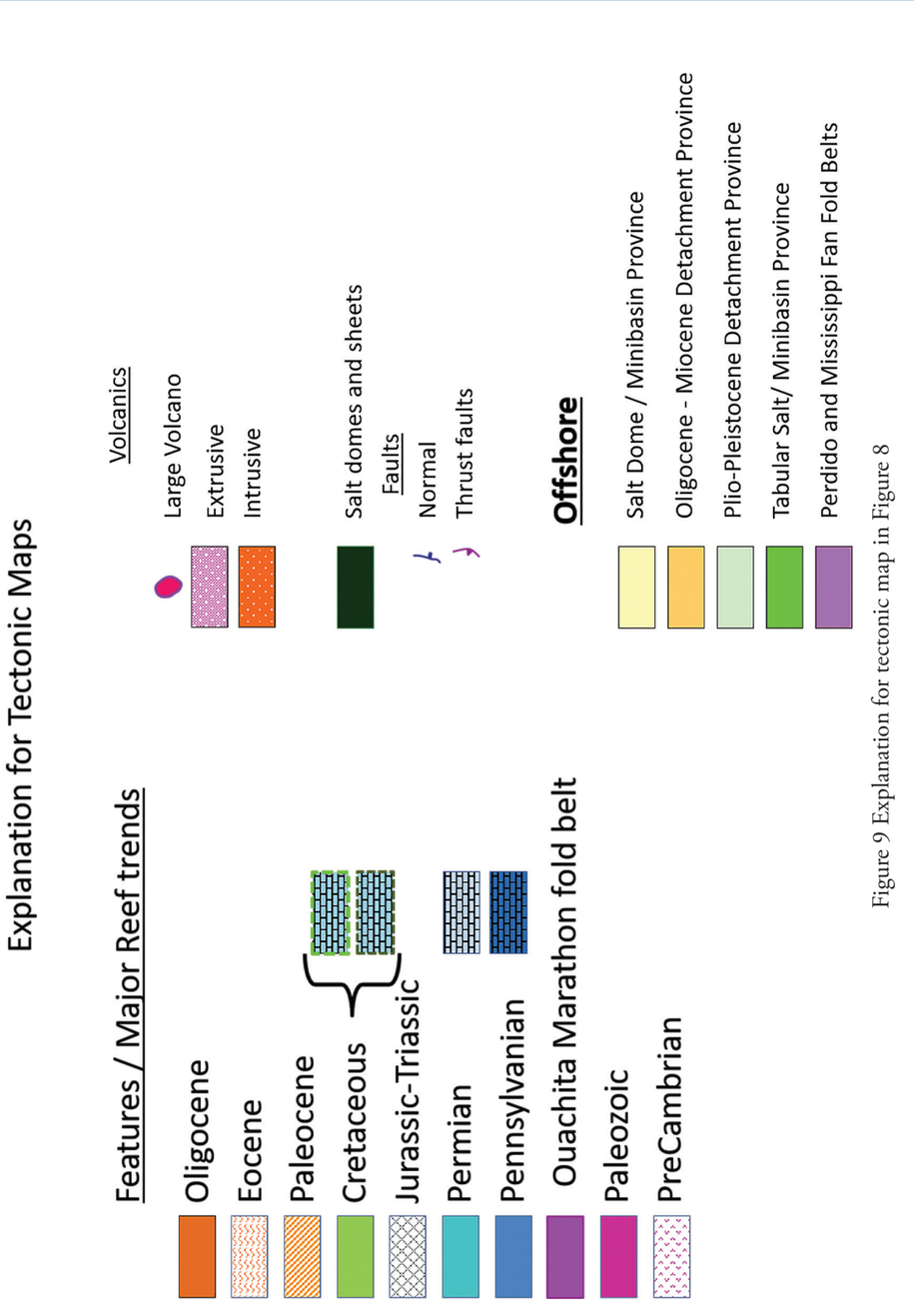


Figure 9 Explanation for tectonic map in Figure 8

Units used in geochronology and stratigraphy			
Segments of rock (strata) in chronostratigraphy	Periods of time in geochronology	Number recognized	Conventional Geologic Duration
Eonothem	*Eon*	4	half a billion years or more
Erathem	*Era*	10	sereral hundred million years
System	*Period*		several tens of millions of years
Series	*Epoch*		up to tens of millions of years
Stage	*Age*		millions of years
Chronozone	*Chron*		smaller than an age/stage

Figure 10 Terminology for time and rock units used by geologists. When we are talking about a set of strata, we may disagree on how long it took to deposit them. However, by talking about a period or an epoch, we can all mean that the amount of time that it took for that strata to be deposited regardless of how long that was (adapted from Wikipedia).

Systems of strata deposited during each of the periods that make up these eras each have their own distinctive characteristics with their own depositional patterns and distributions that changed through the time over which these rocks were deposited, regardless of how long that was. Several of the periods have particularly interesting strata that are key examples studied by geologists from all around the world. The Permian rocks exposed in West Texas and New Mexico include classic examples of rocks that were deposited in particular environments that are amazing. If a set of geologists were asked where is the best place in the world to go and study a section to learn about ancient depositional environments, this area would definitely be on everybody's short list, if not number one. The stratigraphic section from the Cretaceous through the Pleistocene is expanded in a series of *depositional belts* that are well documented and have been studied in great detail. Some of these are classic expressions both in their depositional styles and the way the rocks were deformed by faulting and folding.

If you traced the layers of a vertical slab of rock running across the area, you would have we would term a "geologic cross-section." Figure 11 presents a generalized schematic cross-section across this area that runs approximately two thousand miles (3,200 km) long. It is colored by the relative age
of the rock and shows the styles and scale of sedimentary deposits present. The Phanerozoic section, the fossiliferous section above the Precambrian, gets to be up to about 7.5 miles (12 km) thick. The geology along this cross-section is tightly constrained by much data and is well understood. The surface geology has been mapped many times by many workers and the general framework is very solid. One of the major strengths of this study area is that the subsurface is also extremely well constrained. In Texas alone, the relative stratigraphic ages through the area are documented by over eight hundred thousand wells and thousands of miles of seismic lines! My own experience is fairly extensive in this area, given that I studied the area both in school and in the oil industry. This experience includes studying the Permian Basin and northern Mexico in graduate school at the University of Texas at El Paso (UTEP). I also worked West Texas in the oil industry at both broader exploration scales and at very detailed production scales. My experience also includes working the onshore south Texas area in oil exploration and for several years being involved in exploration and production in offshore Texas,

working both on the shallow water shelf and in deepwater. The wide variety of sedimentary rocks were deposited in a wide variety of depositional environments making the area geologically fascinating and the extensive igneous rocks provide even more features to study. Fortunately, much data is now available in the public domain, making it possible to present such a document as this. In particular, the Texas Bureau of Economic Geology (BEG) and the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) have published many, many reports documenting the Paleozoic, Mesozoic, and Cenozoic sections and the beautiful examples of environments there.

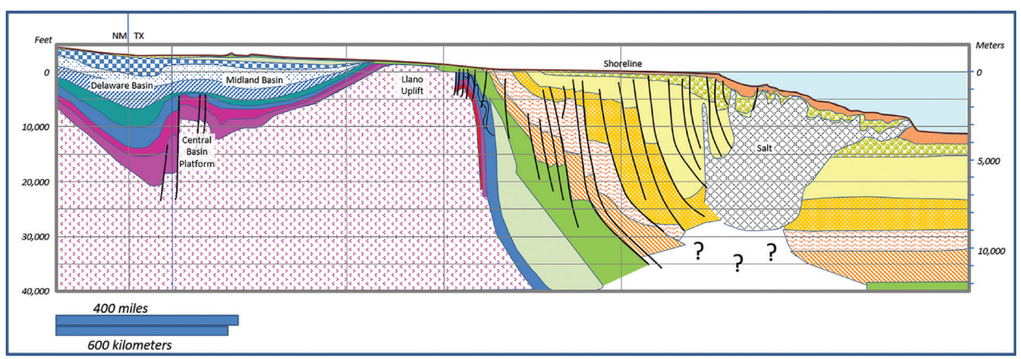


Figure 11 Generalized Cross-section A-A' Location is shown in Figure 7. The section compiles information from a number of sources including: Diegel et al. 1995; Ward, Kendall, and Harris 1986; Worrall and Snelson 1989; Renfro, Feray, and King 1973; Beaubouef, et al., 1999; Saller and Dickson, 2011. Please keep in mind the high degree of vertical exaggeration shown. If shown without vertical exaggeration, the lower section would be 30 times longer and features would look much flatter. The general understanding of the geology that this is based on is constrained by thousands of wells and thousands of miles of seismic. Across West Texas, though it is difficult to see, the green Triassic and Cretaceous units thin but are present all the way to the end of the cross-section.

Figures 6 to 9 and 11 summarize a vast number of observations from many, many geologists that detail the geology as told in the rock record. The relative age of the vast majority of these strata can be demonstrated using the basic rules of superposition and recognizing that a feature that cuts through strata is younger than the strata that it cuts. The general stratigraphic column is shown on the map explanation with the relative age of the units that we have found (Figure 7). The geologic map and cross-section show where the rocks are located in space with colorful patterns that tell much about the history of the area. The geologic map shows the relative age of the strata that are found on the surface. The cross-section shows the age and structure of the rock interpreted to be in the subsurface beneath the line and is ultimately based on well and seismic data. One observation from the cross-section is that it is at a large scale, organized, and layered. We will see this at smaller and smaller scales. The overall processes that caused the rocks to form was systematic, not chaotic. The oldest

rocks are in the northwest and in the area labeled as the Llano uplift, getting progressively younger to the southeast.

The geologic history of the area took a long time to be worked out, but the last thirty years have provided a great deal of new information. Maybe this illustration will help you to appreciate how this new data helped. Imagine this scenario: You are one of a group of people charged with mapping and describing in detail the insides of a large chamber that is roughly the size of the Superdome in New Orleans. I don't know if you have ever been in such a large stadium, but it is pretty impressive. Like the Superdome, your chamber is made up of many different levels and areas that are separated by various kinds of barriers. Inside this structure are many kinds of things that you have never seen before. Members of your team are given a few minutes at a time to go in to make and record observa- tions. Your group is charged with putting together maps of the chamber and explaining the contents and how they came to be.

This could be a relatively simple exercise, but your team has a couple of limitations. First, the huge chamber is completely unlit. It is so black that nothing is visible. In itself that would make the task impossible but your team is given special lamps to carry, but they can only illuminate things that are at most three feet ahead. Your team diligently works on its task and puts together a set of maps and descriptions. Then one day, a breakthrough occurs. Lights begin to be strung through the entire chamber, first as long strings of lights and then as small flood lights that begin to show bigger and bigger portions of the chamber in great detail. Now for the first time, you can walk in and see the whole chamber. Relationships that you had to work hard to understand are now totally clear. At first you might be very nervous. Big mistakes might have been made and your maps and understanding would all be obviously wrong.

This picture is analogous to what happened in the subsurface of this study area with the lights beginning to come on with new geologic information available from the 1980s to the present. A lot of tremendous work was done in earlier years, but the workers were a bit like our intrepid mappers in the story above. It was difficult to see the whole picture. Surface geology provided a great picture but had some major limitations. The picture of the subsurface is always pretty limited when it is based only on what we can see at the surface. Like most areas, this study area also had a lot of it covered by cities, forests, and fields. Oil well drilling provided some very detailed information about the subsurface. It included occasional sizable samples of rock in the form of cores—round tubes of rock cut by special diamond-tipped bits and brought to the surface. Detailed geologic correlations eventually came together for a good picture of the subsurface. Reflection seismic profiles provided pictures of the geology between the wells and a lot could be seen, including faults and depositional geometries. At least that is true today. Early seismic lines were often pretty poor quality. We were a bit like the apostle Paul because we could see but only partially (1 Cor. 13:12). Onshore seismic data into the early '80s was usually especially poor. It also did not image very deep below the surface. Another major limitation also was just the length of the lines available. Onshore typical seismic lines were three to five miles long. Really long lines might be ten to fifteen miles long. It was difficult to really see the big picture. I remember the first long lines that I saw from West Texas. It was like someone had turned on the lights. It is still difficult to get long lines, but they are now available and they have

also improved in quality. Such long lines often show overall relationships very clearly that could only be inferred before.

Offshore, the story has similar themes. The offshore Gulf of Mexico in US waters is divided up into three-by-three-mile blocks that the government leases for oil exploration. Until 1983, companies would request particular blocks to be offered up for them to bid on to lease. Once the blocks to be licensed were announced, companies would go out and shoot focused seismic surveys over the blocks. Lines were typically short, often ten to fifteen miles (25–30 km) long. They were longer than the typical onshore lines but still not long enough to really appreciate the whole basin. In 1983, the government changed its licensing strategy. The whole continental shelf was put up for license. Seismic companies shot long regional seismic grids that covered the entire continental shelf. Again, it was like the lights came on. We could really see stratigraphic and structural relationships as a whole where before we could only get glimpses. We could now correlate directly around faults that we had difficulty getting around before.

Correlations based on biostratigraphy might in theory have been proven totally wrong when the new data came in. That clearly was not the case. The stratigraphic order was confirmed resoundingly. The depositional picture generally confirmed what was interpreted before but with many new details that could not be resolved from just well control.

When Whitcomb and Morris published the classic YEC book *The Genesis Flood* in 1961, they claimed the geologic stratigraphic column was determined by fossils and inherently linked to the assumption of evolution. A column generated in this fashion would be useless to prove evolution because it would have used circular logic. From the standpoint of our study area, the data available in 1961 were so much more limited than today that it might have been difficult to defend the big picture. A lot has changed since 1961. One example is our understanding of the process that forms mountains. Despite the fact that geology was already 170 years old,[10] in the ’50s and early ’60s geologists still just did not understand how and why mountains develop. Much of the rock that makes up mountain chains was clearly deposited in deepwater settings. Why was it folded and crumpled up to form mountains? What type of mechanisms would drive such a large effect? Whitcomb and Morris jumped on this. They said,

> In general, there are currently two main hypothesis of mountain-building. One depends on thermal contraction of the crust, the other on subcrustal convection currents. Another, the theory of continental drift is at present running a poor third. None of them is based on present measurable processes, but solely on hypothetical speculations which may or may not be meaningful. Proponents of the two leading hypotheses have each advanced arguments showing the inadequacies of the other.

[10] There have been observations about the earth and rocks that could be considered geology since the ancient Greek days. In the 1790s William “Strata” Smith began work that led to the first geologic map of England. That is perhaps the beginning of stratigraphy and a work that eventually caused problems for Whitcomb and Morris.

Times have changed. Today most geologists consider what they termed the weak third option, continental drift and plate tectonics to be key fundamental unifying concepts in geology and see them as providing the how and why for many of earth’s features including mountains. A tremendous amount of work went into demonstrating its validity. A very large set of data from very different sources has convinced geologists that the continents have drifted around the globe over the course of millions of years. Near the end of this book, we will briefly look at documented evidence of Arabia colliding into Asia at a rate of 7.9 inches (20 cm) per year using modern GPS devices. The rate of this and other plate movements is quite consistent with radiometric dates, suggesting that the pace observed today is consistent with rates from earlier times. Using modern rates, we can extrapolate to just the kind of distances that we see continents have moved over the times that are predicted by radiometric dating. What was once a weakness for geology is today a strong argument in support of an old earth.

The Genesis Flood, of course, attacked the geological stratigraphic column. They wrote,

> Of course, it is maintained by many stratigraphers that other factors, especially that of superposition of the strata, are also important in geologic correlation and that these factors justify the usual assignment of ages to strata on the basis of their fossil contents. The usual situation is that only a few formations are ever superposed in any one locality and that it is very difficult or impossible to correlate strata in different localities by this principle of superposition. The fossils must be resorted to, and the fossil sequence is assumed to accord with the principle of evolution. Furthermore, even where superposed strata are exposed, it rather often happens that the fossils appear to be in the reverse order from that demanded by the evolutionary history, which paradox is commonly explained by the assumption that the strata have been folded or faulted out of their original sequence?

Information from wells and seismic surveys give good reason to say that today we can be confident that the order of the stratigraphic column in our area is demonstrated from top to bottom by superposition. The only large area where the stratigraphy relies solely on biostratigraphy is out in front of and the below the salt of the Sigsbee Escarpment in the Gulf of Mexico (Figure 11).

Geologists have worked extensively to understand how the sedimentary rocks in the study area were deposited. Many of the best examples of ancient environments that were very similar to modern analogs come from this study area. *The Genesis Flood* stated

> Of special significance is that fact that modern sedimentary environments can rarely, if at all, be identified with any certainty [in ancient strata]. Although uniformitarians may question this statement, it is substantiated by the fact that there have been so many different schemes advanced for classifying ancient sedimen-

tary environments, none of them yet generally accepted. Only very rough classifications can be made, such as "marine," deltaic," etc.

There might conceivably have been some basis for saying that in 1961 but so much has been done in the last fifty years that that is far from true today. Even in 1961, much good work had been done in Texas.

Today we can see many, many one-to-one analogs that show that present processes have acted over and over again in the past. We will look at a number of examples later when we look at specific strata. Next, we will look at a few concepts to help and then describe the geology of the chosen area, particularly in terms of features that reflect the time duration and the rates things happened there.

5 Geologic Processes: Filling a Basin

A few years ago, my family had the pleasure of taking a friend from Nigeria to an American baseball game. It seems that anyone who grew up in America is familiar with the general rules and play of the game but having come from a country with no baseball, my friend had no idea what was going on. We needed to give him a brief description of the goal and the rules before he could begin to appreciate the game. Similarly, if you are going to understand how the rocks in tstudy area came to be and appreciate their story, it is worth taking the time to go over a few basic geologic terms and concepts to help. All around the world, there are pockets with very thick accumulations of sedimentary strata. Geologists refer to these areas as basins. Rocks are not just laid down as even sheets around the world or even across a basin. It will help to understand some of the terminology and concepts that geologists use to explain how sediment fills a basin. Both the geologic map in Figure 6 and the cross-section in Figure 11 document that strata get progressively younger toward the Gulf of Mexico basin. When the rocks were deposited during the early Paleogene (Figure 7; also called Tertiary), the coastline was far inland of its present position and ocean front property would not have been far from the present city of Dallas. The shoreline moved over time progressively toward the Gulf of Mexico basin through the Cenozoic era to its present position by a set of processes that together are known as ***progradation*** (Figure 12). In this study area and along most continental margins, rivers bring their load of sediment to the sea and dump it near the coast. When the river water runs into the sea, the velocity of the water flow slows, and a river delta develops. As the water slows down, first the water cannot carry the coarser sediment such as gravels and then coarse sand followed by finer and finer sediments. If river input remained the same and sea level stayed the same for long enough, deltas would naturally build across and completely fill up the basin. The story is always a bit more complicated than that, giving rise to many variations.

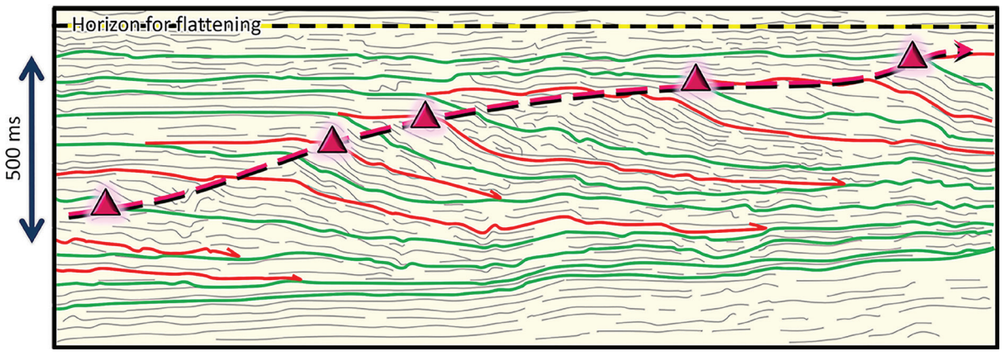


Figure 12 This is a tracing from a published seismic profile showing a set of sedimentary strata filling in a basin from left to right. This particular example is published from lake sediments in Hungary. It was chosen because it is a good example available online that shows a very typical pattern that is seen globally from sediments filling basins. On the left, the seismic reflectors are relatively flat and even, up to a series of distinct points, some shown in the upper figure with red triangles. At these inflection points, the reflectors turn sharply deeper and then flatten out. Sediments that develop this pattern are known as "clinoforms". Such inflection points always develop at about the base of where storm waves act on the sediments. As the sediments were deposited, the inflection points moved upward and basinward, to the right in this figure. The filling of the sediment upwards is called "aggradation" and the shift basinward is called "progradation". If the inflection points are mostly aggradational, we know that the basin was subsiding faster than sediment was coming in. If progradation dominates, then sediment was filling the basin faster than it was subsiding. Each new clinoform package built largely basinward of the last, because there is no space below water level for the sediment to go otherwise. (Sztanóa, et al. 2013)

Clinoforms are one evidence showing that the great thicknesses of sedimentary rocks in basins did not form by filling a deep hole or at least what started out as a deep hole. In most cases, the basin started out as a much smaller depression. The area had to sink over the time the rocks were deposited or to use the geological term ***subside***. There are a number of causes for this. Even man can cause some relatively small amounts of "subsidence" as we pull out large amounts of fluids such as oil and gas. Land above some oil fields has been documented to sink or subside. The physical weight of large amounts of sediment dumped by rivers can cause the earth's crust to subside. If a basin sinks faster than rivers can bring sediment in, then river deltas don't grow as far basinward and progradation goes slower. There is then interplay between subsidence and progradation that works to control how basins fill. This effect is documented over and over and must be accounted for, regardless of the time-frame proposed. These many cycles would seem very difficult to understand if little time is available.

We see subsidence and progradation taking place most actively on major river deltas. It is recorded in the way the deltas changed over time. Basic physics dictates that rivers always flow along the lowest and shortest path to the sea. As a river dumps its sediment, a delta forms. The area not being fed directly by the river sinks (subsides) deeper and deeper under the weight of sediment. Eventually what was once the optimal path for the river will no longer be the actual lowest and shortest path. Then the river will naturally change its course and switch to a new lower, shorter path. The water is always driven by gravity to reach the sea by the shortest, lowest path. Geologists have documented many times when rivers and deltas have switched, often over recorded history. One of the best documented cases in the world is the Mississippi River delta. The Mississippi River drains the largest river drainage area in North America (Figure 13). The river has not stayed in one place, but through time the river and its delta have switched back and forth (Figure 14). The whole area subsides but in the areas without the delta depositon, the subsidence wins and the area sinks. The river on documented occasions has changed its course and abandoned one delta and formed a later delta in a new place. The US Army Corp of Engineers has been controlling the location of the river ever since the Mississippi River Commission (MRC) was created by the US Congress on June 28, 1879. As a result, other areas such as the Atchafalaya swamp have subsided but the river did not switch to flow through them because of the federal control. Understanding this process of switching helps us when we examine older rocks and see evidence of the same processes. We see how evidence that ancient rivers deposited multiple delta lobes in one area and then eventually prograded forward to deposit new ones basinward.

Subsidence is not the only thing that affects how and where deltas form. Rivers that run to the sea are also controlled by sea level. Many lines of evidence show that sea level has not remained constant through time but has gone up and down by hundreds of meters over time. Some sea level rises and falls have been linked to climate and glaciations. Global warming and cooling are not new man-made inventions, though we may do our part to change their pace. The formation of the sedimentary rock that fills a basin is a constant interplay of sediment input, subsidence and the rise and fall of sea level.

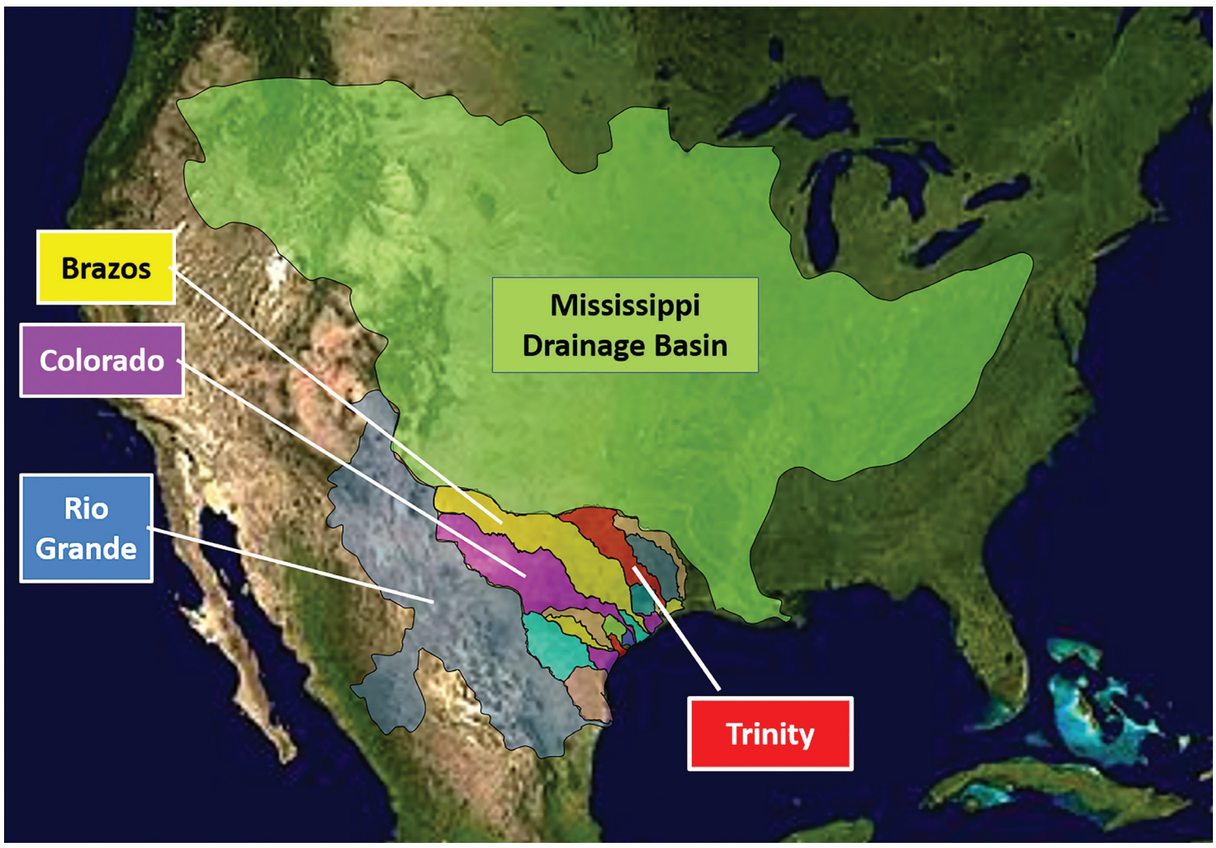


Figure 13 Mississippi River drainage basin and other river drainage basins in the study area. (Coleman 1988; Bureau of Economic Geology 1996)

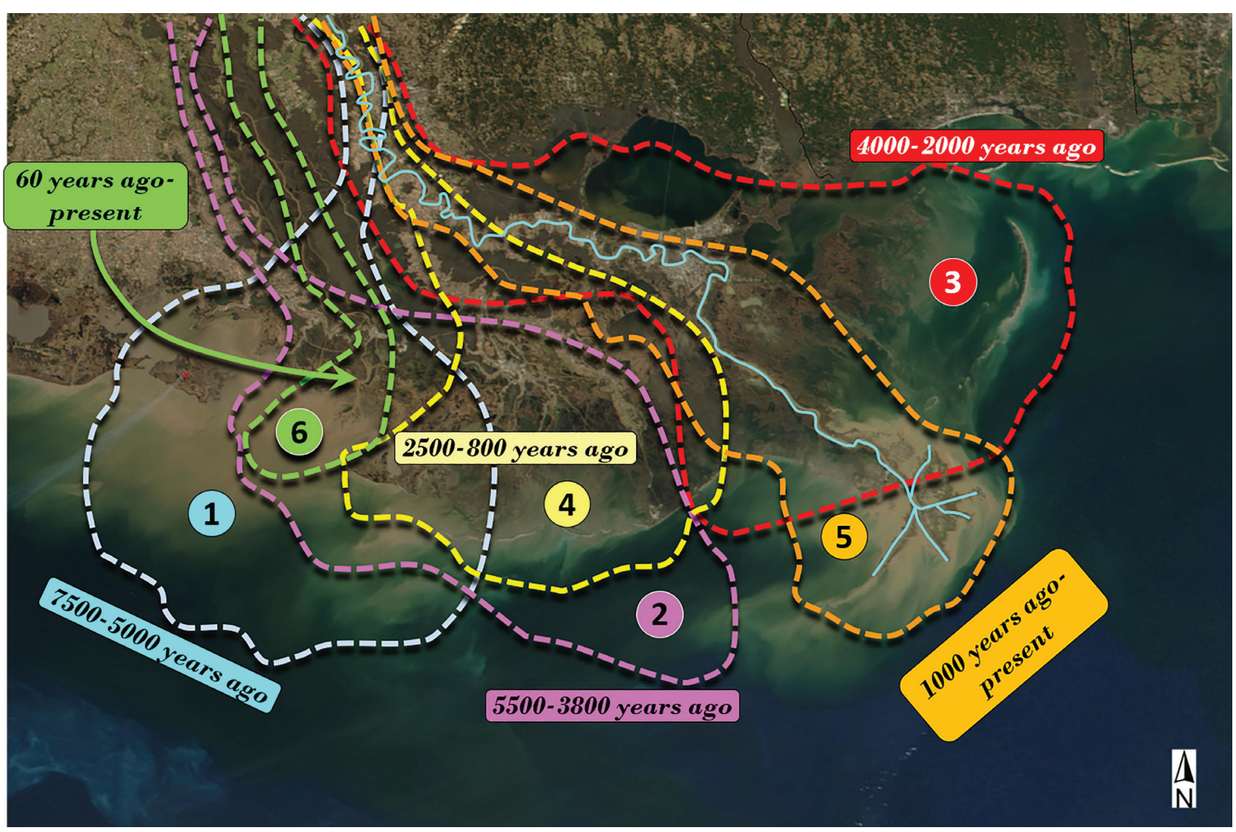


Figure 14 Mississippi River delta lobes numbered by the order in which they formed. (Coleman 1988) Each had a very similar order of events from the time they began until the point when they subsided.

Modern geologists have a better understanding of how sea level change affects sediment deposition, based on the study of regional seismic lines, well logs and physically modeling the depositional processes. Such models demonstrate that when sea level rises, sediment load never reaches the deepwater parts of the basin but forms a wedge of sediment that is deposited as river and delta deposits and associated shallow water environments (Figure 15). This all changes when sea level begins to drop. In these periods, rivers have to go farther to reach the base level, the sea. They begin to erode out the shallow water sand and move it to the deep water. This period of falling sea level is the time when most of the deepwater channel systems and submarine fans are believed to have grown. Such deepwater sand systems have been the target of much oil exploration in present day deepwater areas all around the world since 1990. We will look at such systems in this book's study area and what this tells us about their deposition and ultimately the time involved.

Both large floods and normal day-to-day sediment movement have the same primary force driving them. Gravity. It drives the process of moving sands and muds along rivers and streams toward the places where they are deposited. Gravity is predictable in that it always moves them toward the most stable, lowest position available. This position reflects the space available and in a basin, subsidence creates the space and determines the position for the rivers to deposit their load. If the sediment is coming in faster than subsidence creates the hole, then the sediment will prograde across the basin. If the sediment is coming slower than subsidence, then the hole will get larger and deeper. The type of sands and muds actually preserved to become rock in this hole is determined by factors such as the climate, the size of the rivers and the interaction between subsidence with sediment supply and the relative sea level in the area. The processes are clearly evidenced in the rocks and seismic. We can demonstrate how the processes work in other ways as well. Tanks known as *flumes* act as scale models to allow us to observe how sediment switches back and forth and reacts to the controls that we predict in nature. Mathematical models predict how sediment accumulates and can be viewed in two dimensions and three dimensions, providing visual demonstrations of how sediment preservation shifts through time.

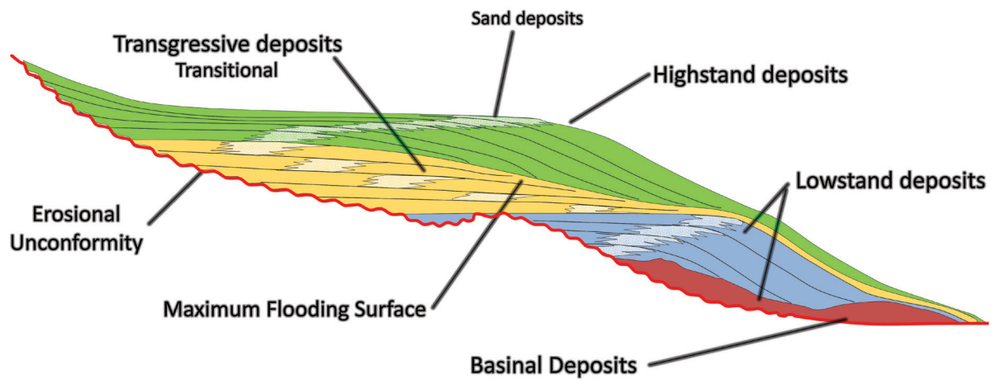


Figure 15 This figure was originally developed by Peter Vail and shows many of the key concepts in what is known as "sequence stratigraphy." It shows how sediment filling a basin responds to changes in relative sea level. It is termed "relative sea level" because whether the land goes up or the sea level drops, the sediments respond the same. When sea level began to drop, erosion took place along the red surface called a "sequence boundary" and lowstand sediments were deposited in the basin. As sea level rose, the beach sediments, in this case, sand moved landward and the transgressive sediments were deposited. As sea level reached its highest point, sediments here labeled "highstand deposits" were deposited. This process is repeated over and over through the geologic record. Local settings make the deposits take different forms, but the process is recognizable nevertheless.

Non-geologists often find it difficult to understand why at any one location, we do not see a complete record. YEC frequently use this as an argument to say there is too much missing time. At any one location, there is more time represented by nondeposition and erosion than is represented by deposition. Do geologists believe that rivers just don't flow for much of geologic time? Modeling sea level change versus subsidence has allowed us to demonstrate how sediments can be constantly brought to a basin and yet the sediment preservation will shift dramatically in response to the relative sea level and subsidence changes. We see that over the entire period of time of the rock record, rivers continued to bring sediment but where it was deposited and preserved changed. We understand that the gaps represent local erosion and *hiatuses*, periods of nondeposition. In some basins, with slow subsidence and little sediment input, the processes are slow but just because things happen slowly, that does not mean that nothing is happening anywhere in the basin.

So far, we have considered clastic systems with rivers that deposit gravels, sand, and mud. There are other types of sedimentary rocks. The study area rock record includes a lot of limestones and dolomites that together are known as carbonates. Limestones are chemically composed of calcium carbonate dominantly and dolomite is composed of calcium magnesium carbonate. These are not brought down by rivers unless those rivers are eroding older carbonates. How do they fit in? Are they controlled by the same sea level versus subsidence processes? These are linked even more directly.

Studies have demonstrated that neither of them are formed by precipitating from sea water, but are formed almost entirely by biologic activity (Wilson 1975). Most are deposited in shallow warm water within the photic zone. Sunlight provides energy, allowing algae to grow, and this is the hub of the system. Reefs don't grow up above the water, and if they are exposed by a sea level drop, they die. This means that deposition is always at or below sea level. Carbonate systems also require environments that are protected from too much sand and river mud. Just as with the clastics, the carbonates require space created by subsidence and their progradation is controlled by relative sea level. If a basin either subsides slowly or sea level rises slowly, then carbonate systems can prograde across a basin.

In both carbonate and clastic settings, we find evidence of sedimentary rock forming systems that prograded or stayed in position while getting thicker (aggraded) in response to sea level changes and subsidence. This is true in modern systems and in ancient systems as well. Any explanation for the rock record must explain this repetitive pattern of sedimentation that ties well with the concept of progradation and aggradation controlled by relative sea level changes. We will look at what these patterns tell us about the amount of time required for basins to fill in coming sections.

6 Fossils

Sedimentary rocks very often contain evidence of the life that was living when they were laid down. The fossils take many different forms, ranging from mammoth carcasses that have not changed much since the beast died to shell fragments to footprints and casts of lifeforms, even to simply chemical changes in the sediment that resulted from the presence of life. Any evidence of ancient life can be considered a fossil and evidence to be studied in paleontology, the branch of geology that studies fossils. If you looked at sediment deposited in the last hundred years, you would again find plenty of evidence of today's living organisms. Most creatures die and leave little trace, but whenever sediment is preserved, it almost always carries some evidence of life.

Many YEC authors are troubled by paleontology for several reasons. They recognize that it presents a challenge to "flood geology" and their model for the age of the earth. Often, they see it as inherently linked to evolution. Here is a quote from YEC author, Billy Caldwell (b. 1932):

> Thus respected paleontologists and geologists can unwittingly show up their real lack of certainty concerning the strata when they write,
>
> "A trained paleontologist can identify the relative geologic age of any fossiliferous rock formation by a study of its fossils almost as easily and certainly as they can determine the relative place of a sheet of manuscript by looking at its pagination. Fossils thus make it possible to correlate events in different parts of the world and so to work out the history of the earth as a whole."
>
> Or an even greater admission:
>
> "The only chronomatic scale applicable in geologic history for the stratigraphic classification of rocks and for dating geological events exactly is furnished by fossils. Owing to the irreversibility of evolution, they offer an unambiguous time scale for relative age determinations and for world-wide correlations of rocks." (Caldwell 2005)

Dr. Caldwell questions the use of fossils to determine the relative ages of rocks because of what he sees as a linkage to the theory of evolution. Do the rocks show that life has changed through time? What type of linkage is there to the evolutionary theory? When I went to undergraduate school at the small university of Eastern New Mexico University in the small town of Portales, New Mexico, in the mid-'70s, the professors recognized the controversial nature of the word *evolution* and all that it connoted. We were allowed and encouraged to use the terminology of "faunal succession." I still like that terminology. Faunal succession recognizes that life has changed over the period of time that the rock record has been deposited. It does not infer the mechanism for that change. It is good descriptive science. Evolution used in this context means not just change with time but a set of mechanisms and causes for that change. Modern evolutionary theory contends that the entire spectrum of life descended from a single source by the interaction of natural selection, random mutation, and chance occurrences (Darwin 1859; Mayr 1991; Shanks 2004; Johnson 1991; Behe 2007) Natural selection and mutation have certainly occurred, but it is another step entirely to make them adequate mechanisms to explain the life we have today. It is not the purpose of this book to prove or disprove this concept of evolution.

YEC writers have often rejected biostratigraphy, following the example of George McCready Price as in this quote: "Hence the Cambrian fossils, for example, cannot be proved to be intrinsically older than the Carboniferous, the Cretaceous, or the Tertiary; in short, no one kind of fossil, can be proved to be really older than another, or than the human race" (Price 1913). Price believed that the different fossil assemblages resulted from populations, similar to the way African and American plants and animals are different today though living at the same time. The only other faunal succession that he accepted was quite local.

The Genesis Flood also attacked the geological stratigraphic column as in this quote:

> Of course, it is maintained by many stratigraphers that other factors, especially that of superposition of the strata, are also important in geologic correlation and that these factors justify the usual assignment of ages to strata on the basis of their fossil contents. The usual situation is that only a few formations are ever superposed in any one locality and that it is very difficult or impossible to correlate strata in different localities by this principle of superposition. The fossils must be resorted to, and the fossil sequence is assumed to accord with the principle of evolution. Furthermore, even where superposed strata are exposed, it rather often happens that the fossils appear to be in the reverse order from that demanded by the evolutionary history, which paradox is commonly explained by the assumption that the strata have been folded or faulted out of their original sequence?

Whitcomb and Morris referred to "the all-important question of the sequence of deposition of these stratified beds." Both of these YEC books confidently claimed that the fossil evidence was

bogus and predicted that more examination would prove the fossil order to be useless, particu- larly as originally recognized in Europe.

The study area for this book is an excellent test for this prediction. The fact is that over all of North America, the stratigraphic order is certainly in broad terms well documented by superposition. In this study area, it is very well constrained. Once the relative age of sedimentary rock has been demonstrated by superposition, the fossils contained in the strata have been meticulously cataloged. It has been demonstrated over and over that the types of fossils found have a predictable sequence. This faunal succession can be used to decipher the relative age of rocks where superposition is not easy to work out. The discovery that this was true was a major breakthrough for geology. Early British geologist William "Strata" Smith (1768–1839) is credited with discovering this relationship in the late 1700s. YEC author Andrew Snelling's book *Earth's Catastrophic Past* provides a good summary of the historical development of the stratigraphic column in Europe. Davis Young (b. 1941) and Ralph Stearley's book *The Bible, Rocks and Time* provides a more detailed account and it is particularly helpful in understanding the strong Christian views of many of those who developed it.

The portion of modern paleontology that specialized in the use of fossils to decide the relative age of strata is biostratigraphy. Biostratigraphy at its basic level is a descriptive enterprise. It involves documenting the fossil assemblage, all the fossils found at each stratigraphic level using rocks from both outcrops and oil wells. Different stratigraphic levels definitely do have different fossils in them. There could be a number of possible explanations for the differences. Rocks deposited in different environments would have different kinds of fossils. Layers might have been deposited in terrestrial versus marine environments or the climate might have changed or in marine settings, the water depth varied as a basin filled in. The records of the fossil assemblages that biostratigraphers put together also quickly demonstrate a progression of forms that changed even for the same environments. This is faunal succession. There are many obvious examples of fossils of animals that we have been missing for all human's recorded history. Everyone thinks of the dinosaurs but this also includes things like trilobites, ammonites, crinoids, and bryozoans and a host of other forms (Figure 16). All these were really abundant in certain parts of the rock record and are not found or are clearly changed today. Perhaps, even more difficult to understand from a YEC perspective, the opposite is also true. The paleontologists find almost none of the species that we know today in the Paleozoic rocks. There are a few species that have continued through the entire Phanerozoic era, such as some algae and the brachiopod order Lingulida, but such examples are very rare. It is true that we often have similar species living today, but the modern species are not found in the early rocks.

- Early strata have very different forms of life than we have today.
- Modern forms are never found early in the rock record.

The study of biostratigraphy is a life of charts. A biostratigraphic chart might look unimpressive but such charts detail the history of life recorded in the rock record (Figure 17). Biostratigraphers normally list species across the top and the stratigraphic position down the side. Fossils of large ani-

mals can be presented this way, but the real usefulness and detail comes from tiny fossils, the study of which is named micropaleontology. This data forms the majority of the basic framework that has been developed for biostratigraphy. Large vertebrates are interesting and can be exciting but such are relatively rare in the rock record. Microscopic fossils are usually much more abundant. They also have another advantage. When we drill an oil well, even if we hit larger fossils they will typically be obliterated by the drill bit. Not so with the microfossils. Techniques have been developed to concentrate and study them.

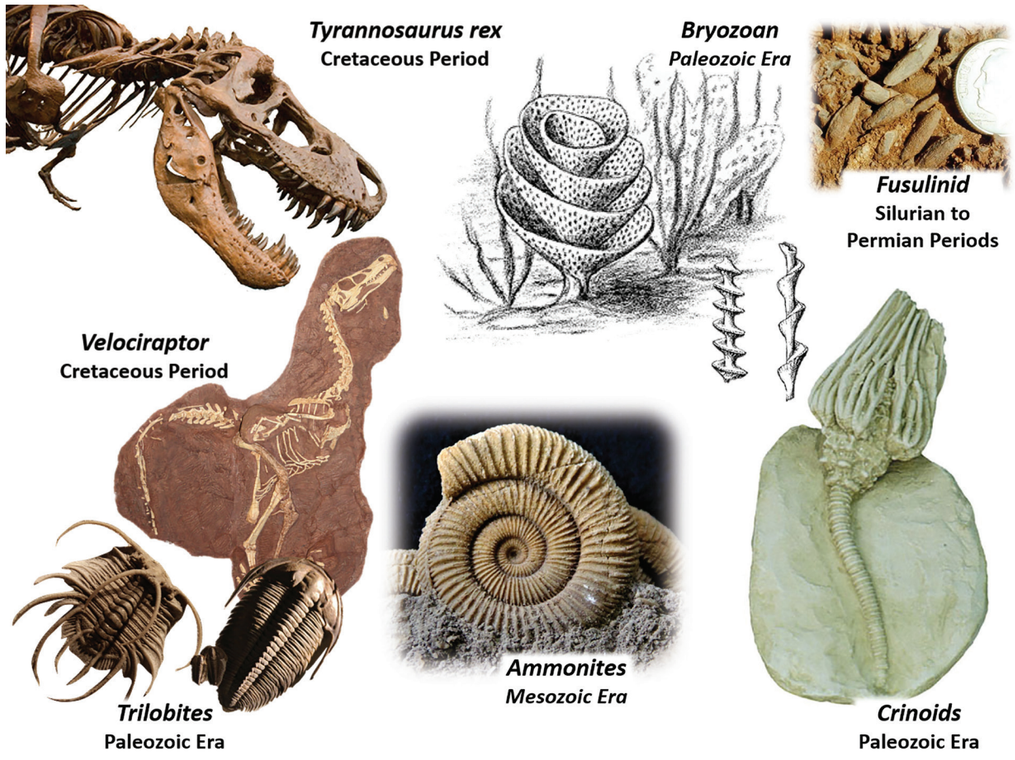


Figure 16. Examples of species that are clearly extinct today. There do remain a few species of crinoids, bryozoan and ammonites but they are clearly different than those that lived in the past.

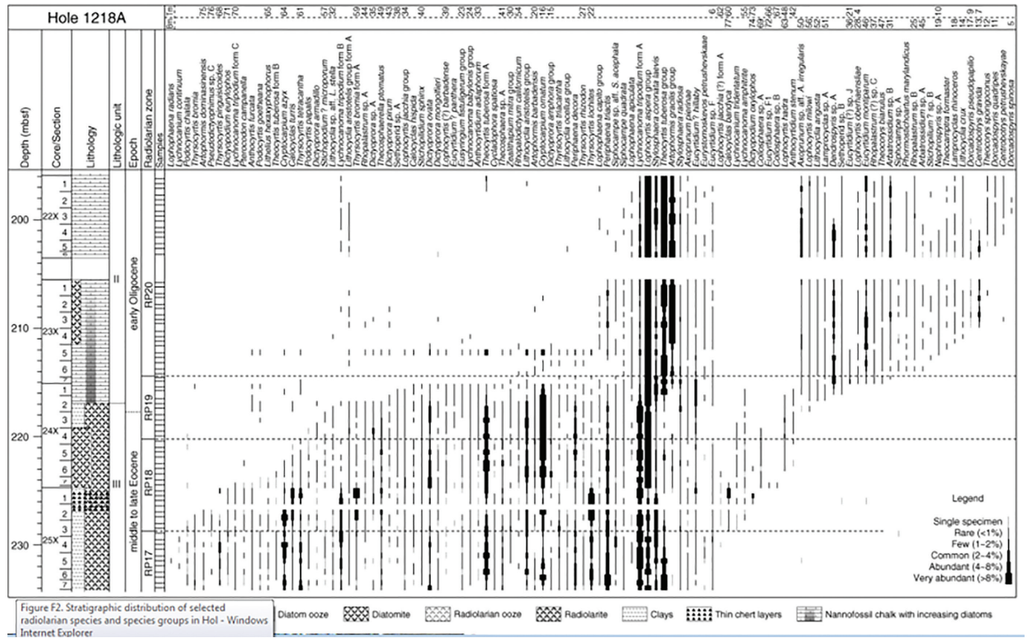


Figure 17 Example of fossil chart. Across the top are the species and down the vertical axis is the depth. This particular chart is of radiolarian species from one of the Ocean Drilling Program (ODP) wells. Radiolarians are microscopic protozoans that leave very intricate skeletal fossils in the oceans, often as oozes in the deep oceans (ODP 2007).

If we take a series of wells or outcrop ***measured sections*** from across Texas or New Mexico in areas where we know the rocks have not been overturned, we will find that over and over again changes in fossil species occur in the same order. It is very clear that the order is anything but random. As noted before, the effect of changes in depositional setting and climate must to be taken into account. Even the types of fossils available to use changed through time. No one type of fossil is present throughout the record so the different types of fossils end up being used for different times, yet a very consistent pattern emerges. The pattern is not based on any theory of origins. There is no presumption of an evolution of simple becoming more complex imposed on it. Such patterns are present at times but probably just as often, the opposite is also true. I want to be clear that biostratigraphic methodology is basically descriptive. It says a certain set of species were found at certain stratigraphic levels. The key is to find fossils or features that are geographically widespread and changed through the stratigraphic record. Good examples of this are the microscopic ***index fossils*** known as conodonts. (Figure 18). These tiny fossils are great examples of the descriptive nature of biostratigraphy where clearly there has been no presupposition of any evolutionary model. Conodonts were one of the real enigmas of paleontology. These tiny specimens, from two hundred microns to five millimeters in length, are composed of the mineral apatite. They were obvi-

ously some sort of fossil, but no one knew just what type of creature they came from. Whatever lifeform they came from, they were found to be widespread in Paleozoic sedimentary rocks. Different forms were found at different stratigraphic levels. Anything that was widespread and changed in recognizable ways through time can serve as a stratigraphic marker for the rocks they are found in and help to build a strati- graphic framework in an area. This was true for conodonts, and they are used in many rocks to under- stand the stratigraphic order. Eventually in 1983, the mystery began to be unraveled. Conodonts were found with soft imprints and paleontologists discovered that these little fossils were once teeth for a type of boneless sea creature resembling eels. All geologists were pleased to have the mystery solved. However, the discovery changed nothing about their use as an index fossil or the frameworks they helped to build.

Many types of fossils are used to correlate stratigraphy across local areas and eventually around the world. Figures 19–21 are examples of the key fossil groups used. Each has its limitation in terms of when they lived and in what environments they lived in. Different types are used for different intervals. Changes in conodonts or forams or ammonites occurred over large areas and demonstrate how small changes in the faunal succession can be consistently recognized and be very useful. Biostratigraphy is quite specialized. A professional is usually not just a micropaleontologist but a specialist in palynology (spores and pollen) or nannofossils (tiny calcareous algal cysts) or forams (and then often specializing in tropical forms or arctic forms). Any explanation for the rock record must account for the changes in the larger macrospecies but also for the continual progression of changes in the small flora and fauna that are consistently present. The faunal succession on which modern biostratigraphy is based is not the fundamental changes in what the Bible might call "kinds" (Genesis 1:11, 24–25). It is better termed microevolution. Proving that these processes alone can account for major changes is different and arguably this proof has not been done. The small-scaled changes documented are easily accounted for with natural selection and mutation.

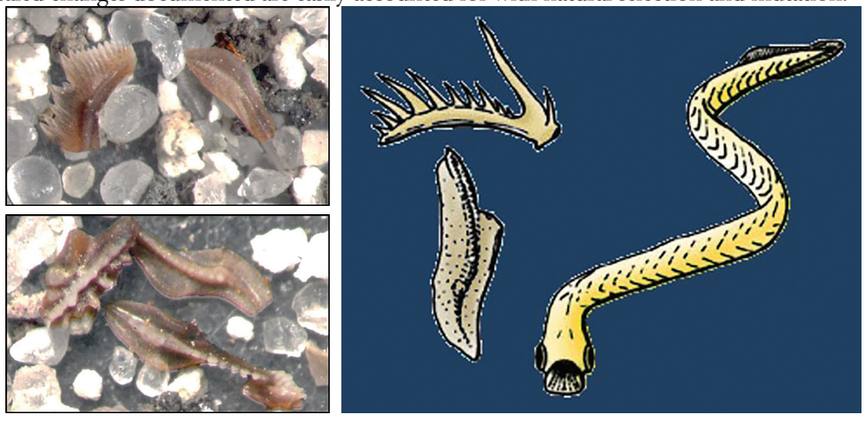


Figure 18 Left photo shows a series of Mississippian conodonts from the Chappel Limestone in central Texas. Although no one knew what exactly they were, they were correlative over large areas and formed an important basis for stratigraphy in the Paleozoic. (Drawings from Wikipedia (Philippe Janvier 1997 - Tree of Life Web Project))

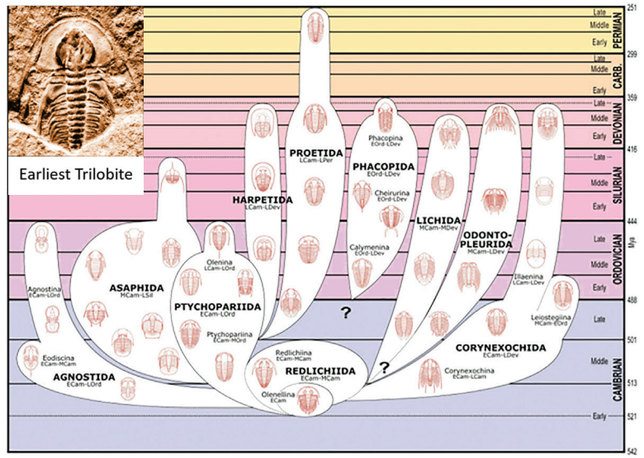


Figure 19 Trilobites changed in form throughout the Paleozoic Era. Identifying the species provides a strong means of correlating strata deposited during this time. The earliest trilobites that we know of, pictured on the right appeared early in the Cambrian, with no known predecessors. They were part of what is known as the Cambrian explosion when many complex lifeforms appeared with no apparent predecessors. Reproduced by permission of S. M. Gon III (Gon 2009).

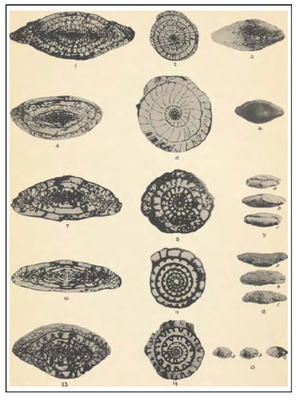
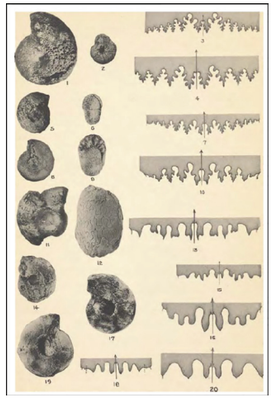


Figure 20 Fusulinids, a type of foraminifera, were one-celled animals that left "shells" known as tests that changed in consistent ways through the rocks. They provide good biostratigraphic zonation of the Silurian to Permian Periods. Reproduced by permission of the Bureau of Economic Geology (Sellards, Adkins, and Plummer 1932).

Figure 21 Ammonites (not the ancient enemies of the Israelites) were coiled cephalopods that were similar to today's nautiloids. They floated at or near the water surfaces, and as an animal grew, it built new larger chambers separated by walls known as sutures. The suture patterns changed through time and are used to provide correlation, particularly through the Mesozoic era. Reproduced by permission of the Bureau of Economic Geology (Sellards, Adkins, and Plummer 1932).



Geologists routinely use fossils as tools to correlate between wells and between outcrops. Are these really valid? Fossil correlations have been borne out by incontrovertible seismic correlations over and over again. Fossils have often provided local correlation across faults where later additional data has proven them correct. Biostratigraphic interpretation is routinely used to provide stratigraphic correlation to other parts of a basin. As more wells were drilled and new data has come in, those biostratigraphic correlations have been proven correct time and time again. In order to be trusted, a regional stratigraphic framework must fit all the surface data, all the seismic data, and all the well data including the fossil stratigraphy. Structurally complex areas typically rely heavily on biostratigraphy, but the basic order has been developed in areas where the rocks are undeformed and in their original depositional order. Even today, many YEC authors follow Whitcomb and Morris (1961) in not accepting the faunal succession but some do not. This quote from Paul Garner's article *The Genesis Flood: 50 Years On* reflects conclusions from more recent writers who are more knowledgeable about fossils:

> Today, the geologic age of most strata is recognized using small changes in microfossils.

> Order of the fossils. One of the areas of contention between George McCready Price and Harold Clark concerned the sequence of rocks and fossils (often summarised in textbooks as "the geological column"). Price argued that this sequence was an artificial construct based on the assumption of evolution. But Clark was persuaded that there really was a consistent sequence, and sought to explain the order of the fossils as the order in which different ecosystems were inundated and buried during the flood. Whitcomb and Morris questioned whether the order of the fossils was as consistent as most geologists had assumed, but appealed to the ecological zones of the pre-flood world as one explanation of any order that did exist. Today there is still debate within creationism about these matters, although it is probably fair to say that most of the creationist geologists with field experience have sided with Clark. (Garner 2011)

YEC authors who are very familiar with paleontology find a way to work the faunal succession into their system. Joachim Scheven (b. 1932), a German biologist, describes the fossil record as "the unassailable palaeontological order which a Biblical earth history does not question at all" (Scheven 1990). What Whitcomb and Morris described as "the all-important question" seems to have been resolved in favor of the standard geologic column that geologists have painstakingly put together over the last two hundred years.

The order of the strata and the succession of fossils are generally recognized as confirmed. Andrew Snelling described it this way: "Foremost among these is the implication that just as the order of physical rock units throughout the whole geologic column is real, then so also is the sequence of

different fossils and fossil assemblages found in the rock units of which the geologic column is comprised" (Snelling 2009).

Similarly, YEC author, Michael Oard shows that he accepts the general validity of the conventional column when he makes the following statement: "The geological column is a general Flood order with many exceptions" (Oard 2010). Why the exceptions? I would suggest that these are cases where he cannot fit the flood model, rather than places where the fossil record is mistaken.

It is very significant that we can trust the fossil record to help build a framework of what order rocks were laid down but it does not stop there. While some marine microfossils provide relative stratigraphic age information, others provide a different kind of information. Age correlations often are based on one-celled forams that float near the top of the water column. Upon death, their body chambers, known as tests, drop to the water bottom as a constant, if slow, rain of these floaters known as planktonic forams. Another type, known as benthonic forams, live on the water bottom. Species of these don't seem to have changed quite as quickly as the planktonic forams, making them less useful as index fossils. They do seem to be picky about what water bottom conditions they live in though. Studies show that the assemblage of species of benthonic forams along the water bottom changes with water depth and with the environment such as deltaic or open marine (Figure 22). We see the same progression of assemblages in the rock record as well. This assemblage is often a very helpful piece of evidence used to piece to together the depositional history of strata. This is often linked with the depositional geometries and sedimentary structures and other information to put together an integrated picture of how the rocks were deposited. This makes one more set of data that any explanation for the rock record, YE or OE, must also account for. They need to explain the way the fossil assemblages vary through the rock record and that they vary with the same patterns that we see it in the present oceans with normal processes. The answer must explain the way these assemblage patterns link together with the other sedimentary characteristics to paint a coherent recognizable pattern that is very much like what we see in normal settings today. The OE explanation is simple: similar assemblages were deposited in the same water depths and environments as we see them today.

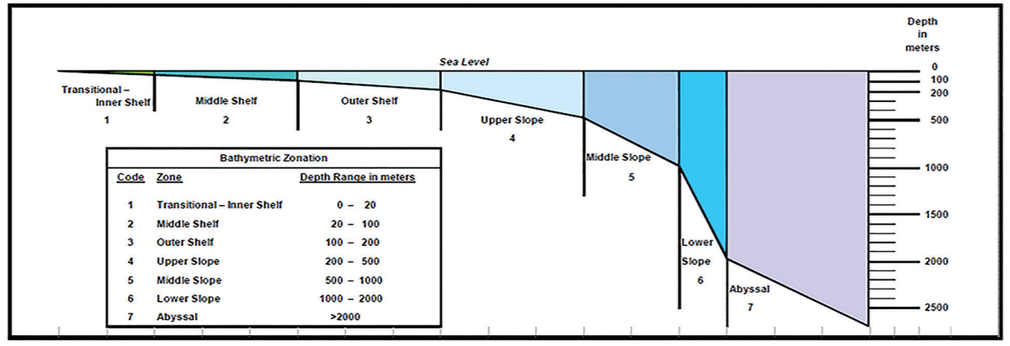
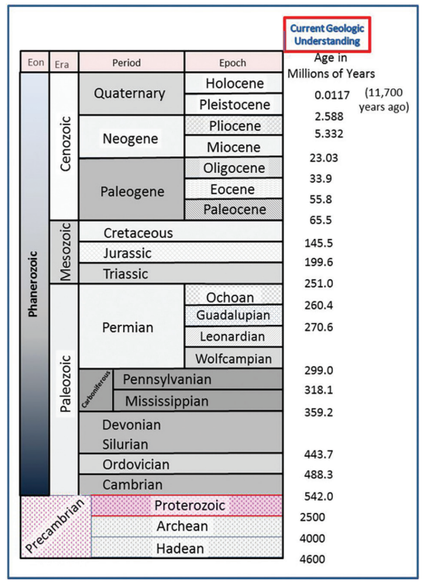


Figure 22 Each of the water depth ranges in the figure has distinctive types of forams. Recognition of these environments helps to understand what the water depth was when the sediments were laid down.

7 Short History of the Study Area Geology

We could describe events and buildings in human history in terms of various periods. In recent history, people commonly speak of the World War II period or Cold War period. Americans will remember the Vietnam era as a portion of the Cold War period. We usually think in terms of the human culture of the periods, but we might include natural events such as earthquakes or great storms. In this section, we will look at the general geologic characteristics and events that took place in our study area. They will be described in terms of the geologic eras and periods. Most geologists think of these periods as each representing millions of years, but we can look at some of their features and you can make up your mind about that. Some readers may find the geologic descriptions less than exciting and may choose to skip this and go on to the next section where we will compare the specific predictions demanded by "flood geology" to the record that we have in this area. It is necessary to give an overview of the rock record in this study area in order to provide a real basis for evaluating the viability of "flood geology" as an explanation for these rocks. There are a lot of rocks to describe. Deliberately this section will be more description than evaluation, though I will point out many features that have implications for the time involved and rates involved. We do not have room to present all the data behind the story, but I will try to present the story in a fair way. This will then provide the input for the next section to compare the specific predictions demanded by "flood geology" to the record that we have here.

Proterozoic



The base of the stratigraphic column of Texas is Proterozoic, late Precambrian in age. A tremendous amount of at least apparent geologic history is recorded in other parts of the world, but our story here will begin with these late Precambrian rocks. The Proterozoic rocks in this study area are exposed in a few areas such as the Franklin Mountains outside of El Paso. Both igneous granites and metamorphic rocks are exposed.

One of the metamorphic rocks is the Castner marble (Figure 23), a rock that was originally a limestone with well-developed stromatolites in the lower part of the formation (Pittenger, Marsaglia, and Bickford 1994). These ancient mats were formed as cyanobacteria (blue-green algae) developed films that trapped layers of other sediment. Stromatolites are one evidence that life existed very low and early in the stratigraphic column. Stromatolites such as these formed in an intertidal zone, the zone between high tide and low tide. This reflects regular tides over some period of time. Modern laminations have been measured to grow at rates of 1.6 to 5.6 years per lamination (Petryshyn 2013). Modern examples from Shark Bay as pictured in Figure 23 have been studied and found to grow at an average rate of less than 0.4 mm per year (Chivas, Torgersen, and Polach 1990). That suggests that the classic columns found there developed over the last one thousand years. Certainly, rates may have been faster in the past, but there are limits to what we might expect.

One very prominent outcrop area of Precambrian rocks is the Llano uplift in the center of Texas (Figure 6). This roughly circular area where older rocks are exposed was formed partly by uplift and partly by the sinking of the rocks in the surrounding area into deep basins (Figure 24). Between the Llano uplift and Van Horn, Texas, basement deepens down to below twenty thousand feet (6 km) below sea level. This deep depositional trough is known as the Permian Basin. It includes a western deeper basin known as the Delaware Basin and an eastern portion known as the Midland Basin (Figure 8). East of the Llano uplift, basement deepens to below forty thousand feet (12,000 m) into the Gulf of Mexico basin. Precambrian rocks or basement are penetrated in wells across West Texas, particularly along the Central Basin Platform and in the Midland Basin (Figures 8 and 11). Gravity and magnetic data tell us much about its depth and composition in areas where basement is not exposed at the surface or penetrated by wells.

Figure 23 Algal stromatolites from the Castner marble (above) and from Shark Bay, Australia, from recent times (below left; Wikipedia Creative Commons [CC]). The modern analog makes it very clear that at least this portion of the Castner was originally deposited in the tidal zone over a period of years.

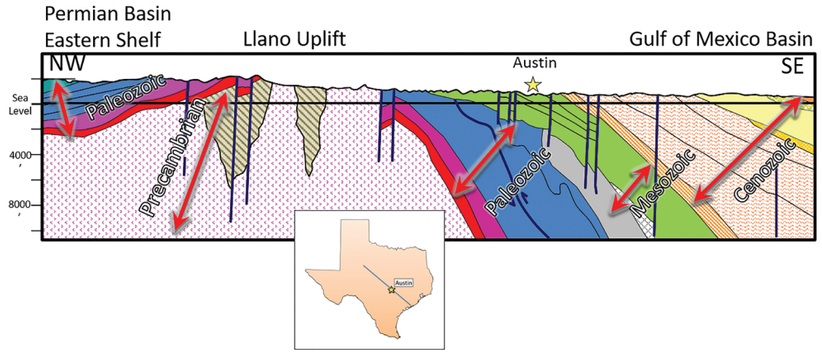
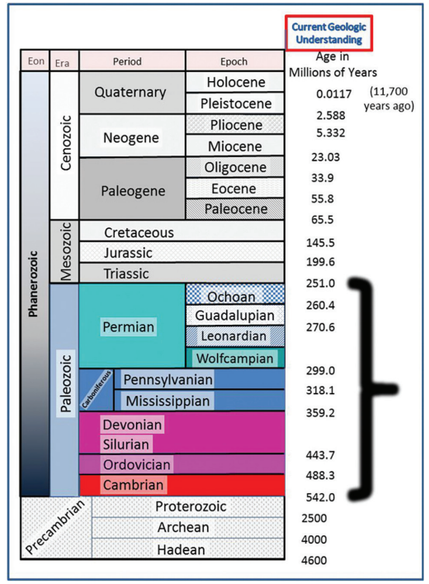
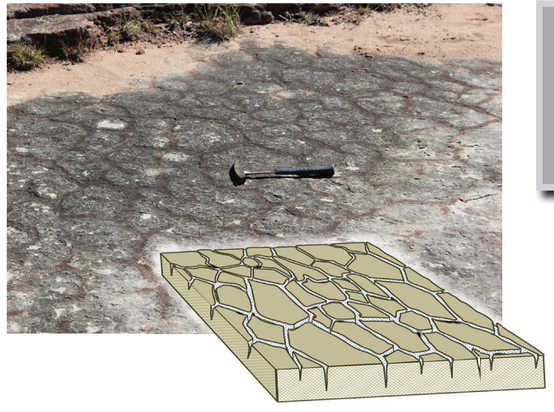


Figure 24 Geologic cross-section through the Llano Uplift. The brown areas are Precambrian sediments overlying older igneous and metamorphic rocks. The Precambrian rocks are covered with Paleozoic rocks on both sides of the uplift. On the right, the Paleozoics are overlain by Mesozoic rocks that are overlain by Cenozoic rocks. The relative ages are clear based on superposition. (Renfro, Feray, and King 1973)

Paleozoic



We live in the Phanerozoic eon, a fact that you may not have been aware of. This is the eon of abundant life, with hard bodies appearing quite suddenly at its base. It is divided into three eras. We will begin with the oldest rocks, the Paleozoic. The lowest and oldest of the Paleozoic rocks are Cambrian rocks, here often consisting of reddish sandstones that were deposited on an erosional surface above the Precambrian rocks. The sandstones are usually arkosic, meaning that they have a lot of feldspar grains and fragments of the granite that often underlies them. Over most of the area, where we find them, the sedimentary features are consistent with deposits in shallow seas. Most are interpreted as storm deposits laid on the old erosional surface as a broad intercontinental basin began to form. In central Texas, the Llano uplift area was exposed above sea level at times during the Cambrian (Figures 6 and 24). Features there are interpreted to represent an ancient soil, known as a ***paleosol*** (Capo 1994). We do not find the roots that we typically associate with paleosols, but then, there is no evidence that plants that had roots even existed at this stratigraphic level. It does tell us that the granites on which the possible soil developed on were deeply weathered before later Cambrian units were deposited. The Hickory sandstone near Fredericksburg, Texas, is interpreted to have been deposited on an ancient tidal flat (Cornish 1975). Many of the sands are ripple-marked or cross-bedded just as we find on modern beaches and tidal flats.



Why would you find cracks from drying mud in deposits from early in a global flood?

Figure 25 Mud cracks from Cambrian Hickory Sandstone in Central Texas (Nielson and Barker 2013)

One package is particularly interesting. Near top of the unit, the sand grains became finer and included mud. The top of the package includes great examples of polygonal fracture patterns, known as desiccation features or mudcracks such today form as muddy sediments dry out on the surface (Figure 23). I still enjoy stepping on the dry curled up mud of modern examples. Sometime after the drying of this muddy surface, the reddish sands again swept into the area, washed into the cracks, giving them the current reddish outlines. It is difficult to understand how these could have developed early in a major flood deposit.

Figure 26 Algal stromatolite reef or bioherm from Point Peak Formation (Cambrian) (Nielson and Barker 2013; Ahr 1971; Chafetz 1973)

The Cambrian Point Peak Formation near Mason, Texas, includes some special limestones. They contain stromatolites similar to those described in the Precambrian Castner Marble. The Cambrian stromatolites developed into localized organic buildups that are considered bioherms or reefs (Nielson and Barker 2013; Ahr 1971; Chafetz 1973; Figure 26). Such isolated organic buildups are typically called patch reefs and though the organisms forming them are different today, the characteristics are very similar. In this area, such patch reefs are preserved all along a long cliff face.

The Cambrian reefs grew up to fifty feet (15 m) thick by 100 feet (30 m) long. The algal mats were basically in the tidal zone, growing in place and sinking into the soft sediment around them.

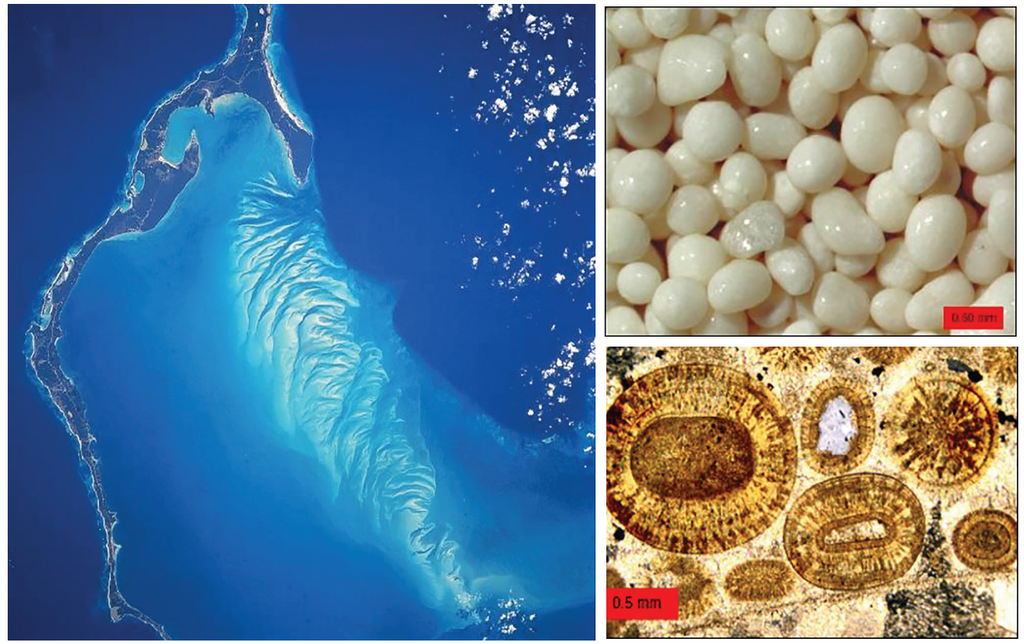


Figure 27 On the left are ooid shoals found today off of Eleuthera Island, Bahamas. On the top right is a close-up of ooids. The bottom right shows a thin section of ooids from the Jurassic in Utah. The core of the ooid is typically a shell fragment or mineral grain. Rolling in the shallow, warm water, they became coated with layers of calcium carbonate. Wave motion concentrated them into shoals. (Photos are from Wikipedia: Left by NASA, Right by Mark A. Wilson (Department of Geology, The College of Wooster))

Overlying the Cambrian rocks are a series of limestones and dolomites known by various names including the El Paso group (a "group" is a set of rock formations that are sometimes mapped separately but often together), the Ellenburger group and the Marathon limestone. Both the Ellenburger and El Paso groups show strong evidence of being deposited in very shallow water settings (Loucks 2008). Here are some examples of the evidence. We find ooid accumulations that are interpreted as ooid shoal deposits just as we have today (Figure 27). Stacks of cross-bedded oolite units are very distinctive and easy to interpret. We find stromatolites that are indicative of tidal deposition. We find more ancient mud cracks that formed as lime muds dried up, cracked, and the mud curled up.

Overall the climate seems to have been arid based on several lines of evidence, including the fact that we find chert nodules where silica replaced ***anhydrite***. We will discuss this in more detail later, but today such anhydrite nodules characteristically form in very arid conditions. Thus we have identified a series of features that we can use to say that these rocks were originally laid down in very shallow water environments in arid settings by processes that we see acting today.

Much oil and gas comes from the Ellenburger group in the Permian Basin. Part of the key to finding oil and gas is finding ***porosity***, the holes and spaces within the rock that hold the oil and gas. One key to finding the porosity in the Ellenburger group is to identify areas where the limestone was exposed to freshwater. The limestone was formed just below the sea level and then either uplifted or the sea level lowered. Porosity formed as freshwater leached out the limestone. The freshwater dissolved out ancient caverns similar to what we see today in modern caverns in areas like Carlsbad, Kentucky, and Florida (Loucks 2008; Målbakken 2009; Tihansky 1999; Figure 28). On the modern surface, these are examples of what we term "karst features." In the rock record, we refer to them as paleokarsts or paleocaves. They demonstrate that enough time must have elapsed for caves to have formed, collapsed, and then have been buried deeply by the later layers of rock. In modern systems, normally several phases of dissolution and cave formation are recognized as the water table raised and lowered through time. The same is true for the El Paso and Ellenburger units.

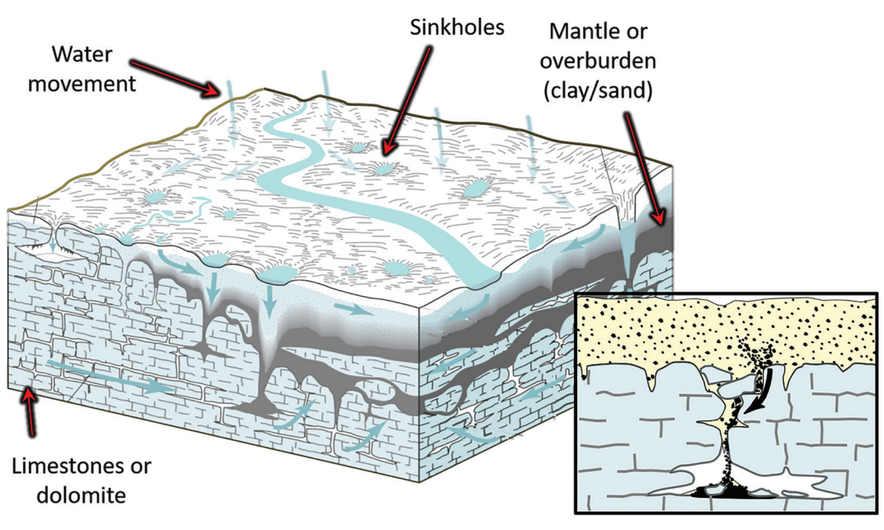


Figure 28 Model of karst features recognized in modern Florida. (Tihansky 1999) Paleokarst features are often recognized in Ellenburger cores and outcrops. The cave deposits and surrounding dissolution features documented in Florida are recognized in Ellenburger deposits. Several phases of karsting are recognized in the Ellenburger Formation, some of which happened early though some developed later in Paleozoic time. The inset sketch shows how material from younger units is carried down into caverns.

If you wanted to understand the history of the United States at a particular time, you might want to look at data from more than one place in the country. Geology works a bit like this. We can understand the time when rocks were deposited better by looking at what was happening at the same time in different regions. The Marathon Limestone was deposited in the Marathon and Big Bend region at the same time as the Ellenburger and El Paso units were being deposited in other areas, but the limestone has very different characteristics, indicating that it was deposited in a different setting by different processes. In this southern part of West Texas, we find dark limestones and shales. The sedimentary structures identify the rocks to have been deposited on sloping surfaces, as turbidites and ***megabreccias***. We can put this together with the other information from the same time to build a more complete story of what was happening then. Geologists use the term ***facies*** to describe rock units with similar characteristic features. In this case, a series of depositional facies are identified, where the rocks were deposited by the same basic processes in an identifiable set of environments. A process of interpretation is used to bring all of the data together to make sense of the facies. It involves integrating outcrops and well data from logs, cores, and often seismic information, and plotting it all on maps. Often many interpretations are possible for individual points but when tied together in a map, distinctive patterns emerge. The depositional processes and sediment types fit together into a set of linked depositional processes or ***depositional systems***. These can be used very effectively to predict what will be found in future oil drilling programs. The map of depositional environments is called a "paleogeographic map" (Figure 29). In the Ordovician rocks, we see a set of features in the Ellenburger formation that indicate shallow water carbonate environments, similar to what we find from tidal flats today. As we go southward, the facies change and the features and fossils look more like an open marine setting of today. Farther south, the Marathon limestone facies at the same stratigraphically equivalent rocks have features indicative of a slope setting. These environments together suggest a depositional system with broad tidal flat areas adjacent to a broad open marine area adjacent to a deeper water slope environment. This general interpretation fits the data very well. In local areas, many more details are broken out. Any different interpretation must still account for this distribution of features.

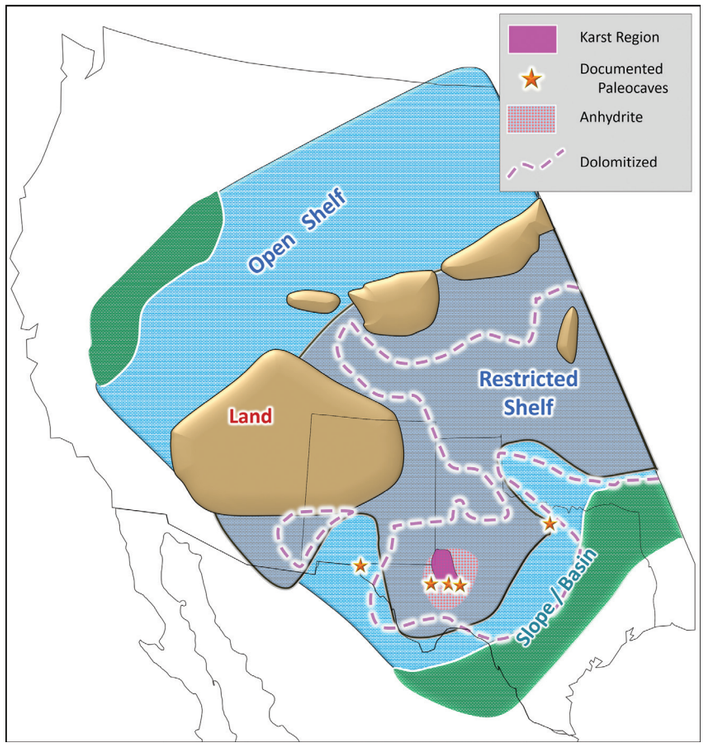


Figure 29 Paleogeographic map of the upper Ellenburger showing the major broad environments that we interpret to have been present at this time. (Loucks 2008)

The Ellenburger fossiliferous limestones were deposited over broad areas. Deposition wasn't the end of the story however. The sediments began as calcite, calcium carbonate. However, they were chemically altered from calcite to dolomite (calcium magnesium carbonate). The general term for processes that alter rocks after deposition is "diagenesis." Geologists don't really have a full understanding of the process that changes limestone to dolomite (dolomitization) over very broad areas like this. Many models have been proposed and each may have been true for particular zones, but none of which seems adequate for all dolomite rocks that we find. Converting large areas of limestone into dolomite would seem to be a slow process though. Much of this sediment would not have allowed fluids to pass through them quickly. No possibilities have been identified that might have rapidly changed big areas. Dolomitization was not a one-time thing. It occurred repeatedly in the Permian Basin.

The Ellenburger is overlain by sandstones, shale, and carbonate deposits in the Middle and Upper Ordovician Simpson Group, the Silurian Montoya formation, and by the Fusselman formation, where again thick limestones have been dolomitized over large areas. The overlying Simpson group includes shales that are bioturbated (chewed up by animals, suggesting normal marine conditions), with plant root remains. Sand grains are usually frosted, a characteristic of modern eolian (windblown) sands.

Some units contain evidence of ***evaporite*** deposition and ***fenestral*** lime ***mudstones*** (stromatolites that have been partially leached by fresh water; Jones R. 2007). All these features seem to fit nicely with normal shallow marine environments in arid areas. The Fusselman limestones and dolomites overlying the Simpson group have many beds arranged in linear trends of ooids that are interpreted to have been laid down as shallow water shoals and beaches just as we found in the Ellenburger (Ruppel 2006). The Fusselman also has clear evidence that early carbonates were dissolved by freshwater as paleokarst deposits formed. In New Mexico, well-developed paleosols are noted in the Fusselman formation, demonstrating that the area was exposed for long enough for the carbonates to dissolve and for soils to have developed on them (Young L. M. 1994). Shallow water shoals, karsts, paleosols, and broad areas turned from limestone to dolomite all fit well into a conventional model but provide challenges for the incredibly short YEC period.

The shales overlaying the limestones and dolomites of the Fusselman are very distinctive. You could hand a geologist from the area a recording made from any well drilled there, known as a gamma ray log from over this interval from any well and they will quickly identify the shale as the Woodford shale. The gamma ray log measures the radioactivity of the rock. The Woodford is up to 660 feet (60 m) of thick shale that is literally off the scale in radioactivity (Comer 1991). This shale has a very high percentage of organic content from algal matter that is caught up with the clays of the shale. The oxygen-poor reducing environment that preserved this matter attracted uranium in high con- centrations. As the organic shales were buried deeper, they heated up. Once buried deeply enough, the organic matter, known as kerogen, generated oil in the Woodford shales. Eventually over time, this oil became concentrated enough that it was expelled into adjacent formations. Much of the oil in the Permian Basin originated in the Woodford shale. Today we are producing the oil that remained in shales like these that once were considered impossible to produce. The sedimentary structures in this shale are consistent with slow continuous deposition in basins that were restricted from the open seas and had poor vertical circulation (Comer 1991). Occasionally silts were flooded into the basin to interrupt the shale deposition. The fossils and amount of organic material present indicate that the upper waters were relatively normal. The conditions that preserved the large amounts of organic material are known as anoxic conditions. The normal shallow water over the anoxic base tells us that the basin was cut off from the main ocean basins. Thick shale units are usually interpreted to repre- sent deposition over a very long time. Shales such as the Woodford formation are dominantly made up of mud-sized particles. Such particles typically settle in a body of water very slowly. A thick sec- tion of shale such the Woodford is composed of many, many fine laminations, suggesting deposition over a very long period of time. Is there another explanation? Snelling points out that fine laminated mud can be deposited quickly (Snelling 2009) When a large mass of the depositional slope collapses, perhaps triggered by an earthquake, much of the material that moves down the slope is mud. Muddy turbidites are common today and such rapid deposition certainly happened in the past. That does

not mean that all mud-sized particles were deposited quickly. A recent study shows that the shales within the Woodford are not all alike. Some did include mostly particles from terrigenous or land sources (Ochoa, Wolak, and Gardner 2013). Some of these were deposited quickly. However most of the formation is made up of a type of sediments describe as "pelagic." Pelagic units are fine-grained sediments that are almost entirely composed of microscopic biogenic material. This material was deposited by settling slowly in quiet water. It happens that these units also are more permeable, meaning that fluids move more easily through them and making them important for producing oil and gas. Later when we compare the YEC flood model to the modern geologic model, it will be worth considering how these fine-grained, laminated sediments could have formed in the brief time available in the flood geology model.

At the same time that the Permian Basin had the Woodford shale being deposited, to the south in the Marathon fold belt region just like for the earlier period, a very different type of deposition was taking place. In this region, an unusual unit, named the Caballos Novaculite was deposited. It is part of a band of silica-rich deposits that stretches across Texas and through Arkansas. Novaculites are beds of chert, a form of fine-grained quartz, commonly used as a whetstone for sharpening knives. The Caballos formation includes novaculite, shales, other types of chert, and even some sandstone and conglomerate. A few years ago, a debate went on about whether the novaculites were deposited in deep or shallow water. Two very well-known sedimentologists debated this for several years (McBride and Folk 1977). Most geologists believe that the novaculites were deposited in a deep basin like the units above and below it. Bob Folk (b. 1925), a famous carbonate sedimentologist who loves a controversy, took a different position. He found features in the cherts that he believed indicated that they were deposited in shallow tidal environments. Earle McBride (b. 1932), a famous sandstone sedimentologist, represented the conventional view. He is probably not as dynamic as a speaker but most agree with his position that the units were all deposited in a deep basin. They knew each other well and each knew the other's evidence as well. They were invited to conferences around the world because scientists love to hear a controversy presented well. In many places, we find cherts formed by silica replacing limestone. The Caballos units were not formed that way. Some of the novaculites, probably all, were deposited as oozes of the tests (skeletons) of microscopic protozoa known as radiolaria that were originally composed of opal (amorphous or noncrystalline silica;
Jones and Murchey 1986; Noble 1992; Figure 30). Geologists believe that these oozes formed very slowly back then, just as they do today in deep ocean floor settings. Today, tests of these tiny creatures are constantly raining down on the ocean floor, but so slowly that if there is any input from normal clastic sands or muds, the clastics dominate the deposits and siliceous oozes do not develop. Forming thick chert beds from such oozes is interpreted to have required unusually high productivity of radiolaria, even given the time spans that geologists envision. Conventional geological dates indicate that the Caballos took many millions of years to form, spanning much of the Devonian Period and the lower Mississippian Period. In the Permian Basin, the Devonian aged Woodford Shale is overlain by thick limestones and shales of Mississippian age. Once considered waste rock, these shales, known as the Barnett Shale, are now being highly touted as a major gas reservoir. Again slow deposition is interpreted with much evidence.

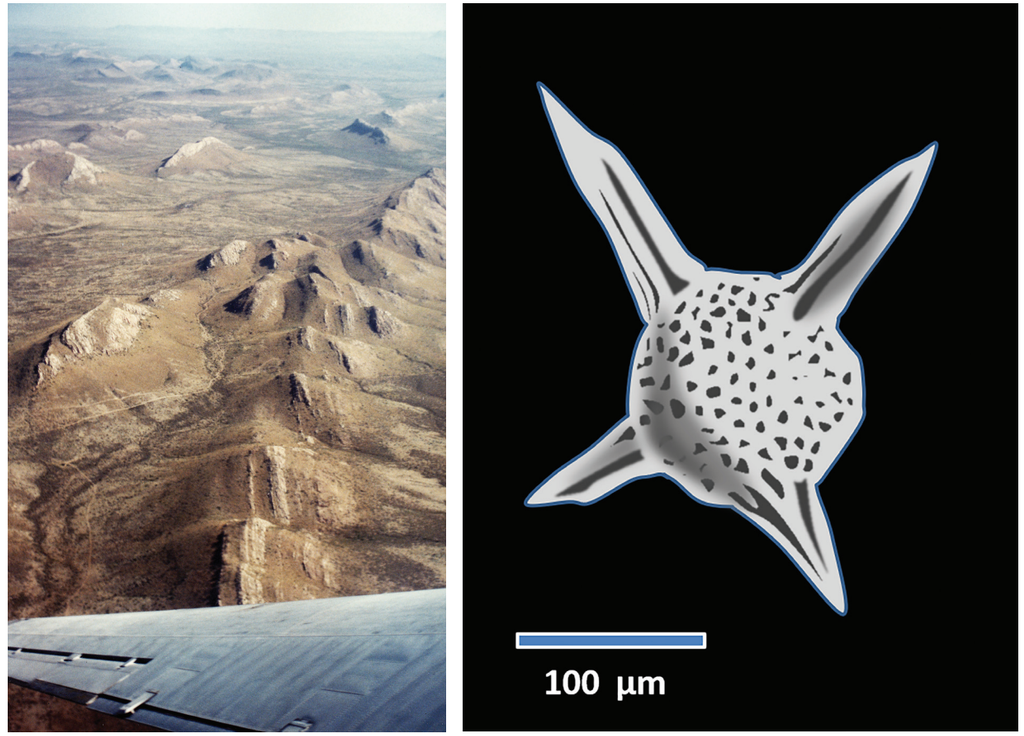


Figure 30 A series of near vertical beds of Caballos Novaculite from near Marathon, Texas. These white chert beds formed as radiolarian oozes that changed from opal to quartz with burial. The drawing to the right is of a radiolaria fossil from the novaculite. (Noble 1992)

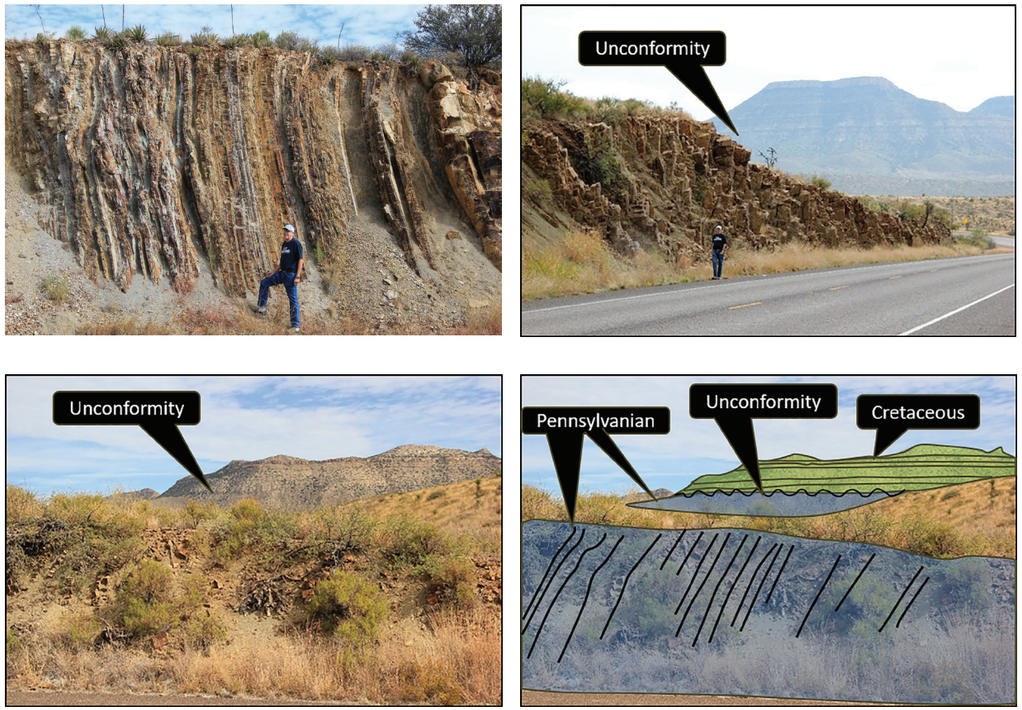


Figure 31 Sandstones and shales that were deposited horizontally, now folded to a vertical orientation as a part of the Marathon-Ouachita fold belt. This folding occurred during the Pennsylvanian period. The other photos show how this section is unconformably overlain by horizontal sediments. In this area, the Cretaceous unconformity has eroded away the Permian rocks that were also sub-horizontal.

During the Cambrian through Mississippian, much of West Texas was a single broad basin. In general, it was an example of slow subsidence. During some periods, river systems brought large amounts of sands and clastics into the basins and sandstones were deposited. Sometimes the clastics shut off and limestones and dolomites were deposited. It was a story that was repeated several times. The basin was always shallow, reflecting relatively even and slow subsidence. That all changed in the Pennsylvanian Period. The deeper water sediments deposited toward the current Gulf of Mexico were shoved and crumpled up along what is known as the Marathon–Ouachita thrust belt that extends from Mexico through Texas, across Oklahoma and Mississippi (Hickman, Varga, and Altany 2009; Figure 8).

Beds that were laid down as normal horizontal layers were later deeply buried, lithified and then folded into tight folds and vertical beds. Examples are seen in the Caballos Novaculite in Figure 31 and can be seen while driving along US-90 east of the small town of Marathon. (Figures 31 and 32).

It is worth recounting the steps that we know happened to just the Caballos Novaculite. Here are the events that we know happened:

1. The Caballos Unit was deposited in a setting where it was calm enough for tiny radiolarian to settle, probably in a deep basin (sorry, Dr. Folk).
2. The unit was buried under about 9,600 feet (3,000 m) of limestones, sandstones, and shales (King, Geology of the Marathon region, Texas, 1937). During this burial process, the opal in the radiolarian tests changed sequentially from opal to the minerals, ***cristobalite*** and ***tridymite*** and finally to quartz (Jones and Murchey 1986).
3. Later pressure caused part of the quartz to be dissolved away, leaving jagged dissolution boundaries known as styolites (Cox and Whitford-Stark 1987).
4. Compression shoved the rocks from the south, forming the folds and thrust faults that we see at the surface today. If there were any doubt, the fact that the Novaculite and other units maintain the same thickness through the process shows that these were not soft sediments at the time of the deformation.
5. The whole area was uplifted.
6. This very hard chert has now been deeply eroded, such that most of the original structure is now missing (Figure 32).

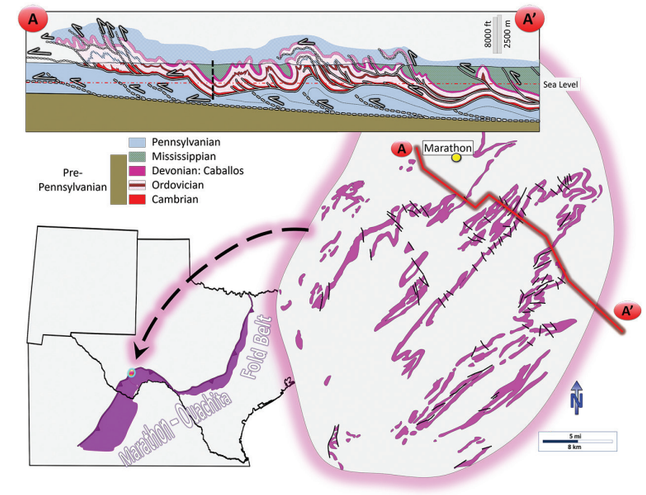


Figure 32 The upper figure shows the distribution of the Caballos Novaculite in map view. The purple broken ribbons are showing the same unit complexly folded and faulted across the area. The cross-section above shows how these units are interpreted to have looked before erosion removed the top portion of the cross-section, above the present-day topography line. (McBride and Folk 1977; Hickman, Varga, and Altany 2009)

This folding that took place in the Pennsylvanian period had huge implications for oil and gas exploration in West Texas. Near the turn of the century apparently a popular saying was "I'll drink all the oil in West Texas!" That made sense if you looked at the rocks surrounding the area. It was obvious that rocks were becoming more and more shale-prone going into what we call today the Permian Basin. It looked pretty dismal for oil drilling. Then, determined wildcatters proceeded to drill and stumbled onto the feature that we now call the Central Basin Platform (CBP; Figures 8 and 11). I love the way some of the early oil fields were found. One driller moved his cable rig out on his wagon. The area was sandy and eventually the wagon got stuck. He decided that this place was as good as any and the Sand Hills oil field was discovered. These explorers discovered that although the facies around the basin suggested that the center of the basin would be deeper water shales, there was a large buried structural feature that was found to hold many millions of barrels of oil. During the Pennsylvanian period, the rocks on the CBP were faulted and folded up into a range of mountains (Figure 33). This folding and faulting included the basement. Again, this too eliminates any question of these sediments being soft and pliable at the time of the deformation (Figure 34). If, for instance, the Precambrian granites were created mature, then folding of soft rock would not have faulted and folded the older rocks that have always been "mature."

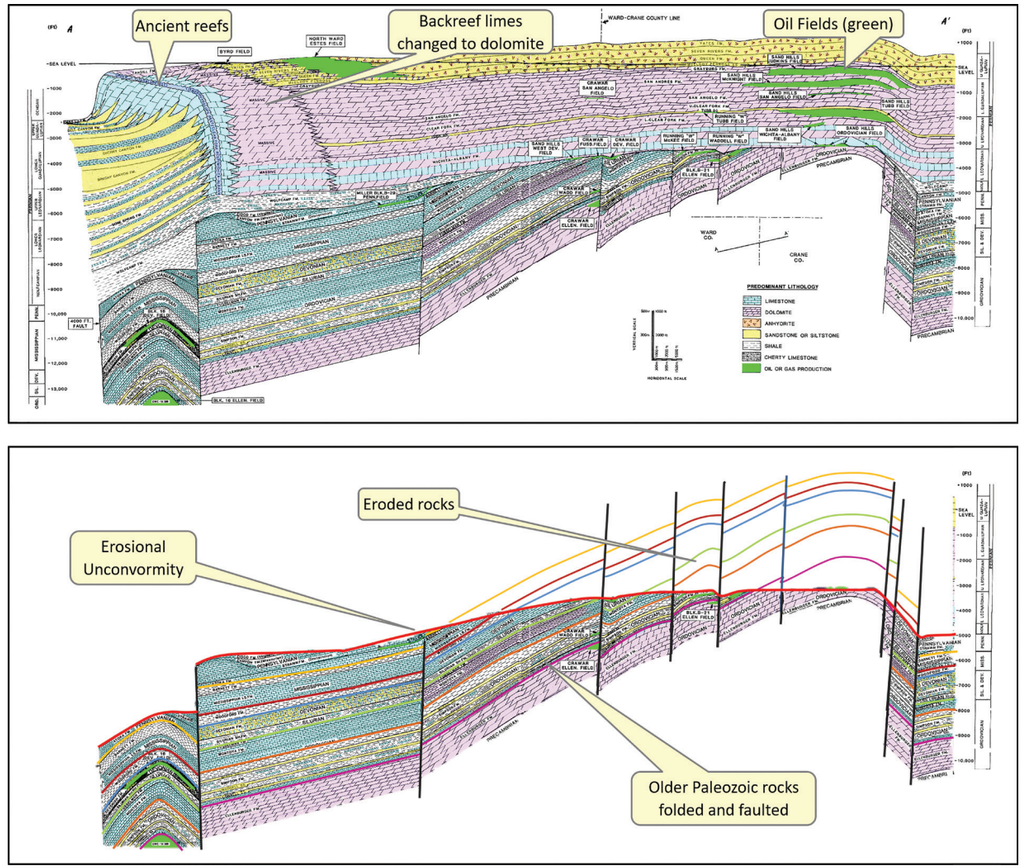


Figure 33 Cross-section across the Central Basin Platform. (Reproduced by permission of the AAPG) The top figure shows the rocks as they looked at the end of the Paleozoic era. The red line shows an angular unconformity that developed during the Pennsylvanian. Basement involved faulting and folding of the early Pennsylvanian through Ordovician rocks brought these rocks up into a mountain range. Above the unconformity are the reefs and back-reef deposits that the Permian Basin is famous for. The lower figure shows the rocks that were eroded during the late Pennsylvanian to early Permian time. (Ward, Kendall, and Harris 1986)

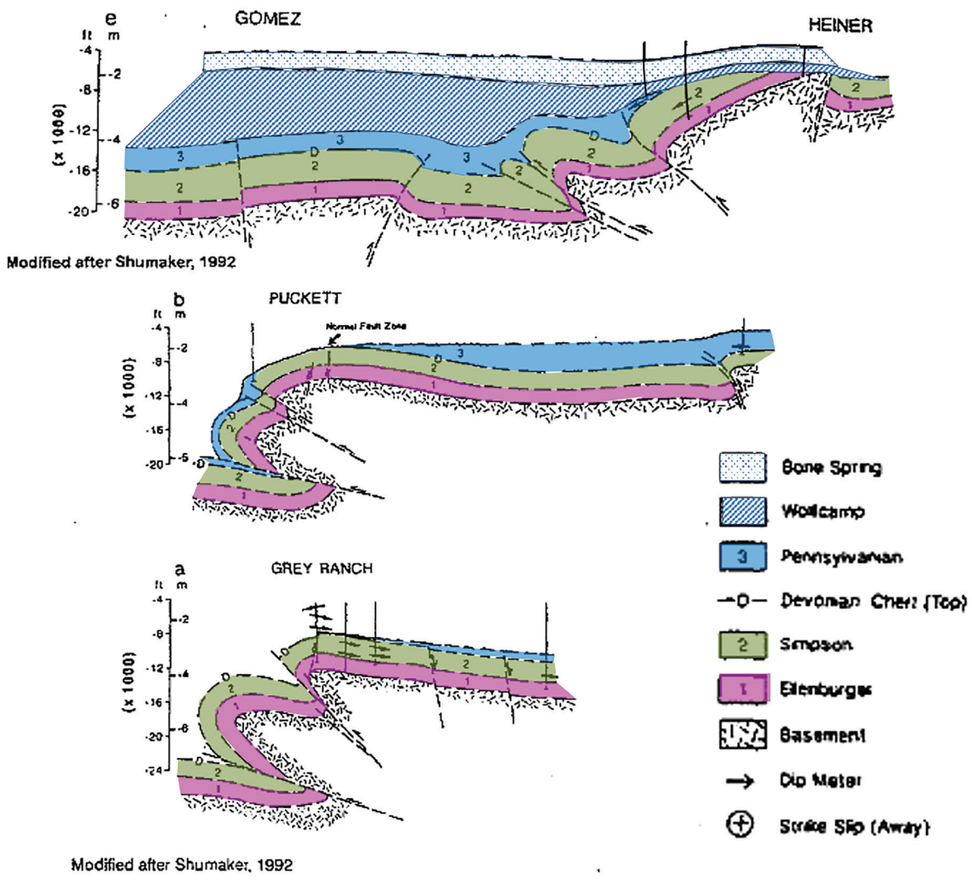


Figure 34 Structural cross-sections through three oil fields along the CBP showing the basement-involved reverse fault movements that developed during the Pennsylvanian structural event. Notice that the Precambrian basement is involved and faulted. (Hoak, Sundberg, and Ortoleva 2009)

Ancient Paleozoic rocks were folded into mountain ranges that were then eroded away. It takes time to fold rocks into mountain ranges. It takes time to erode them away.

Structural development wasn't the only thing remarkable about the Pennsylvanian period. The stratigraphy also changed as well. As the basins changed from broad shallow basins that allowed broad shelfal carbonates to be deposited, large reefs began to grow. The reefs were not formed by corals such as we have today. These were formed as mounds of platy algal masses (Wilson 1975).

Several YEC authors noted the potential challenge that the existence of reefs would be to a "flood geology" model (Whitcomb and Morris 1961; Scheven 1990; Snelling 2009). Later we will look at their claims in more detail. Regardless of the terminology that we use, carbonate stratigraphers all agree that large organically-bound, wave-resistant features grew in the Pennsylvanian period in what is now West Texas. The largest and best known of these was the "Horseshoe Atoll" (Wilson 1975; Burnside 1959; Figure 35). This feature held over 2.5 billion barrels of recoverable oil (much has now been produced) and has been studied in great detail. We can see that as the basin subsided, the mounds grew for as long as their growth was able to keep pace with the subsidence. When the sea level dropped, the reef was exposed and freshwater dissolved away some of the limestone, creating porosity that was later filled with oil. Wilson (1975) reports that as many as twenty layers of porous limestone are separated by shales that were laid down when the water deepened again. It takes time for a basin to subside and for reefs to be established and for thick reefs to form. It takes more time for the sea level to drop and the limestone to be dissolved and then more time for the basin to subside again and the porous limestones to be covered with marine muds. Since this happened twenty times, it indicates significant time passed.

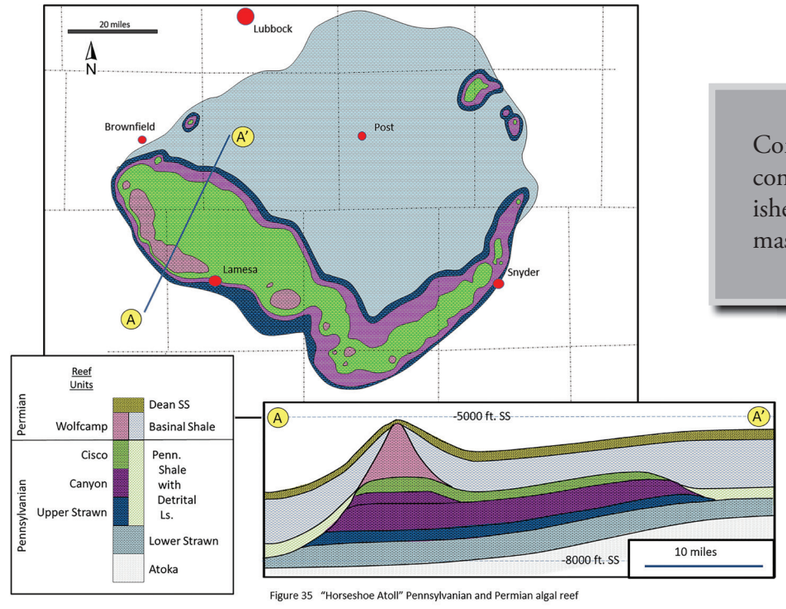


Figure 35 "Horseshoe Atoll" Pennsylvanian and Permian algal reef

Complex biological communities flourished and reformed massive, thick reefs.

Figure 35 "Horseshoe Atoll" Pennsylvanian and Permian algal reef (Wilson 1975

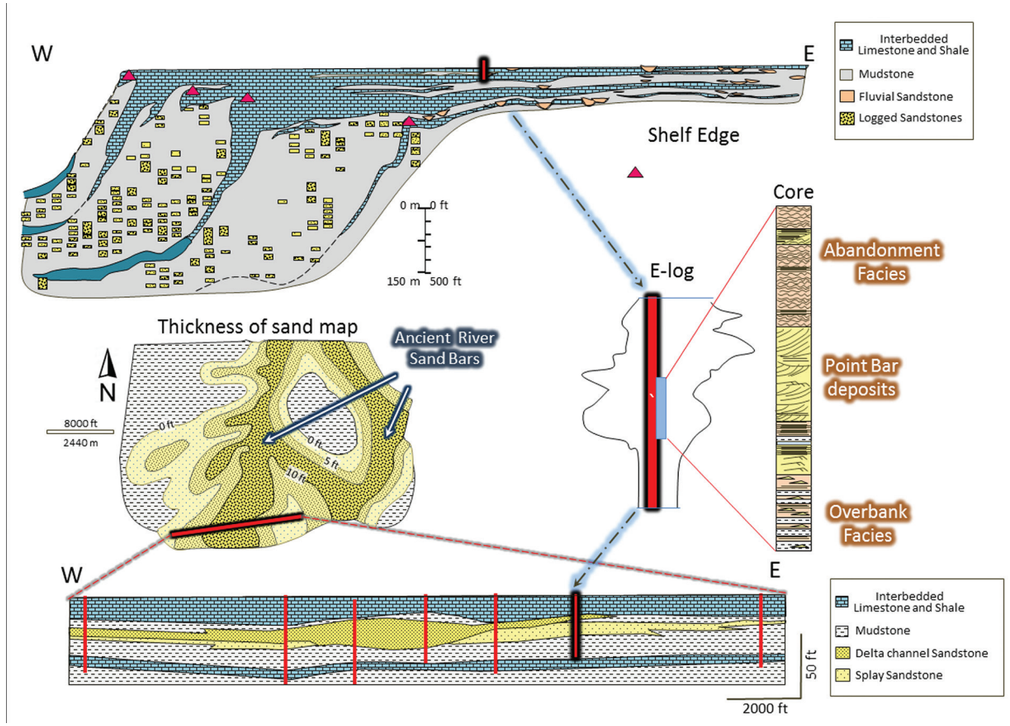


Figure 36 Stratigraphic cross-section across the Eastern Shelf from the Cisco series. During highstands of sea level, limestones covered the shelf up to a shelf edge where the water deepened and beyond which little deposition took place. During lowstands of sea level, rivers brought sand to the shelf edge and deposited sands in the basin as submarine fans. The lower figure shows some of the detailed mapping and cross-section work that goes into the more regional maps. (Galloway and Brown 1973)

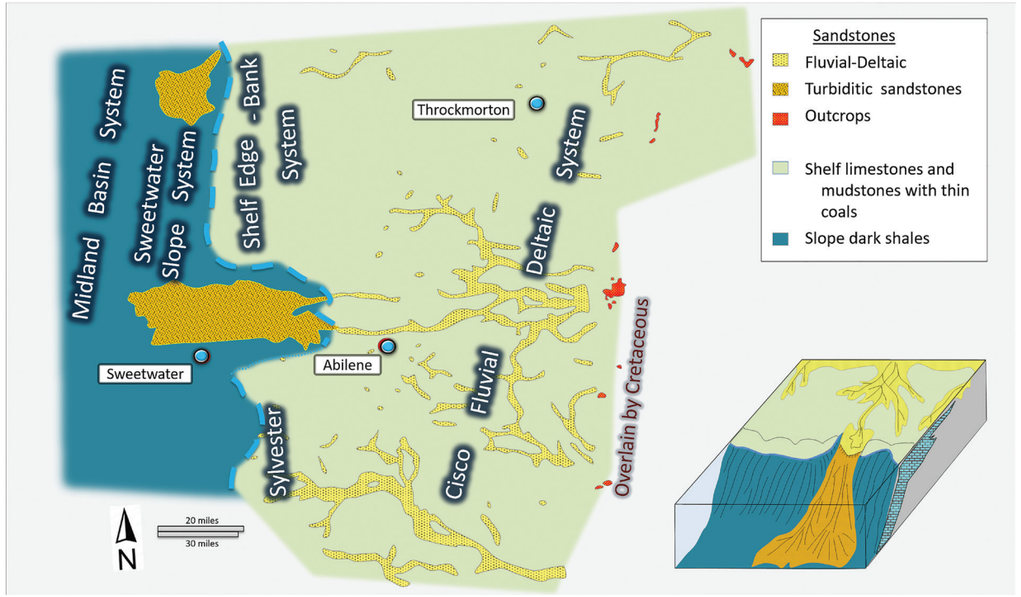


Figure 37 Paleogeography map for one of the lowstands within the Cisco series with sand bodies found within it (Galloway and Brown 1973)

Sands and shales were deposited that show all the features and scale of modern rivers, deltas and deeper basin deposits. Deposits are well organized and predictable.

As with the other intervals, for the geologic story to be reasonable, the depositional system has to fit over an entire area to be right. All the depositional elements need to make sense in map view. In the Pennsylvanian, this is particularly well documented along the Permian Basin Eastern Shelf (Figures 36 and 37). Bill Galloway (b. 1944) and Frank Brown (b. 1928) have done a beautiful job of documenting the clastic sedimentary facies there, using surface outcrops, cores, and well logs, even without three-dimensional seismic such as we have today (Galloway and Brown 1973). The rocks are broken into a series of intervals and mapped as different river systems that fed sand into deltas that prograded across the gentle slope out to a shelf edge where the water deepened into the Midland Basin. The rocks that are interpreted as deltaic contain all the features that we see in deltaic sands deposited today and the thickness relationships between the sands and shales also match perfectly with those found in modern deltas.

Another type of feature is also reported that would be typical of modern delta plains. Paleosols are reported in the landward portion of the area where the deltaic sediments are located. It is not that

just one paleosol is found. Thirty-one separate paleosols have been mapped! These paleosols might not all have been good soils but all are over three feet (1 m) thick so they represent substantial time. Conventional geologic dating indicates that such soils each represent between two to thirty thousand years of time (Kraus 1999). (Figure 38). Many different types of soils are recognized with the same features that we see today in soils in arid/semi-arid settings (Tabor and Montanez 2004). How long does it take to develop a paleosol? Most experts believe that it takes hundreds of years to form one inch (2.5 cm) of good soil.

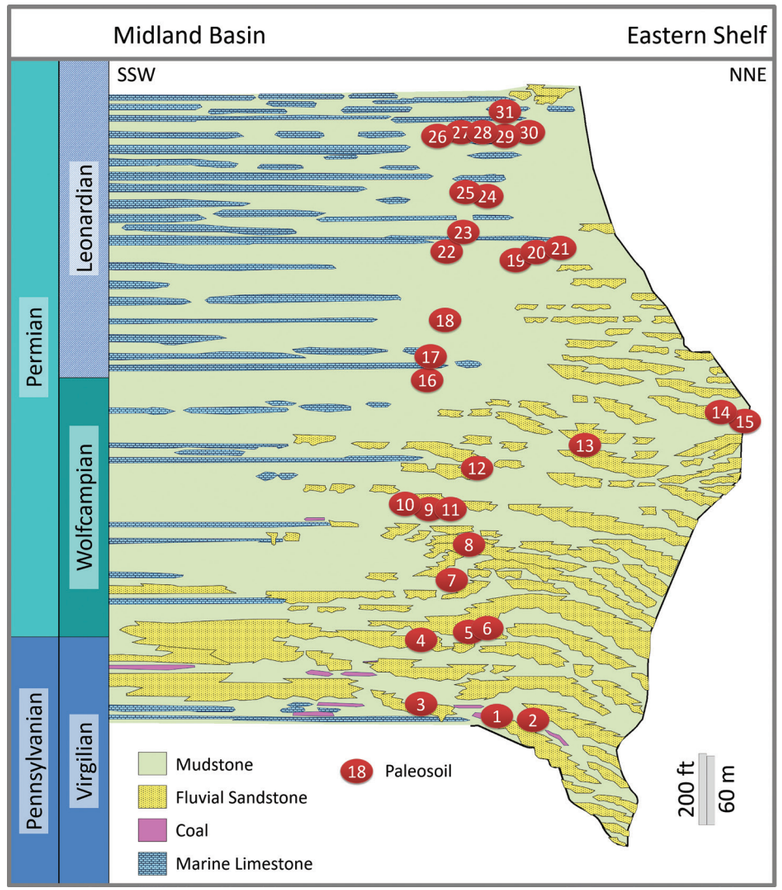


Figure 38 Stratigraphic column through the Eastern Shelf area. Shown in yellow are river deposits. The circled numbers are documented paleosols that developed from the upper Pennsylvanian through the middle of the Permian. Thirty one paleosols are recognized. (Tabor and Montanez 2004)

Beyond the shelf edge, the sands are different and those facies match those in modern deep-water environments. Between the deltaic intervals are limestone units that covered the region. The interpretation is that during relative lowstands of sea level, deltas prograded across the shelf and during relative highstands of sea level, deltas shifted so far landward that very little clastic input ever made it to the shelf and limestones were deposited. This alternating of limestones and clastic units is a theme that we see repeated over and over through time all the way out to the shallow water deposits of the Holocene in the Gulf of Mexico. The hypothesis of changing sea levels has been tested in many ways and seems very solid.

Overlying the Pennsylvanian strata are the rocks that the West Texas area is best known for. The Permian strata here have some of the best examples of ancient depositional environments found anywhere in the world. In the subsurface, they are reservoirs for many of the largest fields in the area. It is no surprise that the area is known as the Permian Basin. The lowest sediments in the Permian are known as Wolfcampian, a globally recognized unit that was actually named for a small town in the Glass Mountains in West Texas. The base of the Wolfcampian is a sharp unconformity on the CBP as shown on Figure 33. The mountains that formed during the Pennsylvanian were deeply eroded in late Pennsylvanian and early Wolfcampian time. The rocks that were eroded included thick limestones, sandstones, and shales that had been buried deeply enough to have become well-lithified, hardened rocks. This unconformity is expressed in many places. Field trips from El Paso often stop in the Hueco Mountains to examine the Wolfcampian conglomerate that is made up of pebbles of rock from the earlier mountains. My former professor, John Hills told of discovering the Tippett oil field on the CBP (Hills 1961). He found it by mapping conglomerates that were found on the unconformity. The conglomerates were composed of pebbles from mountains that were eroded away. The pebbles were later deposited along ancient rivers and in beaches on that erosional surface. The pebbles came from well-lithified rock, mostly rounded gravels of chert that came from the Caballos Novaculite and Montoya formations. All indications are that the climate at this time was semiarid or arid. How long does it take for a mountain range to erode away under these conditions?

The Leonardian and Guadalupian rocks in West Texas and southern New Mexico were deposited as a series of belts of rocks with very different characteristics or facies. These facies have got to be among the most studied in the world. Great geological descriptions of these units can be found online at: http://www.sepmstrata.org/page.aspx?pageid=179 and http://geoinfo.nmt.edu/staff/scholle/gua- dalupe.html#genset. The Permian basin was an inland sea surrounded by land on three sides and a deep basin to the south that became the Gulf of Mexico basin. It is worth looking at the climate indicators in the Permian. I have already mentioned evaporites as indicating that the climate was semi-arid to arid at times. It does seem like some things don't change. My father-in-law grew up in southeastern New Mexico. He would joke about the climate. He would say, "You have heard about Noah's flood, haven't you? We got a quarter of an inch in eastern New Mexico." Most of the Permian rocks were deposited when the climate was very dry. How can we tell that? Finding rocks such as anhydrite (calcium sulfate), gypsum (hydrated calcium sulfate), and halite (rock salt) that often form today as water evaporates in desert conditions is a good sign. It is true that such rocks, known as evaporites can form in deep marine settings, if the basin is restricted enough and the evaporation rate

is high. However, there are many clues for the Permian evaporites that tell us that they were formed in ancient salt flat environments called sabkhas. The Permian deposits share all of the characteristics of such environments when we examine them today in many places such as the Arabian Peninsula (Figure 39). Figure 40 shows a series of examples from one field in West Texas. This field had six cycles of carbonate sands deposited in tidal channels and six cycles of more arid environments. Sabkha environments formed belts of sediment all around what was a deepening basin. Beds of salt and anhydrite were deposited in broad brine pools. Mudstone and sands covered the area occasion- ally. The sand grains sizes and structures are consistent with this material having been brought in by dust storms and then reworked by rainfall (Fracasso and Hovorka 1986; Hovorka 1998; Handford and Fredericks 1980; Presley and McGillis 1982).

Ancient deposits show that they were deposited in very arid climates, just like some are today.

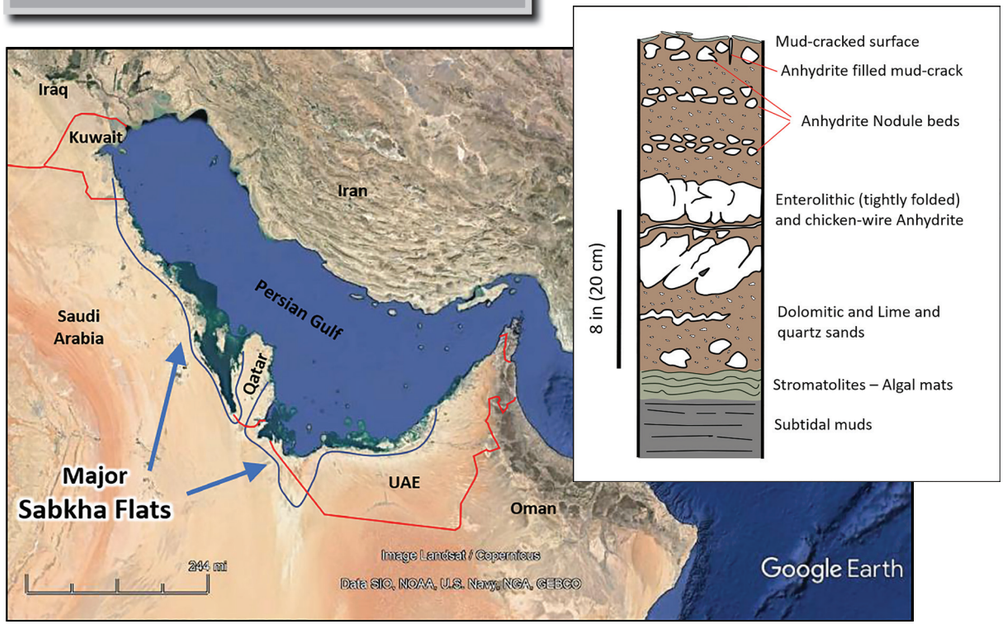


Figure 39 Generalized schematic of a common profile from modern sabkha (salt encrusted) flats in Persian Gulf. (Modified from Sherman 1966 and Kendall, 1984; Outlines of flats from Akili 2004)

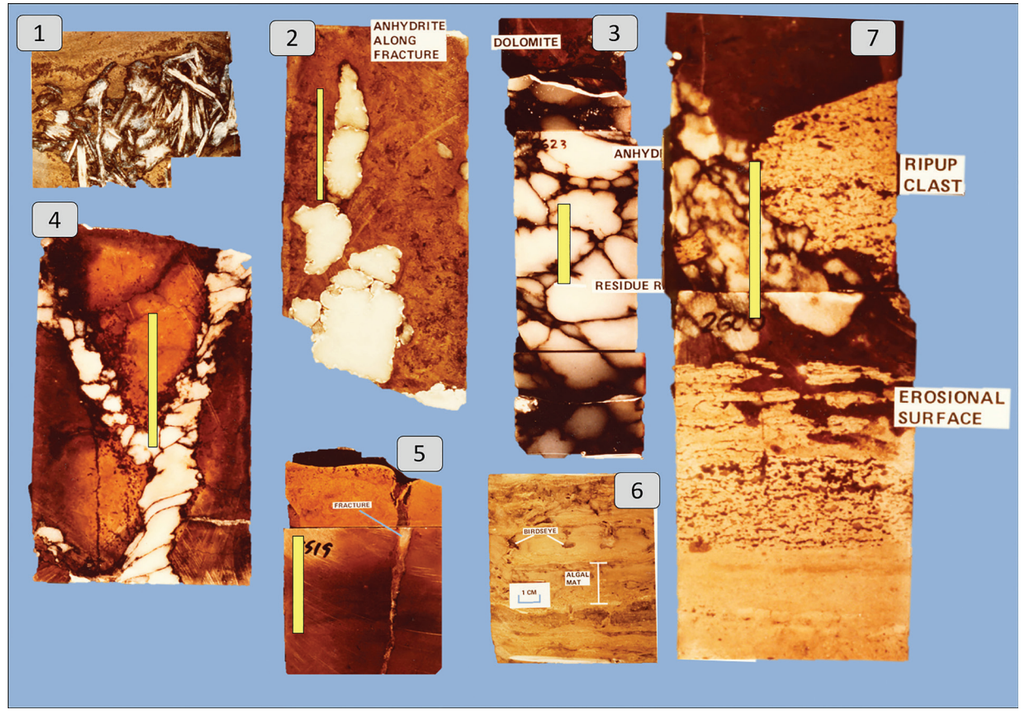


Figure 40 Series of cores from the Permian Clear Fork formation in Mitchell County showing many of the evaporites found commonly in the Permian sabkha settings. (1) Crystal laths formed of gypsum in dolomite but now replaced by anhydrite; (2) Anhydrite nodules in dolomite; (3) large "spiderweb" anhydrite bed; (4) Anhydrite formed along early fracture; (5) Fine-grained dolomite with a desiccation fracture that was filled with anhydrite and then covered with a layer of black shale that folded into the fracture; (6) Algal stromatolites that formed in the tidal zone. "Birdseye" pockets formed as freshwater leached the stromatolites and then these were filled with anhydrite. (7) Algal stromatolites with an erosional surface. Lime muds washed into the holes. Rip-up clasts of the stromatolites are mixed with the muds, ripped up by a storm. Anhydrite nodules then formed in the mud that has now been dolomitized.

Figure 41 Permian red beds, Dickens County, TX

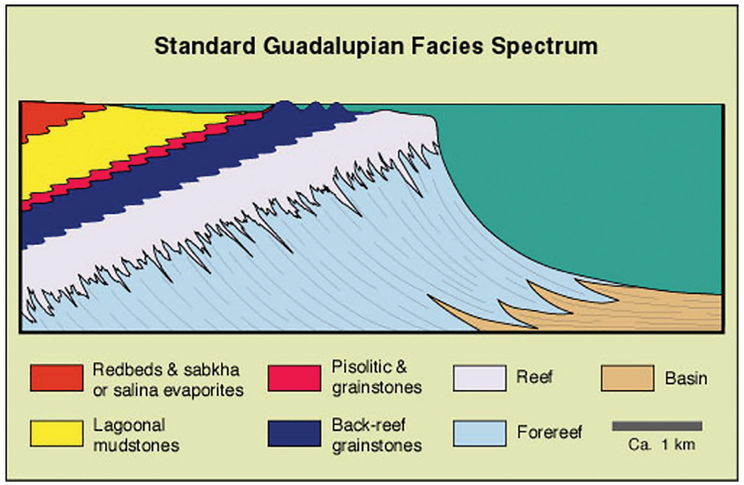


Figure 42 Generalized sketch of the facies belts that were deposited in Guadalupian time in the Permian basin. Deposition along all of the bands was taking place at the same time. They change from red beds shoreward to basinal shales basinward in a consistent way. (Scholle 2000) Reproduced by permission of the New Mexico Bureau of Geology & Mineral Resources and Dr Scholle.

In New Mexico and other landward areas, red shales and silts commonly called red beds were deposited (Figure 41). In central Texas, these are reported as "pervasively desiccation-cracked red mudstone" showing that there were intermittent periods of drying (Jones and Hentz 1988). Moving seaward at the same stratigraphic level, gypsum and anhydrite evaporites were deposited. At the Rocky Arroyo, in the Carlsbad area, the hills are capped with dolomite. Beneath the hills in the northern part of the area, the face of the hills is made up of 100 percent red shales and silts. One can trace the same dolomite and find that the rocks beneath are 100 percent gypsum. In between, the percentage gradually changes lithology in as clear a demonstration of a facies change as can be found anywhere. At the same time, red shales and silts were being deposited in one area, gypsum was being deposited in an adjacent sabkha environment (Figure 42). Moving farther basinward, the evaporites changed to a belt of dolomites that were deposited as very muddy, lime muds with sedimentary features consistent with lagoonal deposits, including many features that show that the rocks were periodically exposed to fresh water. These facies change into a belt of dolomites that were deposited as lime sands that were made up of ooids, shell fragments, and forams such as are common on beaches today in Florida and the Caribbean. Next came the carbonate buildup at the edge of the shelf, now dolomitized (Wilson 1975; Scholle, Goldstein, and Ulmer-Scholle 2007; Hills, *Late Paleozoic Sedimentation in West Texas Permian Basin*, 1972; Newell et al. 1953). Confidence in these relationships is very high.

Highway US180 goes through the Guadalupe Mountains National Park. Guadalupe and Capitan Peaks are composed of the reef core and immediate backreef facies (Figure 43). The reef builders included thirty-five different species that included sponges, bryozoans, algae, crinoids, and other animals (Fagerstrom and Weidlich 1999). It would be hard to overestimate the number of studies that have studied and argued the details of this classic deposit.

This reef surrounded the Delaware basin by late Guadalupian time. (Figure 44) Specific discussion of the YEC explanations will come later but though geologists continually argue the terminology and details, but the existence of an ancient organic framework is extremely well documented.

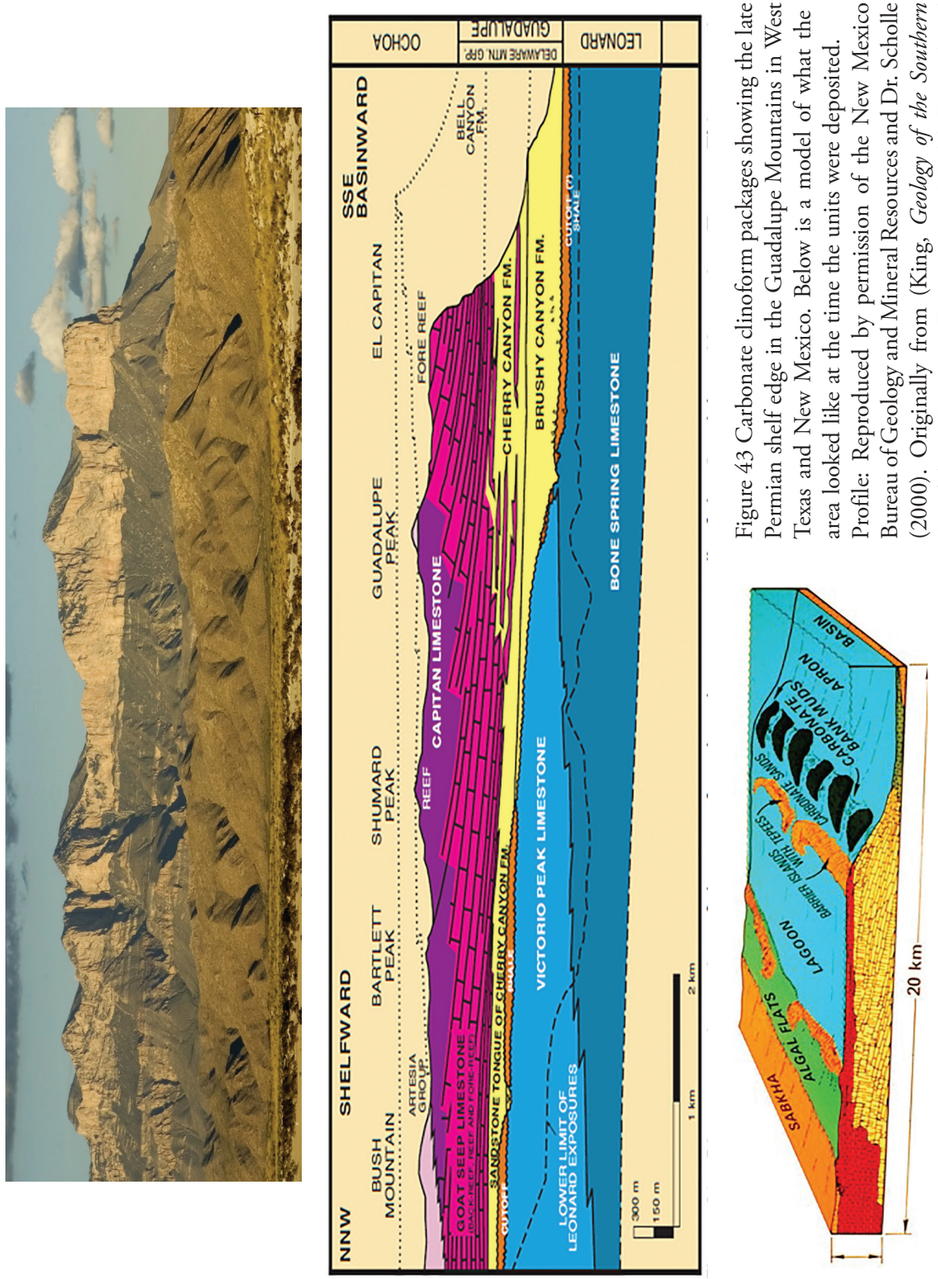


Figure 43 Carbonate clinoform packages showing the late Permian shelf edge in the Guadalupe Mountains in West Texas and New Mexico. Below is a model of what the area looked like at the time the units were deposited. Profile: Reproduced by permission of the New Mexico Bureau of Geology and Mineral Resources and Dr. Scholle (2000). Originally from (King, *Geology of the Southern Guadalupe Mountain*, Texas, 1948); Model: Reproduced by permission of Christopher G. St. C. Kendall (2005).

The facies basinward alternated between dark thin bedded limestones and clastic sand and shale facies. Adjacent to the reef, we can measure depositional dips of up to thirty-five degrees showing that these limestones, shales, and sands were deposited on an ancient slope. Sediments slid down this ancient slope just as they do along modern reef slopes. An example is found in the Guadalupe National Park, along highway US 180 where it cuts through a deposit known as the Radar slide. This deposit formed from a mass of sediment that slid down the slope from the reef. Internally, the deposit is very chaotic with mudstones, siltstones and boulders of the reef included. In fact, these are the only outcrops where we can examine the reef core where it has not been dolomitized but is still limestone.

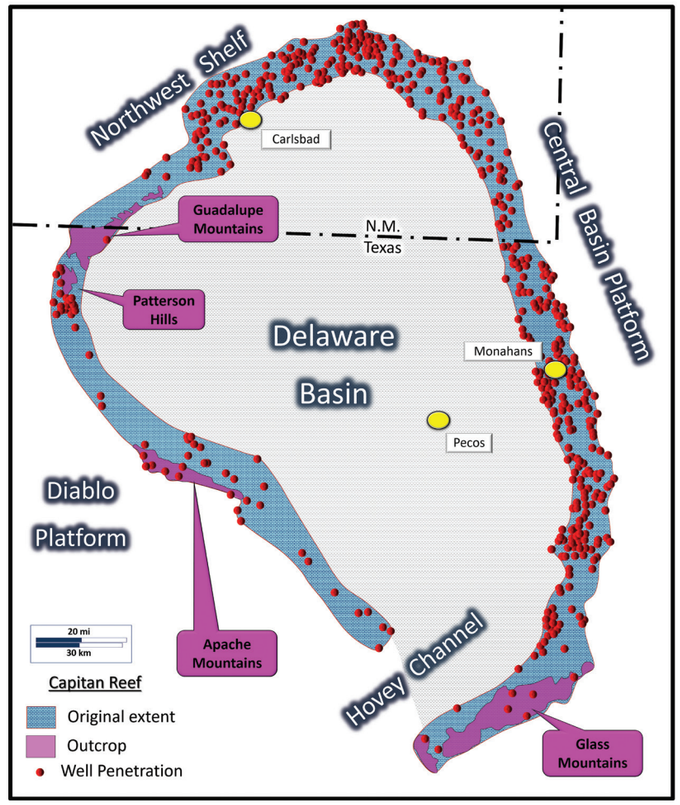


Figure 44 Map showing the extent of the latest Guadalupian reef. The map shows the well penetrations in pink that all have the Capitan reef in them. The Capitan is the youngest and uppermost reef in the area. The reef is highly porous and is a major freshwater aquifer along the CBP (Standen, Finch, Williams, and Lee-Brand 2009).

Basinward the Guadalupian and Leonardian sediments consist of thick sand and shale units separated by thinner black limestones. My first work as a geologist consisted of helping with drilling programs for equivalent sands out in the Delaware Basin. We understood that they were deepwater sands but were confused by their distribution and their relationship to the reefs. Later detailed work demonstrated that the thin limestones in the basin are time equivalent to the reef. We now interpret the reefs to have grown as sea level rose. When sea level dropped, sands were brought to the shelf edge and deposited in the basin as large deep sea fans. These are the same types of cycles of sediment that we found in the Pennsylvanian but at a larger scale. When oil companies began to drill in deepwater sands in present-day deepwater settings in West Africa and around the world, where did they go to look for analogs? Right back to the best stratigraphic outcrops in the world.

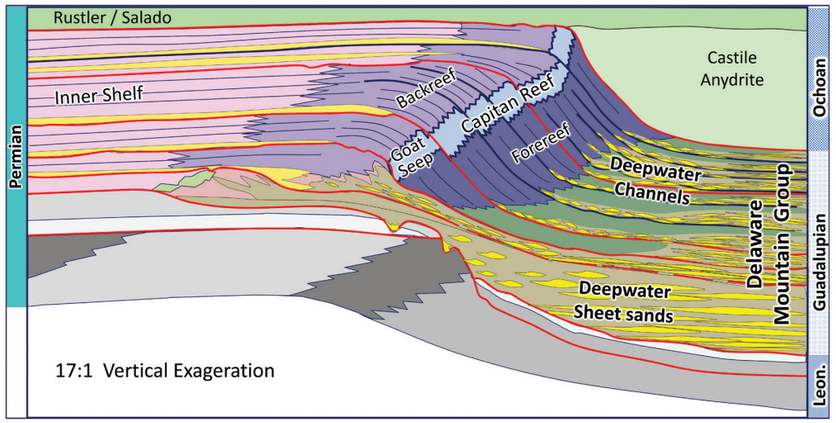


Figure 45 Stratigraphic cross section that comes from the shelf into the basin. The sands in the basin (yellow) are thick deepwater sands deposited by turbidity currents during lowstands of sea level. The limestone reefs grew as sea level rose and then were exposed and died as sea level dropped. (Beaubouef, et al. 1999; Kendall 2005; Kerans and Kempter 2002)

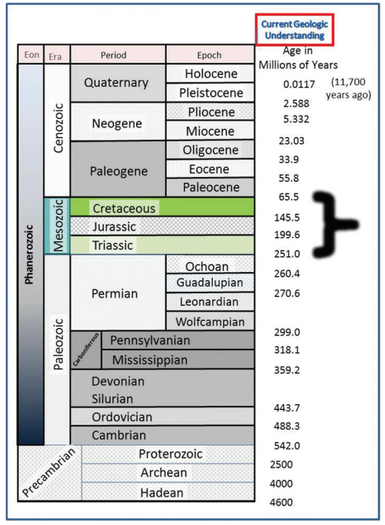
The Permian basin deepwater sands, known as the Delaware Mountain group, have been studied extensively and are used as analogs for oil fields in deepwater sand systems all around the world (Figure 45). Here it is possible to study sands deposited in deepwater in a whole series of settings from the uppermost slope where the sands were deposited in narrow channels to more distal settings where the sands were deposited in broad lobes.

In West Texas, the highest strata in the Permian are known as Ochoan in age. Elsewhere in the world, this is viewed as such a short interval that it is not separated from the Guadalupian. The rocks in the Delaware basin from this series are the Castile Anhydrite, and this unit is pretty unique. The unit has the potential to tell us directly how long it took to be deposited in years and that is unusual

in the rock record. It consists of thousands of thin layers of alternating anhydrite and gypsum with occasional layers of salt. The only explanation for their banding that seems plausible is that these represent seasonal changes in water conditions in this very restricted basin. We find such cyclic thin deposits known as "varves" commonly in lakes where the water changes or flips during the year with the seasons. If these are indeed varves, then counting the couplets of anhydrite and calcite tells us how many years it took for the formation to be deposited. The layers have been correlated over the basin and counted methodically. Anderson et al. (1972) report that there are 260,000 couplets. (Anderson, Dean, Kirkland, and Snider 1972). If these are seasonal varves, then that is how many years it took for this relatively thin unit to be deposited. If the water flipped four times per year, it would have then taken 130,000 years to deposit. Studies have developed predictive models to help understand how the layers could have formed as varves and what would have controlled them, but they cannot be considered "proven" (Dean, Kirkland, and Denison 2000). I have not seen anyone propose a reasonable explanation for the unit and its cycles forming rapidly, such as over a few weeks or days as would be suggested by the YEC model. A process would need to have fed water rapidly into the basin and evaporated it very quickly and evenly in some sort of cyclic fashion and deposited thin layers incredibly evenly, such that they are correlative over the whole basin. No options seem to be available. One more unit is recognized that is important for the topic that we are considering. The final Ochoan unit is the Quartermaster Formation, consisting of a relatively thin package of redbeds that cover the entire area. Later we will consider it in more detail because it also includes special rocks that were used to make some of the favorite arrowheads for ancestors of today's Native Americans.

Most geologists would say that the twenty thousand feet (6 km) of sediment in West Texas were deposited over about 290 million years. As described, many different types of rocks were deposited by a variety of processes. The rocks all have features of sediments that are formed today in modern settings by relatively slow processes. Many of the rocks have been folded and faulted, and we saw that an ancient mountain range was completely eroded away and then covered by later reefs and evaporitic deposits. In later sections, these rocks will be compared more directly to the predictions made by YEC "flood geologists." First though, the other intervals will be described.

Mesozoic



The next era is the Mesozoic, famous to the public as the age of the dinosaurs. Indeed, this study area has a new cast of characters such as dinosaurs and rudists (supersized clams), large- scaled salt deposits that eventually were deformed into some strange shapes and the era had an ending that was epic. Much of the Paleozoic period discussion revolved around the West Texas Permian Basin, but it had largely stopped subsiding and sediments began to be deposited in new areas, though most of the same processes acted in the new areas. The oldest strata deposited during the Mesozoic era are from the Triassic Period. The base of the Triassic is an erosional surface, a major uncon- formity. No sediments have been preserved all across this study area from the lower and middle Triassic, the earliest part of the Mesozoic era. In terms of conventional geologic dating, twen- ty-five million years passed and left no sediments over large parts of North America, and in fact, most of the other conti- nents are the same. Is this a problem for conventional geology?

Did rivers just stop flowing for twenty-five million years? This definitely was not a local effect. It needs a much larger explanation. One option might be that the erosion resulted from a global flood.

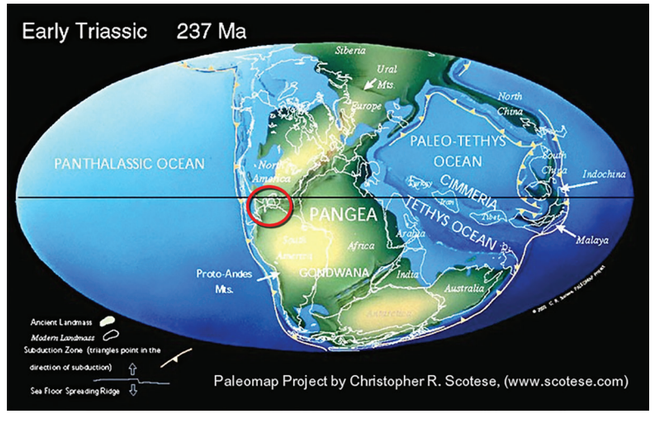


Figure 46 Reconstruction of plates and environments showing how continents were arranged in the early Triassic. All of our modern continents were joined together into one large continent called Pangea. During the Triassic, the Atlantic Ocean began to open. The study area is shown in the red circle. Reproduced by permission of C. Scotese. (Scotese 2001)

Geologists use a different explanation. The geologist's interpretation sees this as an effect of plate tectonics, the theory that the earth's crust is made up of large plates that drift around the globe through time. You can find a good summary of plate tectonics theory and the evidence for it here: http://www.moorlandschool.co.uk/earth/tectonic.htm, http://geology.com/plate-tectonics/. The evidence that we have points to all the continents having been together at the beginning of the Triassic (Figure 46). This big combined continent was high and erosion shed sediment off it, resulting in relatively little deposition on them. The thin sediment deposits that did form were redbeds, similar to those deposited during the late Permian. There are clear clues as to what type of environments these formed in. Extensive deposits of Upper Triassic red shales and sands in the Dockum group cover large areas in eastern New Mexico and the Panhandle of Texas. The fossils are all nonmarine fossils. The red shales are very consistent with modern nonmarine mudstones and the included sands have all the features and size dimensions of modern river deposits (Lehman and Chatterjee 2005). The Triassic rivers of West Texas and eastern New Mexico have been mapped. These rivers did not flow toward the sea but into one central area. What type of modern setting has rivers flowing into an area with nonmarine shales and nonmarine fauna? Modern lake deposits form just this way. The Dockum formation is interpreted to represent deposits from ancient lakes. Think about an ancient lake forming during a flood. All the fossil and sedimentary structures also indicate that these formed in an arid climate. Again, some things never change.

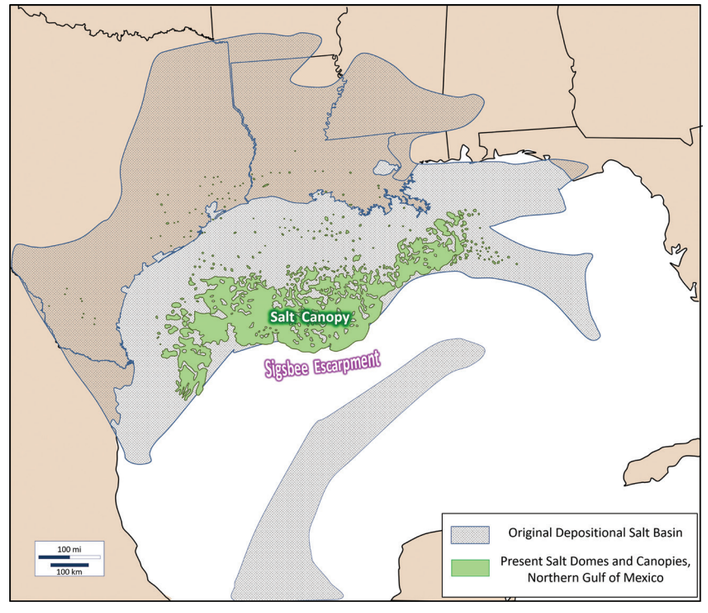
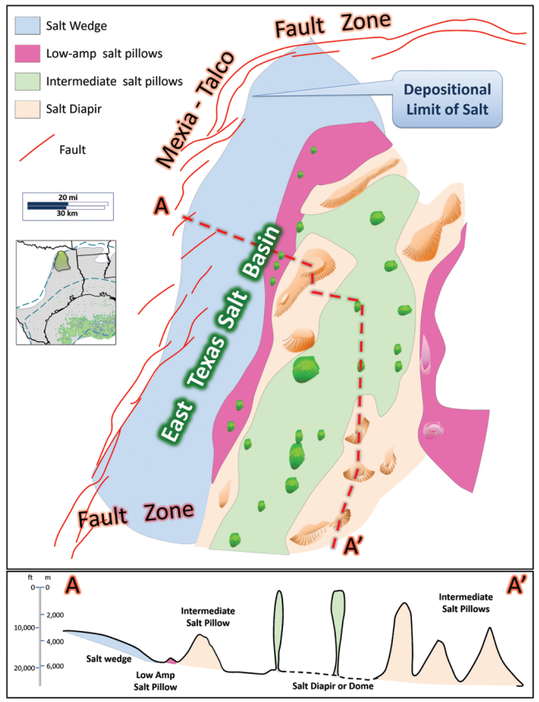


Figure 47 Original limit of the Louann salt in the Gulf of Mexico basin shows the vast area of evaporation during the Jurassic Period (Galloway 2005)



Massive amounts of salt were deposited, corresponding to massive amounts of evaporation of sea water.

Figure 48 Map and cross-section showing Jurassic Louann salt in the East Texas basin. The cross-section shows some of the many types of salt pillows and domes that are found there. (Mondelli 2011, modified from Jackson and Seni 1984)

Overlying the Triassic units are the Jurassic rocks. The Jurassic is perhaps most famous as the heyday for dinosaurs that ruled the period. Dinosaur tracks have been found in New Mexico. However, the only Jurassic rocks that have been mapped at the surface in Texas are in the Malone Mountains, a small set of mountains in West Texas along I-10 between El Paso and Van Horn. If Jurassic rocks were deposited in West Texas, they are eroded away now. Such rocks are found in northern Mexico and are well represented in the subsurface in East Texas. The Lower and Middle Jurassic rocks, known as the Louann group, include large amounts of salt deposited in what would become the Gulf of Mexico (Figures 47 and 48). Along the edge of this early salt basin, the Louann Salt is found in normal stratigraphic position, behaving like a normal sedimentary bed. Where the salt was thicker, away from the edge, it takes a host of different forms, as it flowed under the weight of later deposits. When sediment is deposited unevenly over salt beds, the loading causes the salt to shift and move away from the load. The shapes along transects such as in Figures 11, 48, and

49 might seem strange and unpredictable, but in fact, geologists understand a lot about how these developed. Seismic from just a few years ago could not begin to image the entire salt bodies the way we can today. It is now often possible to image entire salt bodies, including the base and to build scale models that allow us to watch how salt deforms through time to form similar bodies (Ge et al. 1997). Soft bodies, typically made of silicone polymers that are scaled to behave like salt, are loaded with sediments. The polymers develop pillows and domes and shapes just like we see in salt basins such as the Gulf of Mexico. A first reasonable guess might be that salt domes formed as large masses of salt were squeezed forcibly up from below through the rocks. Certainly, some YEC reports suggest that the domes formed this way, rapidly in response to the cataclysmic flood event. It is well documented, however, that salt started moving very early, when there was relatively little sediment above it. It then stayed at or very near the surface, while sediments loaded around the structures. You might picture this as being like what would happen if you gradually loaded a layer of Jello along one side of its top, with very fine sand (or maybe fine sugar for better flavor). If you loaded it from one side, it would shift away, continuing to move as long as the sand was fed in. Salt moved the same way in sedimentary basins such as the Gulf of Mexico. As it happens, one of the best places in the world to examine such salt features known as diapirs at the surface is in this study area, in the La Popa basin in northeastern Mexico (Figure 8; Rowan et al. 2003; Lawton et al. 2001). Here it is possible to walk on the rocks around salt features and document how they moved as sediment was deposited around them. Blocks of well-lithified Jurassic rock were folded and pieces were caught up into the salt as it moved. Phases of sands and shales were deposited alternately with phases of thin bedded limestone that are often fossiliferous. The diapirs certainly did not move quickly in response to a single event. Salt domes and associated deformation demonstrate processes that took time.

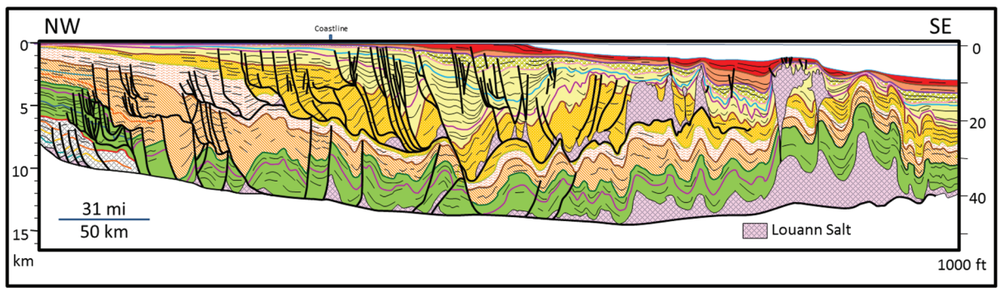
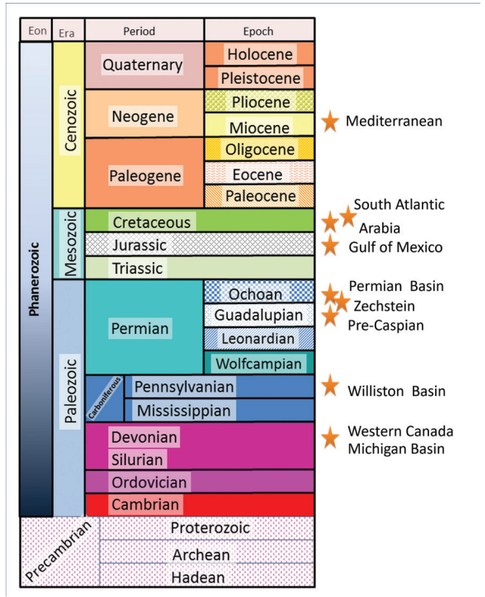


Figure 49 Tracing of interpreted seismic profile from offshore Texas showing how modern seismic allows complex salt geometries to be imaged and interpreted (Radovich, et al. 2007)

So far, we have looked at what this large amount of salt tells us about time, based on its deformation. Where did the salt come from? Just like in the Permian, the large amount of salt deposition in the Gulf of Mexico and Mexican salt basins resulted from a large amount of evaporation. Major

salt basins like these developed at a number of stratigraphic levels around the world with very similar features. (Figure 50) A normal stratigraphic evaporite explanation works well for each of these basins. We find salt deposition taking place today, but not at the rate that it did at times in the past. As noted before, geologists recognize that present processes are a key to the past but recognize that the past was also different in terms of rates and scales. Any YE explanation must account for how the large salt deposits formed at each of these different stratigraphic levels. It would be difficult to associate them with any particular phase of the flood.



Today the Jurassic salt has been deformed into many varied forms. This deformation folded rocks and shaped deltas and deep water sand deposits, proving that this did not take place quickly in human terms.

Figure 50 Stratigraphic column showing seven major salt basins that developed at very different stratigraphic positions around the world. Any explanation for the salt formation must allow for it to work at many different stratigraphic ages. This complicates the options for choosing what constitute flood deposits. (Sarg 2001)

The East Texas basin Jurassic section is very thick and includes other formations that also can be traced all the way from Texas to the tip of Florida. The mixed clastics and carbonate environments that at times developed here are much like we find them in modern sediments in Belize today. Our old friends, the ooids, were deposited along a facies belt that extends around the entire northern edge of the Gulf of Mexico (Budd and Loucks 1981). Once again, we are confident that these formed ooid shoals similar to what we see in the Bahamas today. We also have a belt of limestone muds with evaporites, here anhydrite, interpreted to have been deposited in a sabkha environment similar to what

we find in arid climates today and in the Permian deposits in West Texas. The thick Jurassic section is split into a series of formations consisting of sandstone, shale, limestone, and evaporite units that can be mapped around the northern Gulf of Mexico. The facies trends can be carried coherently around the entire area (Foote, Massingill, and Wells 1988; McGowen and Harris 1984). A trend of oolite shoals has been mapped within it and adjacent to it is a band of limestones known as biostromes or reefs formed by a variety of ancient biologic communities (Spaw, Balderas, and Ziegler 2000). In the Cotton Valley formation, the reefs included corals, calcareous algae, calcareous and siliceous sponges, and microbial deposits. Once again, these would have had little porosity preserved except that some of the reefs were exposed above sea level long enough for fresh water to create secondary porosity that makes such reefs better reservoirs than those that were not exposed. Reefs indicate many years of development and more years later as they were leached by freshwater, creating porosity.

The youngest period in the Mesozoic era was the Cretaceous Period. The lowest Cretaceous rocks in Texas were apparently deposited like the Upper Jurassic along a gentle ramp where the sediment changed from landward areas in a seaward direction from redbeds and conglomerates to oolitic limestones and lime mudstone deposits (micrites) interpreted to have been an open shelf (Foote, Massingill, and Wells 1988). Climbing section (moving up the stratigraphic column to younger strata), the lithologies alternate just as we have seen over and over, with limestones alternating with shale and sand units. The facies indicate that were all deposited in fluvial and shallow shelf environments. Deeper water environments would have been basinward toward the Gulf of Mexico, but those rocks are buried deeply under younger Cenozoic rocks now and are largely unpenetrated.

Many YE proponents also are especially interested in the Lower Cretaceous rocks in Texas. There is a controversial claim made about features in these rocks that has convinced some that these rocks are very young. Dinosaur tracks are found in many Mesozoic rocks in the study area (Figure 51), but none are more well-known than in the Paluxy Formation near Glen Rose, Texas. Whatever else the tracks may indicate, they clearly demonstrate that throughout the Mesozoic, there were often land conditions. The footprints were not made below the sea. Any water there would have been measured in inches rather than feet. The Paluxy Formation contains all the features that we find in modern meandering river and sandy beach environments (Caughey 1977). Many dinosaur tracks are found in the Paluxy formation including those at the Dinosaur Valley State Park near Glen Rose. All would agree that most are typical tracks from sauropods, large herbivores that walked there, probably grazing along rivers and beaches there and therapods, carnivores that hunted there. The most commonly viewed are on what is termed the "main tracklayer," a sandy, dolomitic layer that has been heavily burrowed into by invertebrate animals (Farlow et al. 2012). Some of the tracks are beautifully preserved, though exposure to the elements has taken its toll on many. It so happens that some are not so pretty and classic and some have appeared that are not so natural. The controversy involves claims that some of the tracks are not dinosaur tracks, but "man tracks," demonstrating that humans coexisted with the dinosaurs (Figure 52).

In some ways, there are similarities between this controversy and another that raged early in the last century. Darwinian evolution demands that there be vast numbers of intermediate animal species and the ultimate find dreamed of was a clear fossil link between apes and man. Bone

fragments including two skull fragments and a jawbone fragment were found in southern England. Arthur Smith Woodward (1864–1944) of the British Museum displayed them to the Geological Society of London as the "missing link" with features of both man and ape. It was such a perfect find that it was almost too good to be true. Thirty years later, they were examined and proven to be fake (Boese 2011). It was a case where the scientific community looked for something and when someone claimed to have found it, the community bought it, hook, line, and sinker. Too good to be true turned out to be just that.

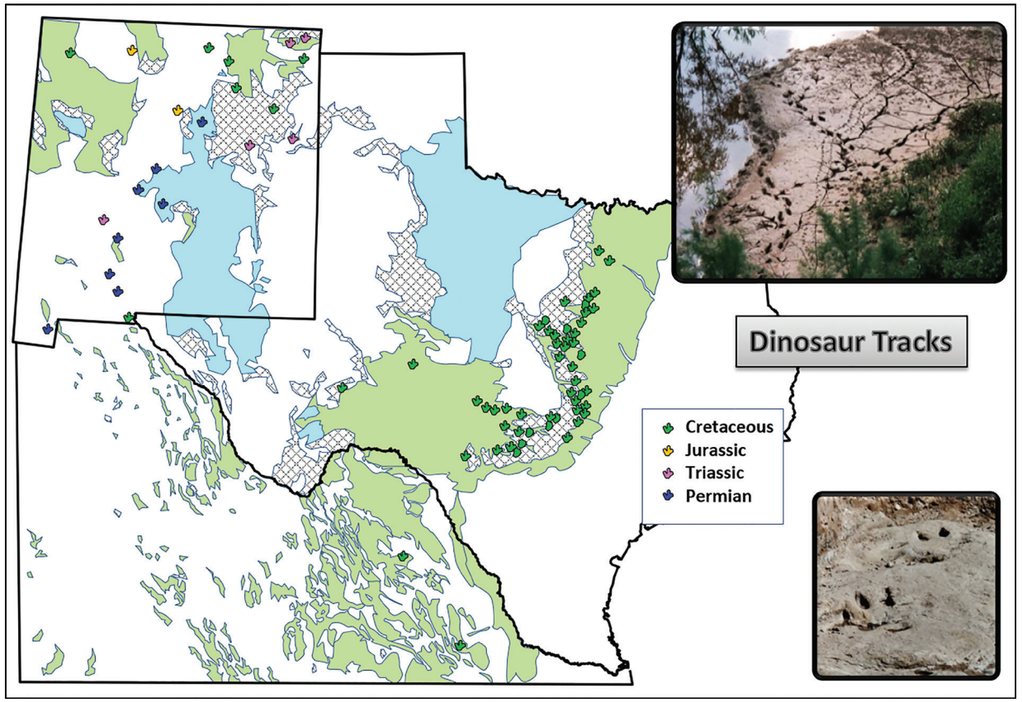


Figure 51 Map showing dinosaur track sites from the study area (Bureau of Economic Geology, n.d.; Hunt, Lucas, and Huber 1990; Meyer, et al. 2005; Rivera-Sylva, et al. 2006; Kappus and Cornell 2003)

YE proponents are eager to find evidence that the earth is young, and when the claim is made that the Paluxy Formation has human tracks, they are eager to believe it. This claim is so good that it suffers from the Piltdown syndrome of being too good to be true. Many of the prints are simply misidentified dinosaur tracks and odd features that with creative lighting can look a bit human. Some are human in a different sense and even more like the Piltdown example. The print called as "Burdick Print" is the

best known of the last case and really does resemble like a human print. It, like the Piltdown skull, is a fake. The "Burdick print" is one of several examples that are on loose stones, where the actual place the stone originated is unknown and key details are missing. It is difficult for such pieces to be evaluated seriously by scientists. Detailed examination of the "Burdick print" has demonstrated that the "human print" was carved (Kuban 2010). One key problem is the fact that it was carved on the wrong side of the rock. Fossil algal mats, the stromatolites, our old friends are the "smoking gun." They are upside down in the print. Although it is unproven who forged this print, Clifford Burdick (1919–2005) who brought the footprint to fame is at least guilty of bad judgment (Numbers 1993). Just as the Piltdown scandal did not disprove evolution, the "Burdick Print" fake does not disprove "flood geology."

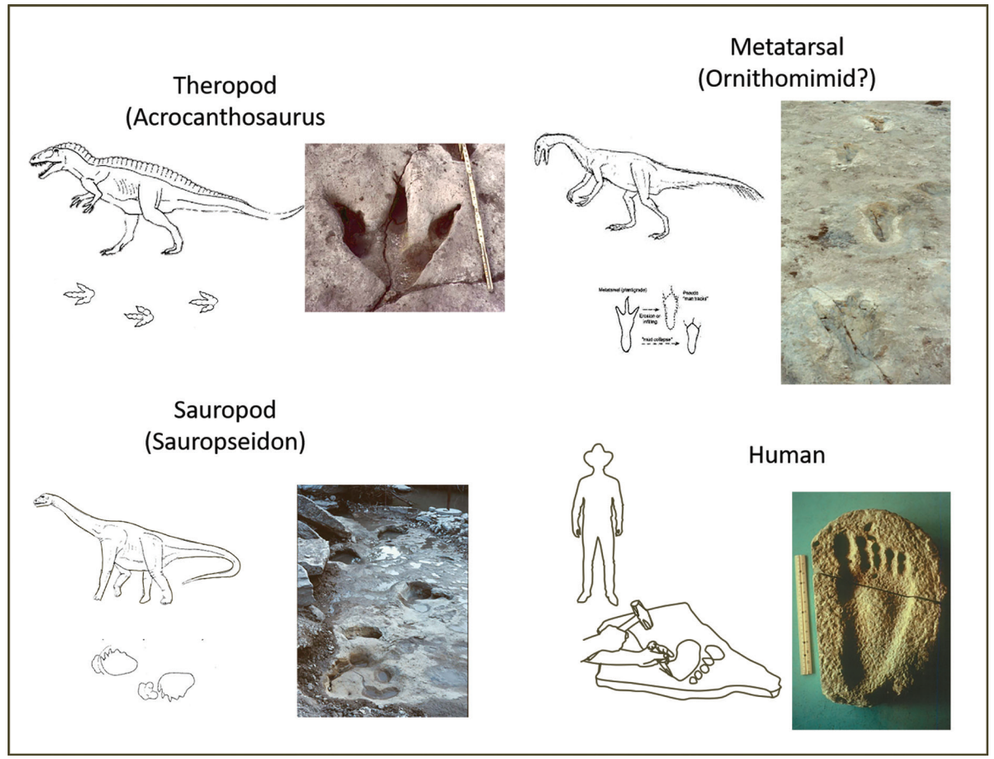


Figure 52 Four sources of tracks from the Lower Cretaceous Paluxy formation. The two track types on the left are clearly from dinosaurs as agreed by all. Those on the right are often taken to be Cretaceous human tracks. The upper right tracks are identified as a type of dinosaur known as "metatarsal". The lower right "track" is known as the "Burdick Print". This track is on a loose stone and is not authentic. (Kuban 2010) Reproduced by permission of Glen J. Kuban

Other prints have been found that are claimed to be human, but such claims would need to have very good evidence. All prints that I have seen or seen pictures of seem pretty unconvincing to me. They are typically just too poor to prove any claim that they are human. Stratigraphically younger than the main tracks near the Dinosaur Valley State Park is an additional layer with tracks. They are located at a location known as the Taylor site. Here an entire path of prints was recognized and many YEC interpret them as human. You can find a number of YEC Web sites that present the Taylor tracks and other such tracks as authentic human tracks. Fortunately, in this case, it was investigated in depth by Glen Kuban while the tracks were in their best condition and the details show that while the tracks are authentic, they are not human. This web address provides a description of his investi- gation: http://paleo.cc/paluxy/tsite.htm. He has demonstrated that the best explanation is that the tracks were made by tridactyl (three-toed) dinosaurs who walked a bit differently, by impressing their lower leg or metatarsi into the sediment. The result is that the footprints tend to be elongated, and when less than perfectly preserved, they can appear almost human. Kuban was able to document that in other sites the tridactyl dinosaurs had a variety of walking styles that varied from the more common toe—walking to walking partially on their metatarsi, including tracks similar to the Taylor site.

Overall it is clear that there is no good evidence for humans until the Pleistocene sediments, far up the stratigraphic column. Given all of the rock deposited between the Cambrian and Pleistocene with no evidence of human existence, it is hard to make a case that the poor tracks in the Cretaceous are actually human prints. Garner's essay on the *"The Genesis Flood" 50 Years On* makes this statement:

> Another argument used by Whitcomb and Morris against the geological column was the phenomenon of misplaced fossils. Specifically they referred to the alleged discovery of human footprints alongside those of dinosaurs in the bed of the Paluxy River in Texas. *But subsequent investigations by creationists and evolutionists have shown that the so-called human tracks are a combination of misidentified dinosaur tracks, random erosional marks, and carvings made during the Great Depression.* Consequently, the Institute for Creation Research stopped promoting the Paluxy "man tracks" long ago, although they still crop up in some popular books, articles and websites. (Garner, *The Genesis Flood: 50 Years On*, 2011; emphasis added)

In a later section, we will again look at dinosaur tracks and their implications for flood geology. In the meantime, the Cretaceous rocks have much more geologic information to consider that is relevant to our investigation. Large-scale limestone deposition took place through the middle part of the Cretaceous throughout the entire Gulf of Mexico region. From the middle Cretaceous onward, there are many repetitions of the processes and deposits that we saw in the Paleozoic. We find reefs that grew during high sea level stands and clastics deposited during lowstands. It is the same but different. It seems to be a bit like looking at an episode in one of those long-running soap operas. You can miss the series for a week or for five years. When you begin watching again, you find that the themes and plots are the same. The cast may be different and the details of the story will be different,

but it is still very familiar. Through the Paleozoic era, in the Permian basin and surrounding region, the characters changed a lot through time. However, rivers ran downhill, eroded rocks and sands were carried to the seas. Life flourished, even if it took different forms and reefs developed when conditions made that possible. We see that the cast in the Cretaceous season of the soap opera is different than the Pennsylvanian season or the seasons of the Permian. Cretaceous reefs began to grow around the margins of the Gulf of Mexico from the Yucatan Peninsula to Florida. These reefs were different from the early algal reefs or the coral reefs that we see today. They were dominated by large bivalves known as rudists (Wilson 1975; Moore and Bebout 1989). Rudists were like clams on steroids, and they formed shelf margin reefs and patch reefs. The change from a ramp to a trend of reefs is the same process that we saw in the Permian Basin for older rocks. The Cretaceous Stuart City reef trend (Figure 53) was a key feature that influenced the structural development in the Gulf of Mexico from the Cretaceous to the present. Just as with the Pennsylvanian and Permian, this is not just one simple episode of reef development. The reefs were repeatedly exposed to fresh water leaching. Porosity from this freshwater leaching is very important to Texas because this allows these ancient reefs to hold what is perhaps the most important resource that comes from rocks: fresh potable water. The Edwards limestone is the largest aquifer for the state (Eckhardt 1995–2013). Evaporitic facies with gypsum and anhydrite were deposited behind the Cretaceous reefs just as they were in the Permian Basin (Moore and Bebout 1989). Dry conditions seem to be a chronic description of Texas.

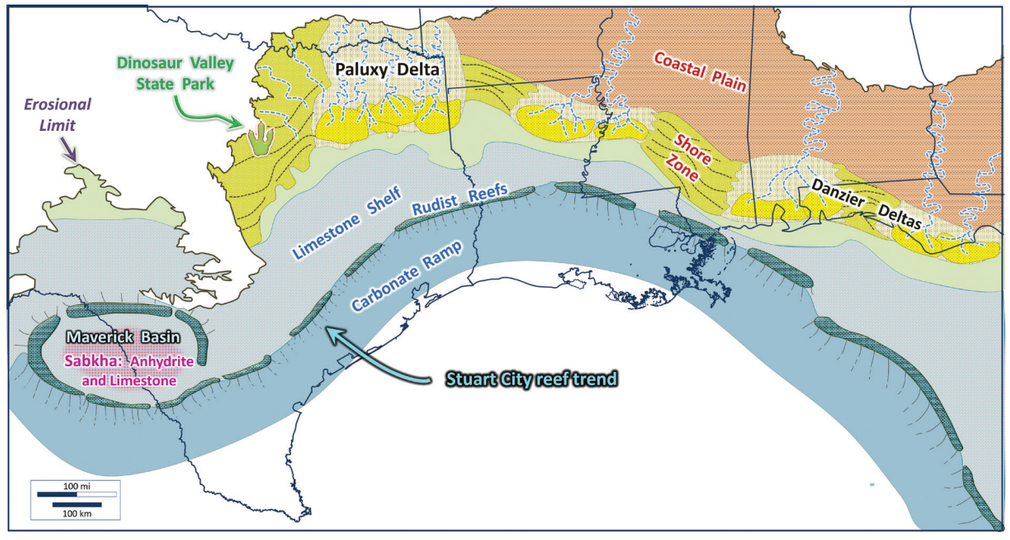


Figure 53 Cretaceous reef trend shown across the northern Gulf of Mexico. It extends all the way to Florida where it is clearly seen on seismic but has not been drilled because of environmental restrictions on drilling. Modified from: (Galloway 2005)

Cretaceous rocks in this study area have many different depositional and structural settings that had complex histories. One example that I am particularly familiar with comes from the middle Cretaceous in northern Mexico. There I mapped a series of Cretaceous carbonates for my master's thesis in Chihuahua, Mexico (Mitchell 1980). The small mountains of Sierra Gomez are interesting in part because they have uranium deposits in the limestone. (Mitchell et al. 1981). Many of the limestones were black and very rich in organic matter. It is very likely that if they were deeply buried, they would be oil source rocks. Studying them was interesting but the field area was not particularly hospitable. Almost all the plants had thorns. Even the massive limestones weathered into a pitted form that was almost thorny. Sierra Gomez is located in the tectonic feature known as the Chihuahua Trough, a basin that formed in the Jurassic and had salt deposition similar to the Gulf of Mexico (Carciumaru and Ortega 2008). The surface rocks were highly folded and thrust faulted, middle Cretaceous limestones (Figure 54). There were no indications of significant soft sediment deformation.

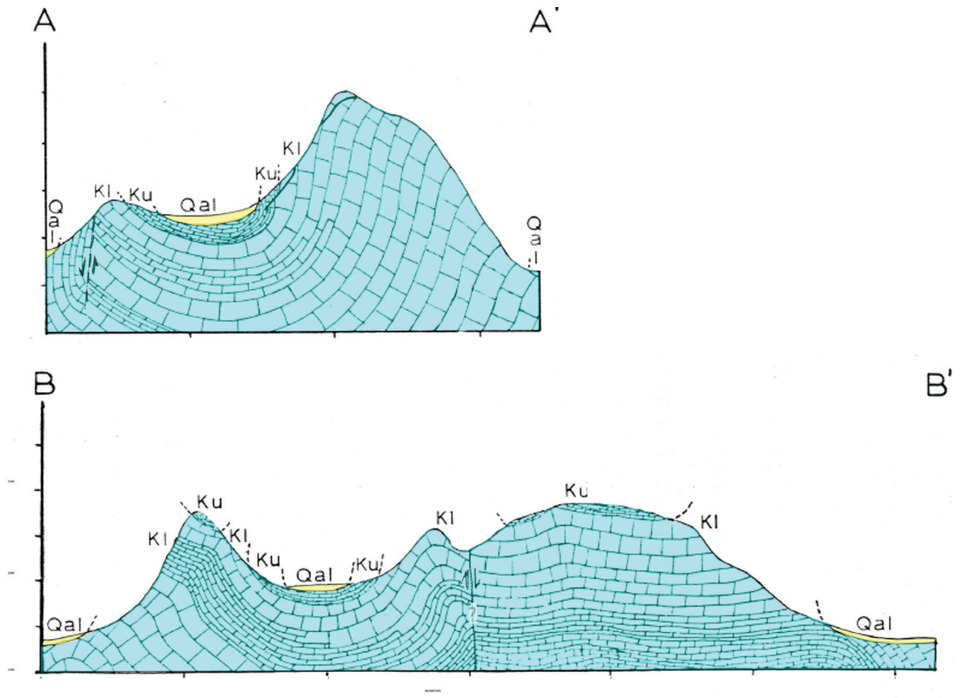


Figure 54 E-W structural cross-sections through the Sierra Gomez study area. The whole range is a large upthrown fault block within the basin and range province where the downthrown areas are desert valleys today. (Mitchell 1980)

The limestones were well lithified and folded as solid limestones. Thin-bedded units were more ductile (easily folded) but even these had fractures and faults that developed after the lithification. The thick bedded units had thrust faults that were indicative of brittle deformation (Figure 55). In view of the time frames predicted by "flood geology," it is worth just listing all of the geologic events that are documented in this one small area. Any "flood geology" explanation for these rocks must explain all of these in a few thousand years.

1. Jurassic salt deposition—indicative of evaporation of large amounts of water though we do not have enough data here to determine the exact conditions
2. Deposition of at least 1,640 feet (500 m) of massive and thin-bedded limestones. Initially these were believed to have been deposited in deeper water, well below wave base, but I discovered many indications of very shallow water environments. These included thin foraminiferal sands and an amazing variety of delicate fossils, many of them clearly in growth position (Figure 56). Many of the units appeared to have been subaerially exposed. Evidence for this includes gypsum crystals that grew as a result of evaporation but were later replaced by quartz. The dark limestones with large amounts of organic material tell us that much of the time, circulation was very restricted such as in a lagoon.
3. After deposition, the limestones were buried, and many of the fossils were replaced by quartz. Silica came from siliceous sponge spicules that are common in the black thin-bedded units (Scholle and Ulmer-Scholle 2004). The rock needed to have been buried deep enough to reach about 20°C. The depth that this represents would have depended on the *geothermal gradient* at the time and that is unknown. Upper Cretaceous and early Paleocene rocks were probably deposited but are eroded away now. The lime muds became limestone.
4. Later we recognize the regional compressive event that folded and faulted the rocks. This took place as a part of the Laramide orogeny (mountain building) that also created the Rocky Mountains. If this event had taken place over few thousand years, these rocks would have been shattered completely (Figure 57).
5. These rocks were later uplifted and eroded deeply. Eroding through limestones takes time. Paleokarsts developed as freshwater dissolved away limestone. These are commonly filled with red paleosols and iron-rich mineral deposits.
6. The area was then later covered with thick subaerial lavas that were part of broad igneous events that took place in the Cenozoic. There are no indications that any of these lavas formed underwater.
7. Later the rocks were faulted with normal faulting as a part of what is called the "basin and range province." This created the series of upthrown mountain ranges and downthrown valleys that cover the large parts of Mexico, New Mexico, Arizona, and Nevada.
8. My interpretation is that groundwater percolated through the lavas and concentrated uranium that was deposited largely along the paleokarsts and thrust faults. Yellow uranium silicates and other uranium minerals formed.

9. Next, the hard volcanic tuffs that covered the limestone were eroded away, except for a few small bumps in the adjacent ranges. The limestones themselves were deeply eroded as well to give the present landforms. *Alluvial fans* were deposited that filled in much of the downthrown blocks adjacent to the mountains and thin alluvial deposits were laid down in the valley through the center of my study area. No indications of humid conditions were found.
10. Then a soil developed in this valley, often over a meter thick. It is reasonable to expect that this soil was in place when the Spanish conquistadors came through northern Mexico in the 1500s.

Figure 55 Thrust faults from Sierra Gomez. Photo A is from a road cut with moderate bedding thicknesses. Photo B shows an exposed thrust plane in thicker massive limestone.

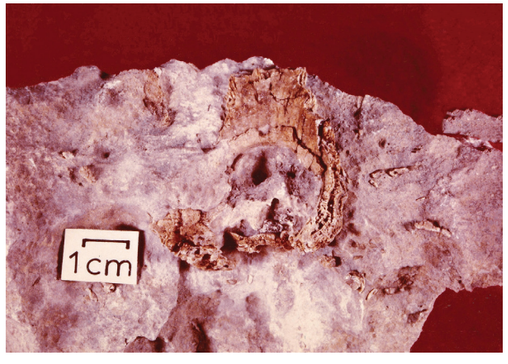


Figure 56 Radiolitid rudists in growth position. Many of the massive limestone units had many of these, all oriented just as they were in life. They simply lived, died, and were buried in the same place. These were deposited originally as calcite, but the calcite was replaced by quartz after the strata were buried.

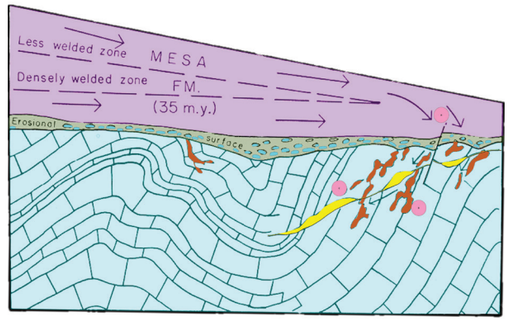


Figure 57 Schematic drawing showing some of the model we developed for uranium emplacement. Light-blue limestones were folded and cut by thrust faults (yellow). The area was eroded and karst features developed (B). Thin erosional sediments overlaid the limestone with many limestone fragments. The subaerial volcanic tuffs were laid down (pink). Groundwater moved through leaching uranium from the tuffs and deposited it in the paleokarsts and along the faults in the limestone (Mitchell 1980).

The upper Cretaceous includes yet another series of cycles of limestone and clastic rocks. The clastic soap operas of the Cretaceous are very similar to those of the more famous younger Cenozoic ones, but for this area hold the first major appearance of another player, coal. This actor in our drama will be more fully developed later, but even so, Cretaceous onshore deposition included some of the most important coal deposits in Texas. This coal, like most, was deposited in swamps and marshes (Lehman 1985).

YEC author Snelling (2009) proposes that coal was largely deposited by flood waters, perhaps from large clumps of plant material that were swept off the continents or else as large floating masses of plants that grew on water. He postulated that huge floating islands were present before and during the flood. Dinosaur tracks help to show that this was certainly not the case for some coals, and it is really unlikely that it was for any. I was on a field trip in Utah to learn from examples of sandstone on the surface in order to better visualize what happens in the subsurface. These Cretaceous sandstones form a broad band across Utah and are interpreted to have been deposited along large wave-dominated river deltas similar to those found off the Texas coast today. Interfingered with these sandstones towards the coast are coal beds. The leader of our trip, Dr. John Balsley, has done extensive work mapping in these coals (Balsley 1980). His mapping inside the coal mines shows fascinating features. Often within these massive coal seams are thinner beds of silt that were carried into an ancient swamp by local floods. Very similar layers are deposited over swamps and marshes today, particularly when large spring floods occur. The base of these beds provides a snapshot view of what the area looked like during coal deposition. When the lower beds of coal are thick, the common practice is to mine the lower bed of coal and leave the siltstone in place. Dr. Balsley mapped features in the base of the silt bed that formed the roof of a mine. One feature mapped was where the coal preserved the root systems of the trees (Figure 58). Plant fossils, commonly as leaf impressions, included conifers, palms, and ferns. Many of the trees were clearly in growth position when the silt bed formed, demonstrating clearly that they were not rafted plant debris.

> These coals formed over time in a swamp where trees grew and that dinosaurs walked around, feeding on them.

The firmness of the silt over the swamp apparently provided a nice firm place for dinosaurs to walk on. Dinosaur tracks are common there and John mapped their position. It looks like the base of a modern cattle feedlot except that the feeders were dinosaurs instead of cows. You can see where the dinosaurs walked around, feeding off tasty ferns. This all suggests that very normal rates of sedimentation were taking place then, just as they do today, except that the cast of animals and plants was different in the Cretaceous. These coals were not deposited as clumps by the great flood or as floating plants.

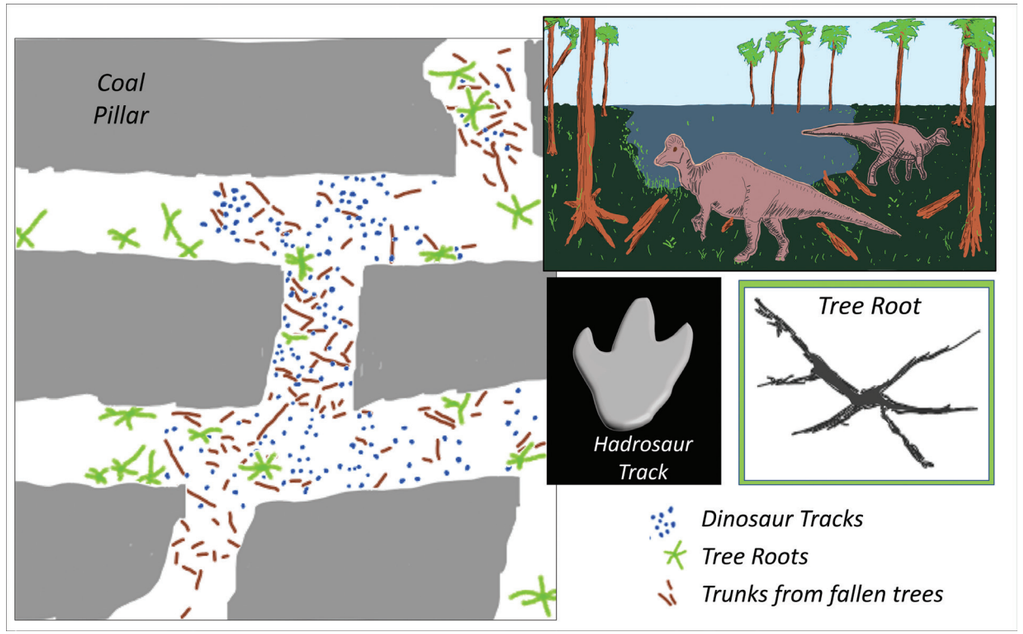
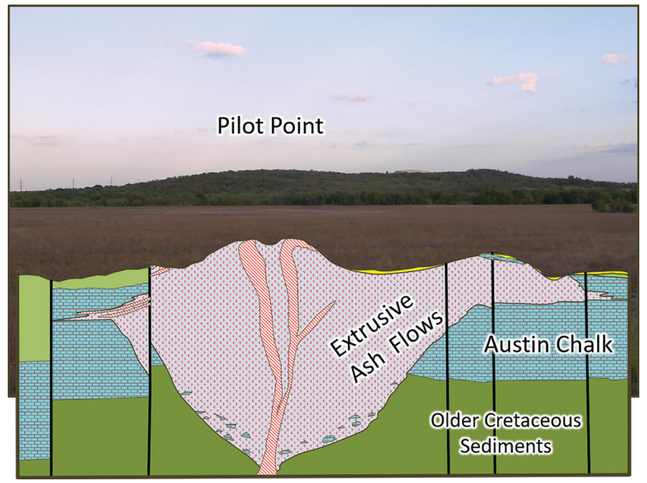


Figure 58 Map looking up at the base of a silt layer above a Cretaceous coal seam mined in Utah (Balsley 1980)

Widespread changes happened in the western US beginning in the late Cretaceous. The Rocky Mountains began to form, affecting a very large area as Sierra Gomez showed. Volcanic activity stretched into Texas including a volcano that developed just seven miles southeast of the center of Austin. The Pilot Knob volcano began in Cretaceous shallow seas and its volcanic ash beds interfinger with the Cretaceous limestones (Figure 59; Matthews 1986). Pilot knob is one of a number of volcanic cones that formed during this late Cretaceous period. The volcanos were bathymetrically positive features that developed carbonate shoals on them because they were shallower than the surrounding area. The development of multiple levels of volcanic rock and lime sand shoals indicate

that in human terms, a long time passed as these rocks were formed. In some cases, deposits of biologic communities known as biostromes developed over the mound of an old volcano only to be cut by younger volcanos (Luttrell 1977). A long time was required for the volcanic eruptions, subsidence and normal deposition, other phases of eruption and more phases of deposition. Yet this "long time" all took place in what was stratigraphically a very small part of the Cretaceous system.

For the season finale, the Mesozoic eon went out with a bang quite literally. If you saw the start of the 1998 Bruce Willis movie *Armageddon*, you might remember that it started by recounting the dramatic asteroid collision that is blamed for the dramatic extinction of the dinosaurs and 85 percent of earth's lifeforms (Canada Museum 2008). A major impact crater was formed very near the end of the Cretaceous in Mexico. The impact provides a clearly correlatable event that resulted from a cataclysmic phenomenon. Physicists Louis Alvarez (1911–1988) and Walter Alvarez (b. 1940) noticed that a clay layer in Italy at the boundary between the Cretaceous and Cenozoic periods had an unusually high concentration of iridium, an element that is normally very rare on the earth. They found that this same layer could be found literally around the globe. In time, this event was traced to a circular feature in Mexico that we now recognize to be one of the largest impact craters identified on the earth (Figure 60). It is estimated that the asteroid that formed the crater was 6–8.5 mi (10–14 km) in diameter and that it caused a crater almost 125 miles (200 km) in diameter. (Athena Publications, Inc, 1999) Today the crater itself is buried under approximately three thousand feet (1 km) of Cenozoic rock. (Kring 2006).



A long period of volcanic activity is demonstrated by multiple levels of volcanos in the Cretaceous, each with limestones formed by carbonate sand shoals.

Figure 59 View of Pilot Point, a Cretaceous volcano near Austin, TX with a simplified profile. Volcanic rocks are interbedded with the Austin Chalk, a Cretaceous limestone unit (Young, Caran, and Ewing 1982; Matthews 1986) The photo is by *Larry D. Moore CC BY-SA 3.0.* (https://en.wikipedia.org/wiki/Pilot_Knob_(Austin,_Texas)#/media/File:Pilot_knob.jpg)

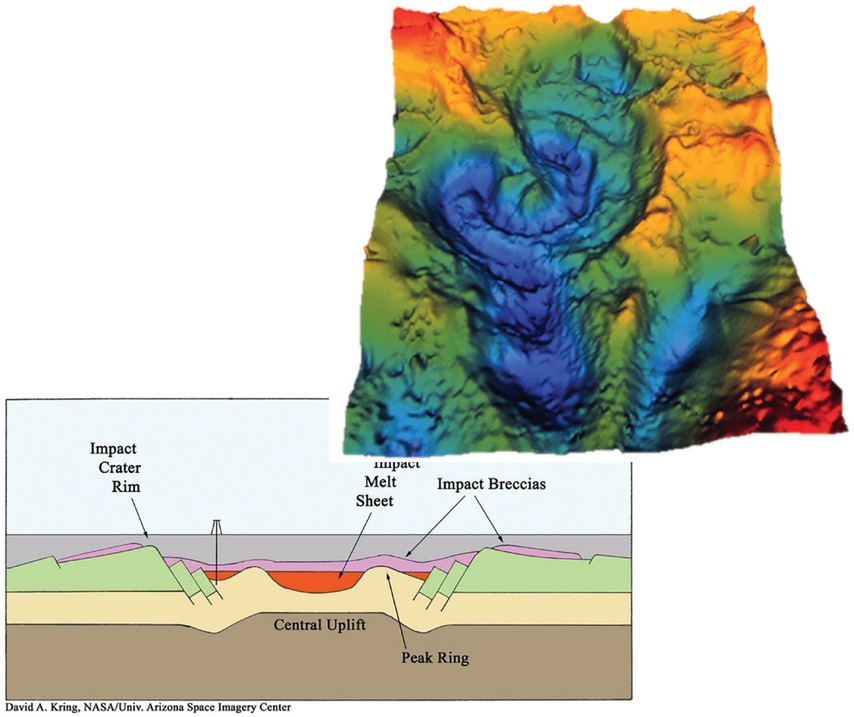


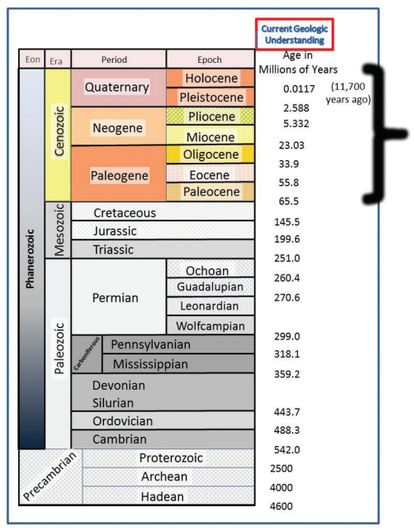
Figure 60 3-D Gravity map of Chicxulub Crater found on Mexico's Yucatan Peninsula above and schematic cross-section across the crater. (Lunar and Planetary Institute & NASA, 2004) (Athena Publications, Inc, 1999)

For the purposes of this document, we are interested in this impact's effect on geology in our study area. This is not something where "the present is the key to the past" works really well because we just don't have any comparable events going on (thankfully). Texas was affected in a major way. Just as the 2004 Indian Ocean earthquake was felt around the world, Texas at one thousand miles (1,600 km) away had to be affected. The iridium and distinctive spherules that were generated by the impact allow the deposits to be correlated with high confidence over vast areas. Several studies have been conducted along the Brazos River where this section outcrops and not surprisingly, there are several different geological interpretations of how those deposits formed. Before the asteroid hit, fine grained muds were being deposited, indicative of quiet environments with slow deposition. The impact brought an abrupt change and the deposition of high-energy conglomerates and sandstones, but they are typically less than three feet (1 m) thick. They have been interpreted to be the result of a tsunami by Schulte et al. (2006) and also interpreted as deposits from a debris flow and large

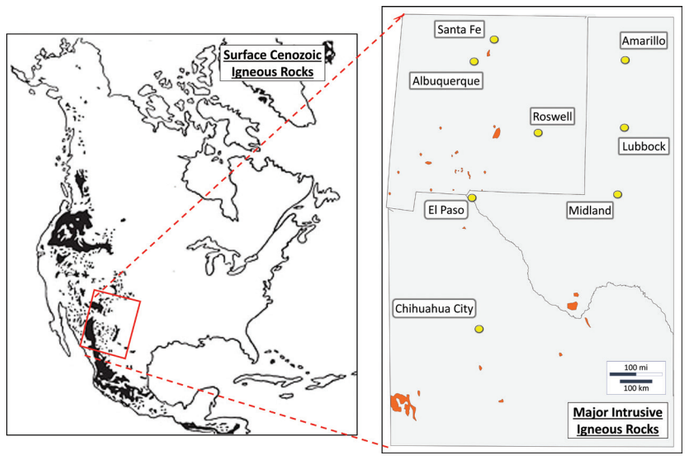
storm deposits by Yancey (1996; Keller, n.d.). The unit shows that there are some events that can be correlated over broad areas, in this case globally, with very high confidence. It also is a case where geologists recognize catastrophic processes within the geologic record. We know that rocks result from such processes, but often we cannot put all the pieces together to understand the causes and how they link to the effects that we see.

The Mesozoic erathem includes thick intervals of limestone and clastic sediments, reefs, evaporites, coals, and volcanic igneous rocks. Paleogeographic maps are available for each of the intervals and show patterns that are consistent with deposition processes that we see active today. Most of the rocks imply the passage of long periods of time. The significant exception is in the catastrophic Chicxulub impact deposits. We will compare the Mesozoic data to the YEC "flood geology" interpretations in more detail later, but first, there is one more era to describe.

Cenozoic



We live today in the Cenozoic era. Though life has changed through it, more and more familiar types are found as fossils through its strata. West Texas, New Mexico, and Mexico were lands of active volcanos through much of the era (Figure 61). Large lava flows covered vast portions of the land extending across much of the western US and northern Mexico. There were no pillow basalts here. These volcanos and flows developed in a completely nonmarine environment. It is often difficult to use superposition or even biostratigraphy to see what their relative age is compared to other parts of the column. Radiometric dating says that they are of different ages ranging from the Paleocene through to the Miocene. Even without this data, it is evident that most were after the Cretaceous period and well before man was in the area. Most of the volcanos have collapsed and all of the volcanic rocks have been eroded deeply. The igneous rocks consist not only of ancient lavas and rock deposited on the surface, known as extrusive igneous rocks. There are also many Cenozoic igneous rocks that were formed under the surface, as molten rock cooled forming rocks known as intrusive igneous rocks as shown in the figure. Many of these are exposed as the surface, exposed by the erosion. What were once very large magma chambers known as batholiths have now been exposed in the Big Bend National Park (Cepeda and Henry 1983) and across New Mexico. The Sierra Madre Occidental, Mexico includes very large batholiths emplaced in the late Cretaceous and early Cenozoic.



Tremendous amounts of igneous materials flowed from subaerial volcanoes while others cooled deep beneath the surface. Much of the lava has now been eroded away now.

Figure 61 Maps showing Cenozoic volcanic fields. Expanded box shows some of the major intrusive igneous rocks in the study area. Where major intrusive bodies are at the surface, much material had to have eroded away to expose the intrusive bodies. The left map is from the USGS. The right map is from Figure 6.

These batholiths provide another challenge for the YEC timeline (Ferrari 2007). Why are they a challenge? The presence of a former batholith at the surfaces means that several things have happened. First, it means that one or more large bodies of molten magma that were between 600 and 1,200°C in the subsurface have cooled and solidified. If these had cooled quickly, then there would have been only microscopic crystals present, such as form when lava cools at the surface.

These cooled more slowly because the crystals are visible with the unaided eye. This tells us that they were buried deeply while they cooled. The rock that buried them in the earth has now been eroded away and exposed them. Young and Stearley (2008) powerfully demonstrated that batholiths in California whose dimensions and properties are well documented, cooled from 750–825°C and this required a long time (Young and Stearley 2008, *The Bible, Rocks and Time*). Borrowing their analogy, it takes a long time for a cooked turkey to cool, especially when left in the oven. Bigger birds take longer to cool than smaller birds and bigger batholiths took longer to cool than smaller ones. Calculations and modeling demonstrate that some of the California batholiths required upwards of six hundred thousand years to cool to their present temperature. Cooling them in a few thousand years seems to be impossible, let alone also eroding off all the rocks under which they were buried.

The Cenozoic sedimentary rocks also tell us a great deal more about the geologic history of the area and the time involved. Depositional environments onshore in the study area were similar in many ways to those of today. In New Mexico, northern Mexico, and around El Paso, the rivers do not have nearly enough water to carry sediment out of the system. When water is available, such as during storms, ephemeral rivers carry sediment out of the mountains and deposit them in valley areas as fan-shaped deposits known as alluvial fans. For example, these occasional storms have

formed alluvial fan deposits that are about nine thousand feet (2,700 m) thick in the El Paso area. These alluvial fan deposits are separated by arid paleosols that formed over various periods from the Miocene to recent (Gustavson 1991). Older paleosols have been documented in the Eocene in east-central Texas. Yancey described two of them this way:

> The paleosol zone, a 2.5 m (8 ft.) unit of stream and overbank deposits with two thick paleosols, overlies the lower ash unit. The lower paleosol is a fine grained mudstone that overlies siltstones containing lenses of small (cm-scale) cross-bedded sandstone, suggesting deposition by small streams. The upper paleosol formed on sand deposits, which have thin zones of carbonaceous wood debris and logs. Both paleosols contain common large and small (to 10 cm diameter) vertical root penetrations and stump casts (to 30 cm diameter), which also penetrate down into underlying sediments. The rooting horizons within the paleosols record *the presence of a deeply rooted forest cover on the land before deposition of overlying sediments*. The upper paleosol is directly overlain by a thick layer of altered volcanic ash. (Yancey 1995; emphasis added)

The presence of such soils demonstrates the type of depositional setting present and the elapse of considerable time as they developed. They provide more evidence that the same type of processes and rates were happening then as are happening today.

In the Texas Gulf Coast region, the Cretaceous carbonate shelf provided a tectonically stable base for the next sediments to prograde over. Cenozoic rivers prograded over the older shelf into what would become the Gulf of Mexico. Clastic sands and muds were not stable on the relatively steep limestone slope and proceeded to collapse into the rapidly subsiding basin. Deposition and the styles of faulting were strongly influenced by the Jurassic Louann salt and by the river systems that fed into the basin.

Today, Texas river drainage basins and discharge are much smaller than the Mississippi River today, and throughout the Cenozoic era, it was the same. We see smaller depositional systems along the Texas margin. Though the river systems were never as large as the Mississippi system, at times they were somewhat larger than today and brought large amounts of sand to the coastline (Figure 13).

Texas developed long linear fault trends that roughly paralleled the ancient coastline when they were active (Worrall and Snelson 1989; Diegel et al. 1995; Galloway 2005; Figure 62). The faults are curved or listric in profile view, going parallel to bedding with depth into either shale or salt (Figure 63). The faults are considered "growth faults" because they were active as sediment was deposited and on the downthrown side of the fault, the section is thicker than on the upthrown side. The same sedimentary facies were normally deposited on both sides of the fault, however the facies are thicker downthrown and in the case of the Gulf Coast faults, that means much thicker.[11] It might be

[11] A great site to see how the Gulf of Mexico faults developed is here: http://www.searchanddiscovery.com/documents/karlo/ It is particularly good because it has some of the better seismic lines available online. Most of the good data is proprietary and is usually too small in presentations to see in detail.

tempting to think that the thick sediment on the downthrown side resulted from the rapid filling of a deep hole. Physical models can help us to understand how these develop. An amazing laboratory to study such processes has been built right on the Mississippi River in Minneapolis, Minnesota. The St Anthony Falls Laboratory uses the abundant water supplied by the river to study depositional processes and hydrologic problems. They built a large tank with which to simulate a subsiding basin and used fine sand and coal dust to simulate sand and shale like a river system (Heller et al. 2001). They supplied constant flow of sand and coal dust to the tank and then allowed the water in the basin to rise and fall slowly and then to rise and fall quickly, simulating sea level rises and falls.[12] They were able to then slab through the resulting sediment pile and study the deposits. What they found was very much a scaled down version of the same kind of geometries and patterns that we see in the Gulf of Mexico today (Heller et al. 2001). They were genuinely surprised to see that the model developed growth faults in the deltaic sediments. They went back and examined movies taken while the water was flowing to see the surface expression of the faulting, but there was none. How can that be? Tim Demko, one of my colleagues at ExxonMobil, explains it this way. He calls it the "groundhog day phenomena" after the 1993 Bill Murray film *Groundhog Day*. If you will remember the film, Bill Murray found himself trapped in a cycle where he woke up every day to have the same day repeated over and over again. This is analogous to the development of the growth faults along the shelf of the Gulf of Mexico. Along downthrown side of faults, a very small amount of additional space was created by the fault moving. As the space developed, it was filled in by sand and shale. Over time, the fault moves a bit more and the sand fills that space in. This process of fault movement is repeated many, many times until the downthrown side is thousands of feet thicker than the upthrown side. Eventually though, it takes so much energy to move the sediment down that the fault moves to a new location, basinward of the first fault. Normal depositional processes acting over long periods of time will generate these types of depositional packages over such faults.

[12] Coal dust was used rather than mud because it forms very fine particles like clay and because mud has chemical bond characteristics such that it wouldn't behave in a model the way it does on actual river deposits. Besides, the black coal dust contrasts beautifully with the white sand to make changes visible.

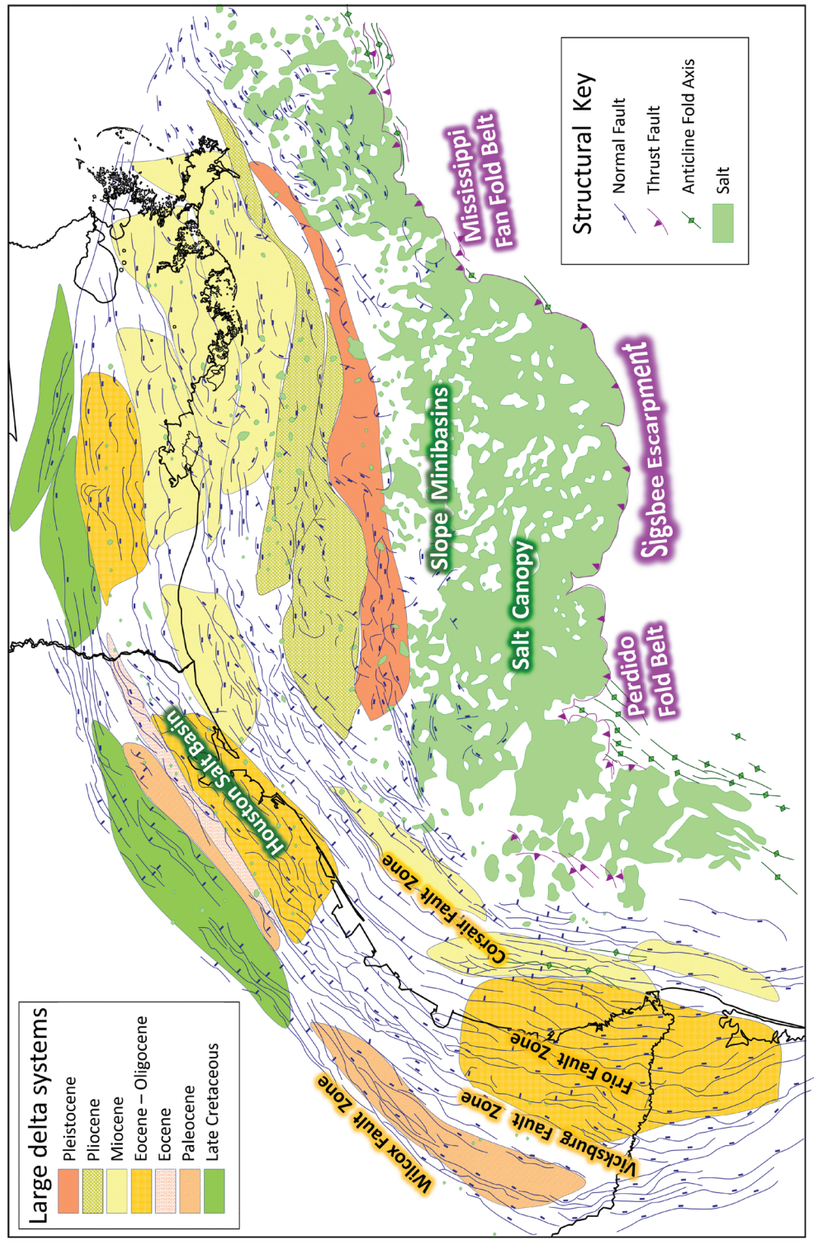


Figure 62 Fault trends and salt canopy map for the northern Gulf of Mexico basin. Long linear fault trends are common both onshore and offshore Texas, many of which are named (Galloway 2005)

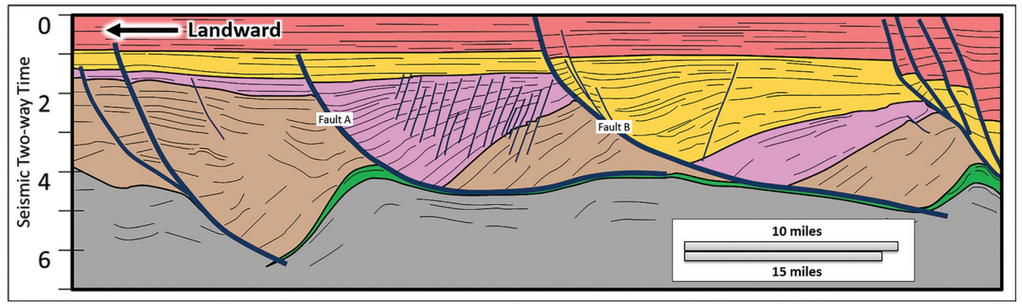


Figure 63 Large listric fault from Gulf of Mexico. Pink section expanded (grew) dramatically across fault A. The section prograded and then the orange section expanded across fault B (Diegel et al. 1995)

Thousands of feet of deltaic sediments developed very large faults and folds by the same processes that we see active today in the same region.

Major changes in fault systems, shifting basinward happened during major sea level changes. At least sixteen major expansion systems are found in just the Cenozoic section that prograded into the Gulf (Figure 64). Think about how long it might take one of these faults to grow and then multiply it by at least sixteen for these systems that developed, as the sediments prograded basinward two hundred miles (320 km) to the current shelf break. If this progradation took place in a few thousand years, then the faults had to have been moving dramatically on all these faults at the same time. This rapid movement would have generated almost constant large earthquakes. Think about life with the number of earthquakes that would have occurred.

The Cenozoic era (or soap opera series, to use that illustration again) in the Gulf of Mexico region was dominantly a story of clastic deposition in a deepening basin. The distribution of the sediments and the structures that developed were the result of the constant interaction of small and large river systems, sea level rising and falling and the loading of salt and soft shale forming ridges and diapirs. The oldest sediments are the Paleocene series. The strata and the fault system along it that developed in Texas are known as the Wilcox system (Diegel et al. 1995; Xue 1997). Wilcox river system deposits have been studied and mapped along the outcrops and in the subsurface in beautiful detail (Fisher and McGowen 1967). Sands and other sediments were deposited in six distinct geometries and styles.

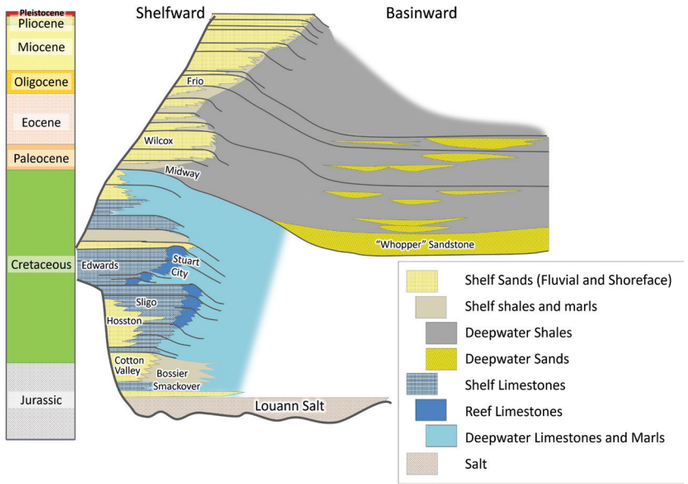


Figure 64 shows the relative position of the depositional shelf edge from the Jurassic to the present. Light blue areas indicate carbonate shelf sediments. Light yellow areas have clastic shelf sediments. Areas with diagonal lines had carbonate reefs at the shelf edge. The shelf aggraded at times and prograded at others. The Tertiary sediments prograded out through the Wilcox interval and then backed up. It then began a major progradational period that continues to the recent. (Winkler 2007)

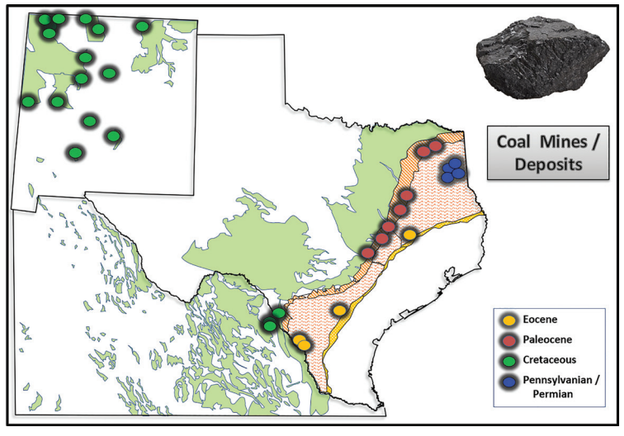


Figure 65 Map of coal and lignite mines in the study area. The brown circles in Texas are from the upper part of the Paleocene Wilcox zone. (Combs 2008; Fassett 2016; Wegemann 1914; Osburn 1983)

1. Small sandstone bodies are found in the Texas hills with the geometries and internal characteristics of small streams that are in modern dendritic tributary settings.
2. Moving southward and now in the subsurface, sand bodies are a bit larger, matching a type that we call “low-sinuosity” streams, those that begin to meander, a very common stream motif today.
3. Between the stream deposits, the lithologies are mostly muddy just as we see in the coastal plain today between streams. Interestingly another lithology is also present between the ancient river sands. Most of the economic coal deposits in Texas are from such areas. The fossils and sediment structures make it clear that the coals formed in swamp and marsh deposits along the trend (Figures 65; Combs 2008).
4. Toward the Gulf of Mexico, sand bodies are typically larger and the geometries and internal characteristics are consistent with a coastal plain where more sizeable rivers meandered widely across the plain.
5. Basinward, Fisher, and McGowan identified the ancient coastline. Sand bodies along the ancient coastline, like the modern coastline had a variety of sand patterns. In some areas, the sands had a more distributary pattern with mixed muds and sands, like a modern delta.
6. Typically, basinward, the sands were thicker and more continuous, just like a modern delta where delta front lobes to develop. The sands interpreted as Wilcox deltas were not randomly distributed along the ancient coast line but were deposited basinward of the major interpreted meandering sands.

Modern deltas are not all alike because they are shaped by several processes to different degrees. Three main processes are recognized that shape deltas where rivers run into the sea: fluvial (river) processes, tidal processes, and ocean waves. Geologists classify delta systems according to which of the processes is dominant (or was dominant, in the case of ancient deltas). If the rivers are not very large, but there are strong tides in the area, then we would call them tide-dominated. If the river supplies so much sediment that it overwhelms tides or waves then we would say it is river-dominated such as is the case for the Mississippi River today. Along the Texas coast today, most deltas were dominated by wave energy. The sands systems that were similar in the Pennsylvanian Period in the Paleozoic, except that these Wilcox deltas seem even more like the modern rivers in Texas. The Wilcox and other younger Cenozoic systems show strong wave influence just like those along the modern Texas coast today. When we look at the sedimentary structures present in the ancient rocks, we see the same interplay of sedimentary structures and geometries that we have along the Texas coast today. The river systems did shift around through time and have been mapped in detail across the Texas coastal plain (Figure 66).

As the deltas prograded over the older Cretaceous reef trends, the long trends of growth faults developed (Figure 62). During lowstands of sea level, thick sands were deposited on the downthrown side of the faults. When sea level rose, the sands retreated and were covered with muds. As the faults continued to move, this combination of reservoir sands with shales on top and faulted structures made a great oil and gas play and many companies have done well by exploring along these systems. We will later look at these many river system deposits in terms of a YEC interpretation and where they might fit in.

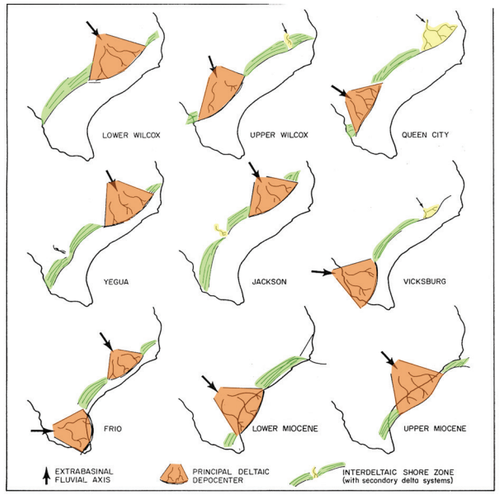


Figure 66 Location of principle deltas from the Paleocene Wilcox through the Miocene. Reproduced by permission of AAPG (Galloway 1989).

For years, petroleum geologists mapped the Wilcox intervals and other Cenozoic stratigraphic intervals by contouring the percentage of the interval that was composed of sand. These sand percent maps were very effective at predicting trends along which to explore for oil and gas in these depositional shelf sand environments. On the landward side, such maps usually had a very high percentage of sand, almost 100 percent. This would be great for finding reservoir for an oil field, but without enough shale to seal the structure, oil and gas just leaked away. Most oil and gas fields are found where the ratio was in the 25–50 percent range.

Once the percentage got below 10 percent, any exploration drilling became very risky. Once the percentage reached zero, it was time to go home. The conventional wisdom of most exploration companies was that offshore Texas, and most of the Gulf of Mexico would have mostly thick shales in the deeper water. There were however hints that sands were transported into deeper water. The shelf system of the Wilcox had a large feature known as the Yoakum Canyon that demonstrated that there were systems to feed sand to the deepwater basin, but this canyon was largely filled with shale on the shelf (Dingus and Galloway 1990; Figure 67). In the mid to late ’80s, seismic surveys showed us that there were big fold features out on the abyssal floor in front of the Texas fault systems and in front of the salt. We were excited about the Perdito Fold Belt but were not sure what type of rocks were folded. One strong seismic event was mapped around and generally called the MCU or mid-Cretaceous unconformity though no one could prove what its age really was. When technology allowed wells to finally be drilled out there, everyone was surprised. The MCU turned out to be the top of a major sand unit that was equivalent in age to the Wilcox trend on the shelf. This sand is known as the Whopper sand and is known to be very extensive and is a major exploration play in the Gulf of Mexico. (I don’t think Burger King has any percentage.) It is a great example of a linked system of river deposits, coastal systems, and deepwater depositional systems such as occur over and over throughout the Cenozoic. Lowstand deposits provide major oil and gas exploration targets through each of the delta systems and each has a linked deepwater system of one size or another. The deposition of these systems is very logical using the basic understanding that geologists have developed over the years but can they be explained with a YEC model?

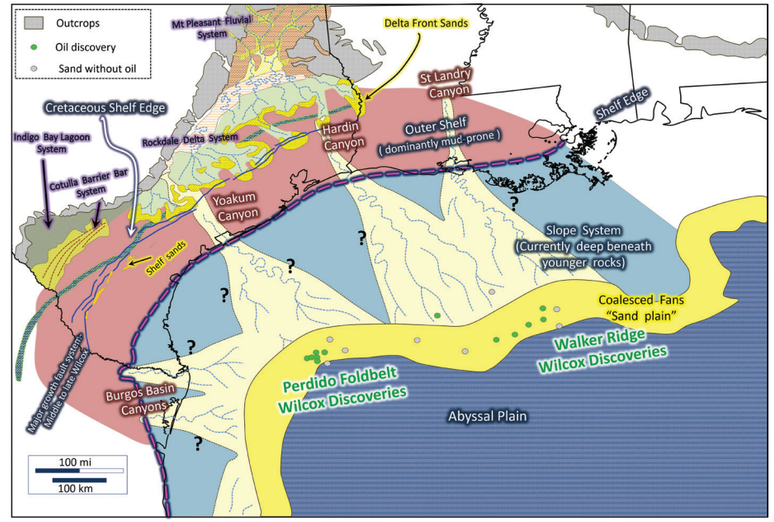


Figure 67 Map of lower Wilcox depositional environments. Sands moved from the shelf during the deepwater basin. It is interpreted to have formed a broad sandy plain. The deepwater sands are collectively known as the “Whopper sand.” Oil has been discovered in many wells across the basin in this zone. Deltas along the shelf were mapped years earlier but the discovery of a major sand system in the deepwater surprised many (Berman 2007; Galloway 2005; Fisher and McGowen 1967).

Clastic depositional patterns associated with rivers and deltas are just one area that must be explained by the competing models. The deposition of the sands and muds in wave-dominated deltas gave rise to distinctive structures with the faults and folds that must also fit the model we believe. The large deltas that developed during the Eocene and Oligocene epochs had their own growth fault systems. Some of these, such as the Vicksburg growth fault system had really remarkable amounts of growth. The downthrown section is over 0.6 miles (1 km) thicker than the upthrown side and the oldest rocks were displaced ten miles (16 km) basinward of the upthrown faults (Diegel et al. 1995). The Eocene and Oligocene fault and delta systems prograded out to near the position of the Texas coastline today. We find Miocene river deposits preserved onshore across Texas from rivers much like todays. The growth wedges of the Miocene series of rocks developed out beyond the current coastline. The logs and cores demonstrate that the wedges of sediment were deposited by deltas that formed when sea level was much lower than today. It may be that global warming will melt the polar ice caps and cause sea level to rise farther, but there is no doubt that today’s sea level is already very high compared to much of the Cenozoic era. Much successful oil and gas exploration has targeted these deltas.

The Middle Miocene series includes deposits across one of the largest faults to develop in the Gulf of Mexico. The Corsair fault trace is even larger than the Eocene Vicksburg fault. It is over two hundred miles (320 km) long and extends over 28,000 feet (9 km) below the sea bed (Worrall and Snelson 1989).

Locally it has displacements of up to nine miles (15 km; Withjack et al. 1995; Figure 68). As a geologist, I am amazed that this fault can expand 11,500 feet (3 km) in ten million years. This degree of growth across a fault in such a short time is rare. It certainly required the presence of salt to act as a soft, ductile material to be evacuated. Salt moved basinward as the delta dumped sediment on the downthrown side of the fault. In human terms, it took a long time for the fault to move that far. The fact that we see 28,000 feet of almost entirely fluvial and shallow marine sedimentary rock is amazing in itself.

The Cenozoic of the Texas coastal area is best known to geologists for thick clastic deposits and salt influenced structures, but they are not the only features to be found. Salt domes in the offshore were often shallower than the surrounding water and provided hospitable environments for organisms. Large amounts of clastics usually overwhelmed carbonates, but in the Oligocene Epoch, a series of salt domes provided environments above the clastics and reefs flourished (Frost and Schafersman 1978). The reefs were primarily built by branching coral, but fossils from many flora and fauna are preserved, just like are found on modern reefs. The reefs outcrop south of Houston and detailed mapping shows all of the environments that one might expect for a modern reef. The reef is only a tiny part of the thickness of the Oligocene sediment, and this speaks to the overall time represented by the Cenozoic.

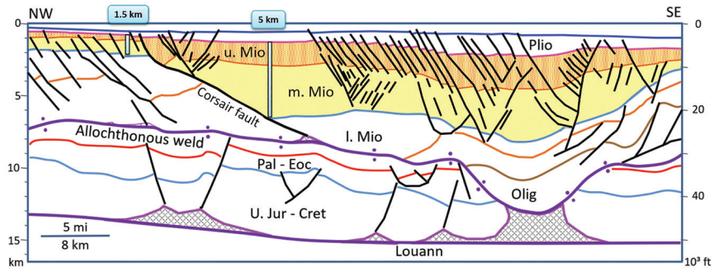


Figure 68 Interpretation of a depth processed seismic line showing large expansion or growth that took place in the upper and middle Miocene across the Corsair fault. (Rowan, Inman, and Fiduk 2006

We can identify with confidence depositional processes along the shelf such as deltas and reefs. The confidence does not stop at the ancient shelf edges. Exploring in deepwater has also come a long way since I began to be involved with it in the mid-'80s. This is true both in terms of the water depths where they are located today and in terms of reservoirs that were deposited in deepwater. While working for Mobil Oil in Houston, I started to work on offshore projects in 1986. One of the fields that I was responsible for was the East Breaks 160/161 Cerveza field in what was then the astounding water depth of one thousand feet (300 m). Cerveza means beer in Spanish. The operator, Unocal, named it this because its platform was built much more cheaply than Shell's Cognac platform. Today we drill wells in over seven thousand feet (2,100 m) of water and are building oil production facilities for these depths. In 1986, on the geology side, I had one of Mobil's first three-dimensional seismic surveys to study.

A three-dimensional seismic survey consists of a dense grid of seismic lines processed together by comput- ers so that the layers of rock can actually be imaged in their proper position and the entire volume can be studied together from any direction. We really were not sure how the Cerveza sands were deposited. We had internal reports that considered them delta deposits and others that used a submarine fan model. A team of Mobil's experts became involved, and soon it was apparent that they were deepwater sandstones but we really did not understand how to map or predict how sandstones shapes and sizes varied. Today, deepwater reservoirs, particularly those that are not deeply buried, can be analyzed using modern three-dimensional surveys in amazing detail. An analogy might be digital photography. When Kodak sold the first digital camera in 1975, it had a resolution of one-hundred-by-one-hundred pixels (0.01 megapixels). The images were pretty crude. Modern cameras commonly have a resolution of eighteen megapixels and are capable of vastly better images. A similar revolution occurred in 3D seismic and now we can image and understand the geometries of the beds and predict the distribution of reservoir and non-reservoir facies, often in detail and that greatly reduces the risk. That is good because drilling wells in thousands of feet of water is expensive and has its own risks. Modern deepwater systems have been cored and studied in detail in order to provide good understandings of the processes involved. Excellent examples include classic studies of the Mississippi fan (Bouma, Stelting, and Coleman 1983–1984; Dixon and Weimer 1998), the Amazon fan (Flood and Damuth 1987), and the Congo fan (Anka et al. 2009) to name just a few. Sediment failures on the shelf cause sand collapse onto the slope and the sands move down toward the ultimate basin floor. Meandering channels develop that look much like those on rivers above sea level. We can distinguish the two by the setting and by the internal facies both in the sands and particularly in the shale facies (Kolla, Posamentier, and Wood 2007)

Petroleum geologists spend a lot of time and money studying the relatively recent sediments in the Gulf of Mexico. Why not just spend that effort on the interval where the oil is? Offshore seismic acquisition that is designed for oil exploration has cables that receive the sound after it is reflected off of layers miles down in the earth. If you have ever lived in an apartment, you may have noticed that the bass or low frequency sound travels amazingly well through the walls. It is the same with seismic signals. Regardless of what signal we put into the earth, by the time it has been reflected off deep layers, the highest frequencies have been filtered out and only the lower frequencies are received. That is unfortunate from the standpoint of seeing details in the deeper layers. Higher frequencies make it possible to see thinner layers and more detail. If the signal were able to retain the higher fre- quencies, we would be able to image and interpret the layers down in the earth much better. When we are studying the very shallowest section, whether for scientific research or for evaluating positions for oil production facilities, surveys can be run that include very high frequency data. The data does not come from very deep in the sediments but can include the type of frequencies that we can only dream about in the oil reservoir levels. These high-frequency surveys give extraordinary details about the shallow sections, both in the shelf and deepwater environments and we can apply what we learn about these well-imaged systems to the deeper systems (Berryhill, Suter, and Hardin 1987).

We find that in the youngest strata, the Holocene, most of the deepwater fans systems are basically quiet. The only sediment deposition is from a slow rain of fine clay particles and the tests of microorganisms that reach them today. Most of the coarser sediment today is being deposited up

in the shelf environments and along today's beaches. Not far below the youngest levels, the picture was very different. Suter and Berryhill (1987) used high-frequency shallow seismic to map fluvial patterns from the late Pleistocene period (Figures 69 and 70). At that time, the sea level was much lower and the rivers were larger, bringing sand all the way to the continental shelf edge. Sand and coarse sand were sent down the slope into small basins formed by salt withdrawal and on to the deepwater fans (Beaubouef, Van Wagoner, and Adair 2003). Cores and electrical logs from oil wells confirm that the same depositional processes and geometries that are present in these shallow sediments also caused deposition of those buried miles below the surface. Rates varied, especially as sea level varied and those variations are recognizable through the entire Cenozoic interval in the Gulf of Mexico. I have described how in the Paleozoic and Mesozoic strata, the lowstands of sea level were dominated by clas- tic sediments while the highstands were often dominated by carbonate deposition. The highest and youngest strata in the Gulf of Mexico show that these same cycles continued to be present. Relative lowstand deltas formed as shown above. Very thin sediment layers were deposited during highstands. A study of cores taken to prepare sites for offshore platforms shows that these highstand deposits are rich in carbonate shell debris and include large bioherms that were buried by clastics when sea level dropped again (Coleman and Roberts 1991). It is interesting that this change in sedimentation types and rates can be studied where we have the highest precision and calibration of sea level.

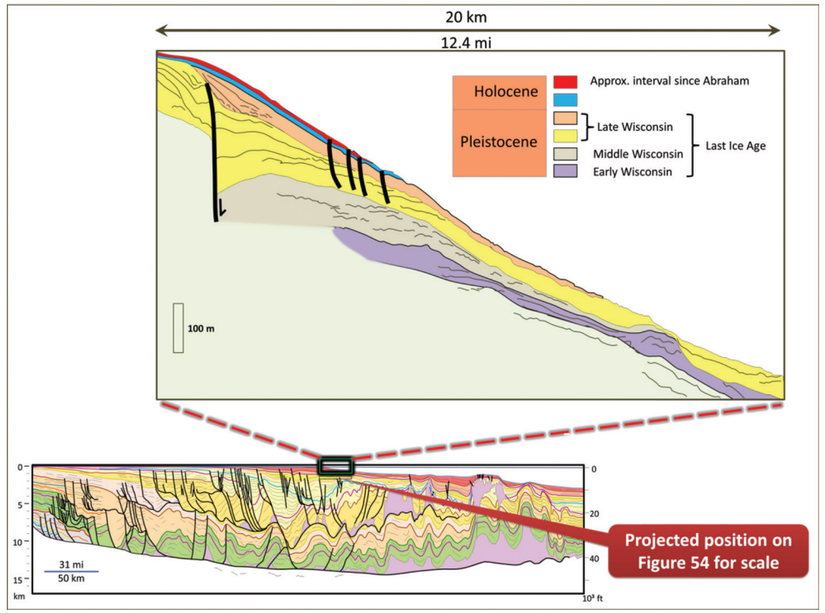


Figure 69 Interpretation of a shallow high frequency seismic line showing a growth fault from offshore Texas. The light orange and below were deposited during the low sea level stand associated with the

last ice age. The youngest intervals, shown in light blue and red are up to 50 ft. (15 m) thick. This is one of the thicker deposits from the Holocene period of offshore Texas. On normal seismic sections, the yellow through blue would all be so thin that they would not be resolved. Abraham lived during the late Holocene period. (Berryhill, Suter, and Hardin 1987)

Stratigraphically, the youngest of the shallow ancient deltas and active slope sand deposits coincided with the last major continental glaciation, known as the Wisconsin (Figure 70). Even though actual continental glaciers only went south as far as the middle of Illinois and Indiana, the climate was much colder and wetter over the entire northern hemisphere. Late Pleistocene deposits have another part to play in this story, one that is very close to the village where I grew up, in an area that most people would consider the middle of nowhere.

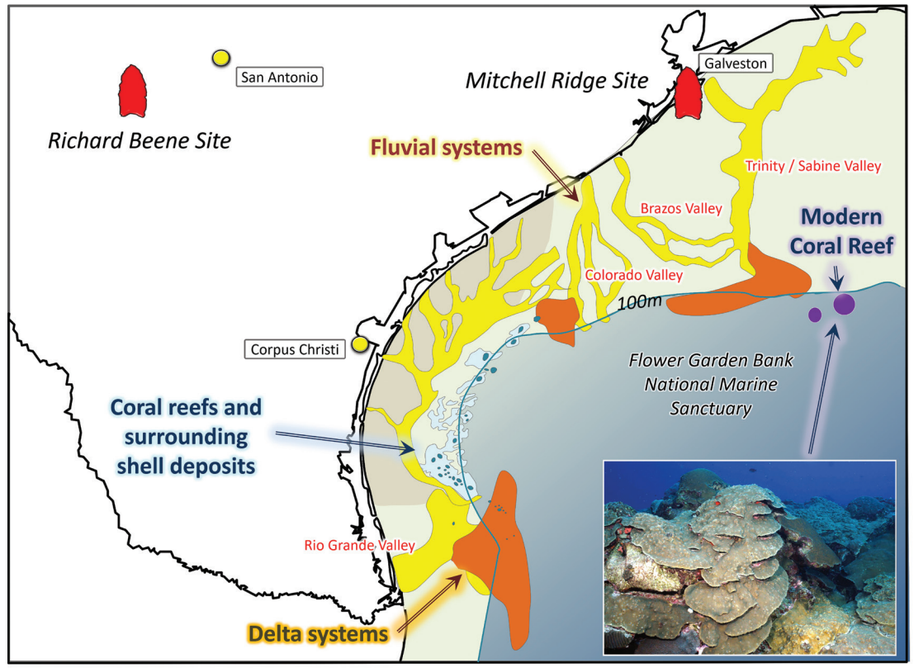


Figure 70 Environment of deposition map of offshore Texas for the last ice age (late Wisconsin interval; Late Pleistocene). It shows larger river systems that prograded deltas out to today's continental shelf edge in the south and east. Smaller river systems also prograded out, though not as far. They form a band of sandy beaches that ran along the coast about 30 miles (50 km) beyond today's coastline. The blue dots out on the continental shelf represent carbonate reefs that grew along a band where

less mud and sand was able to reach them. The position of the modern Flower Garden Bank reefs is shown. Also shown are two archaeological sites from that will be discussed later. (Berryhill, Suter, and Hardin 1987; Anderson and Fillon 2004) Photo by NOAA

The Llano Estacado or translated the "staked plains" lies in southeastern New Mexico and western Texas. Towns like Levelland and Plainview are well named. The flat plains are surrounded by relief as you come "off the cap." The "cap" makes cliffs and is resistant today because it is largely composed of caliche, a light-colored calcite rich rock that formed in a semiarid environment similar to todays, as calcium carbonate was slowly washed down into the soils and accumulated there because there was not enough water to carry it out of the area (Reeves 1972). Above that surface, fluvial gravel beds have been mapped that were deposited by rivers that in ancient times ran from the mountains in central New Mexico to the Gulf of Mexico. One such stream ran through between today's towns of Portales and Clovis, New Mexico. Here, along an ancient streambed is a site know to archaeologists as Blackwater Locality No. 1. It is important because it represents the earliest place where all agree that humans lived in North America. Here in the late Pleistocene, early human hunting parties were able to kill mammoths (Figure 71). Distinctive arrowheads, known as Clovis points, are found with the mammoth bones, apparently from an early barbeque. Radiocarbon dating indicates that these are eleven to thirteen thousand years old (Hoppe 2004; Holliday 1997). Even without considering the radiometric data, it is certain that they postdate most of geologic history. The strata with the Clovis points are covered with layers of windblown sand and sediment that include a younger style of arrowheads known as Folsom points with many bison bones. No more mammoth bones are found. The Folsom layers are then followed by later Paleoindian artifacts. The three different styles represent cultures that extended over broad parts of North America, but seldom is the evidence as clear about their relationships as it is at the Blackwater Draw in New Mexico. The cultures are usually distinguished by the styles of arrowheads. The arrowheads were typically made from various siliceous rocks. A favorite stone was quarried from sites today recognized in the Alibates Flint Quarries National Monument near Amarillo, Texas. The stone though commonly called flint began as lime muds that were dolomitized and then silicified to an agate. This agate had certainly hardened, such as we find it today, by the time early man quarried and made arrowheads from it.

Figure 71 Mammoth tusks found near Portales, N.M. at the Blackwater Draw site. Also shown is a Clovis point from the same site. Such points are found in many places across North America and represent among the earliest evidence of humans in the Americas. Stratigraphically these are late Pleistocene in age. (Stiebel 2012)

8 Comparing "Flood Geology" Prediction to Texas Geology

The last section provided a description of this book's study area and pointed out a number of features that must be reconciled by any viable explanation for the time involved. The YEC "geologic time scale" makes predictions and those can be tested. Figure 72 compares the stratigraphic timing indicated by various YEC publications in terms of the intervals of the geological stratigraphic column. Notice that in this geologic column, all of the units are shown with the same thickness. If the column were drawn with the time to the scale as best constrained by radiometric dates or any other measure of the relative time represented by the units, then it would look very different. Many units, particularly in the Cenozoic would be so thin that they would be difficult to see. The columns from the "flood geology" publications are colored and divided as in Figure 3. The striking differences between YEC writers reflect the difficulty that there is to fit this interpretation to the earth's strata. Here in this study area, the problems are major and it is fair to say that there are many additional issues in other parts of the world. Apparently, it is not easy to recognize a global flood.

Another way to look at the predictions in the study area is to look at how much rock was deposited overall in each of the YE stratigraphic units. Obviously, the unit boundaries depend on the author. Figure 73 attempts to capture the maximum thickness of each of the geologic units in this study area. I have estimated the total to be almost thirty-seven miles (60 km) thick, based on compiling data from many sources. This is much more than the thickness at any single point. If one could total the units deposited during sea level lowstand and the units deposited during sea level highstands, then the overall thickness would definitely be a lot thicker. This helps to understand the scale of the predictions that are made.

For instance, this shows that some YEC authors are effectively saying that 120,000 feet (37 km) of rock were deposited after the flood in 450 years by essentially normal processes. It is also worth noting that these are not the thickest that these units reach globally though for a few units, these might be the thickest in the world. We will now look at each of the YEC stratigraphic units and consider if the YEC timeframe and processes can be considered viable.

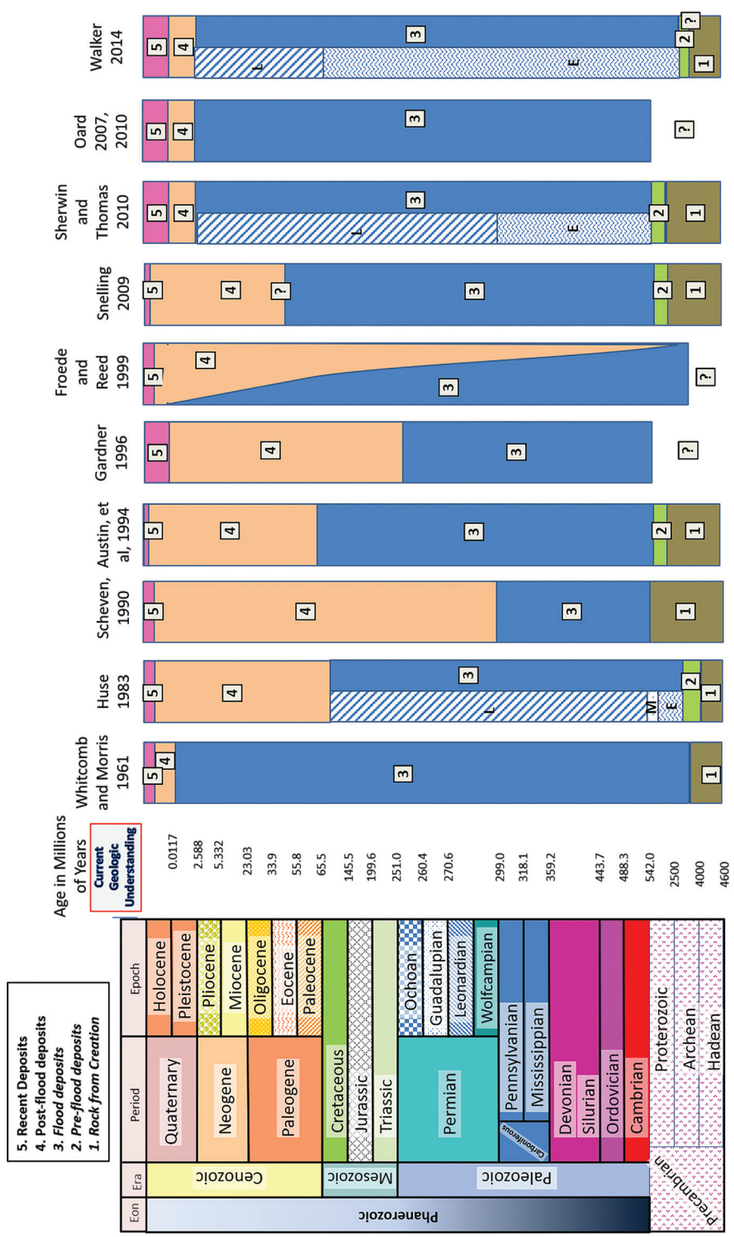


Figure 72 Compilation of correlations reported by YEC papers and the geologic column. See figure 3 for the time spans of the YEC intervals. Some authors do not recognize the validity of the column at all. Whitcomb and Morris, 1961 do make general statements that make it clear that they consider most of the Cenozoic section to be the direct result of the Genesis flood. Some, such as Huse 1983 and Sherwin and Thomas break out early, mid and late flood deposits. (Whitcomb and Morris 1961; Sherwin and Thomas 2010; Huse 1983; Scheven 1990 Austin, et al. 1994; Froede and Reed 1999; Snelling 2009; Garner 1996; Oard 2007; Oard 2010; Walker 2014)

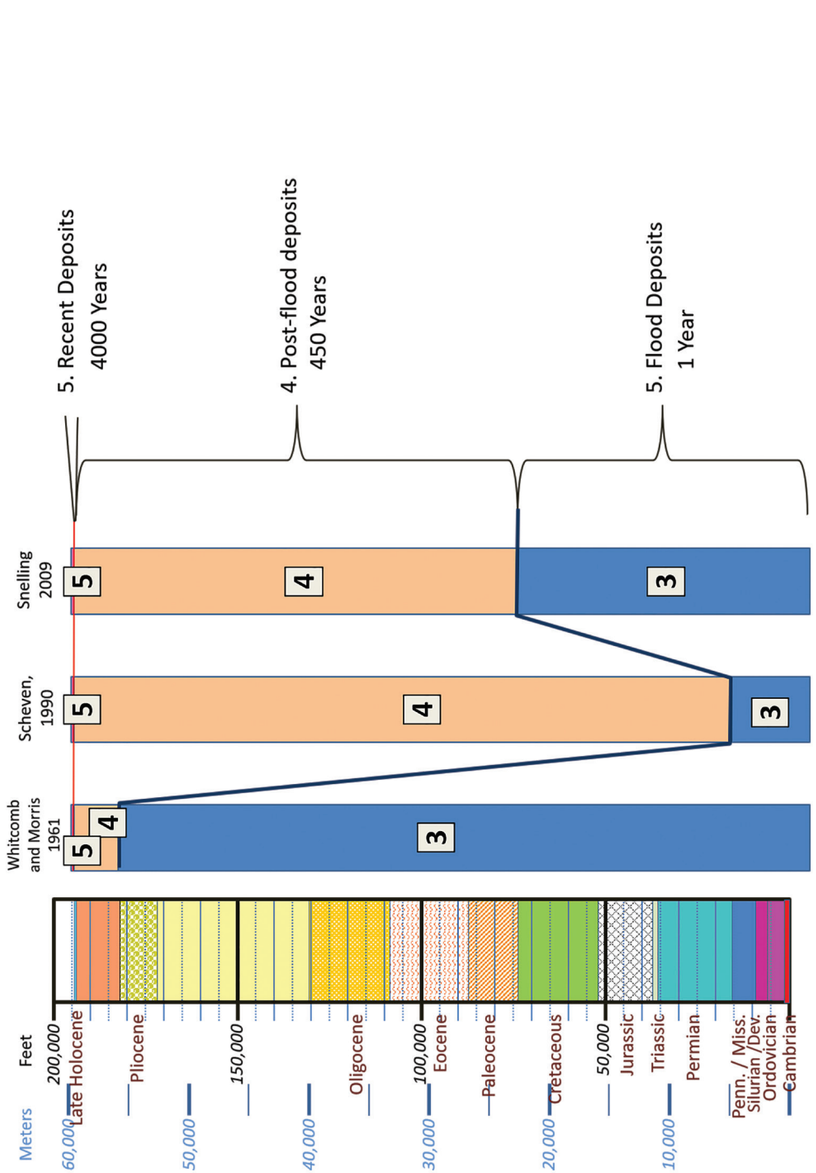


Figure 73 Compilation of maximum thickness of sediment in this study area, by the stratigraphic ages, here compared to three examples of YE published interpretations. No sediment interpreted as 1) rocks from creation or 2) pre-Flood deposits are included. Note that interpretations by Sherwin and Thomas, Oard and Walker are similar to Whitcomb and Morris's 1961 view.

Unit 1 Rock from Creation

Duration: 0 years

This book has not really attempted to document the characteristics of rock potentially created as rocks, because they are often described as "created mature." The validity of this claim is a theological issue, not a geological issue. Figure 74 illustrates how this might have appeared along a hypothetical basin margin. All we can say from Texas and New Mexico is that early non-fossiliferous rocks are present.

Most are igneous or metamorphic and thus fossils would not have been preserved anyway. Snelling (2009) suggests that the break between rocks created looking "mature" and those from before the flood may be within the Proterozoic era, approximately 1.2 billion years ago, if one were using radiometric dates. He notes that multicellular algae appear at that point. Apparently, rocks could have been created with single-celled algae fossils. He states, "Because the products of Creation Week processes appear to be exactly comparable to the products of today's "natural" processes, there would have been continuity across this Creation Week/pre-Flood boundary between these respective geologic processes" (Snelling 2009).

For instance, he would treat algal mounds depositing stromatolite layers as organisms that were created growing in place (Snelling and Purdom 2013). His hypothesis really is better examined in other parts of the world such as Australia where the earlier Precambrian strata are exposed to see if this is reasonable. However, such older rocks are not well exposed in this study area.

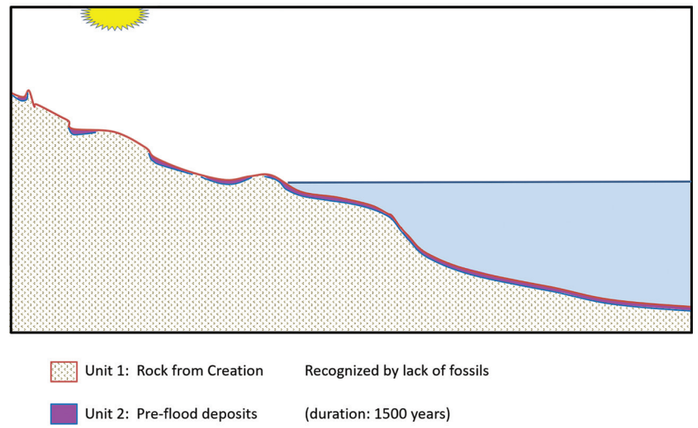


Figure 74 Hypothetical sketch along a profile along a margin of a basin showing Units 1 and 2 by the "flood geology" model. The sediment is drawn as a thin wedge. If the last 1500 years is a measure of normal erosional and depositional rates and such rates acted during this hypothetical time, then this figure exaggerates the thickness. This would be particularly true if it did not rain during that time.

Unit 2 Pre-Flood Rocks

Duration: 1,500 years

None of the authors from Figure 72 interpret much of the stratigraphic column to have been developed during the period between creation and the flood. In fact, both Whitcomb and Morris (1961) and Scheven (1990) report that essentially no sediment would have been preserved.

> If there was no rain before the Flood, then there was no erosion that could have washed sand etc. into the seas. Consequently, *there was no deposition of any kind*. This being so, no geological work can have been accomplished between the Fall and the outbreak of the Flood: neither erosion, nor deposition, nor volcanism (as we shall see), nor mountain-building activities, nor, of course, any entombment and lithification of fossils can have taken place. (Scheven 1990, *The Geological Record of Biblical Earth History*; emphasis added)

Most YEC authors agree with Scheven's interpretation that the earth had no rain before the flood, based on Genesis 2:5–6. Snelling (2009) takes a different position. Recognizing Precambrian rain prints documented in South Africa and Norway, he contends that the lack of rain indicated in the Genesis text refers only to the Creation week. That would simplify matters. Rivers such as the Tigris and Euphrates are referred to in Genesis 2:10–14. Rain is a very normal way of supplying the water to feed such rivers. Erosion and deposition would be implied regardless of the source of the water. Snelling's scenario would have very active erosion and deposition of all normal sedimentary lithologies for the 2,348 years from creation week to the flood. Most of this would have been after Adam's fall, so life would have degraded dramatically over a very short time. In the end, all of the lifeforms, both ancient and modern should have been present during this period of time. Snelling recognizes thick deposits from this period. Candidates for such rocks in this study area would include units such as the Castner marble in the Franklin Mountains near El Paso and the Van Horn Sandstone in West Texas. Some of the Precambrian rocks are heavily metamorphosed today, but isn't it strange that we do not find any of the newer life forms as fossils in any of the exposed rocks? Surely after the fall, not all plants and animals lived for over two thousand years. Paleontologists are almost always very detail oriented people. Maybe all of these detail oriented specialists just overlooked all the modern forms. Snelling suggests that tectonic events must have been very mild to help account for the lack of such fossils. It is still difficult to imagine that nowhere in the world conditions existed that were conducive to preserving hard bodies or shells.

We do not even find pollen in the sandstones. Perhaps it would be simpler to take the stance that all such deposits were washed away by the flood. Such a hypothesis would at least be more difficult to test.

Unit 3 Flood Deposits

Duration: One to a few years—2348 BC using Ussher creation date)

A major key to any convincing case for the validity of YEC "flood geology" has got to be the ability to convincingly define criteria and recognize the deposits from the global flood. When I described the YEC geologic column, the unit 3 flood deposit section included some specific predictions of characteristics that should be found in a global flood deposit and other characteristics that should be absent from the deposit formed by such an event. Figures 75–78 schematically show a series of profiles illustrating the order of events that might shape sediment geometries in the "flood geology" model. The first key is to define and recognize the start of the flood deposition. The base of the flood deposits should be a major unconformity. All the authors referenced in Figure 72 consider the top of pre-flood units to be stratigraphically at or below the base of the Cambrian. So far so good. In this study area, Precambrian igneous and metamorphic rocks are typically separated from younger units by a major unconformity. In some areas, the unconformity is not dramatic, such as near Van Horn, Texas but a subtle unconformity is recognizable nevertheless (Davidson 1980). It would be difficult to make a case for an unconformity at this stratigraphic position in many parts of the world, but we are immediately concerned with this study area.

The next key is to recognize the deposits formed by the flood itself. One would expect that these deposits would be obvious. The proposed event is described as far beyond anything before or after. As illustrated in Figure 72, virtually all published YEC articles conclude that most if not all of the Paleozoic deposits resulted from the Flood. The flood model proposes that the deposits were formed by rapid processes that were quantitatively and qualitatively different than modern sedimentation and one would expect that this would be easily discernable. However, this just does not seem to be case.

Consistent with Figure 73, the Paleozoic section is as thick as thirty-six thousand feet (11,000 m) in the deepest part of the Delaware Basin in West Texas. If deposition began there immediately when the flood started and all of that were deposited in one year, then deposition would have averaged one hundred feet (30 m) per day. Snelling for example would also include the Mesozoic interval that gets to be at least twenty thousand feet (6,000 m) thick in East Texas. If that is included that would mean that deposition would have averaged 150 feet (47 m) per day. Many YEC would interpret the flood deposits to have included a few years after the actual flood as the earth stabilized but that does not change the observation that the YE interpretations demand incredibly rapid deposition. This demands very thick deposits formed by rapid, often chaotic processes. Geologists do recognize a few events that caused deposition at such rates, but the dominant theme through the Paleozoic in

> If one bed or series of beds is demonstrated to have taken more than one year to have formed, then the "flood geology" interpretation cannot be valid.

the study area seems to have been deposition by normal sedimentary processes. None of the sediments that we have considered in this interval are difficult to explain in terms of the normal processes that we see today. The rates may have varied somewhat, but by nowhere near the amount that it would take to make them candidates for a huge global flood deposit. Remember, that if one bed or series of beds is demonstrated to have taken more than one year to have formed, then the "flood geology" interpretation cannot be valid. The Paleozoic sediments are easily divided into formations, deposited apparently by processes that were vastly slower than the flood geologist needs to make his theory work. The depositional systems as briefly described earlier varied widely but have been mapped in great detail. It is difficult to envision any flood scenario that includes the deposition of the thick limestone beds, let alone allows for them to be changed to dolomite. Austin et al. (1994) speculates that flood carbonates were precipitates or eroded pre-flood carbonates or pulverized pre-flood shell debris. The evidence here and around the world indicates that very little lime was in the past or today deposited by direct precipitation. For one thing, many fossils are found in growth position. If direct precipitation were a major process for forming limestones, what would have caused it to have happened so rapidly over broad basins? This explanation for the limestones does not work. In addition, I see no realistic explanation for how to form a thick dolomite formation in one year, yet "flood geology" demands that many of these were deposited. The dolomites that we do find can be demonstrated to have been deposited as lime muds that were altered over time to become dolomites.

What about other features that are recognized that are not compatible with a global flood deposit? A number of such problem features were noted in the study area summary. Figure 79 illustrates the stratigraphic position of a series of examples of features that are difficult to impossible to reconcile as a part of a deposit from a one-year long flood.

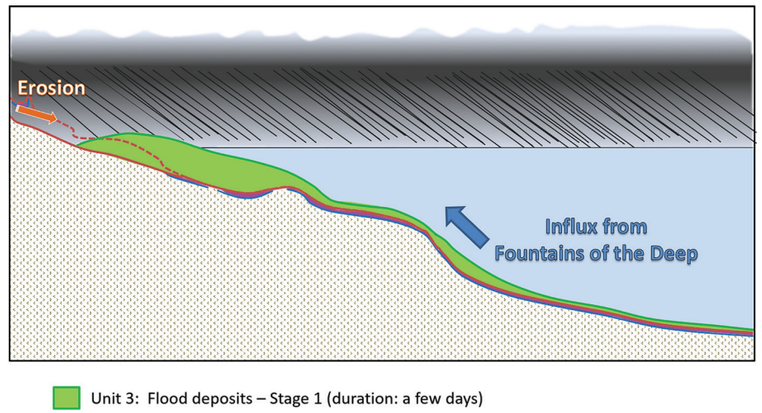


Figure 75 Hypothetical sketch along a profile along a margin of a basin during the flood. The YEC model is that dramatic amounts of sediment were eroded globally by the combination of 1. rain and 2. water brought in from the "fountains of the deep". Notice that it would be probable under this scenario that most of the thin pre-flood strata would have been eroded away. It is fair to assume that the deposit formed would have been a poorly consolidated mass of sediment. It is also safe to assume that it would be poorly organized and poorly sorted. The closest analogy that I can think of from today might be a large fan delta apron. Water moving from both below and above should lead to some very confusing patterns of sedimentation.

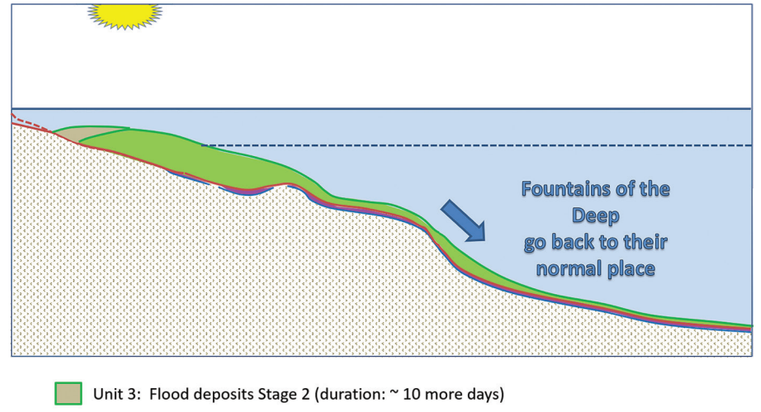


Figure 76 The rains ceased after 40 days. According to the YEC model, the whole globe was submerged. Many believe that much of the earth's topographic relief did not exist until after the flood. This is a theory with no particular Biblical or scientific support.

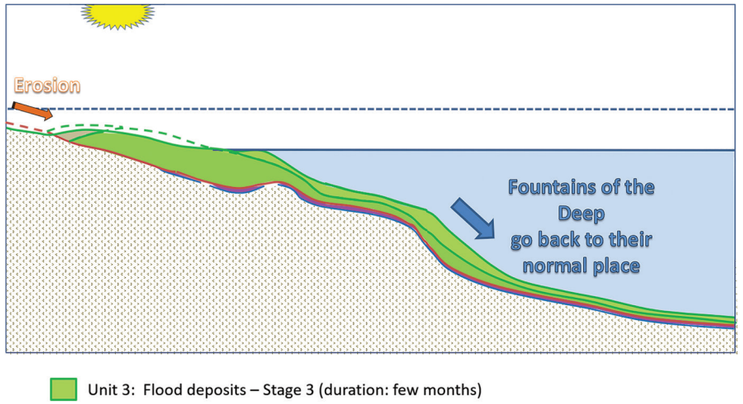


Figure 77 Shortly, the flood waters began to recede. Drainage would have developed over whatever topography remained. Geologically this would represent a very rapid lowering of sea level. One would expect rapid erosion above sea level to the degree that normal rainfall would allow.

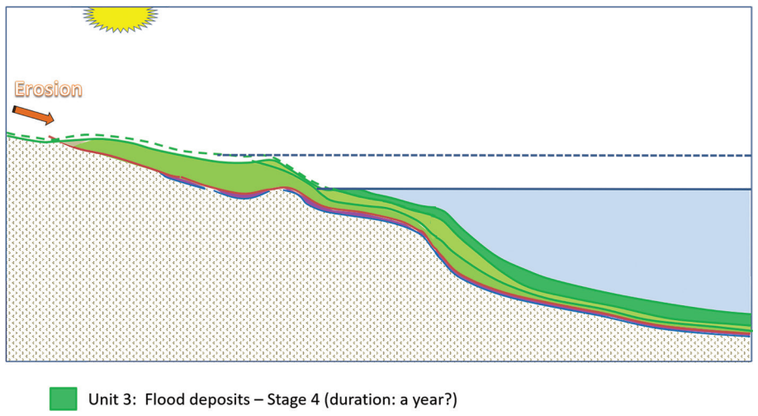


Figure 78 Eventually sea level would have stabilized at approximately what we call its normal level. Possibly one might expect terraces to have been present, representing levels where it stabilized temporarily on its way to the final position. Deposition still would have been very rapid.

7.

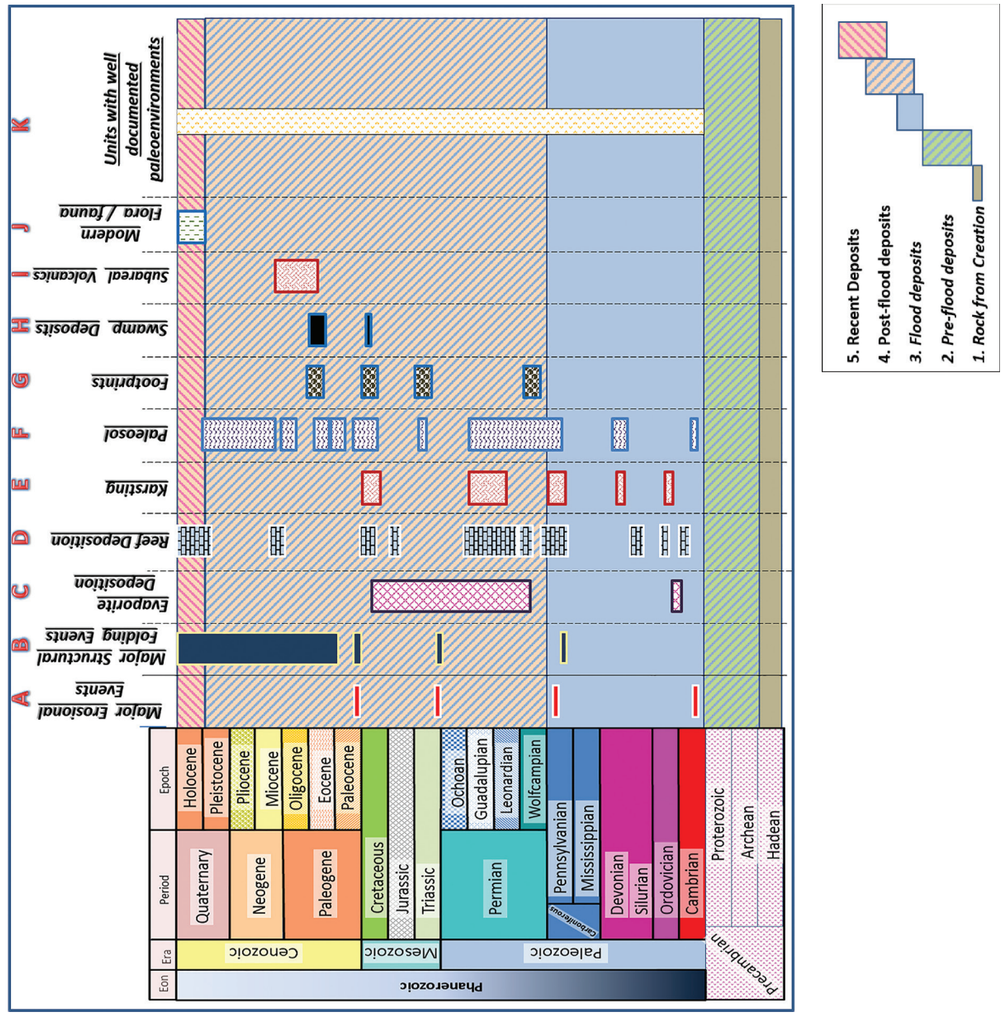


Figure 79 Stratigraphic position of key features that must be accounted for by “flood geology”. Major erosional events might be considered as candidates for the pre-flood / flood boundary. The remaining features are difficult if not impossible to explain as developing in or being preserved as parts of a catastrophic flood deposit. These are all well documented in the study area. If all of North America or the earth were being considered, many more occurrences would be added and additional features noted.

Major Erosional Events

Four major erosional events from this area are shown in column A, each of which often is expressed as an erosional unconformity. Significant amounts of erosion took place at each. in at least local areas. Each could be considered as a candidate for the pre-flood/flood boundary, but they are widely separated stratigraphically and did not result from any single event, regardless of whether that event was one year long or thousands of years long.

If the erosional events were just isolated phenomena within the flood, then below the erosional surface would have been soft, unconsolidated sediment at the time of the erosion. The sediment eroded at each of these unconformity surfaces included rock, lithified sediment, not just sand and mud, as demonstrated by pebbles and boulders above each unconformity. Rain and subsequent erosion from a single event would not erode away mountains of lithified rock, let alone then bury them with more rock that is then later folded. Yet that definitely happened to the Paleozoic rocks during the Paleozoic era.

Major Structural Folding Events

"Flood geology" demands that most of the folding that we see in the rock record in the interval interpreted as flood deposits took place in that one-year period.[13] Obviously that is drastically different than the normal geological interpretation. Whitcomb and Morris (1961) "postulated that the earth's great complex of faults and folds was produced fairly rapidly when the strata were still soft and plastic." They contend that the folding of rock is not only permissible in a YEC model but actually demanded by it. The logic flow might look like this:

1. Thick large scale folded units of rocks are observed today.
2. Rocks are strong and resist folding and cannot behave ductilely as lithified rocks.
3. Therefore, the rocks were not lithified at the time of the folding.
4. The thick intervals of rock, many thousands of feet thick that are folded today must have all been soft and pliable at the time.
5. For thick intervals of rock to be soft and easily deformed, they must have been formed "fairly rapidly."
6. The thousands of feet of rapidly deposited soft sediment must have been deposited by the Genesis flood.

[13] For a basic description of folding and faulting try this Web site: http://web.eps.utk.edu/~faculty/tennmaps/lectures/TennMaps_Structure.pdf.

Does this idea stand up under examination? Step 1 is certainly true. In this book, folding of Paleozoic rocks has been documented (Figures 32, 33, and 34; Figure 79, column B). We observe folding at all scales. Figure 34 illustrates that the Pennsylvanian structural event did not just fold sedimentary rocks but also involved folding of older metamorphic and igneous rocks as well. Mesozoic rocks are also deformed by folding as illustrated in Figures 49, 54, and 55. The timing of much of this folding such as that on Figure 49 clearly involved deeply buried sediments. The same could be said for Cenozoic folding as illustrated in Figures 49, 63, 68, and 69. The Cenozoic folding highlighted on Figure 79, column B reflects the large amounts of folding associated with the large growth faults and salt movement in the Gulf of Mexico basin.

Geologists certainly agree with Step 2 over a few thousand years, but does this change if longer periods are involved? Solid as a rock is an expression of strength but time can change the ability of a substance to resist deformation. We see this in everyday life. We have a lot of boxes in our attic. The cardboard boxes can be stacked in any order and the cardboard will seem to be firm and stable. However, experience says that what is stable in the few minutes that it takes to stack them is not necessarily stable for the long term. We have demonstrated this by stacking heavy boxes on top of light boxes and coming back a few months or years later. We have often found that the "stable" solid cardboard boxes have collapsed. The cardboard ended up folded because stress was applied to it over time.

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).

One example that Hubbert used involved changes since the last ice age. We may get another example if the global warming continues and the ice in Antarctica melts. When the weight of the ice is removed, the continent will come up or to use the geologic term, be uplifted. That is what happened in North America and Scandinavia after the last ice age. The area is still being uplifted or "rebounding" from the removal of the ice. Hubbert was able to demonstrate that the measured rates of rebound of the land match estimates of the viscosity that one would expect in the rocks given their physical properties. Solid rocks are being folded over the course of time and we can measure the rate at which they fold.

Hubbert's paper was written seventy years ago. Experiments to determine how rocks flow or "creep" were just beginning. Devices were created that could measure the deformation of rock samples, but early techniques were not as accurate as we have today. One of the most significant papers

was published in 1961, the same year that Whitcomb and Morris published *The Genesis Flood*. Biot, Ode, and Roever (1961) published a paper in the Geologic Society of America Bulletin titled "Theory of Folding of Stratified Viscoelastic Media and Its Implications in Tectonics and Orogenesis." (Great light reading) They were able to use models to develop equations that predict the rates of folding of rocks under compression and gravity. They demonstrated that "it can be seen that for periods of the order of 10^5 or 10^6 years, a relatively small load may produce explosive folding, even in hard rock." Thus, very hard rocks can be tightly folded given hundreds of thousands or millions of years.

Many new techniques are available today. It is possible to describe and quantify many processes that happen as rocks change shape under geologic stress. Major controls that determine the rate at which rocks deform include the lithology, temperature, pressure, and water content. Rocks deform more easily when they are hotter (deeper buried) and have higher water content. Pressure can make them more difficult to deform but more ductile (Karato 2013). Many studies provide quantitative evidence for deformation processes and the rates at which they act (Evans and Kohlstedt 1995; Rana1969; Kenis et al. 2005; Tullis and Tullis 1986). There is one caveat though to all of this work. We are extrapolating tests that run over relatively short times against our understanding of geologic rates that are in the thousands to millions of years. We can project results out and demonstrate that over long periods of time, rocks will deform. We typically test small samples of relatively uniform rocks, but geologic features formed in the sedimentary column are folding large volumes of rocks with widely varying properties over long periods of time. Other factors come into play. Field work, for instance, has demonstrated that limestones deformed over geologic time even faster than some of the measurements of deformation in the lab suggest (Gunzburger and Cornet 2007). Does this mean that the rocks were soft and pliable at the time of deformation? It does mean that the laboratory tests are not taking something into account. As it happens, the tests are unable to account for the pressure dissolution that occurs in limestone in the form of styolites (Alvarez, Engelder, and Lowrie 1976).

Given the studies available today showing the way solid rocks deform, Step 2 of the YEC logic above fails for rock when long time frames are involved. Some rocks definitely were folded while they were still soft, but it is possible to recognize the characteristics of these folds. In fact, there is a continuum of deformation styles from soft sediment folding to brittle faulting (Waldron and Gagnon 2011). Structural folding events such as observed in Pennsylvanian rocks cannot be considered as soft sediment deformation partly because of the types of brittle behavior included.

Step 3 is dependent on step 2 and thus is no longer valid. It is true that thousands of feet of rock are involved in folding events, as stated in step 4, but the case that they were not lithified cannot be based on the fact that they are folded. Lithification, the process of turning soft sands and muds into rock, for clastics is based largely on depth of burial. The overlying weight, pressure, and increase in temperature associated with thousands of feet of burial caused the muds and sands to have become shales and sandstone. Calcium carbonate based materials including muds, sands, and biologic communities, became competent rocks even more quickly. Sometimes they are converted to "*hardgrounds*" that constitute competent, hard-to-fold beds with no burial. Lithification provides a problem for the YEC position where they are in effect "stuck between a rock and a hard place." If they argue that lithification takes place slowly, then the well-lithified Cenozoic rocks have not

had time to lithify into the rocks that we find today in their timeframe, but if they argue that they lithified
quickly, then they do not have time for them to have developed the folding that they exhibit.[14] Michael Oard said this about hardgrounds, "Even if such features are difficult to fit into a Flood chronology, it does not mean that the Flood could not form them" (Oard 2007). How many things are "difficult to fit" before the model does not work?

The implication of a long time is even more compelling when we see that not only were rocks folded in the Paleozoic but again, entire folded mountain ranges were eroded away (Figure 33). It seems that every YEC loves to point out that erosion can be very rapid, pointing out rapid erosion of volcanic ash that took place following the Mount St Helens volcanic eruption in 1980 (Austin 1984). It is worth pointing out that it is one thing to rapidly erode volcanic ash and quite another to erode limestones, dolomites, sandstones, and shale. Rome was established on its seven hills, apparently over 2,700 years ago and the hills are still doing fine. It looks like Jerusalem began around 5,500 years ago and Zion is still there. Maybe lithified rocks don't really erode away so fast.

Modern geologists, as noted previously, have come to accept the theories of plate tectonics and continental drift as powerful explanations for a large number of geologic observations that come from many disparate sources. The ability to provide a unified explanation for so many different kinds of observations is considered strong evidence for the basic validity of these theories. Continental drift was originally proposed as an explanation for why the outlines of North and South America seem to fit together so well with Europe and Africa. Now, with the plate tectonic theory, we have a theory that explains things such as magnetic data, bathymetric features, paleontological data, seismicity such as the location of earthquakes and the depths at which they occur, where mountains and seas are located today and back through time, movement of GPS points through time, and the radiometric ages of volcanic rocks in many parts of the world. It becomes very difficult to imagine another explanation that could explain all these datasets. Good descriptions of plate tectonics are found in many modern geological textbooks such as Wicander and Monroe's *Historical Geology, Evolution of Earth*

[14] 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 were 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 Tampeats 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.

and Life through Time (Wicander and Monroe 2007).[15] It is important to recognize that most of these datasets are consistent with and really demand a geologically long timeframe. They are incompatible with movements that would have occurred during a one-year-long flood event, regardless of the catastrophic events associated with it. Does the evidence show that God chose to move that way?

Evaporites

The next issue on Figure 79 is evaporites (column C). Deposition of salt, gypsum, and anhydrite by evaporation should be the last thing one would expect in a global flood deposit, yet these are major depositional facies within the study area. The sheer amount of evaporation demanded by salt deposits such as the Louann salt does not fit in a time frame of a few thousand years, let alone the one year demanded by the "flood geology" model. Evaporites such as were deposited during the Permian are intimately associated in sabkha deposits characteristic of very arid climates. Scheven (1990) chose to place the flood/post-flood boundary at the Pennsylvanian/Permian boundary in large part because he recognized that the evaporites of the Rotliegendes of Europe cannot be flood deposits. Snelling (2009) documents the fact that there are multiple hypotheses regarding the details of how major salt deposits developed. None would allow for the time frames demanded by the YE model. He suggests that evaporites in the rock record may result from:

1. turbidity current deposits of evaporites that were created as such
2. rapid precipitation around hydrothermal vents (as he states, these may be associated with bedded evaporites)

Even if one concedes that geologists do not agree on how some evaporite units formed, it is certain that most evaporite units did not form by either of his proposed methods. The arid sabkha association of facies found repeatedly in the study area are well documented and do not fit the YE model. The Jurassic Louann is also problematic for the YEC, because it was deposited and then deformed into complex salt domes and other masses that clearly were present and influenced later sand deposition and reefs.

[15] Wicander and Monroe, as with the majority of modern historical geology texts certainly teach the theory of evolution by mutation and natural selection as the cause for the diversity of life that we see today. It does not delve into the origin of life itself. The fact that life has changed through geologic time is a clear observation that must be recognized.

Reefs

Repeatedly this book has referred to a special set of carbonate deposits described as "reefs." It is easy to understand how these deposits represent a difficult challenge to try to incorporate with deposits from a single flood. Trends of deposits referred to as "reefs" are found within this study area in strata that range in age from late Cambrian to the modern (Figure 79, column D, and Figure 80). The size and constituents of these features were different, and for each these major features, there are hundreds of small ones. It is apparent that thick modern reefs such as are found on atolls or the Great Barrier Reef in Australia cannot have grown within a one-year flood event. Explaining these massive features in the four thousand years since Noah's flood by the YEC timeline is also totally unrealistic.

What explanation is provided for the many rocks recognized by geologists as reefs by YEC authors? It is not as though any proposed flood interval on Figure 72 avoids this problem. Geologists recognize reef deposits in "flood deposits" interpreted by every author. They must each provide an explanation that allows all these thick special units of limestone, at times hundreds of meters thick to have formed in much less than one year. Whitcomb and Morris (1961) proposed this: "During the flood, extensive reefs formed in the warm waters of the antediluvian seas would have been eroded and deposited, often giving the appearance now of an ancient reef of great extent" (Whitcomb and Morris 1961).

Snelling suggested that many fossil "reefs" were actually "accumulations of sediment swept in by water" or "rapidly accumulating debris flows" (Snelling 2009). Certainly some carbonates formed by such methods. First, it is important to look at the terminology. Early on, the term reef was used to refer to any hard bottom that represented a hazard for ships. At the other end of the spectrum, some YEC want to restrict the term to refer only to coral reefs such as are found in warm seas all around the world today. Geologists often have not helped matters. Some geologists have at times used the term *reef* for any limestone units that they considered prospective for oil and gas. Many well-known oil reservoirs are referred to as reefs, and as a result, some decided that the term *reef* could be used to entice investors to drill prospects.

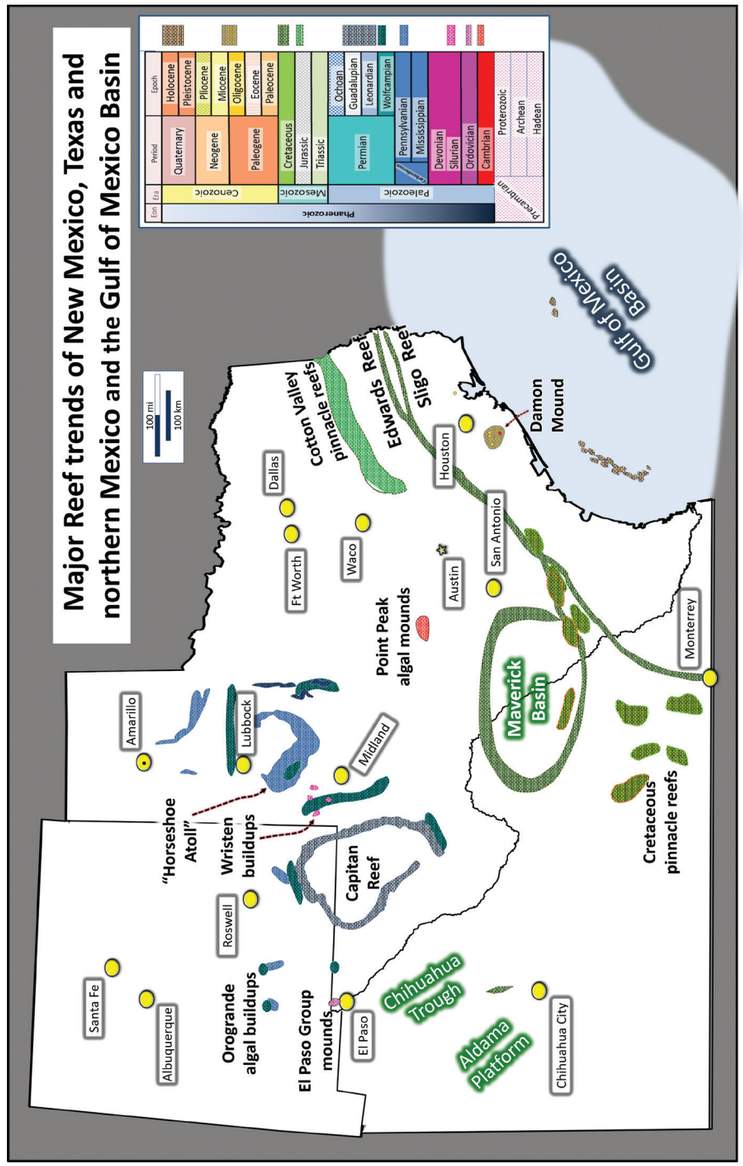


Figure 80 Major reef trends in the study area (Saller 2013; Stege, et al. 1981; Standen, et al. 2009; Dutton, et al. 2004; Wilson 1975; Foote, Massingill, and Wells 1988; Fritz, et al. 2000; Frost and Schafersman 1978; Berryhill, Suter, and Hardin 1987; Ahr 1971; Toomey 1970; Handford and Dutton 1980; Goldhammer 1999)

Terminology does vary according to purpose. Defining terms makes for good communication. When the purpose is to provide technically precise descriptions, many different terms are used. For instance, one might use the term ***bioherm*** for a mound-shaped deposit or biostrome for a deposit from a biologic community that did not generate a mound. One might describe a reef by the organism that formed it such as an algal reef or a coral reef. Some terms describe the shape and position of reefs, such as a pinnacle reef is cone-shaped and a fringing reef grows along a coastline. A barrier reef is a linear reef with a lagoon behind it. Many such terms are found describing modern settings and in ancient rocks. If the purpose here is to recognize carbonates that are significant in terms of being clearly identifiable and having taken significant amounts of time to form, then that means a fairly general definition of a reef will do. With that purpose in mind, I will use the term *reef* for carbonates that meet these criteria:

1. Represent a concentrated organic accumulation

   Many ancient and modern lifeforms, both animals and plants, have left accumulations of lime skeletons. Examples here include algae, corals, and rudists.

2. Is a build-up or mound

   Reef will be used for accumulations that had topographical relief. Other organic lime accumulations took long times to form but would not here be referred to as reefs.

3. Is locally derived, some growing in place

   Modern coral reef deposits include some coral that grew in place but much is broken and much ends up eaten by various animals. Even so, the reefs considered here all have some species that are found in their growth position.

4. Associated facies are consistent with modern reef settings

   Surrounding facies should be consistent with modern reef settings. In each of the cases on Figure 92, internal facies of the reefs have been mapped in as much detail as the deposits will allow and they are consistent with reefs and the facies around the reefs have been mapped and are consistent with environments around reefs today.

Through the previous sections and in Figure 80, many different examples of ancient to modern reefs are given. YEC authors recognize that if any of these meet the criteria above, then their interpretation of geology is in need of serious revision. All authors in Figure 72 interpret the lower Paleozoic rocks as flood deposits. Yet many examples in this study area show very strong evidence of reefs that developed over many years. All but one of the authors would consider the Permian to be within the

Unit 3 flood interval. Yet the Permian reefs in West Texas are among the best documented ancient reefs in the world. YEC publications and Web sites commonly cite a paper by Stuart E. Nevins titled "Is the Capitan Limestone a Fossil Reef?" (Nevins 1972). Nevins was a pseudonym used by Dr. Steven A Austin as a graduate student, apparently because of concerns that his YE views would have worked against him in pursuing a PhD in geology (Numbers 1993). A lengthy quote is given here from his abstract in order to accurately give his view:

> The famous Capitan Limestone in the Guadalupe Mountains of southeastern New Mexico and western Texas is alleged by many geologists to be a classic example of a fossil "barrier reef."
>
> Study of the strata cast doubt on the various depositional and ecologic environments alleged to be associated with "Capitan Reef." So-called "backreef lagoon" and "forereef talus" deposits were not contemporaneous with "reef" accumulation. Furthermore, the Capitan lacks large, in situ, organically bound frameworks and deposits of broken debris which can be shown to be derived from an organic framework.
>
> The Capitan is composed primarily of broken fossil fragments in a fine-grained matrix of lime silt and sand which were not wave-resistant when deposited. The fossil flora and fauna of "Capitan Reef" represent a shallow water assemblage which was not especially adapted to a wave or strong current environment. Reef-forming organisms which could bind sediments and build frameworks are either altogether absent or largely inconspicuous.
>
> The available data certainly do not require many thousands of years for the Capitan to accumulate, and, therefore, seem to present little problem for Biblical chronology. Instead the lack of large organically-bound structures, which would grow during thousands of years, suggests that the deposition was very rapid. It is proposed that the Capitan Limestone accumulated either during the last stages of the Noachian Flood or shortly thereafter.

Carbonate stratigraphers have studied the Capitan reef extensively and have expressed many different ideas and used many different terminologies to describe it. "Nevins" seems to be the only writer who suggests that it could have been formed in less than many thousands of years. Peter Scholle, a recognized expert on carbonates in general and in particular this area, gives a good summary of the proposed ideas in geologic literature, and he notes that a couple of workers suggested that it was "an unconsolidated shelf margin skeletal mound" though most consider it a true barrier reef (Scholle 2000). This quote helps to understand the character of the Capitan reef:

> Overall, the high biological diversity of this environment; the abundance of framework calcareous sponges, bryozoans, and hydrocorallines; the ubiquitous presence of encrusting organisms (Tubiphytes, Archaeolithoporella, Girvanella, and others); the remarkably high productivity of organisms generating vast

> masses of reef and fore-reef skeletal debris); the distinct internal faunal zonation; the presence of abundant inorganic, radial-fibrous, originally aragonitic cements; and the large-scale fragmentation and disruption of fabrics by wave and current activity are all features of the Permian reef complex which are highly analogous to modern reefs. (Scholle 2000)

The comment by "Nevins" that the "backreef lagoon" and "forereef talus" deposits were not contemporaneous with "reef" accumulation is hard to understand. It is true that many of the backreef facies found in the mountains are older than the late Capitan reef portion that is preserved in the Guadalupe Mountains. The equivalent backreef environments for the late Capitan in these mountains have been eroded away today (Figures 41–44). However, backreef lagoon environments are present for the early Capitan in the Seven Rivers Formation. In the subsurface, distinctive sand grains from the Yates Sandstone have been traced through the reef, providing a time surface through the reef that makes it certain that these units are indeed correlative with reefs of the middle Capitan Formation (JM Hills, personal communication; Ward, Kendall, and Harris 1986). Again, in the subsurface, the backreef Tansill formation is easily demonstrated to be equivalent to the upper Capitan using both wells and seismic data. The equivalence of forereef talus deposits can be observed in outcrop, wells, and seismic in many places.

In the reef definition for this book, one component is "some growing in place." It is not necessary that all the organisms be found growing in place. In modern reefs, many broken reef parts are found over the reef, often dominating areas. Careful work has demonstrated that much of the Capitan fauna is in its living position (Newell et al. 1953; Fagerstrom and Weidlich 1999). This trend of in-place fauna, cemented in place by microbes is documented through the older Goat Seep reefs and through the Capitan reefs (Hovorka, Nance, and Kerans 1993; Wahlman, Orchard, and Buijs 2013). It appears that the last forty years have not brought much support to "Nevins" proposal to reinterpret the Capitan as a rapid deposit.

"Nevins" suggested that the Capitan formation was deposited in "the last stages of the Noachian Flood or shortly thereafter." Most of the YEC authors interpret the Mesozoic units to have also been deposited during the Genesis flood. Globally many major reefs are interpreted throughout the Mesozoic interval. In this study area, the Jurassic pinnacle reefs and many Cretaceous trends are well documented. Cretaceous reefing in this study area is well documented in outcrops, wells, and seismic data.

The chief framework organism in the Cretacous was the large bivalves known as rudists. Many reef core areas are found with tightly packed rudists in growth position. A wide variety of reef types are recognized. AJ Damman demonstrated effectively that the Edwards limestone reefs are directly comparable to the modern coral reefs of Bermuda (Damman 2011). Both areas have barrier reefs that protected a large backreef area where many lower-energy "circular to irregularly-circular reefs" grew. Facies within the reefs are very comparable despite the differences between corals and rudists. Currently paleontolo- gists estimate that rudist reefs grew one to five centimeters per year, much slower than the five to

twenty centimeters per year estimated for coral reefs.[16] It is clear that unless all of the features identified are not reefs at all, then eight- to ten-meter thick reefs did not deposit during a one-year-long flood interval. Imagine the problem for the "Horseshoe Atoll" reef that is three thousand feet (900 m) thick or the Permian reefs that are up to five thousand feet (1,500 m) thick.

Paleokarsts

Another problem for the flood model is the presence of many layers with paleokarst deposits (Figure 79, column E). The description of the study area noted well-developed caves and paleokarst deposits in sediments deposited during five different geological periods: Ordovician, Devonian, Pennsylvanian, Permian, and Cretaceous. It is doubtful that it would be possible to expose a limestone, dissolve out caves, and then bury it over a few thousand years, let alone in the one year available during the flood. According to Wikipedia, "The quickest growing stalactites are those formed by a constant supply of slow dripping water rich in calcium carbonate [$CaCO_3$] and carbon dioxide [CO_2], which can grow at 3 mm [0.12 inches] per year."

Paleosols

Figure 79, column F, shows that paleosols are documented repeatedly through the interval interpreted as having been deposited by the flood. These all would need to be explained as something else because even if they take less than the twenty to thirty thousand years that is conventionally expected, to form in one year during a flood is not a possibility. Think about many layers with roots representing different periods of growth. If even one was a real soil, then the theory would fail. The rates demanded by YEC predictions mean that there would have been no time for rooted plants to have grown but in-place roots are common in paleosols.

[16] Interesting that Whitcomb and Morris (1961) also quote this reef growth rate but accept only the modern reefs.

Footprints

How could you have animal tracks such as dinosaur tracks preserved within the flood deposits? Well, preserved examples are found from Permian and Mesozoic sediments all around the world and in this study area (Figure 79, column G). It is hard enough to explain preserving the tracks at all, but in the middle or near the top of the flood deposits? How would that work? Creative solutions have long been proposed from Whitcomb and Morris (1961) to Snelling (2009). Some invoke the idea that more mobile larger creatures were moving up into the higher lands. During the few hours or days that might have been available, were they running for high ground? Remember if we considered the thickest deposits in this study area, deposition had to average 150 feet (47 m) per day when the Mesozoic is included as flood deposits. Locally the rates might have been much slower, but still keep in mind the rate things had to have been happening in the YEC model. Farlow reports that the sauropods from the Paluxy Formation in the Glen Rose area were preferentially moving southward (Farlow et al. 2012). Why would they have been running toward the modern Gulf of Mexico? The tridactyl tracks show that these three-toed dinosaurs went both north and south. They must have been confused. If they were running toward mountains that existed before the flood, it is really unclear where the mountains were. If the footprints were located stratigraphically on layers that might have been close to granite or some rock that the YEC could say were created mature, then the scenario might be considered. At Glen Rose, the Paleozoic and Mesozoic section below the prints is about eight thousand feet (2.4 km thick). How do you get dinosaurs walking around atop over a mile of recent flood deposits? There were no massive coals to represent floating islands here.

Why were no dinosaur tracks preserved running during what was supposed to have been the early flood? Why don't the late Precambrian or Cambrian or Ordovician sediments have footprints? No such prints are found, not just here, but anywhere in the world. In the YEC model, one might expect dinosaur tracks in the unit 2, pre-flood deposits, but late in the flood? YEC author Paul Garner observed, "The occurrence of in situ eggs and nests in Triassic, Jurassic, and Cretaceous sediments indicates that at least these systems must be post-Flood. This deduction is supported by the recent discovery of apparently in situ termite nests in the Triassic sediments of Arizona's Petrified Forest National Park" (Garner 1996). I am not aware of any dinosaur nests identified in this book's study area, but the Petrified Forest is not far away. Why no dinosaur nests in the Paleozoic? Probably because they were not around then.

Coal (Swamp Deposits)

Coal deposits in the Cretaceous and Paleogene represent deposits from swamps and marshes on coastal plains (Figure 79, column H). The flora and fauna were different for coals of different ages.

These coal deposits fit within the surrounding sediments where one would expect swamp deposits. Most are swamp or marsh deposits that represent many years of deposition, not the deposits of a one-year flood. Similar deposits formed at many different stratigraphic ages around the world but all after the Carboniferous. If all plants were flourishing in the pre-Flood world, why do none of the lower, older rocks include coals?

Subaerial Volcanics

The subaerial volcanic rocks also demonstrate that the early Cenozoic deposits did not form under global flood conditions (Figure 79, column I). If flood waters covered the earth, then any active volcanos would have spewed out lava onto the seafloor. Much of Mexico, New Mexico, and parts of West Texas were covered by lavas (Figure 69). Some of these came out of volcanos that are classed as "supervolcanos," capable of ejecting greater than 240 cubic miles (1,000 km) ðf volcanic material (Figure 9; Crumpler 2001). The fact that no submarine lava flows are identified in the study area is a strong indication that these rocks were not deposited during the flood.

Other Issues

Even the general location of all this sediment points out another basic problem for "flood geology." If the flood sediments formed by eroding the sediments off pre-Flood landmasses, then why are the thick sediments located on the continents and not in the ocean basins? Austin et al. (1994) interprets this to be the result of the water flowing from the ocean basins, uplifted by hypothesized tectonic movements, onto the continent. One of many problems with this model is the fact that we do not see sediments fed from the ocean basins. It can be demonstrated that in the study area, over and over again, sediment was fed from the north and west. If it flowed from the ocean basins, it would show current indicators and thickness relationships coming from the south.

How about the fossils? If the flood event took place, such that there was one year of flooding and perhaps a few years for systems to equilibrate and reestablish themselves, then surely fossils should be essentially uniform throughout. (Not to mention indistinguishable from the pre-Flood deposits.) Is that what we find in the rocks? Hardly! (Figure 79, column J). Fossils assemblages are different for each of the different periods. Even in the Mesozoic, Triassic, Jurassic, and Cretaceous series all have their own assemblages of fossils. Even individual types of fossils such as the ammonites can be observed to change over the periods of time that they lived. No one has ever reported any of the vast number of the dinosaur species from the Mesozoic in the Paleozoic rocks. Imagine the dramatic

news that would be generated by a discovery of a single mouse skeleton found in Cambrian or Ordovician strata. Even a guppy fossil in the pre-Devonian would be amazing. A human skull from any of the Precambrian, Paleozoic, or Mesozoic eras would be a historic discovery.

If the predicted picture is one where the deposits of the flood represent a chaotic jumble of material quickly shed off the continent, then that is missing in Texas. It certainly cannot be said to represent any large portion of the Paleozoic or Mesozoic records. The fossils indicate a continuous progression of forms just as we see in other eras. There certainly were isolated catastrophic events that left deposits, but there seems to be no reason to call for the "catastrophic tectonics" predicted by some authors. Looks like we will need to look for other options, but first we need to look at the "post-Flood" section within the Cenozoic.

Units 4 and 5 Post-Flood

Year 2348 BC to present using Ussher creation date

One might expect that the difference between cataclysmic flood deposits and the post-Flood normal depositional processes would be very easy to recognize. Apparently not, because as Figure 82 illustrates, there are widely varying opinions about the location of the boundary. Perhaps one reason for this disagreement is the difficulty in reconciling the amount of post-Flood sediment with the limited time available in the YE model to allow for its deposition. This is likely at least one motive for why Whitcomb and Morris, 1961 and Sherwin and Thomas, 2010 place so little of the geologic record within the post-Flood sections. If the top of the flood deposits were positioned using the proposed position from Snelling (2009) and Austin et al. (1994), then the entire Cenozoic section represents the post-flood interval. Perhaps when many YEC picture the Cenozoic post-Flood deposits, they picture a relatively thin veneer of sands and gravels such as are found in many places across the continents such as at the Grand Canyon (Austin et al. 1994). Geologists recognize that the majority of Cenozoic deposition took place along the margins of the continents. As shown on Figure 73, all added up, the thickness of the Cenozoic along the Texas margin is approximately 120,000 feet (37 km) all of which would have been deposited after the flood. That is quite a challenge in the approximately four thousand years since the flood! Even more deposition would have to be accounted for if we expanded the area to include the Mississippi River delta. YEC author Michael Oard argues that the flood deposits must include most of the Cenozoic.

Why?

> Furthermore, they need to explain the biblical basis for post-Flood catastrophism required to deposit thick sequences of Cenozoic rocks in many areas, particularly the continental shelf deposits. Included in this explanation would be the reasons for the absence of human documentation of these catastrophic events, since they would have occurred alongside human resettlement of major continental areas. (Oard 2013)

What determines how long it takes to fill a basin? One of the biggest limiting factors is how fast it can subside. Reefs are a great example to show this. It doesn't matter how fast they grow. They still will not grow above sea level. That is why they sometimes prograded and grew farther and farther into the basin. The basin was not subsiding as fast as they could grow. For basins to subside, deep solid crustal rocks must be warped downward. How fast can basins subside? The fastest subsidence that I know about is in the Gulf of Mexico where the Mississippi River dumps its sediment every day into the Gulf. Today, as the river progrades, it brings sandy sediment out over muds deposited by earlier systems and they sink rapidly. Geologists are amazed that the delta plain there subsides at up to three millimeters per year.

Morton et al. (2002) has demonstrated that there is one local part of the delta that subsides much faster. Here the subsidence rate is as high as twenty-three mm per year (Morton, Buster, and Krohn 2002). Why would it be faster here than everywhere else? It seems that something is moving out from beneath the area. In fact, the authors tie this enormous rate of subsidence to oil and gas fields where fluids are being pumped out of the subsurface at a high rate. This suggests that in order to get high rates like this, there ought to be rapid withdrawal of something from beneath the basin. If the Cenozoic Gulf of Mexico basin sediments were deposited after the Genesis flood, then this withdrawal would have to be taking place at an enormous rate through the whole time the post-Flood sediment was being deposited. That would seem to be at odds with the YEC theory that the water from the flood actually went back below the surface into the "fountains of the deep." If water were going back into the subsurface at some dramatic rate, there would not be subsidence. Table I compares the Louisiana subsidence rates to subsidence in the area around the Corsair fault in offshore Texas (Figure 68). The subsidence rate along this fault was probably as rapid as anywhere in the study area and this provides one example of what would have been required at one spot. It just doesn't seem possible to subside the Gulf of Mexico basin and fill it that quickly, especially with the variety of rocks and processes that we see evident in the rock. Rates from Table I indicate that the average subsidence rate predicted for the whole time since the flood (using the most commonly assumed date for the flood of 2348 BC) would be 775 times the fastest rates we record on the Mississippi without man's help! If we were to assume that the Gulf was about the same depth in Abraham's time, that would give only 450 years and this would require a subsidence rate of over six thousand times that abnormally high rate. Even with the longest timeframe permitted by the YEC argument, the rate would need to be forty times the fastest local rates recorded and that would have been the aver- age rate over essentially the whole Texas coastal plain and continental shelf. Conventional geologic expectation would be that there would be periods of time when the area would experience higher than normal rates, but for much of the time, the rate would be much slower, such as we see today. We will see other indications of the time represented by the sediments interpreted to have been deposited after the flood but these will be looked at as we examine units 4 and 5, where we have more agreement and we can use it as calibration.

Inputs:		Rate m/yr	Years	Thickness Meters	Thickness Feet
Depth of Cenozoic section	Miocene depostional thickness downthrown to the Corsair Fault with conventional geologic years		22,000,000	8,537	28,000
YEC predictions available time for deposition	1) Total years since flood		3,670		
	2) Years before Abraham		450		
	3) Total years since flood if gaps in geneaologies are accepted.		9,670		
Rates of subsidence	Maximum rate in rapidly subsiding delta	0.003	3 cm / year		
	Maximum in rapidly subsiding delta above large oil and gas field	0.023	23 cm / year		
Calculated predictions					
YEC predictions					
Maximum rate in rapidly subsiding delta		Fastest rate under normal conditions (only right at mouth of big river)			
Prediction 1 (Total years since the flood)		0.003	3,670	11.0	36
Prediction 2 (Only the years before Abraham)		0.003	450	1.4	4
Prediction 3 (Includes gaps in Genesis genealogies)		0.003	9,670	29.0	95
Maximum rate in rapidly subsiding delta above large oil and gas field		Fastest rate when man intervenes (only right at mouth of big river)			
Prediction 1 (Total years since the flood)		0.023	3,670	84.4	277
Prediction 2 (Only the years before Abraham)		0.023	450	10.4	34
Prediction 3 (Includes gaps in Genesis genealogies)		0.023	9,670	222.4	730
Subsidence rate required to match YEC predictions		Rates demanded during period where no Biblical basis for miracles is found			
Prediction 1 (Total years since the flood)		2.326	3,670	8,537	28,000
Prediction 2 (Only the years before Abraham)		18.970	450	8,537	28,000
Prediction 3 (Includes gaps in Genesis genealogies)		0.883	9,670	8,537	28,000
Using conventional geologic dating		Would mean away from major rivers, subsidence is much, much slower on the average			
Absolute max rate observed		0.023	371,156	8,537	28,000
Reasonable max		0.003	2,845,528	8,537	28,000
Observed average rate		0.000388	22,000,000	8,537	28,000

Table I

Unit 4. Post-Flood deposits (500–4,000 years; 2348 BC to approximately 1900 BC—time of Abraham). Unit 5. Recent deposits (0–4,000 years; approximately 1900 BC to present)

We will begin by calibrating the YEC stratigraphic column further, looking for an approximate stratigraphic point of known age that can be accepted regardless of what one's view of the overall age

of the earth is. That stratigraphic position will be used to separate YEC units 4 and 5. These units would be predicted to be a lot alike in terms of processes and rates (Figures 81–83). Nothing in the Bible suggests any other miracles that would have influenced Texas geology (or any other geology on a large scale). The first thing to decide is where to separate units 4 and 5. Where is the oldest stratigraphic position that we can use as a reference? Radiocarbon dating would be very useful. Snelling (2009) suggests that radiocarbon dates prior to 400 BC shouldn't be trusted because they diverge from dating of materials based on historical dates that are known, such as from tree ring data (Snelling 2009). While I would not accept that conclusion, one option would be to consider a date of 2,400 years ago based on Snelling's proposal. However, as suggested earlier, from a biblical perspective, the time of Abraham, 3,900 years ago seems to be a reasonable target. If we do not accept radiometric dating, we will have to rely on other techniques, knowing they may not be precise, but luckily in this case, we probably don't need a precise answer to evaluate the proposals and draw conclusions.

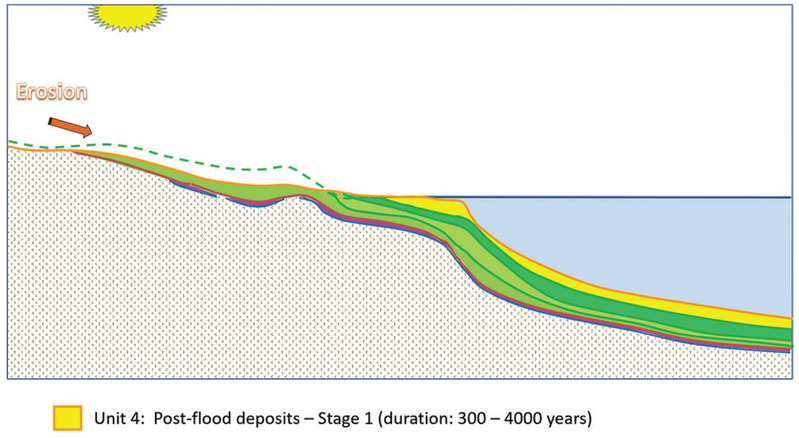


Figure 81 When the system stabilized a few years after the flood, rivers would have easily eroded the poorly consolidated flood deposits above base level. There would still be a thick section preserved below base level unless the "fountains of the deep" prevented their deposition. Deposits in the "Tertiary Wedge" would have been very poorly organized, given the time available for deposition.

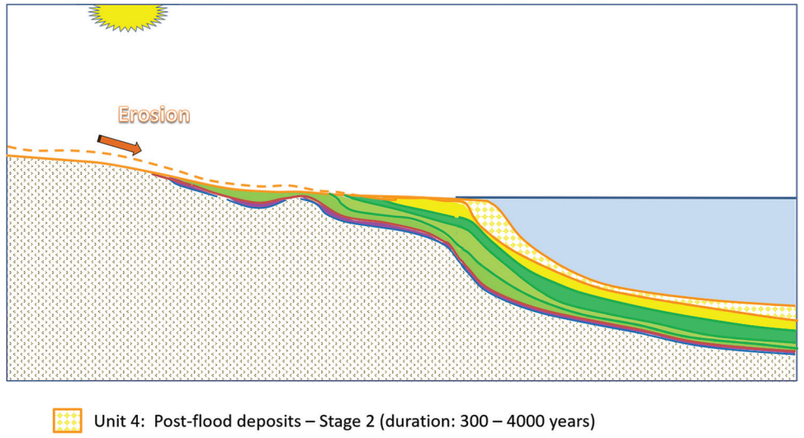


Figure 82 As the Tertiary wedge developed, processes should have been much as we see today. There is no basis for suggesting a dramatic difference from what we have seen over recorded history. There would have been no time for glacial ages, so today's rates and processes should have been the rule of the day.

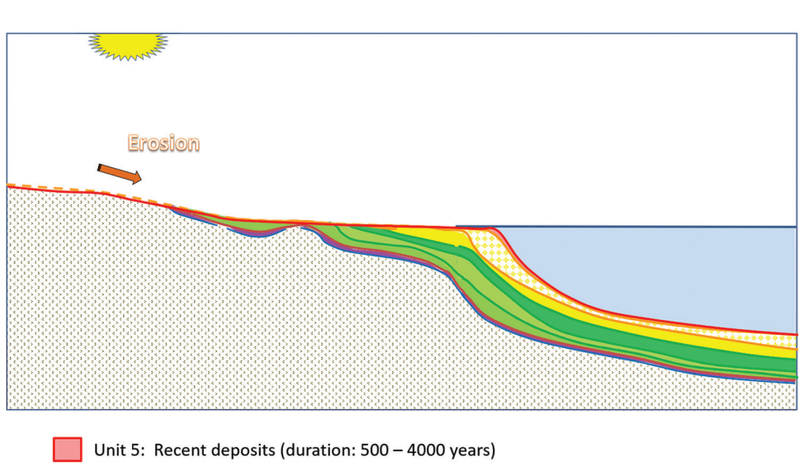
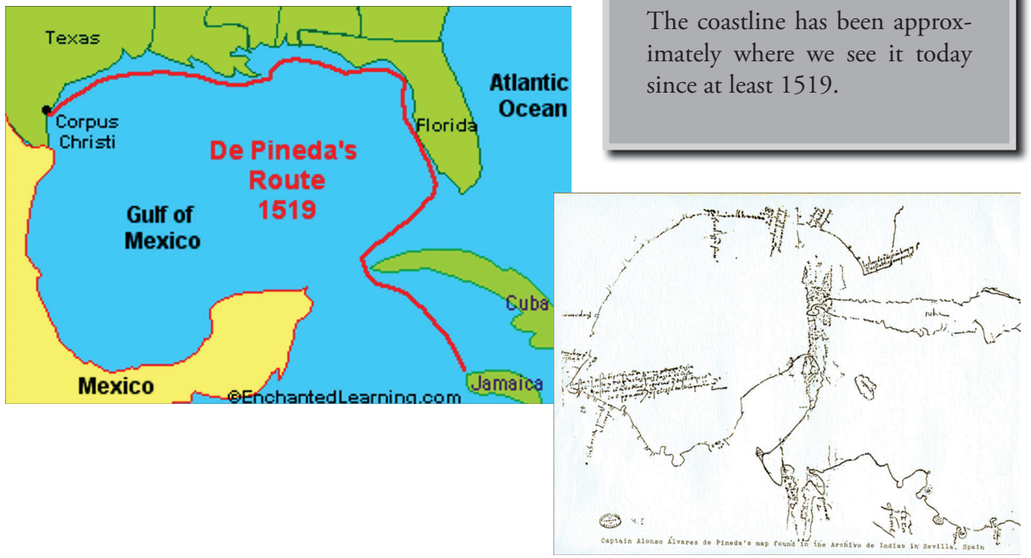


Figure 83 We have calibration onshore for recorded history and can tie that to the offshore. We find that over the last 4000 years a thin veneer of sediment has been deposited.

In New Mexico and Texas, we have historical records that go back about five hundred years. The earliest known maps of the Texas coastline were made by Alonso Alvarez de Pineda (1494–1520) in 1519 (Figure 84; Wikimedia, n.d.). While his map is not perfect or precise, it shows that over the last five hundred years, not a lot has changed. Archaeologists can find artifacts in places that demonstrate when Spanish influence began. It is pretty clear that on the scale of Figure 11, the deposition that has taken place in the last five hundred years is within the width of one of the thin lines. There have been local changes but in general not much deposition or structural movement has taken place. More has taken place on the Mississippi River delta, but the smaller Texas rivers don't really carry much sediment today and they did not in the recent past (Figure 13).



The coastline has been approximately where we see it today since at least 1519.

Figure 84 Maps showing route of Spanish explorer De Pineda in 1519. Right map shows his map of the coastline. This demonstrates that the coastline 500 years ago looked essentially like it does today

If we use the analogy of Europe, or the Middle East or China or Japan or Egypt where historical records exist, then we could stratigraphically recognize that away from the major deltas, the deposits of the last four thousand years are very thin (Figure 69). Archaeologists have worked extensively in North America. One interesting site is on Galveston Island, along what is named the Mitchell Ridge (no relation; TBH Web Team 2009). They concluded that early Native Americans established campgrounds along the coast on Galveston Island around 500 BC. The age that they have assigned is assuredly based on ^{14}C dating, but even if we were to question the absolute date, it is evident that

they started using the site a long time ago. This tells us that the coastline has been approximately where we see it today since that time.

How thick can the YEC Section 5 sediments be? In a short survey, the thickest onshore deposits of any extent that I found evidence for are in central Texas along the Medina River. When they were preparing to build a dam along this river, they stumbled onto what is known as the Richard Beene site (TBH Web Team 2006). Here, where local sediments are thickest, along the river, evidence is found for human occupation buried sixty feet (18 m) below the surface. Even here, this is a pencil width on the profile in Figure 11. Archaeologists conclude that humans occupied the Richard Beene site almost eight thousand years ago. It certainly does not seem a stretch to believe that just like in the Middle East, Europe, and other places, the depositional record of the last four thousand years is very thin. Can that be real? Consider the Mississippi Delta. Over and over, it has been used as an example of rapid processes that act on a big scale. How far has it grown? If the last one hundred years are a guide, then it is losing ground (Figure 85). Subsidence is winning the battle. Part of that is due to US government intervention, but even so, it is hard to make a case for a lot of progradation of the whole delta in the last four thousand years.

> If Noah's flood occurred in 3500 BC, that would mean that the huge Cenozoic wedge of sediment along the southern, US, shown in the yellows and browns in Figure 11 was deposited in approximately 450 years. Thus, over the last 4,000 years, rivers have moved the coastline very little, but in that 450 years, using normal geologic processes, they prograded the entire coastline approximately two hundred miles (320 km) to today's coast.

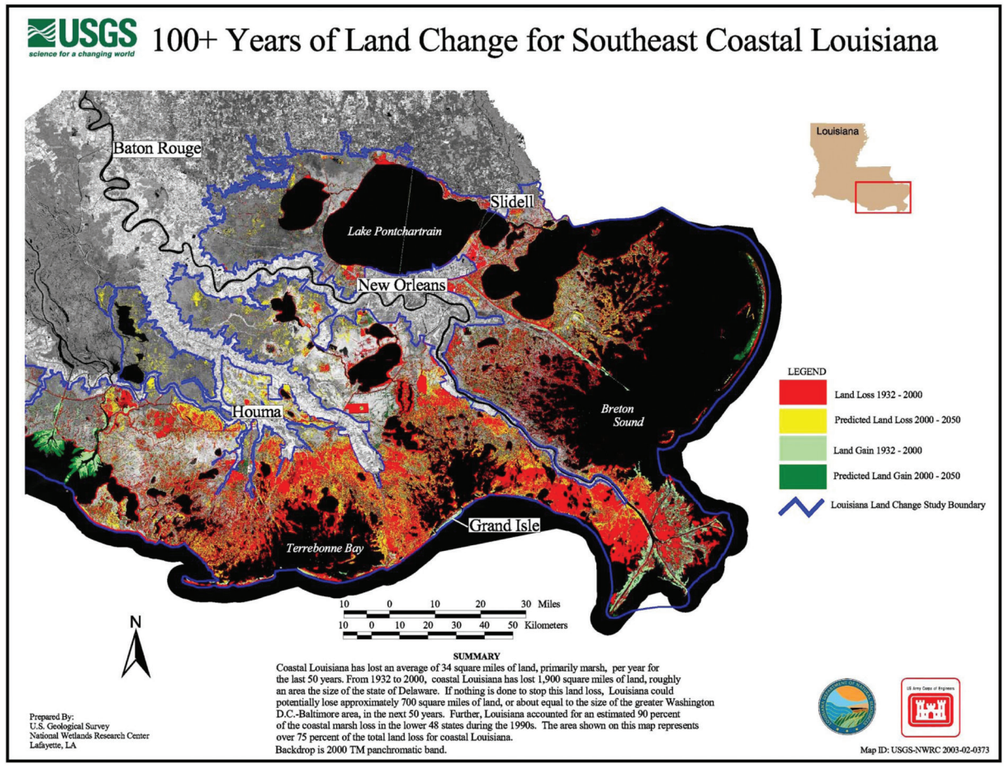


Figure 85 Image of the Mississippi Delta. Areas in green have become land in the last 100 years. Areas in red were above water 100 years ago. (Kleiss 2009)

The YEC assertion that Noah's flood occurred approximately in 3500 BC would mean that the huge Cenozoic wedge, shown in the yellows and browns in Figure 11 was deposited in approximately 450 years (Figure 3). Thus, over the last four thousand years, rivers have succeeded only in depositing enough sediment to move the coastline about twenty miles (32 km) at the bigger delta mouths and deposited very little elsewhere. However, in less than one-fifth of that time (450 years), using normal geologic processes, this YEC hypothesis says that they prograded the entire coastline approximately two hundred miles (320 km) to today's coast. The case is actually more challenging. We can document that when sea level was lower than today, there were once ancient deltas at the continental shelf edge, up to 150 miles (250 km) offshore. Thus, in only 450 years, this YEC proposal demands that

rivers had to deposit a vast amount of sediment and prograded the coast about 350 miles (560 km). That would have been impressive!

Just as the distance that the shoreline prograded cannot be reconciled with the YEC timeline, the sheer volume of sediment that was deposited is totally inconsistent with such an explanation. My rough estimate is that over 250,000 cubic miles (1 million km^3) of sediment were deposited as the Cenozoic wedge prograded out to the current shelf before the time of Abraham. I would then estimate that at most, 355 cubic miles (1,500 km^3) were deposited after the time of Abraham. Admittedly, there were periods in the past when sediment did deposit faster than during the last four thousand years. However, if that entire wedge of sediment was deposited in 450 years, the amount of time available for a six-thousand-year-old earth, then the deposition would have averaged over six thousand times faster in than we see in our times. Even if four thousand years were available, that would be over seven hundred times faster. It is worth noting that if the flood were a few thousand years earlier, the problem is essentially the same. It is a bigger issue than just selecting an older YEC model.

What processes could deposit a wedge of sediment the size that we find in the Gulf Coastal region in such a short time? Nothing we have seen in the last four thousand years is at all comparable. Perhaps my YEC friends would say that the flood sediments were so unconsolidated that they eroded much faster than today. If the sediment wedge were deposited by dramatically faster rates, then that would dictate that the rivers would have been dramatically larger than those today, but geologists have mapped these river systems and they are very much the same scale as we see today. Three-dimensional seismic allows us to image the sinuous river deposits of the river plain and those systems are very analogous to modern systems. It is probably true that there are not too many examples in the literature, partly because many are above the intervals where oil and gas are explored for. A 2016 article by El-Mowafy and Marfurt does however document fluvial systems from the Oligocene middle Frio section, onshore Texas using great 3D images (El-Mowafy and Marfurt 2016). The Oligocene would be fairly early in the Cenozoic section. As expected, the rivers deposits that they imaged look very much like the small Texas river systems of today.

If the Cenozoic sediments were shed off vast areas of unconsolidated sediments, where were these sediments located? If the flood eroded off mountains somewhere to form this large amount of sediment and then this sediment was stored somewhere to be shed into the Gulf of Mexico basin, then I find it difficult to understand where the mountains might have been or the sediment shed from. I have not been able yet to draw a scenario that is logically consistent to account for the sediment (Figures 81 and 82).

Are there clues in the sediments that tell us about the processes and the time their deposition took? Using the soap opera analogy again, in comparison to the Paleozoic and Mesozoic, the Cenozoic is like watching a soap opera from a different country. Some things are different and the sets have changed, but a lot of the problems and story lines are just the same. The Cenozoic in this study area does have different fault styles and thinner carbonates and evaporites. Many individual depositional episodes have been mapped and the same basic themes are present in each of them that we saw in the Paleozoic and Mesozoic. Each has its own details, but the rivers ran to the sea. Beach deposits formed along the coast. Sea level went up and down, here apparently tied closely to the gla-

cial episodes that left soils and distinctive deposits across the northern US. Perhaps the Paleozoic and Mesozoic soap operas were from another country, because the patterns in the Cenozoic began to look even more and more like the Gulf Coast that we know today. There is no evidence for a dramatic difference in rates and processes such as would be demanded by the YEC proposed explanation.

Coals are a case in point as a problem for the YEC. They have argued that the Paleozoic coals could not have formed in the millions of years in the swamp and marsh environments. Then we find that most of the coals in Texas were deposited in the post-Flood unit 4, at least under most of the YEC reports (Figures 65 and 72). Wait a minute. Hang on. How does that work?

Many reefs are found in the Cenozoic, even in this study area. It seems a major struggle to build a case that the YEC timeline gives enough time for even the modern reefs to have grown. We saw Oligocene mounds near Houston that grew, though these were less than one hundred feet (30 m) thick. Using the reef growth rates quoted for coral reefs earlier, this would suggest that these Oligocene reefs took 150–600 years to deposit. If one chose to believe that the earlier Cenozoic rocks could have been deposited catastrophically fast, it would still be hard to grown the Oligocene reef in a short time. Surely all of that rapid deposition would have involved environments where the filter-feeding corals would not have lived. Here it is worth looking at one example from outside of this study area to make a point. This example comes from younger rocks than the Oligocene example in Texas. Looking globally, many major reefs grew in Miocene time, near the top of our geologic columns. One example that I am familiar with is in Indonesia. The reservoir for the Arun gas field on Sumatra, Indonesia, is a Miocene-aged coral reef. This reef is one of a string of large coral reefs that grew in eastern Asia at the time. The field was extensively cored and studied by Mobil Oil Company after its discovery in 1971. Profits from this huge field kept the company alive during the mid-'80s, when oil prices went very low. The reef is up to 1100 feet (330 m) thick (Jordan and Abdullah 1985; Abdullah and Jordan 1987). Using the reef growth rate estimates from before, that would suggest that if rates were constant, it would have taken 1,650–6,600 years to be deposited. We know that the rates were not constant because the reef was periodically leached by freshwater and this leaching formed the porosity that held the gas and condensate that was produced. We also know that the field was buried later by approximately ten thousand feet (3 km) of sediment, allowing it to trap the hydrocarbons. It is clear that most of the thick, modern reefs grew long after the Arun reefs were dead and buried. The Great Barrier Reef, Australia, is four hundred feet (122 m) thick and is believed to have grown over the last ten to twenty-five thousand years (Gischler, Droxler, and Webster 2011). Even if it grew in the last 2,400 years, as suggested by Whitcomb and Morris (1961), all the earlier reefs would continue to present major problems for "flood geology" explanations.

What about the fossils? If unit 4 was deposited in just 450 years or even a few thousand years, then surely fossil assemblages should be essentially the same throughout. We know that over the last four thousand years, some species are gone but essentially no new kinds have come in. Here again, the fossils do not support the YEC case. The macroscopic lifeforms have changed. Many forms are missing now, that were present before, especially in the early Cenozoic. Many modern forms apparently were absent in those early Cenozoic sediments. How about the microfossils? How could we explain the progression of changing forams, nannofossils, spores, and pollen? We find

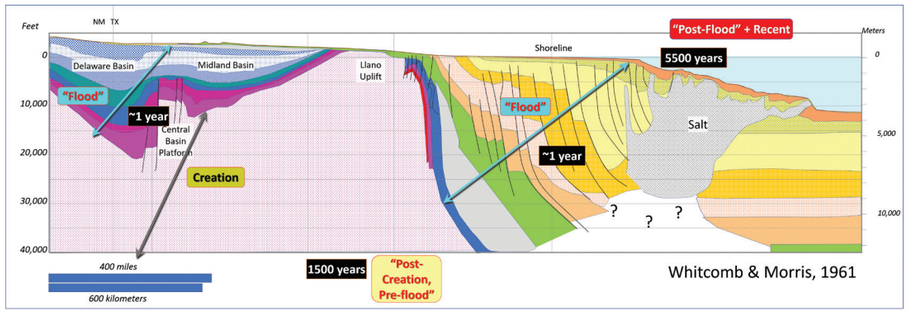
planktonic forams that floated in ocean water columns found over large portions of the globe today. We find a succession of different forms in the past without many of the forms that we have today. If these are sediments quickly eroded off a post-Flood deposit, then why do we not find the Cenozoic fossils in the Mesozoic and Paleozoic rocks that were eroded? Looks like unit 4 doesn't work any better than unit 3 did.

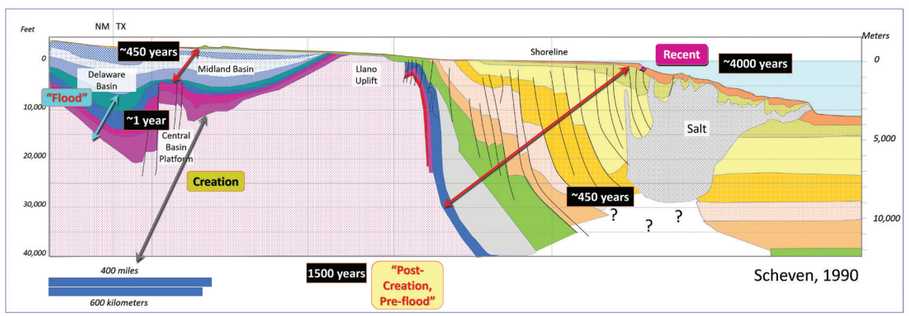
Alternate Options for YEC Sections

Are there options that might be available to solve this dilemma? Could we fit the YEC sections—differently into the stratigraphic column and have it fit the flood model? It is worth considering the possibility of reassigning the position of the sections shown in Figure 72. Figure 86 shows how the various proposals made by YEC authors would be reflected in the study area along the profile shown originally in Figure 11. Can one slide the flood to a different stratigraphic position and make it work? I am afraid that this would be a bit like a person who owes two people $100 each. He reaches into one of his pockets and finds ten $1 bills. He then reaches his hand into his other pocket and finds twenty $1 bills. He can switch some of the bills from one pocket to the other, but he still has a problem when either man shows up and wants his money. If you move the flood earlier, it makes the problem even bigger for the unit 4 post-Flood deposits. If you move it later, then units 2 and 3 have bigger problems than they had before.

Maybe the flood itself encompasses more of the column. Figure 79 illustrates that even aside from the fossils and other issues, most of the column includes strata and features that are incompatible with a flood origin. Could it be that some of the YEC sections included longer timespans than those in Figure 3? Scripturally, this would be an appeal to gaps in the genealogies. Both Whitcomb and Morris (1961) and MacArthur (2001) put the outer limit of this at ten thousand years. If you add ten thousand years to section two, all the problems remain essentially the same. Even if one were to be a bit bolder with the gaps and allow that the earth were one hundred thousand years old, one still has to resolve just where to put the extra time.

Even harder is to propose a defendable explanation for what constitute flood deposits. Many have tried that over the last two hundred years. Making the earth ten thousand years old or one hundred thousand years old seems a bit futile to me. It has all the scientific weaknesses that the six-thousand-year-old earth has, all the scriptural questions and no particular new strengths on either side that I can see. The most common recourse has been to deny the entire validity of the stratigraphic column, but anyone really knowledgeable about the rocks and drilling in this study area alone knows that the relative age of the rocks is well understood.





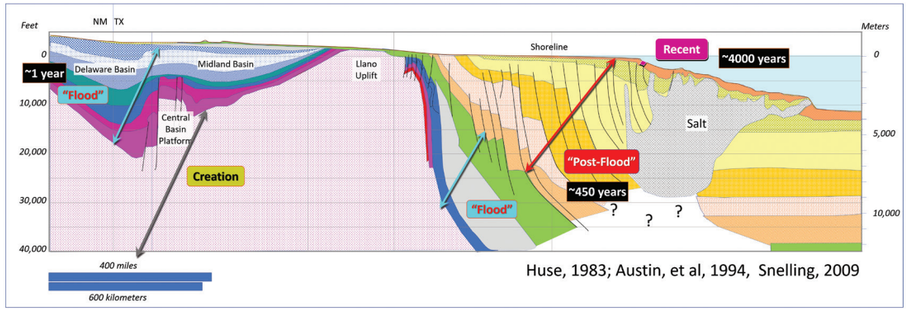


Figure 86 Profile shown in Figure 11 with various proposed "flood geology" interpretations of the stratigraphy. The Whitcomb and Morris 1961 interpretation makes most of the stratigraphic column be flood deposits. This accounts for the thinness of the post-flood deposits but has numerous problems as shown in Figure 89. The Scheven 1990 interpretations has the narrowest flood deposits but makes all of the post-flood, section 4 rocks extremely thick. The proposals that make the base of the flood deposits be the base of the Cenozoic has all of the problems of the other proposals.

9 "Flood Geology"—Summation

The "flood geology" position has long been difficult to reconcile with the general understanding of the earth's history that has been developed by science. The scientific understanding developed and evolved over time based on the work from many, many scientists. Is it possible that given more time and resources, the YEC approach will be refined and provide a reasonable alternative interpretation for the rock record? Here, we will first look at how the YEC geologic arguments have evolved over time. Many of the basic arguments presented by George McCready Price in 1913 continue to be given today. It is instructive to look at his basic arguments and see how his points have fared over time. Figure 87 provides an outline of key geological assertions made by Price (1913). The picture shows a "house of cards" because his explanation for the rock record is based on these assertions, and if these fail, then his explanation collapses. Price was strongly convinced that the relative time scale that geologists developed was completely artificial, a construct based on circular reasoning. It is significant that this argument is no longer considered valid by the major YE authors. If the "flood geology" position were solely based on his books, then this alone would seem to have collapsed the house. His other arguments are secondary, though they are still used in modern papers.

YE creationism seemed to be going away until Whitcomb and Morris published *The Genesis Flood* in 1961 (Numbers 1993). Figure 88 outlines their key geological arguments. As you can see, much of the text is in blue, representing that they are the same positions presented by Price in 1913. Henry Morris had more advanced scientific training and brought in a number of new examples. Together Whitcomb and Morris were able to present more scientific sounding defenses of the arguments. Like Price, they argued that the geologic column was based on local columns that could not be correlated from basin to basin. More knowledgeable modern authors have found that position impossible to defend as noted earlier. That card has been removed from the house. By 1961, radiometric dating had provided the relative geologic column with ages in years. These were clearly incompatible with "flood geology" and were denounced, though few scientists would be bothered by their arguments. Overall Whitcomb and Morris's arguments were similar to those of Price and many are not carried by modern writers or have been modified significantly.

The Genesis Flood was hugely influential in some groups but its arguments were definitely dated. Dr. Morris selected Andrew Snelling to write a new update and in 2009, *Earth's Catastrophic Past* was published with a forward by Henry Morris. It constitutes the most modern and most detailed expansion of "flood geology" available at this time. Gone are the claims that the stratigraphic column is a fantasy and some of the other particularly undefendable claims such as the human footprints with dinosaur tracks. The book is very direct in its acceptance of the relative age of the rocks as determined by the geologic community. In two volumes and 126 chapters, Dr. Snelling tried to address many complaints against "flood geology." This work, along with those of Price and Whitcomb and Morris, has been referenced repeatedly through this book. An outline of many of his geologic arguments is shown in Figure 89. Many of his arguments can be traced back to Price. For instance, all the authors refer to certain formations as "fossil graveyards" that supposedly cannot be explained by any agency but Noah's flood. It is indeed possible that some of these are deposits from catastrophes but they were not same catastrophe. Young and Stearley (2008) describe in some detail how a number of these are very easily explained in terms of normal processes. While Whitcomb and Morris (1961) considered plate tectonics to be a desperate effort to explain mountain building, Snelling described a supercharged version as "catastrophic tectonics."

The Fundamentals of Geology and Bearings on the Doctrine, of a Literal Creation

George McCready Price
1913

Key assumptions
- Universe created in 6 days
- Noah's flood was global

- **Standard stratigraphic column artificial construct**
  - **Faunal succession is an artificial construct**
    - **"No kind of fossil can be proven to be really older than another or the human race**
    - **Fossils of different periods reflect different local species – similar to today's Africa vs. North America**
    - **Any age of fossils can set on Archean aged rocks or may be metamorphosed or become crystalline**
    - **Fossils can come in any order**
      - **Regional thrust faults and overthrusts interpreted because fossils in wrong order**
      - **Subtle unconformities only because fossils missing**
    - **Species extinctions largely caused by sudden ice age**
    - **Fossil species skip ages**
    - **Living fossils**
- **Rocks demonstrate a global flood**
  - **Most fossils formed in flood**
    - **"Fossil graveyards" demand flood explanation**
  - **Climate changed by flood**
    - **Global climate before flood was tropical**
    - **Ice age after flood**
  - **Rivers seem to have begun cutting rocks at same time**
  - **Animal life has "degenerated" (modern forms are smaller than extinct)**

Positions not held even by modern leaders in flood geology

Points from Price, 1913
Points from Whitcomb and Morris, 1961
Points from Snelling, 2009

Figure 87 Outline of selected points from this YEC "Flood Geology" book

The Genesis Flood

The Biblical Record and Its Scientific Implications

John C Whitcomb and Henry M. Morris

1961

Key assumptions
- Universe created in 6 days
- Noah's flood was global

- Standard stratigraphic column artificial construct
  - Faunal succession is an artificial construct
    - Fossils out of sequence
      - Generated to support evolution
      - Human footprints in Texas
    - Often in reverse order
      - Large scale thrusts impossible
    - Fossil order caused by flood processes
      - Fossils sorted by hydrodynamic sorting
      - Higher mobility of vertebrates
    - Living fossils
    - Fossil order arbitrary
      - "grave doubt in the validity of foraminiferal dating"
  - Radiometric dating false
    - Methodologies flawed
    - Radioactive rates not uniform
- Rocks demonstrate a global flood
  - Tectonics and volcanism demand cataclysmic explanation
    - Geosynclines demand a flood
    - Modern volcanism cannot account for igneous rocks
    - Tectonism and earth movements the result of flood (no acceptable geologic explanation by normal processes)
  - Rocks formed by cataclysmic processes
    - Fossilization requires rapid processes
    - "Fossil graveyards" demand flood explanation
  - Climate changed by flood
    - Global tropical climate before flood
    - One ice age after flood
  - Alternate possible explanations for apparent slow deposition
    - Rates of deposition for sands, shales, limestones were rapid
    - Coal formed by allochthonous water transportation
    - Reefs formed quickly
      - Ancient reefs not real reefs
      - Modern reefs could have grown rapidly
    - Geologists just don't understand depositional environments
    - Evaporites actually water-lain, possibly from pre-flood deposits
    - Buried forests
      - Not really in growth position

Positions not held even by modern leaders in flood geology

Points from Price, 1913
Points from Whitcomb and Morris, 1961
Points from Snelling, 2009

Figure 88 Outline of selected points from this YEC "Flood Geology" book

Earth's Catastrophic Past

Geology, Creation & The Flood

Andrew A. Snelling

2009

Key assumptions
- Universe created in 6 days
- Noah's flood was global

- "The billions of years geological timescale has been imposed upon this relative times sequence of events that produced the rock record"
  - Modern rates of sedimentation faster than geologic time predicts (hence billions of years flawed)
  - Radiometric dating false
    - Methodologies flawed
    - Rate of decay changed during flood
- Rocks demonstrate a global flood
  - Catastrophic tectonics – driving force of the flood
    - Runaway volcanic and seismic events
    - Plate tectonic movements in the flood
  - Strata result from cataclysmic water deposition on a global scale
    - "Fossil graveyards" demand flood explanation
    - Tracks prove rapid burial
    - Folding by soft sediment deformation
- One ice age after the flood
- Alternate possible explanations for apparent slow deposition
  - Sandstones and shales all be deposited rapidly
    - Laminated shales from turbidites
    - Bioturbated sands minor and formed rapid
    - Sands interpreted as Aeolian dunes formed by fast moving water
  - All limestones could have been deposited rapidly
    - Ancient muds not analogous to modern lime muds
    - Ancient "reefs" formed as debris flows and other rapid water processes
  - Fossil order caused by flood processes
    - Fossils sorted by hydrodynamic sorting
    - Higher mobility of vertebrates
  - Buried forests
    - Not really in growth position
  - Fossilization can be rapid
    - Petrified wood can form in human lifetimes
  - Bedded salt deposits formed as result of intense volcanic activity
  - No significant time at unconformities

Positions not held even by modern leaders in flood geology

Points from Price, 1913
Points from Whitcomb and Morris, 1961
Points from Snelling, 2009

Figure 89 Outline of selected points from this YEC "Flood Geology" book

Unfortunately, as we will see later, it does not hold up under examination. Many of the assertions, such as the explanation given for buried forests in Wyoming, draw on rocks far from this study area and are not addressed in this book. Yet as this study area shows, this approach also has some of the same difficulties as the others. Each and every bed or group of beds in the Paleozoic or Mesozoic that takes longer than one year to be formed refutes the theory. Presenting the strata of the entire Cenozoic as having been deposited in 450 years or even a few thousand years presents another insurmountable difficulty for this system.

Comparing the YEC flood model to the rock record in Texas and New Mexico helps to explain some of the reasons that few geologists can accept any of these proposed interpretations of geology. Geologists Carl Froede and John Reed tried to apply the YE models to the northern Gulf of Mexico and also predictably found difficulties (Figure 72; Froede and Reed 1999). They find it impossible to reconcile the standard stratigraphic column which they refer to as "global uniformitarian stratigraphic column" (GUC) with predictions from creationists. In their paper "*Assessing Creationist Stratigraphy with Evidence from the Gulf of Mexico*," they evaluated proposals to place the end of the flood deposits, top of my unit 3 at both the Paleozoic/Mesozoic boundary and the Mesozoic boundary and found that neither worked. In the case of the Paleozoic/Mesozoic boundary, the sheer volume of sediment with all the demonstrated sea level changes in the Mesozoic and "the difficulty in describing an adequate source for the sediments apart from Flood conditions" causes them to reject this as an option. They draw similar conclusions regarding the Mesozoic/Cenozoic boundary as shown by this quote:

> If the model proposing that the Mesozoic/Cenozoic boundary represents the end of the Genesis Flood, it must explain the following:
>
> - The tremendous volume of sediment deposited after the Flood (the cross-section reflects a sediment wedge ranging up to six miles thick and extending some 360 miles out into the NGOMB along much of its lateral extent),
> - The dramatic variations in mean sea level that appear to have ranged from near the fall line during the Cenozoic to well offshore in the present Gulf of Mexico during recent times.
> - The difficulty in justifying the high energy levels during post-Flood time required for this volume of sediment to be eroded and deposited in the NGOMB, and
> - The difficulty in describing an adequate source for the sediments apart from Flood conditions.
>
> Like the Paleozoic/Mesozoic boundary proposal, we do not believe that any reasonable explanation can be offered for these conditions in the NGOMB. Again, either the boundary is incorrectly placed in this proposal relative to the GUC, or the difference between plausibly setting the boundary at the base of the Cenozoic in selected locales but not in the NGOMB suggests that the GUC cannot be harmonized with biblical history. We find this proposed Flood/post-Flood boundary inadequate in explaining the Cenozoic sedimentary sequence in the NGOMB, and therefore unacceptable as a viable young-earth Flood model. (Froede & Reed, 1999).

Froede and Reed (1999) essentially proposed throwing out the stratigraphic column and somehow making high-energy deposits to have been directly from the flood and low-energy deposits to be considered post-Flood. The authors are one of the few examples of YEC authors recognizing the scale of the problem represented by the thick rock record along the Gulf Coast. They tried to accommodate it in their proposals instead of just ignoring it. The article does not have examples of how they would be apply this concept to the actual stratigraphy of the Gulf of Mexico, but presumably they would somehow separate the coarser grained, higher energy deltaic and beach deposits from the more distal slope deposits. It is however not difficult to show numerous seismic examples that demonstrate the time equivalence of the deepwater deposits with the deltaic and beach units. Regardless of what the absolute age of the units is, their overall relative ages are very solid as conceded by YEC authors such as Snelling. However, the article does illustrate the futility of trying to fit the flood model into the rock record of the Gulf Coast.

Here are two summary lists of problems and challenges that would need to be resolved in order to consider a "flood geology" origin for the sediments in the study area described in this report. The geologic observations made fit nicely in the conventional geologic model, but each issue is a potential "show stopper" for "flood geology." First, for unit 3, the flood deposits:

1. Identify the base and top of the flood deposits in a way that is defendable over multiple continents.
2. Explain why the depositional processes of a one-year long global flood event look just like the normal rivers, delta and delta plains, submarine fans, carbonate beaches, reefs and banks of today.
3. Explain how solid rocks were folded instead of shattered over the course of one year.
4. Explain just where did the huge pile of sediment in the sedimentary basins come from.
5. Explain how you erode away mountains of solid rock in a short portion of one year.
6. Explain how absolutely all the paleosols recognized by geologists were something else.
7. Explain how caves and caverns and evidence of related processes formed quickly throughout a flood.
8. Explain the observation that the fossils change consistently through the stratigraphic column during a flood.
9. Explain why fossils of modern species do not occur throughout the column.
10. Explain how thick evaporites were deposited during the flood.
11. Explain how arid sabkha deposits formed through the flood.

12. Explain how thick carbonate reefs were deposited at many levels during a one-year-long flood and also, why were they formed by different organisms that changed consistently over time.
13. Explain how thick lime deposits were quickly transformed into dolomite during a flood.
14. Explain why footprints of dinosaurs and other animals were left on land in what are identified as middle to late Flood deposits at numerous stratigraphic levels.
15. Explain how thick coal deposits were formed, including why they have strong indications of having been deposited in swamp and marsh settings, even with associated dinosaur prints and root patterns showing that trees grew in place there.
16. Explain how finely laminated, organic rich shales such as the Woodford shale could be deposited during a flood, particularly the pelagic portions.
17. If high-speed plate tectonic movements are proposed, then dramatically evident fault zones should be shown and evidence given that the sediment above them deformed appropriately. Such zones should exist along all continental plate boundaries.

The interval after the flood must also fit the proposed explanation. If the Flood/post-Flood boundary is stratigraphically below the Holocene boundary, then a reasonable mechanism must be provided to deposit massive amounts of sediment in a very small amount of time by nonmiraculous means. Examples of the issues to be explained for post-flood deposits include the following:

1. Explain the formation of very, very large wedges of sediment formed in a relatively short time when the calibrated last four thousand years deposition took place dramatically slower.
2. Explain why things in the Gulf of Mexico slowed so dramatically after the time of Abraham (or Jesus or at least the Spanish Conquistadors).
3. If rates were vastly faster in this study area than in Europe or the Middle East then explain why.
4. Explain how deltaic and reefal deposits that are kilometers thick formed in such a brief time.
5. Explain how basins could subside at rates far beyond those we see today.
6. Explain rapid lithification of solid sandstones and shales.
7. Explain the cooling of large magma chambers to form igneous rocks that are exposed at the surface today.
8. Explain rapid erosion of limestones, sandstones, volcanos, and thick igneous rocks.
9. Either explain how paleosols developed almost instantly or what else these units represent.
10. Explain how salt diapirs formed rapidly without deforming the surrounding rock in dramatic fashion.
11. Explain how the depositional cycles of sedimentation formed so quickly, when they fit the model so well for lowstands and highstands of sea level with normal rates of deposition.
12. Explain why we see the evident change in fossils through the post-Flood time.
13. Explain why we do not see modern forms in the earliest "post-Flood" deposits.

14. If the Cretaceous units are included, then once again there are buried karst deposits to explain.

It is worth pointing out that there is a difference between providing an explanation and providing an adequate explanation. The Flat Earth Society also has explanations for all the evidence that is reported to show that the earth is a sphere, but few find their explanations adequate, regardless of how sincerely they might be held or how elaborate or elegant they are. I have read many proposals from the YEC community for explanations of geologic deposits such as reefs and coal and find them inadequate and unconvincing. The flood model seems to be over and over trying to explain why the simple, obvious explanations are wrong. The YEC model demands that the Paleozoic, Mesozoic, and Cenozoic sediments be deposited and often deformed at rates that just do not fit the observations that geologists make.

The geologist has an advantage of freedom that the YEC "flood geologist" just does not have. If someone takes a unit from the rock record that has been interpreted to have formed over several million years and makes a convincing case that it was formed rapidly, then geologists will normally be excited and eager to see if there are other cases to apply the new learnings. The "flood geology" interpretation constrains its advocates. Each and every interpretation that makes the flood units take longer than one year to form or the earth to be more than a few thousand years old threatens to collapse the entire house.

In the last fifty years, since the publication of Whitcomb and Morris's *The Genesis Flood*, thousands of geologists have poked and probed the rock record. Knowledge has exploded in every aspect of the record. This study area is an excellent example of this and there have been numerous examples where the data explosion has resulted in new ideas and new understanding of the geology. It is safe to assume that over the next fifty years, knowledge will continue to grow. New ideas will come out and there will be new ways of describing the depositional and structural processes. Continued improvements in seismic imaging and closer examination of units such as the oil shales will change our ideas in many ways. How will that affect conclusions to the questions asked here? The only one who really knows the future is God. However, looking at the results of the last fifty years of change is useful. If the "flood geology" theory is real, then one would expect that there would be numerous strains on the conventional OE understanding. The rock record is like a very complex jigsaw puzzle piece. If the YE model is true, then trying to fit the millions of years, slow processes and environments such as the arid sabkhas into the deposits of a global flood ought to show problems along every edge. Trying to fit the deposits of millions of years of continual sedimentation and deformation with a virtually uniform set of lifeforms into a few hundred years of post-Flood sediment should become increasingly difficult. There are still things we do not understand about the depositional, structural, chemical, and biological development of earth, and this study area is no exception. However, I am not aware of any of difficulties that the young earth model seems a better match for.

Another advantage that the OE interpretation has is that it matches with other independent lines of evidence from other sciences such as physics and astronomy. One example is the radiometric data that uses nuclear physics to date the rocks, quite independent of the geological interpretation.

Radiometric dating uses many independent isotopes and consistently points to an old earth (see Appendix: Radiometric Dating). Another line of evidence that is perhaps one of the simplest to understand comes from the stars. When light leaves the sun, it takes eight minutes to get here. When we see Alpha Centari, the closest star, we are looking at events from 4.2 years in the past. When we watch the Andromeda galaxy, we are watching events from 2.9 million years ago. Explanations have been proposed, such as to claim that light has sped up through time or that the light was created on its way. Changes in light velocity such as this would require would make for a strange universe indeed. If the light was created on its way, then we really have no indication that the stars are really out there. The YEC proposals that I have read come across as desperate attempts to explain away the obvious. They make God be too much like the Wizard of Oz, telling Dorothy to ignore the man behind the curtain. Hugh Ross's book *Creation and Time* helps to understand both the scientific evidence from astronomy and theological arguments (Ross 1994). He is a Christian astronomer and cosmologist whose organization, Reasons to Believe, is a great resource for investigating issues of science and faith. The geologic conclusion that the earth is more ancient than many expected may have come as a shock but the evidence is overwhelming. It is consistent with many other lines of evidence and needs to be faced. The case that the earth is far older than the young earth model is proven beyond a reasonable doubt.

Part II

Science Meets Genesis

An Old Earth and Genesis

As a geologist, too many of the predictions and natural consequences of the YEC "flood geology" explanation are contrary to what we actually see in the rocks. Too many things just don't fit. This book uses geology from one area, but similar problems occur all around the world and in many fields of science. Many, perhaps most, people have already decided the matter and will not be convinced regardless of the evidence. Polls suggest that 46 percent of Americans believe that the earth is less than ten thousand years old (Gallup 2001). Of course, we cannot determine real truth by taking a poll. Many of those polled probably assumed that the Genesis flood accounts for geologic history. I wonder what percentage of those have taken the time to examine the evidence for either position. How many believe that the universe is less than ten thousand years old on the basis of evidence other than the basis of the Bible or perhaps the Quran? How many of today's scientists believe this? My guess would be none. If God created the universe in such a short time, then He has certainly gone to a great deal of trouble to make it appear old.

Perhaps early geologist and Christian, Hugh Miller (1802–1856) was right when he said,

> "Plain men who set themselves to deduce from Scripture the figure of the planet" had little doubt that the earth was flat "until corrected by the geographer"; "plain men who set themselves to acquire from Scripture some notion of the planetary motions" thought that the sun moved around an earth at rest "until corrected by the astronomer; plain men who have sought to determine from Scripture the age of the earth" were confident that the earth was about six thousand years old "until corrected by the geologist." In sum, plain men have quite properly learned the way of salvation from the Bible but every time they "sought to deduce from it what it was not intended to teach—the truths of physical science—they have fallen into extravagant error." And if such error is casually or, worse, boldly or even belligerently endorsed, it must necessarily mar the overall credibility of the church (Young 1995).

I do not know what type of conclusion you, the reader, will come to after reading the evidence presented here. Perhaps you have never thought about how the global flood interpretation would have to really look in the rocks. Maybe you have read one side or the other's views and been convinced. If you are one of the 46 percent above, perhaps you now recognize that the "flood geology" explanation is difficult or impossible to use in practice. Perhaps you even see that there are difficulties with explaining how the earth could be less than ten thousand years old. If the rocks and stars do conclusively demonstrate that the earth is well over ten thousand years old, then the biblical account has to be interpreted differently. That is true whether the earth is twenty thousand or twenty million years old. Why not billions of years old? There does not seem to be any particular theological or biblical difference between a one-million-year-old earth versus a four-billion-year-old earth. What should you do? Another metaphor might help. Imagine that you are a detective on a police force, and you are investigating a murder. You have an obvious suspect and you know he did it. You are sure you know how he did it and have devoted all your energy to proving your scenario. Then something is discovered that shows that your theory just won't work. What would you do? What does the TV detective do? This happened on a recent episode of "Murder in Paradise." All the theories that the police had ~~just~~ been proven wrong. The main detective told them what to do. He said, "When you come to a dead end, you throw out everything that you think you know, and start over." They had to go back to the beginning and reexamine all the clues and all the presumptions that were included. Maybe that is the answer here as well.

Where would we begin? The Christian faith rests, not on the age of the earth but on the resurrection of Jesus. Despite the vocal objections from atheists, there is plenty of evidence to say that the universe is designed—it had a creator. This evidence ranges from the physical constants of the universe to the just right nature of earth to the incredibly engineered life around us. The creator actively participated through time. He did not just give the universe a shove and see what happened. Here are some references that I recommend Strobel (2004, *The Case for a Creator*), Behe (2007, *The Edge of Evolution*), Ross (1989, *The Fingerprint of God*, Ross (1989, *The Creator and the Cosmos*), and Geisler and Turek, (2004, *I Don't Have Enough Faith to Be an Atheist*). However, just as we can be sure that there was a creator, if Jesus was not resurrected, we could also be very sure that the creator was not the Christian God in any form.

> And if Christ has not been raised, then our preaching is in vain and your faith is in vain. We are even found to be misrepresenting God, because we testified about God that he raised Christ, whom he did not raise if it is true that the dead are not raised. For if the dead are not raised, not even Christ has been raised. And if Christ has not been raised, your faith is futile and you are still in your sins. Then those also who have fallen asleep in Christ have perished. If in Christ we have hope in this life only, we are of all people most to be pitied. (1 Cor. 15:14–19)

Surely the idea that a particular person who lived and died two thousand years ago was the creator of the universe is as unlikely as anything one could imagine. Fortunately, the case for the resurrection is backed up by large amounts of evidence as well. (See McDowell, 1979 or Strobel, 2007 for readable discussions. Many more extensive books are also available.) No other explanation has been proposed that actually fits all the evidence. If we take it that there is a creator and that Jesus's resurrection tells us that that creator is indeed the God of the Bible, what does that mean about the Bible's accounts?

Going back to the illustration, you might have been investigating a case in which you knew who is guilty, but if your first theory of how they did it proved to be wrong, perhaps you must step back and consider the options. In this case, if we believe that God is the creator, and yet find major difficulties with our interpretation, then we need to step back and look at our interpretation of the biblical accounts.

Perhaps the problem is not with the Bible or with the evidence that tells us that the earth is billions of years old. In a criminal case, two basic types of evidence are presented: personal testimony and physical evidence. If the personal testimony is true and the physical evidence is characterized correctly, then both sets of evidence should ultimately tell the same story. It still may take some work to reconcile them and understand how to interpret them. The Bible represents the testimony of God, given through humans who wrote in different times, languages and cultures. The scientific evidence represents the physical evidence, but its interpretation is complex and it is incomplete.

Perhaps a different illustration will help us to understand the difference in this personal testimony and the physical evidence. Imagine this setting, an aging ex-President Ulysses Grant is sitting on a porch and his eight-year-old grandson crawls up into his lap and demands this of him: "Tell me all about the Civil War." President Grant, of course, was lieutenant general and commander of all the Union armies that won that war.[17] He could have expounded for hours about the war in great detail. President Grant had a real sense of history and could have discussed the war from almost any angle. However, he would have known that his grandson could not understand most of that detail. The grandson also would not have really cared about much of the detail. Grant would have tried to tell his grandson the information that he needed but in a simple enough way that the boy would have been able to understand it. God speaking to man through Genesis is a bit like the imaginary scene above. The difference in the level of understanding would be vastly greater between God and man than between Grant and an eight-year-old. In some ways, we are much farther along today

> Similarly, I believe that in Genesis, God provides a story of real people and events but only those that suited His purpose. They would have been meaningful for the human author and his readers but God would have known what we need today as well.

[17] If you happen to be an ardent southerner, feel free to substitute General Lee, though it seems more appropriate to use the general who won the war and Grant's memoirs of the Civil War are highly acclaimed even by those who did not like him.

compared to the original intended readers of the book of Genesis, but when compared to God's understanding, that difference probably isn't all that significant. What might President Grant have told his grandson? In theory, he might have made up an imaginary tale, using totally imaginary characters. I really expect that he would have used real people and real events, although he would have told only the parts that suited his purposes. Similarly, I believe that in Genesis, God provides a story of real people and events but only those that suited His purpose. They would have been meaningful for the human author and his readers but God would have known what we need today as well.[18] Grant's discussion of the Civil War would have represented personal testimony by one the principal participants. It would be significant to any historian trying to understand the conflict even if the historian could not interrogate Grant themselves. Similarly, God's testimony on creation is vitally important to our understanding it, even if it is not written to answer all the questions that we bring. A historian reading a child's account of Grant's words would need to take into account who the words were spoken to and for what purpose. We must do the same with Genesis.

Another imaginary setting could be a modern archaeologist studying a battle from one thousand years before, perhaps from one of the Americas. There would have been no eye witness accounts and indeed no written records at all. The archaeologist would have many, many instruments that could provide very detailed data about that which he found. He would be able to study the findings using many different scientific disciplines. However, without the benefit of written records, there would still be details that he just could not provide. He might miss parts of the story because he would not be able to undo the damage that might have been done when roads cut through the battlefield or the fact that a five-hundred-year-old historic building covered key elements. His interpretation of the battle might change many times as new datasets were analyzed. Once all of the available data were compiled and analyzed, it would be possible to describe things learned from it. Each piece would have limitations and uncertainty ranges associated with it. Some things could be determined with high confidence, but the archaeologist would have to be very careful not to jump to conclusions or to pick a scenario too quickly. He might be tempted to see that scenario in all of the later data, even if they really did not fit it. Fortunately, our archaeologist would want to publish his findings. Once he submits his report for publication, the editor will send it to several peers who are considered experts in the field, and these experts would try to poke holes in it. It is best for him to have thick skin at this time. The process does help weed out a lot of weak logic and unsubstantiated claims. (Sometimes I wish the Internet had some required review.) The scientist's data would be analogous to physical evidence in a criminal case. The data must be interpreted to be of use. However, the truth will fit the real physical evidence.

[18] If we were to carry this analogy into the New Testament, it might be more like a young college student approaching General Grant. General Grant would have known that the young college student would have needed much more detail and more support than the eight-year old would have. General Grant might have rolled out some maps and called in some other witnesses to give their versions of the war. In the New Testament, we see that regarding the life of Christ, we have multiple eyewitness accounts often with their testimony effectively signed in blood, records from the actual period, accounts from "hostile witnesses" and large amounts of archaeological evidence supporting the general knowledge of the period.

To continue our imaginary scenario, imagine that we come upon an actual written document for the battle scene that our archaeologist friend has studied so intensively, but it was written from the perspective of the President Grant scenario. It is a description of the battle written by a man who learned about it as child from one of the generals. If we were to put the data from the two information sources together, we would get a more complete picture of the battle. Wouldn't that be an interesting project? It would not be easy. The spotty granularity of the scientific data probably would show apparent contradictions to the written document. Add that to the fact that the scientific data would have an inherent uncertainty in its dating and that uncertainty might at times be even greater than that appreciated by the scientists. Which account would be most believed? The biblical accounts are a bit like a document from such a battle scene, written in an ancient language to a people whose needs and questions were different than ours. Some of our most important needs however are just the same as theirs and God does provide the answers that we need. It helps if we understand a few basic historical context questions in order to be sure that we apply the answers the right way. One answer is to try to discredit or just ignore the scientific data. Most YEC authors use that tactic. Other Christians are confident to use the biblical lessons that have been taught for years and not worry about correlating the other data. That carries at least one risk. God may have meant something different than what we recognize without understanding more about the historical setting.

Putting together the Bible and scientific data is not an easy task, but the potential rewards are great. A detailed verse-by-verse examination of the scripture in the original languages might be needed to build an airtight case, one that reconciles all the data. That is certainly beyond the scope of this work and ultimately beyond my ability as a layman. Here we can consider a few key issues that are critical. The OEC and TE must deal with these to be compelling in their biblical case and able to hold both their faith and their beliefs about nature without contradiction. If it can be shown that there are viable options to these three questions, then it is also likely that the other questions could also be resolved. Here are the proposed key questions:

I. Can the Genesis 1 account of creation over seven days be reconciled with the scientific understanding of time?
II. Can the biblical account of Adam and Eve be reconciled with scientific data?
III. Is the biblical account of Noah's flood a record of a real historical event and if so, what can we say about it?

Dealing with these three questions is important because the answers affect the way the rest of scripture is to be treated. The Bible claims to be God's word—God's revelation of Himself to man (Rom. 15:4; Gal. 3:8, 22; 2 Pet. 1:20; Matt. 5:17; 2 Tim. 3:15). Does this mean that it is true in the real historical sense? Does God really act in nature and in our lives? This is important. Truth matters! Neither the OEC nor the TE are saying that God was unable to create the universe quickly. The Christian geologist is not saying that God is unable to flood the earth. The question is not what God is able to do. The question is—what did He choose to do? When Jesus walked on earth, He chose to heal many people. As the creator of earth, He had the power to instantly heal all of the afflicted. He

has never chosen to heal all. We learn much about God by studying what Jesus actually chose to do. If the creation and flood are simply fables, then it becomes very difficult to decide where the fable ends and the history begins. Who gets to decide?

You may be expecting that I will present simple clear answers that you can either accept or reject. Unfortunately, I don't think that we have the data to resolve these questions completely. I do want to show that there are options that can honor both scripture and data available from science. Each of the three questions above will be addressed in a chapter in this section. At the end of each, I will add a discussion of what seems to be the best answer for me today. I reserve the right to alter this as more becomes known.

1 Genesis 1—How Long Were the Days?

Christians have held a wide range of views about how long God took to create the world. At one extreme was Augustine (354–430 AD) who considered creation to have been instant and the seven days of Genesis 1 to have been a literary devise used to present this work to man. What did the seven days mean to the human author? Just as a police investigator will carefully consider who is giving testimony and what their motives are, an important starting place to understanding the account of creation found in Genesis 1–3 is to consider who wrote it, who they wrote it to and what was their intended purpose or purposes. Regardless of how skeptical your mind-set, Genesis is a very ancient book written in an ancient language to a very different people. Certainly, there is much debate about when the book was written, but there are good reasons to date it to the approximate time of Moses. Genesis does not specifically say who wrote it, but Moses is traditionally considered to have been the author. The Pentateuch is often written from the perspective of Moses and there doesn't seem to be any really good reason not to consider him the author or at least the primary one responsible. The Genesis material about the patriarchs actually came from that earlier period, the early second millennium BC when they lived (Kitchen 2003). The early covenants reflect customs from Abraham's time, not the time of Moses. Thus, the author clearly had access to information from much earlier periods. We can only guess what these might have been and what forms they were in. We do know as we read the words that a writer in the time of Moses, he wrote from a very different cultural context than we are in today.

Whether the author was Moses or his official historian or whoever, some of the author's purposes are clear. The author wanted to provide a straightforward answer to the polytheism and mythical imagery common in the ancient Middle East. He explained the origin of the world and how man relates to his creator. Are we to understand this as a historical account? The personal views of Moses on the cosmos and other scientific questions would probably be considered simple or simply wrong, given today's understanding. For example, he may well have believed that the sun revolved around the earth and had some views of space that have been abundantly disproven today. Evangelical theologian and biologist Denis Lamoureux (b. 1954) considers the early chapters of Genesis to have been

written from an "ancient phenomenological perspective" and to have included some of these ancient wrong ideas into the text (Lamoureux 2013). For instance, this means that when Moses wrote about sunrise or sunset, he would have meant that very literally. Lamoureux and others who hold this view of the creation accounts believe that to analyze Genesis 1 from a historical or scientific respect is incorrect and would be interpreting from it information that it never meant to convey. They recognize the purposes of (1) answering polytheism and (2) giving the spiritual explanation for sin's origin and they largely stop there. I want to be clear here. Many who hold each of these views are clearly Christians with thoroughly biblical understandings of the most important doctrines of Christianity. There is considerable debate between believers who hold that the early chapters of Genesis are figurative versus those who hold that Genesis 1 can be correlated with scientific data. If the Bible and history from scientific data can be correlated, then that is to say that there must ultimately be agreement or "concord" between the Bible and the facts from nature. Hence the belief that the two sources of information can be correlated is termed "concordism." Both the figurative and concordian views find no difficulty in accepting billions of years of geologic history. The issue at hand to examine is whether either of these views can honor the biblical text without forcing interpretation onto it that is unacceptable.

The author, under God's guidance, wrote down the Genesis account using a particular literary form and our recognizing that form can help us to understand how to interpret the author's intent. The Old Testament includes historical narratives, hymns, poems, law code, and records of prophetic visions. Each literary form carries truth, but recognizing the form makes it far clearer what the meaning was to the author and early readers.

There seems to be no real basis for taking the Genesis account as anything but some form of prose narrative. Even taken as prose, it is beyond the normal prose . . . an elevated prose.

If Genesis 1 were interpreted as Hebrew poetry, then one would expect more figurative language than if it were a basic historical narrative. The Psalmist uses many literary allusions to help convey the significance and meaning of creation and other historical events (Ps. 8, 74, 95, 102, 104). Is the first chapter of Genesis a poem? Not according to most commentators (Wenham 1987; Gæbelein 1990; Collins 2006; Schaeffer 1972; Ross 1998, *The Genesis Question*; Boice 1982, 1998; Snelling 2009). It is worth noting that even poems are often about real historical events and use meaningful chronologies. In this case, however, there seems to be no real basis for taking the Genesis account as anything but some form of prose narrative. Even taken as prose, it is beyond the normal prose as this quote from Gordon Wenham (b. 1943) (1987) reflects

> Gen 1 is unique in the Old Testament. It invites comparison with the psalms that praise God's work in creation (e.g., 8, 136, 148) or with passages such as Prov. 8:22-31 or Job 38 that reflect on the mystery of God's creativity. It is indeed a great hymn, setting out majestically the omnipotence of the creator, but it surpasses these other passages in the scope and comprehensiveness of vision. In that it is elevated prose, not pure poetry, it seems unlikely that it was used as a song of praise as the psalms were. Rather, in its present form it is a careful literary composition introducing the succeeding narratives. (Wenham 1987)

Wenham (1987) and C. John Collins (b. 1954) (2006) document the great care with which the passage was written, the symmetry of words and phrases used to describe God's orderly process. This is consistent with the order and beauty that we witness in creation at all levels. Daniel Vestal offered this opinion:

> I would like to argue that Genesis 1–2 is historical narrative in pictorial form. It abbreviates a long history and immense periods of time in language that translates history as well as transcends it. We are not dealing with myth or legend, which presents an idea in the form of a story. Nature is not personified or dramatized as in nonbiblical accounts. And from other parts of Scripture, both Old and New Testaments, we know that Genesis describes actual events and persons. (Vestal 1989)

One key element in Genesis 1 is the description of creation in terms of a seven-day week. Did the writer intend to tell us that the universe was created in 144 hours (six times twenty-four)? Is it possible that the writer used this as a framework in which to place the historical events that God revealed to him? Perhaps he also wanted to frame God's work in such a way that the Hebrews could use it as an example in their own lives, with six days for work and one day for rest and worship. What could the word *day* mean in Genesis 1? Francis Schaeffer (1912-1984) described the answer in this way:

> What does day mean in the days of creation? The answer must be held with some openness. In Genesis 5:2 we read: "Male and female created He them; and blessed them, and called their name Adam, in the day when they were created." As it is clear that Adam and Eve were not created simultaneously, day in Genesis 5:2 does not mean a period of twenty-four hours. In other places in the Old Testament the Hebrew word day refers to an era, just as it often does in English. See, for example, Isaiah 2:11, 12, and 17 for such a usage. The simple fact is that day in Hebrew just as in English is used in three separate senses: to mean (1) twenty-four hours, (2) the period of light during the twenty-four hours, and (3) an indeterminate period of time. Therefore, we must leave open the exact length of time indicated by day in Genesis. From the study of the word in Hebrew, it is not clear which way it is to be taken; it could be either way. (Schaeffer 1972)

Vines Dictionary of Old and New Testament words provides the following on the meaning for the Hebrew word used:

> Yôm has several meanings. The word represents the period of "daylight" as contrasted with night time: "While the earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease" (Gen. 8:22). The word denotes a period of twenty- four hours: "And it came to pass, as she spake to Joseph day by day . . ." (Gen. 39:10). Yôm can also signify a period of time of unspecified duration: "And God blessed the seventh day, and sanctified it: because that in it he had rested from all his work which God created and made" (Gen. 2:3). In this verse, "day" refers to the entire period of God's resting from creating this universe. This "day" began after He completed the creative acts of the seventh day and extends at least to the return of Christ. Compare Genesis 2:4: "These are the generations of the heavens and of the earth when they were created, in the day [b yôm] that the Lord God made the earth and the heavens . . ." Here "day" refers to the entire period envisioned in the first six days of creation. (Vine, Unger, and White 1985)

Virtually all YEC authors recognize that the word *yôm* has multiple meanings, yet they insist that the meaning in Genesis 1 absolutely must mean twenty-hour days. What is their basis? As stated earlier, such an interpretation follows from a simple direct reading of Genesis 1. Does that make this the correct interpretation? A simple and direct reading of Genesis 3:1 leads many non-Christians to believe that Genesis has talking animals that try to lead people astray. Most Bible scholars agree that this was Satan taking a disguise to beguile these people that God placed in this special place. This is an interpretation that involves bringing information from outside of Genesis to bear on the question.

Another interesting instance is Genesis 2:16–17: "And the LORD God commanded the man, saying, "You may surely eat of every tree of the garden, but of the tree of the knowledge of good and evil you shall not eat, for in the day that you eat of it you shall surely die" (Gen. 2:16–17).

A simple, literal interpretation of this verse would indicate that on the twenty-four-hour day that Adam and Eve ate the fruit, they should have died. The NIV translates this as "for when you eat of it you will surely die" but both Wenham and Collins use the word day just as the KJV and ESV do (Wenham 1987; Collins 2006). There are various opinions from Christian commentators on how to interpret this verse, but none would argue that the simple, obvious reading is the correct one. Many would interpret that the death referred to was spiritual death and that Adam and Eve died spiritually immediately when they chose to disobey God. That is a very reasonable interpretation, but it would be very difficult to demonstrate that the author of Genesis used the word *death* in that sense anywhere else. It would even be difficult to demonstrate that use for the word *death* anywhere in the Old Testament. Another possible interpretation would be that Adam and Eve did literally physically die on the day that they sinned. However, the "day" was an indefinite

period of time that began when they chose to reject God's way. It is clear that the word *yôm* can and is often used to mean a period longer than twenty-four hours. There must be other clues to guide the interpretation.

The above examples show that Christian's often agree that the obvious reading does not give a valid interpretation. The Genesis 1 account uses the phrase, "And there was evening, and there was morning." John McArthur (2001) takes the position that this is only meaningful in a twenty-four-hour-day interpretation. He writes the following:

> The problem with this view is that nothing in the passage itself suggests that the days were long epochs. The days are defined in Genesis 1:5: "God called the light Day, and the darkness He called Night. So the evening and the morning were the first day." Night and day, evening and morning are demarcated by rhythmic phases of light and darkness from the very beginning.
>
> The very same expression, "the evening and the morning were the [nth] day" is employed for each of the six days of creation (w. 5, 8, 13, 19, 23, 31), underscoring the fact that the days were the same and that they had clearly defined boundaries.
>
> The only cadence of light and darkness defined anywhere in this context is the day-night cycle that (after day four) is governed by the sun and moon (v 18). There is no reason to believe the rhythm was greatly altered on day four. That means the duration of "the evening and the morning, on the first day of creation was the same as the evening and morning of any solar day." (MacArthur 2001)

Again, there is no denying that a twenty-four-hour interpretation is a simple direct interpretation. Does this phrase prove one twenty-four-hour period or is it an expression meaning that time passed and this period ended? The exact phrase is really only used in scripture in Genesis 1. We find evening and morning in Ps. 55:17 where David says. "Evening, and morning, and at noon will I pray." In Exodus 18:13–14, the phrase *morning till evening* occurs, but in verse 14, it is not referring to one day: "The next day Moses sat to judge the people, and the people stood around Moses from morning till evening. When Moses' father-in-law saw all that he was doing for the people, he said, 'What is this that you are doing for the people? Why do you sit alone, and all the people stand around you from morning till evening?'" (Exod. 18:13–14)

Similarly, in Leviticus 24:3, Aaron is ordered to tend the lamps of the tabernacle "from evening till morning, continually." The order is not for one twenty-four-hour period. There was evening and there was morning could easily be an expression for one day, but it seems that this is not the only option and one cannot use another Bible usage to prove that it does. Again, it is necessary to look for more clues.

An objection to longer periods that is often given is to insist that the days in Genesis must be twenty-four-hour days because they carry an ordinal (a number) before the word *day*. It is said that the Old Testament scripture does not attach an ordinal to an indefinite period of time in

anywhere else, and therefore, the word *day* cannot be referring to an indefinite period here. Dr. George Benthien reports the following:

> Van Bebber and Taylor also said that 358 out of the 359 times "yôm" is used with an ordinal number modifier, it represents a 24-hour day. However,
>
> - There is no rule in Hebrew grammar that requires this interpretation.
> - All of the 358 cases mentioned refer to human activity where the 24-hour meaning would be natural. Genesis 1 and Hosea 6:2 refer to God's activity. (Benthien 2012)

He also notes that the Hebrews had no other name for "a finite period of time of unspecified duration." The Bible does not have another list of periods of time that are numbered. There is no different formula or usage that the writer of Genesis would have used if he had meant ages rather than twenty-four-hour periods.

There are actually more options that relate to the numbering of the days here. The Jewish commentator Umberto Cassuto (1883–1951) did not even consider the Genesis 1 numbers as ordinals:

> The use here of the cardinal instead of the ordinal number, as for the other days, is to be explained, with Nahmanides [Rabbi Moses son of Nahman], as follows: "First implies precedence over another in number or grading, when both are in existence." (Cassuto 1944, *A Commentary on the Book of Genesis, Part One*)

The English translations of the Bible normally translate the Hebrew to say "the first day, the second day, the third day," etc. A more literal translation would render these "one day," "a second day," "a third day," "a fourth day," "a fifth day," "the sixth day," and "the seventh day." Henry Lee Poe explains the significance.

> The presence or absence of the definite article with the ordinal numeral and the noun *day* makes an enormous difference in meaning. If I relate my life and how I came to Union University, I might say,
>
> One day I was born.
>
> A second day I started preaching.
>
> A third day I started being married to Mary Anne Whitten.
>
> A fourth day I started being a father to Rebecca and then to Mary Ellen. A fifth day I started living in Minnesota.
>
> The sixth day I started working at Union.
>
> The seventh day I die.
>
> This narrative is true, and it captures the significant moments that began on particular days. The activity or state that begins on a particular day had not occurred previously, and it continues on into the future. So why does this narrative of my life use a definitive article for day six? The sixth day is the focus of activity in which I am now engaged. (Poe 2014)

In short, there are a number of options that provide scope for long periods of time based on the word *yôm* as it appears in Genesis 1 and the numbers associated with the days seems to do little to prove that the days were twenty-four-hour solar days.

In short, there are a number of options that provide scope for long periods of time based on the word *yom* as it appears in the Genesis 1 and the numbers associated with the days seems to do little to prove that the days were twenty-four-hour solar days.

Another objection that many hold deeply is that there was no death before Adam sinned in the Garden of Eden. It is interesting because Genesis never says that there was no death before the fall. What is the basis for the interpretation? This theological doctrine is primarily based on these two New Testament references:

> Therefore, just as sin came into the world through one man, and death through sin, and so death spread to all men because all sinned—for sin indeed was in the world before the law was given, but sin is not counted where there is no law. Yet death reigned from Adam to Moses, even over those whose sinning was not like the transgression of Adam, who was a type of the one who was to come. (Rom. 5:12–14)
>
> But in fact Christ has been raised from the dead, the firstfruits of those who have fallen asleep. For as by a man came death, by a man has come also the resurrection of the dead. For as in Adam all die, so also in Christ shall all be made alive. (1 Cor. 15:20–22)

These verses do teach that death began with Adam's fall, at least for man. When Paul wrote that sin entered the world, it is very reasonable to infer that he was speaking of the world of man. Thus, with Adam's sin, death came to all men. One interpretation might be that the death referred to was the spiritual death that came instantly with the sin, but most agree that it also brought about human physical death as well. It is a big step to infer that overall death began, including all the animal kingdom.

When God told Adam not to eat of the fruit of the tree of knowledge of good and evil lest he die (Gen. 2:17), how did he even know what death was, if he had never seen anything dead? God designed an amazing and beautiful web of life. It is difficult to imagine that it was designed to work for eternity without death. That would mean that the incredible reproductive systems would cause earth to overflow. In the United States, many well-meaning people believe that it is horrible and cruel that hunters hunt animals, such as deer. In an environment where most of their natural pred-

ators have been removed, deer populations will explode and result in starvation if the herds are not thinned.

Imagine the explosion of life in a world with no death. Most YEC allow for the death of plants and microbes but it is still death. Others allow for the death of insects. Many animals such as the woodpecker were beautifully designed for a diet of insects (Ham, Sarfati, and Wieland 2000). How do you choose what kind of death counts? Romans 8:20-21 teaches that all of creation will be freed from the bondage of decay. "For the creation was subjected to futility, not willingly, but because of him who subjected it, in hope that the creation itself will be set free from its bondage to corruption and obtain the freedom of the glory of the children of God" (Rom. 8:20–21).

Death certainly is a part of that decay, but in my opinion, the teaching that animal death began with Adam's fall is a case where theology has run a long way beyond the actual scripture. God has revealed to us that we were created for fellowship with Him and can live forever with Him. We have no such revelation for the animal kingdom. When a pet dies, children often ask if they will see them again in heaven. We have no such assurance. Over and over again, we must learn that God's ways are not our ways. What to our mind might be needless pain and suffering may not in fact be so from His perspective, irrespective of Adam and the fall.

Another objection is the claim that twenty-four-hour days are demanded by scriptures such as Exodus 20:11 which says, "For in six days the LORD made heaven and earth, the sea, and all that is in them, and rested on the seventh day. Therefore the LORD blessed the Sabbath day and made it holy." Benthien quotes the Hebrew scholar Gleason Archer as saying, "By no means does this [Exodus 20:9–11] demonstrate that twenty-four-hour intervals were involved in the first six 'days,' any more than the eight-day celebration of the Feast of Tabernacles proves that the wilderness wanderings under Moses occupied only eight days." The Hebrews honored the Sabbath to honor God. Jesus said that "the Sabbath was made for man, not man for the Sabbath" (Mark 2:27). The seventh day is certainly special. Many authors have noted that it does not close like the rest in Genesis 2:3. Hebrews 4:3–11 refers to the Sabbath and indicates that God's rest continues through the present day. God gave man the Sabbath as a way to honor Him and to have man break from being consumed and broken by work. It is possible that God revealed his work of creation to man in terms of His seven creative periods in order to provide the model for how we should divide our own work (Wenham 1987; Collins 2006; Ross 1994; Stoner 1997).

Day 6 of creation week provides its own problem for the YE interpretation. Genesis 1:1–2:3 can be taken as creation from God's perspective. Genesis 1:27 tells us that "so God created man in his own image, in the image of God he created him; male and female he created them." Genesis 2:4–25 can be taken as creation from man's standpoint (Ellison 1979). It provides a more detailed account of man's origin and in particular the creation of Adam and Eve. This entire record must be correlated with day 6 in the first account. It is not the obvious interpretation to make this all occur in a portion of one twenty-four-hour day. It is very unlikely, given the very carefully written text of the opening chapters of Genesis, that the author would never have considered the apparent contradiction if he considered day six to be twenty-four hours long.

According to Genesis 2:19, God brought Adam "all the beasts of the field and all the birds of the air" to name. If "all" is literal and exhaustive, Adam must have been exhausted! From my standpoint, just being able to remember all those names would have been a miracle, especially if it all took place in one day. Adam noticed that there were male and female of all the animal kinds but none for him. Over some amount of time, he got lonely. Of course, if this took place in one day, then it didn't take long. Even a simple reading suggests that day 6 was a longer period of time.

A more detailed analysis shows even more issues. Collins (2006) shows that if the Hebrew is taken as it likely meant to the first readers, it is more logical to take this as occurring over a period of time that involved seasons.

> If we consider the geography: God made the man in some unnamed "land" and then moved him to the garden of Eden (2:8); after the disobedience in Genesis 3, he banished the man back to the "land" to work it (3:23). It also helps to recall the climate of the western Levant: it rains in the fall and winter and not at all in the summer. At the end of the summer and with no man to work the ground (by irrigation), the ground is quite dry and barren; after the rains begin to fall, then the plants may spring up. This makes sense, because the text gives a reason for no bush or small plant: "for the LORD God had not caused it to rain" (2:5); this is not at all the same as "he had not yet created them," which is what Driver and Futato seem to require. Rather it is in terms of the ordinary experience of the Israelite audience.
>
> We are then able to understand just what Genesis 2:5–8 means in some land, at the end of the dry season, when the "mist" (or rain cloud) was rising to begin the rains, God formed the first man; he then planted a garden in Eden and moved the man there. Sometime after that he made the woman. (Collins 2006)

Again, it is important to recognize that we are reading an account written to ancient readers in an ancient language. The primary audience for the human author had a different mind-set and the author was not trying to address many of the questions that we ask today. Dr. Collins con- cluded on the basis of a careful analysis of the text in Genesis 1–3 that the text does not claim that the days are twenty-four hours long partly in order to harmonize Genesis 1 and 2. He concluded,

> The days are God's workdays, which are understood by analogy to human work; the analogy in its turn serves to structure the workweek of the covenant people.
>
> The days are broadly sequential, which means they are successive periods of unspecified length; but since this sequence is part of the analogy, it is possible that parts of the days overlap and that events on a particular day may be grouped for logical rather than chronological reasons. (Collins 2006)

We began with the question, "Can the Genesis 1 account of creation over seven days be reconciled with the scientific understanding of time?" Many Christian scholars agree that the Genesis account does not conflict with the scientific understanding. Responses to common objections from the text can be summarized as follows:

1. The Hebrew word *yôm* translated day can be literally translated as an era or period of time. The context here does not rule out such a translation.
2. The phrase "and there was evening, and there was morning" can be an expression that simply means that time passed.
3. Many scholars believe that the author of Genesis used the seven days of creation, at least in part, as a literary device that served as an example for man to follow in his workweek.
4. The objection that animal death did not occur before Adam's sin is a theological interpretation that is not demanded by the scripture.
5. It is much more difficult to understand the events of creation day 6 in terms of a twenty-four-hour interpretation.

There is really one main reason that many Christians hold to the twenty-four-hour interpretation. That is the desire to hold to a simple, direct interpretation of the text. Other lines of objection to longer periods of time are really used to provide justification for holding to that interpretation. That said, a simple direct reading of scripture has a lot going for it. Should we change our interpretation of scripture every time we read a new article online? How do we use scientific and archaeological data in our interpretation of scripture? Data such as this should not be used to invalidate scripture.

Many scholars do reject large portions of the Bible and the Old Testament in particular. I found three books that address this topic to be very informative: Dr. Kenneth Kitchen's book *On the Reliability of the Old Testament*,[19] Josh McDowell's *Evidence That Demands a Verdict*, *Volume 2*, and Timothy Mahoney's *Patterns of Evidence: Exodus* (Mahoney 2015). These books document many cases where the assumptions made by many theologians and archaeologists who reject the historical accuracy of the Old Testament are just not supported by the evidence. Modern archaeology has not found concrete evidence of individuals such as Abraham or Moses, but they also cannot demonstrate valid historical errors in the Bible either. In many cases, when the modern understanding of Middle East history seems to contradict the biblical understanding, a new finding of one piece of papyrus could turn that completely around without contradicting any of the actual data available today.

Is the scientific understanding of the age of the universe and the geology in that same category? Is it going to reverse with one find or a new theory of how to interpret the data? The scientific data comes from many different directions. Even the geologic evidence in this report is not really one line of evidence but many. In his commentary on Genesis, James Montgomery Boice (1938–2000), founding chair of the International Council on Biblical Inerrancy, compared the various interpre-

[19] Dr. Kenneth Kitchen (b. 1932) is a very respected Egyptologist and he has been described by The Times as "the very architect of Egyptian chronology."

tations of creation. Coming from a nonscientific background, he did not really try to answer the science. One suspects that from a purely scriptural standpoint, he would like to accept what he calls "six-day creationism." He writes,

> We must say, as we summarize this first problem with the creationist view, that the creationists have given answers to each of these lines of evidence for an old earth and an even older universe. They have spoken of a lack of uniformity of scientific laws in past ages; of a universe created "in motion," as it were, with light already in progress from a distant point; of radioactive dating methods as unreliable, sometimes giving wildly conflicting data, and so on. But when everything is considered, it seems to many persons (myself included) that the creationists are running against too many lines of more or less independent evidence against their case on behalf of an earth. Therefore, whatever else may be true about their viewpoint, it is hard to believe that the creation of the earth and universe was recent. (Boice 1982, 1998)

Both internal clues and external evidence indicate that the days of Genesis 1 were not twenty-four-hour days. They were not human days, but rather God's days. Such a proposal is not just a turn of phrase but has usefulness in how we think of eternity. Humans, limited to time, cannot really describe a succession of events without references to time. God's time must be different. William Dembski uses this division of human time (chronos) versus time from God's perspective (kairos) as an alternative way to understand the Genesis account (Dembski 2006). He would characterize the creation days as "actual [literal!] episodes of divine creative activity." Genesis 1 certainly speaks to "kairos." Correlating the creation days in detail to "chronos" involves interpreting both scripture and science, and this process brings potential for human error into the picture.

Both internal clues and external evidence indicate that the days of Genesis 1 were not twenty-four-hour days. They were not human days, but rather God's days.

Conservative theologians agree that Satan is a real created being. Most equate him with Lucifer (Isa. 14:12) and interpret him to have been a high angel at one point, although most recognize that this is not the only possible interpretation of that passage. At one point, presumably in "chronos," Satan is described as having led a rebellion of angels. The rebellion was unsuccessful, and he was cast out of heaven to earth (Rev. 12:4). We first met him in the garden when he took the form of a serpent. Two questions are, when was he cast out of heaven and when did he arrive on earth? The young earth timeline makes this difficult to understand. This theological issue involves the interpretation of interpretations and cannot be considered to prove the age of the earth, but it is worth noting that common Christian theology on the issue does fit much better in the old earth scenario.

This Author's Favored Interpretation

In this section, I will summarize some personal views, though these may change as more is learned. Science in general and geology in particular reveal an earth history that is billions of years long. I do not find any real conflict with that in scripture. Genesis provides the explanation for why that history exists and our own significance in it. This author interprets Genesis 1–3, as with the rest of scripture to be concordant with the facts of nature. While I understand that the figurative proposal has merit, I am unconvinced that this is how to interpret these scriptures. While the passages before Abraham are more difficult to tie to documented history, I do not see a break between "real history" and "figurative history." Scriptural accounts should be taken as "real history" unless there are clear internal reasons not to do so, and in this case, I do not find such clues. Some interpret that the ancient cosmology presumably understood by the ancient writers should be used to interpret scripture passages such as the Genesis creation account. I am not convinced that any archaic and errant understandings of the original authors change the way that we should be read and interpret the passages. Just as we continue to use the term *sunset* despite the fact that we now understand that it results from the earth's rotation, this does not affect the course of our normal conversations. In general, very little information about the archaic views of the structure of the heavens is found in scripture. That suggests to me that while the views of the various authors were probably very inaccurate about such things, God kept them out of His word, a part of the inspiration.

Several scenarios have been proposed to correlate the creation events from Genesis 1 with history and current theories for how the universe developed. Good modern examples in book form include *The Genesis Question* (1998) by Hugh Ross, *A New Look at the Old Earth* (1997) by Don Stoner, and *A Biblical Case for an Old Earth* by David Snoke. Perhaps the most we can expect today is to show that the best data and the best theories that we have from science are consistent with a viable interpretation of the ancient Hebrew language as given in the Bible. Consider that correlating any other religious tradition of the origin of the earth with the scientific data on the earth's history is quickly found to be useless. Provisionally, it seems reasonable that the days of Genesis 1 can be tied to periods of "chronos," though obviously the days were not of the same length. It seems to be possible to link the order of the events in Genesis 1 to the order that they occurred in our time, though as we have seen, many question this. It is also possible that the events were arranged more topically than chronologically. The reason God revealed it as seven days seems to be more of a literary tool and an example of His workweek for us to follow than any specific scientific change occurring as the periods progressed.

My "concordian" interpretation is that God revealed His creative work to Moses or one of the sources that he used as he wrote Genesis. The events that he wrote in this elaborate pictorial description were real historic events and their order is real. It is very unlikely that an ancient writer would have come up with an order of events that matches so well with what we have learned from science without divine inspiration. This means that the words convey truth that was often well beyond what the author understood. I understand that this type of thinking can be pushed too far

and I am uncomfortable, for example, with interpreting much modern cosmology into poetic books such as Job. How are we to understand the days in Genesis 1? They do not correspond to specific recognized geologic ages or even divisions such as periods or eras. While each day represents an age of history in God's preparation, the seven divisions are a framework that God used to explain His work to man. This framework is still useful as we understand how God works in our world. The author of Genesis certainly was not trying to write a scientific textbook. If God thought that we needed a scientific account, He could have provided it but that was not the need. I suspect that most of us are quite happy that He didn't. However, where Genesis touches history, it is reasonable to expect that it not contradict real facts of history or science. Here is a listing of the major creative acts recorded in Genesis 1 and some current scientific thinking that may help to think about when they occurred (Note that given the current uncertainty in dating, these days may be consecutive and non-overlapping.):

1. Creation of Universe: One day (Gen. 1: 1)
    - Big Bang in scientific terms (approximately 14 bya)
2. Light reaches earth's surface as dust and debris cleared around the planet: One day (Gen 1: 3)
    - Not datable from rock record but before algae created thus before 3.5 bya
    - The algae (cyanobacteria) were critical to bringing oxygen into the early atmosphere
3. Creation of hydrologic cycle that cycles water through the atmosphere and waters below: a second day (Gen. 1:6–8)
    - Earliest rocks are sedimentary, carried by water by 4 bya (Dostal, Murphy, and Nance)
    - Uncertain timing because a stable hydrologic cycle might mean different things depending on what parts of the system one defines to be required
4. Creation of the continents: a third day (Gen. 1:9–10)
    - >2.5 bya (Tech 2015), some interpret this to have been as early as 4 bya
    - Earth is at least rare among planets in that it has an active tectonic regime that creates continental crust
5. Creation of land plants: a third day (Gen. 1:11–12)
    - I do not think the text is really telling us much about what type of plants these were or what process was used in their creation.
    - This would have been the creation of early forms that would lead to the more advanced forms, thus represents the day the process began
    - Possibly 475 mya (Wellman, Osterloff, and Mohiuddin 2003), though one would suspect that early forms of algal plant life existed on land earlier
6. Clearing of cloud cover so that sun and moon were visible from the earth's surface: a fourth day (Gen. 1:14-18)
    - Not directly datable from rock record
    - Had to have happened before creatures that regulate their cycle by the sun and moon

- At least by Devonian based on earliest insects, 407 to 396 million years ago (Wikipedia)

7. Creation of new forms of sea creatures and the birds: a fifth day (Gen. 1:20–21)
   - Again, I do not believe that the text tells us clearly what creatures these would have included or the process that God chose to use in their creation
   - Possibly 160 mya based on evidence for true birds in the rock record (Switek 2013)
8. Creation of new forms of land mammals, such as cattle and sheep: the sixth day (Gen. 1:24–25)
   - Here, I interpret these not necessarily to be all mammals, though that is possible and again the process is not specified
   - Earliest mammals from Triassic (>160 mya; Douglass 2015)
   - Earliest cow: Pliocene suggesting date of approximately 160 mya to 2 mya depending on which specific animals God had in mind.
9. Creation of humans: spiritual beings designed for special relationships with God: the sixth day (Gen. 1:27)
   - Not the first Hominids or necessarily even the first to be physiologically *Homo sapiens*
   - We will look in more detail at dating this event in the next section

2 Adam and Eve?

The next key question to consider is the origin of mankind. Christian scholars and geologists have been concerned with this since the antiquity of the earth became apparent. Early geologists did not find any evidence that man existed before the traditional time frame for Adam and Eve, but they recognized that if they did, this might challenge theologians. John Playfair (1748–1819) is famous for his 1802 book *Illustrations of the Huttonian Theory of the Earth* that made John Hutton's new theories of geology popular. He accepted Genesis as history but expressed his concerns this way:

> If the high antiquity in question were not restricted merely to the globe of the earth, but were also extended to the human race. That the origin of mankind does not go back beyond six or seven thousand years, is a position so involved in the narrative of the Mosaic books, that anything inconsistent with it, would no doubt stand in opposition to those ancient records. (Playfair 1802)

This is not trivial. The origin of much Christian theological teaching about man begins in Genesis 1–3. Here we find the scriptural explanation for what Francis Schaeffer called the "mannishness of man" (Schaeffer 1968). Here we find an explanation for what is good and noble in man and the evil that is present in even the best of us. These chapters explain the origin of the sin that would one day require Christ's death on the cross to redeem and we find the first promise that that day would come. A good understanding is vital to our faith. Here, we will consider this from three aspects: What does the Bible teach? What does scientific data show? How do they correlate?

What Does the Bible Teach?

Does the Bible present Adam and Eve as historical people? It would be very difficult to read Genesis any other way. The literature style is that of a historical narrative. There have been attempts to draw parallels with other Middle Eastern ancient tales, but the main similarity seems to be in function. Genesis 2–3 did function for Israel as an explanation of their origin as did other stories for different people.

The author of Genesis does not offer any proofs but just writes as though he were documenting the history that the readers already knew and assumed no evidences were needed (Wenham 1987). Today there are several views, even within evangelical Christianity regarding how to understand Adam and Eve.

Christianity Today can be considered the most influential magazine written from a conservative Christian perspective. A recent article in *Christianity Today* delved into this debate. Richard Ostling (b. 1940), the author, asked,

> So, is the Adam and Eve question destined to become a groundbreaking science-and-Scripture dispute, a 21st-century equivalent of the once disturbing proof that the Earth orbits the sun? The potential is certainly there: the emerging science could be seen to challenge not only what Genesis records about the creation of humanity but the species' unique status as bearing the "image of God," Christian doctrine on original sin and the Fall, the genealogy of Jesus in the Gospel of Luke, and perhaps most significantly, Paul's teaching that links the historical Adam with redemption through Christ. (Rom. 5:12–19; 1 Cor.15:20–23,42–49; and his speech in Acts 17; Ostling 2011)

It may be difficult to understand how and when they lived, but abandoning a historical Adam and Eve would have to affect how we understand the rest of the Bible. One indication of this impact would be the difficulty in understanding Jesus' references to them in Mark 10:6 and Matt. 19:4–6 (though admittedly not by name). Some have suggested that when Christ emptied himself and took on the human likeness (Phil. 2:6–8), he took on some of the ideas of the people of the day and those included believing Genesis accounts to be historical even though they were not. We cannot really know what all the human Jesus knew about history or science or other subjects while he was in this form.

However, consider this example. Moses and Elijah met Jesus and three of his disciples on the Mount of Transfiguration, and I expect that Jesus did not need to be introduced to either of them, though we are not told. I believe that He remembered them well. It seems reasonable to believe that Jesus also remembered Adam and Noah as well and not just from having been told or having read about them.

What does the Bible claim? Here is a list of some of the specific claims from the Genesis account:

1. Humans were created differently than the other plants and animals
2. Male and female were created on the sixth day of creation
3. They were created in God's image
4. Adam was created first and then moved to a special garden in the land of Eden
5. Eve was made from a part of Adam to complete him and to be his partner in life
6. Adam and Eve enjoyed an intimate relationship with God in the Garden
7. A dark power took the form of or used an ordinary animal as a mouthpiece to deceive this pair and led them to disobedience (Collins 2006)
8. This disobedience caused humans to experience death
9. God promised a cure for the curse that came upon them as a result of their disobedience
10. These two had sons and daughters
11. Three of these sons were named Cain, Abel and Seth

Genesis does not specifically say that all of mankind is directly descended from Adam and Eve but that is clearly implied. Not only does the account not answer all the scientific questions that we might want to address, it even leaves many obvious questions unanswered. For instance, Genesis 4:16–17 says that Cain went to the land of Nod, east of Eden. We are given no information about where that land was. We are told that Cain and his wife had a son. People have always wondered about where this wife came from. It is not unreasonable that she was his sister, but Genesis does not say.[20] Could this mean that there were other people?

> Thus, some have suggested as does John Collins in *Did Adam and Eve Really Exist?* (Crossway 2011) that if both biblical and scientific clues suggest a larger population contemporary with Adam and Eve (Whom did Cain marry? Whom did God protect him from?), we can still conceive of Adam and Eve as leaders of that original population. That suggestion has the virtue of embracing both a prehistoric couple and a prehistoric population (Ostling 2011).

Cain's wife and Nod are just two of many cases where we know that Moses knew there was more to the story but he chose not to address it. Can science provide data that will help?

[20] Many authors have noted that Adam and Eve may have had many children. No daughters are named but no doubt there would have been many. Population growth can be estimated and given the long lives. it can easily account for large populations (Boice 1982, 1998; Ross 1998, The Genesis Question; Snelling 2009) and many others.

What Does Scientific Data Show?

Fossil finds of hominids extend back over at least the last seven million years.[21] *Merriam-Webster Dictionary* says that hominid "defines any of a family [Hominidae] of erect bipedal primate mammals that includes recent humans together with extinct ancestral and related forms and in some recent classifications the gorilla, chimpanzee, and orangutan"[22] (Figure 90). Certainly, those who accept evolutionary theory consider these to be the direct ancestors of humanity. Evidence for common descent, the theory that all of life descended from simple lifeforms is real. Even some leaders in the "intelligent design" community consider the evidence to be conclusive. Michael Behe (b 1952) originated the term "*irreducible complexity*"[23] and continues to argue convincingly that life has clues throughout that demonstrate the absolute need for a designer. In his book *The Edge of Evolution*, he says, "The results of modern DNA sequencing experiments, undreamed of by nineteenth-century scientists like Charles Darwin, show that some distantly related organisms share apparently arbitrary features of their genes that seem to have no explanation other than that they were inherited from a distant common ancestor" (Behe 2007, *The Edge of Evolution*).

Behe argues that the shared genetic codes can only reasonably be explained by heredity. Part of his evidence comes from DNA codes that have been considered "junk DNA" because they apparently served no functional use. Recent evidence suggests that much of, if not all, of the "junk DNA" is actually necessary. The *ENCODE Project* reports that a staggering 80 percent of the human genome consists of functional elements. With the study's third phase underway, that number may well increase. Yet shortly after the draft sequence of the human genome was first published in 2000, researchers thought only around 2 percent consisted of functional sequences, with the rest being junk (Rana 2013).

[21] The second part of this book will use dating given by the established scientific community. Many dating methods are used, including radiometric methods. I see no reason that these should be systematically in error. Most of those skeptical of them are trying to justify "flood geology" but part one demonstrated the failure of that theory without radiometric dating. Where possible, age uncertainty ranges will be given.

[22] See TalkOrigins page at http://www.talkorigins.org/faqs/homs/species.html for a short summary of the findings. The order and relationships between them are at best highly debatable.

[23] Behe defined irreducible complexity as "single system composed of several well-matched, interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively cease functioning. An irreducibly complex system cannot be produced directly (that is, by continuously improving the initial function, which continues to work by the same mechanism) by slight, successive modifications of a precursor system, because any precursor to an irreducibly complex system that is missing a part is by definition nonfunctional" (Behe 1996).

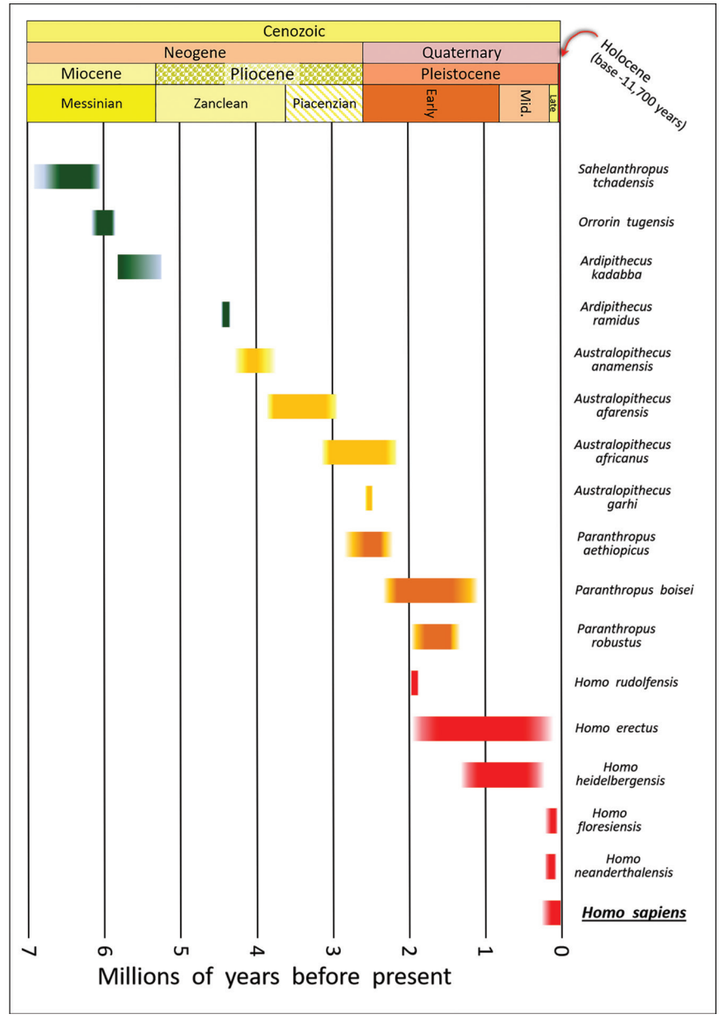


Figure 90 Summary chart adapted from the Smithsonian Institute's Human Evolution website. Dates were determined by a variety of methods including radiometric dates from argon and uranium series, paleomagnetic stratigraphy, and carbon-14 (for the last approximately 40,000 years). Species are colored by group. Many different classifications and relationships between the various species are available. There is far from consensus in the anthropology community about who man's immediate evolutionary ancestor was. Clearly that is not from lack of effort. The Smithsonian's site names the most likely ancestor as *Homo heidelbergensis*. (Smithsonian Human Evolution Research, n.d.)

It seems that once again scientists jumped to conclusions that were not warranted. The genome shows that life is incredibly designed. Arguably God designed life and engineered it actively, often using the common descent of plants and animals. Genesis 1:11 (NIV) says, "Then God said, 'Let the land produce vegetation: seed-bearing plants and trees on the land that bear fruit with seed in it, according to their various kinds.' And it was so." The text doesn't say what that looked like. It can be taken to indicate God's creation process for animals meant that He brought about the "genetic engineering" necessary to bring His will to pass. God almost certainly used some natural selection and mutation within the processes that He chose to use. Was humanity one more step in that genetic engineering project?

What types of scientific data have bearing on the origin of modern humanity? These can be grouped into four types of data and analysis:

1. Skeletal and physical remains
2. Artifacts such as structures, tools, paintings, etc.
3. Genetic analysis
4. Study of human languages

All of these data types yield clues that must be weighed and put together to piece together an integrated interpretation. An interpretation that fits all has a higher probability of being true. The Christian who holds a concordian view of scripture will also expect it to fit a valid interpretation of the Bible. We will survey scientific observations from these wide-ranging fields. Some may wonder why spend so much time this way. Hang in there. Once we have the relevant observations, we will look at the Bible questions and see where the data lead.

How do we decide what to believe? An important place to start is to consider what makes a person human from a biblical perspective. The naturalistic evolution position sees man as just a smarter hominid, descended from other species but the closest relatives are all extinct, making us appear to stand out. Richard Dawkins has written that we are "speciesists" to claim that humans are intrinsically more valuable that apes or chimps (Dawkins 1993). In fact, it is difficult to find a real reason to say that humans are more valuable than mice or cockroaches without God as a part of the equation. The Bible takes a very different view! Man is a created being that is specifically designed and equipped to relate to God. Genesis 1:27 (NIV) explains this by saying, "So God created man in his own image, in the image of God he created him; male and female he created them." In Genesis 3:8, we find God (presumably the pre-incarnate Jesus) walking in the Garden of Eden to fellowship with his unique creation. Man is created with a spirit that allows him to fellowship with God on a level that does not exist for any other of earth's creatures. That is not to say that the other creatures have no value in God's eyes. Man is given responsibility for caring for earth and its inhabitants. Cruelty to animals is one example of being a very poor steward of that responsibility.

How would a scientist recognize the presence of this spiritual dimension? What identifies this distinction that separates man from pre-man? Is there a physical distinction such as cranial size?

Neanderthals had a very similar range in cranial size. What artifacts demonstrate the spiritual dimension? Can we recognize this by studying the human genome?

Skeletal and Physical Remains

The Smithsonian's Human Evolution site reports that "anatomically modern *Homo sapiens*" arose approximately two hundred thousand years ago in Africa (Figures 91 and 92).

> Anatomically, modern humans can generally be characterized by the lighter build of their skeletons compared to earlier humans. Modern humans have very large brains, which vary in size from population to population and between males and females, but the average size is approximately 1300 cubic centimeters. Housing this big brain involved the reorganization of the skull into what is thought of as "modern"—a thin-walled, high vaulted skull with a flat and near vertical forehead. Modern human faces also show much less (if any) of the heavy brow ridges and prognathism of other early humans. Our jaws are also less heavily developed, with smaller teeth. (Smithsonian Human Evolution Research, n.d.)

Early finds are sometimes called "proto-humans." The description above doesn't help much for spiritual capacity, because fossils alone cannot show a soul. The early *Homo sapiens* might well still be within what Gleason Archer called "advanced and intelligent hominids who lived and died before Adam" (Archer 1982). We need more information to consider them what CS Lewis called the "sons of Adam and daughters of Eve." Over the years, scientists have documented that many animals have greater capacities than we might have originally guessed. I am amazed that a monarch butterfly with a tiny brain can migrate 2,500 miles and I need a GPS to get back home sometimes. Even so, humans still have unique capacities. Apparently, few animals have a real sense of self. Richard Leakey described how scientists have come to this conclusion.

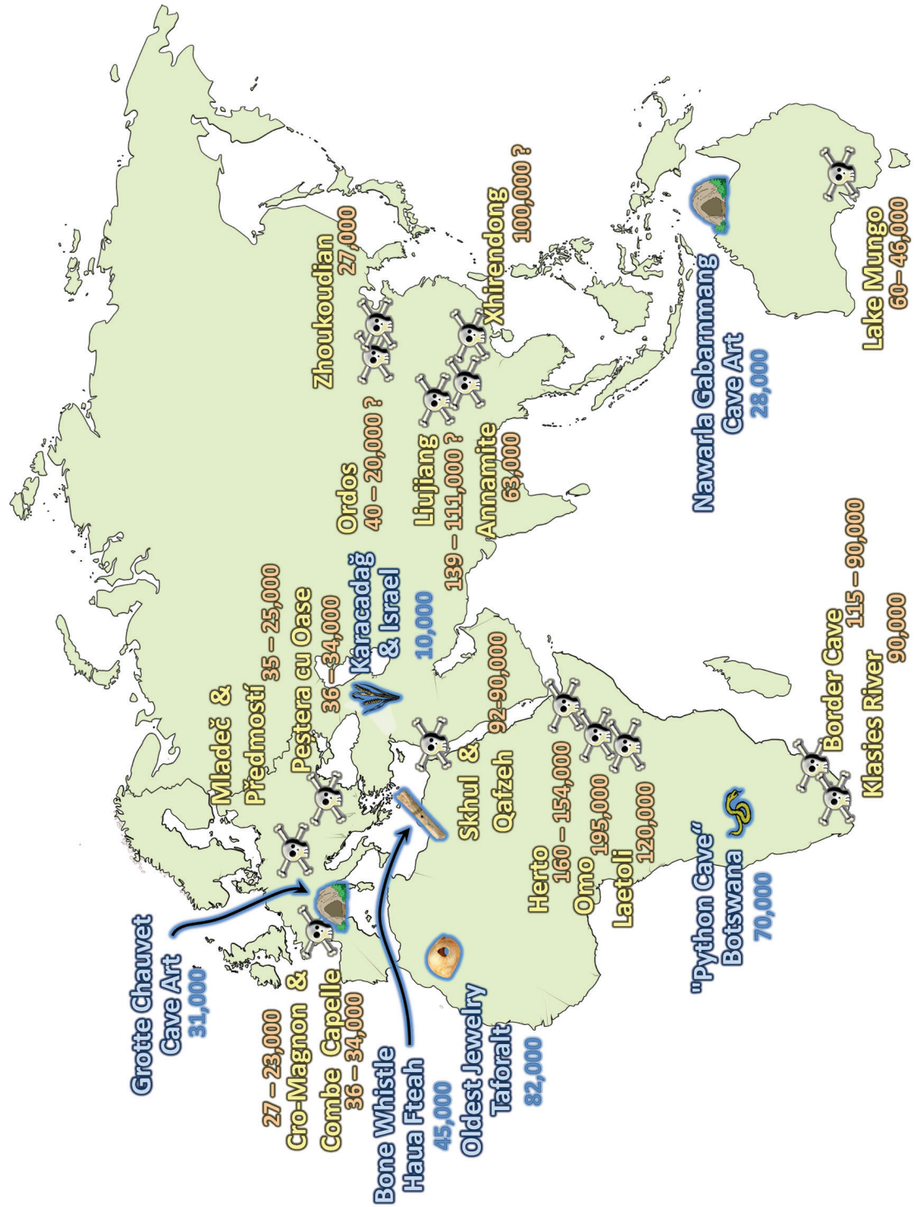


Figure 91 Map showing sites with key fossil evidence for early Homo sapiens and key archaeological artifacts (O'Neil 1999-2012; National Geographic 2007; Ministère de la culture et de la communication, n.d.; Associated Press; 2012; Bower 1995; Horwitz, et al. 2000; Vogt 2006)

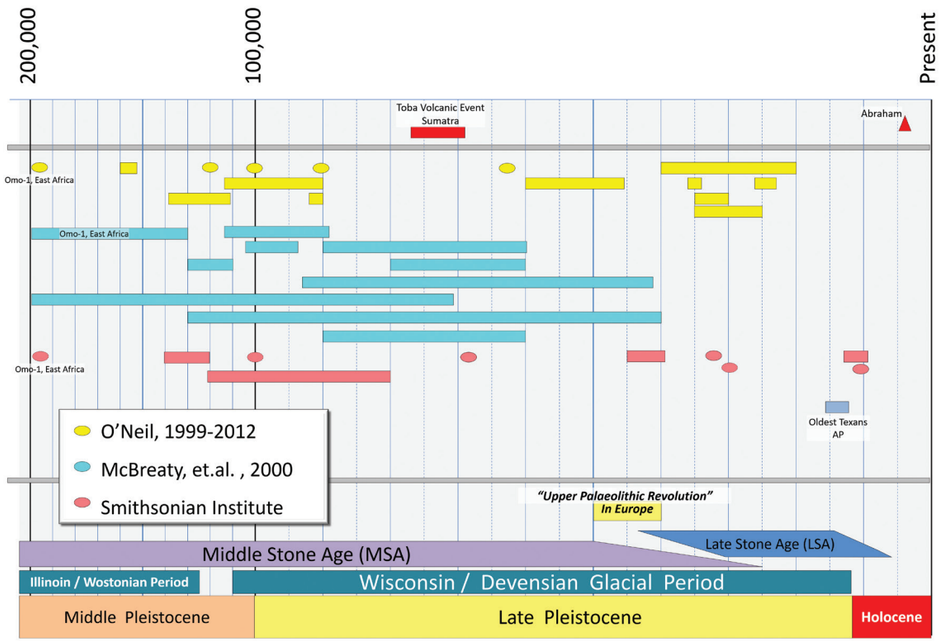


Figure 92 "Anatomically modern Homo sapiens" fossil data colored by source. Bars indicate indicated age uncertainty when provided. (O'Neil, 1999-2012; McBrearty and Brooks 2000; Smithsonian Human Evolution Research, n.d.; Chesner, et al. 1991; Schmid 2011)

> The test is simplicity itself. It involves first familiarizing the animal with the mirror, then marking the animal's head with a red spot. If the animal touches the spot after looking at its reflection anew, then, argues Gallup, the animal does indeed recognize the image as its own. "The first time we tried it with chimps, it worked," recalls Gallup. "These data would seem to qualify as the first experimental demonstration of self-concept in a subhuman form," he wrote in Science in January 1970. In the same paper he reported that neither the stump-tailed macaque nor the rhesus monkey "passed" the mirror test.
>
> Since that time many higher primates have been given the test, and so far only two have shown positive results, the chimpanzee, as in the original study, and the orangutan. The gorilla, the third of the great apes, apparently fails, a result that many observers find puzzling. (Leakey and Lewin 1992)

It appears that only a few primate species have the ability to mentally grasp the concept of self. Yet the fact that some do, means that with such creatures, God had a genetic code nearer His goal of creating man. (That does not mean that man is the only goal but it is clear that he was one goal.) What do the fossils show? Figure 92 shows some fossil finds reported in the literature. There are many choices of sources for such information. The dating of the various finds has been revised many times. There also are probably now and will continue to be other finds that extend this list, but these are significant and come from reasonably reputable sources. The very judgment as to exactly which fossils are considered "anatomically modern humans" is continually debated within the anthropology community. Some key points from Figures 91–92 can be summarized as follows:

1. Fossils from about 195,000 years ago show beings that were very similar to modern man (No one would expect that they were genetically identical because genes change over time, even by purely natural processes)
2. Many finds have been made across Africa, Europe, Asia, and Australia.
3. The oldest finds all come from Africa.
4. Considerable uncertainty remains in the actual date for many of the finds. (There is still uncertainty around the triangle points, but my sources did not give this range.)

Artifacts

Bones by themselves can only tell us so much. At most, they can tell us which hominids matched our anatomy. We cannot tell from them alone about the mental characteristics of the creatures. Artifacts offer additional clues but we must decide what we are looking for. Earlier hominids made arrowheads and stone tools. What would tell us that the artifacts were made by humans? Anthropologist Sally McBrearty describes the characteristics of human behavior this way:

We would argue that modern human behavior is characterized by:

- Abstract thinking, the ability to act with reference to abstract concepts not limited in time or space.
- Planning depth, the ability to formulate strategies based on past experience and to act upon them in a group context.
- Behavioral, economic and technological innovativeness.
- Symbolic behavior, the ability to represent objects, people, and abstract concepts with arbitrary symbols, vocal or visual, and to deify such symbols in cultural practice.
  (McBrearty and Brooks 2000)

These are all characteristics that we see in modern humans that are not found in animals. Archaeological finds document evidence showing that these characteristics were present in ancient cultures as well. Arguably they were not found or at least to any degree preserved in earlier hominid cultures. These may not in themselves prove that such beings had the spiritual capacity that biblical humans were endowed with, but they do each seem to be characteristics that we share with God. Each is important in our relationship with God, and it is reasonable that God may have created humans specifically with such characteristics in order for man to be able to have personal relationships with each other and with God.

Figure 93 places a number of key archaeological finds in chronological order, hopefully to help understand their relationships.[24] Indications of abstract thought, planning, and strategic thinking might also be demonstrated in other ways, but this figure gives some that are easy to recognize. Here are some general points that the figure demonstrates.

1. Symbolic thinking and spiritual interests are documented early.
2. No clear evidence of spiritual development has been dated so far before seventy thousand years ago.
3. Oldest finds for various arts and technologies found to date have a wide range in ages assigned.
4. Locations are varied including Europe, Africa, the Middle East, and Australia.

The cave art preserved in Europe and Australia give windows into the mental and cultural abilities of *Homo sapiens* nearly fifty thousand years ago (Figure 94). It is hard to imagine that the artists were not fully human. It is hard to know what spiritual elements are present in their art, but I would suggest that spiritual humans were present and at least as widespread as Australia by twenty-eight thousand years ago.

In 2006, archaeologist Sheila Coulson reported the discovery of what was hailed in the press as "the oldest human ritual" (Vogt 2006). She found evidence in Botswana for the worship of what is being called a python. The interpretation is that a rock formation there resembles a snake and that some seventy thousand years ago, early man carved three to four hundred indentations on the rock to create scales for the snake. Further, she found spearheads that had been brought from several hundred kilometers away and apparently somehow used in worship at the site. This would seem to be clear evidence of spiritual development at that point, even though the snake interpretation might be debated.

Human burials are often considered evidence of spiritual development. Burial alone might not represent proof of the spiritual side. McBrearty and Brooks (2000) noted that "if Neanderthals did deliberately bury their dead, there can be no certainty that the practice was ritual and not merely hygienic in nature" and "particularly significant is the lack of grave goods in Neanderthal burials." Other animals also seem aware of the dead. Giraffes and elephants are recorded to pay special attention to the body of a recently deceased close relative. Even birds have been reported to pay special

[24] A Web site authored by Dennis O'Neil of Behavioral Sciences Department, Palomar College, San Marcos, California has a good summary with good images: http://anthro.palomar.edu/homo2/mod_homo_5.htm

attention to their dead (Walker 2012). Yet for humans, dealing with death represents a special stage. Richard Leaky put it this way: "The ultimate vicarious experience, of course, is the fear of death, or simply death awareness." He reports that there are no indications that even chimps are aware that they will die one day.

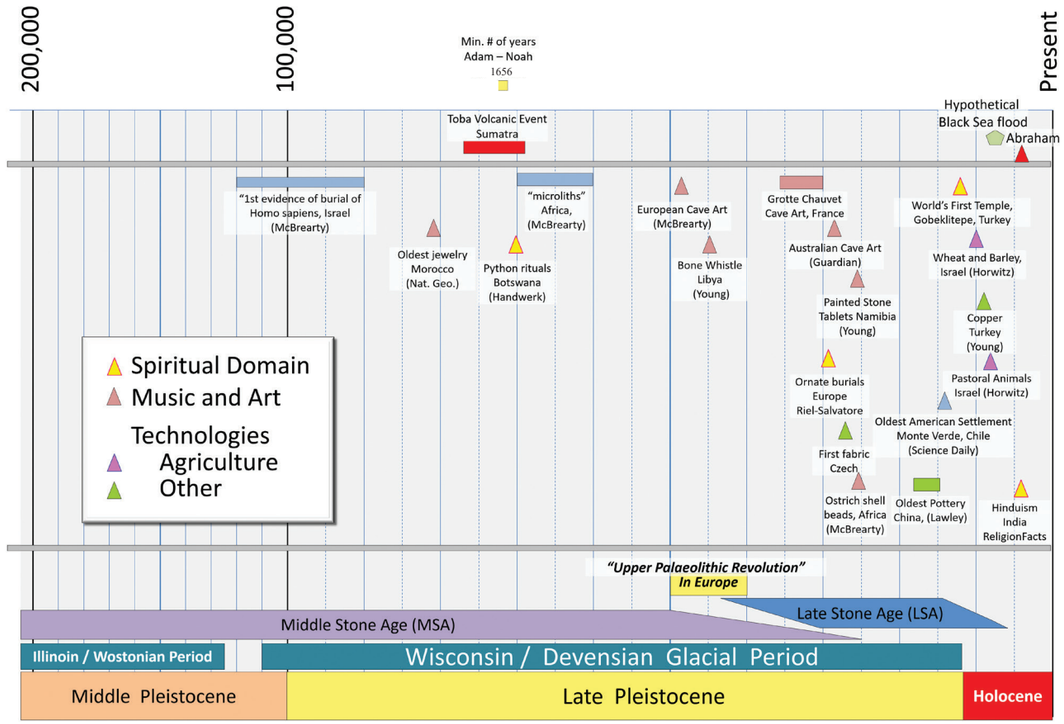


Figure 93. Archaeological artifacts representing first documented occurrences of various technologies and indications of higher mental/spiritual capacities. All are identified as related to "anatomically modern *Homo sapiens*." It is worth noting that many question whether or not the holes forming the "bone whistle" are man-made (McBrearty and Brooks 2000; *National Geographic* 2007; Young 2005, The Antiquity and the Unity of the Human Race Revisited; Ministère de la culture et de la communication, n.d.; Associated Press 2012; Bower 1995; Horwitz et al. 2000; Gobeklitepe 2009; Handwerk 2006; Religion Facts 2004; Science Daily 2008; Lawley 2009).

Figure 94 Cave drawings from Grotte Chauvet, France dated from 30-36,000 years ago depending on the source. © Sébastien Gayet - Syndicat mixte de la Caverne du Pont d'Arc

As shown in Figure 93, early examples are found of ornate burials. These imply that those who buried these recognized a spiritual side and may have recognized something beyond the grave. (Heritage Daily 2013). The earliest burials described as ritualistic have been found in Israel. Mellars (2006) describes them as follows:

> Three features of these finds are especially significant. The first is that at least two of the skeletons in these sites occurred in the form of clearly ceremonial or ritualistic burials, associated with seemingly unmistakably intentional grave offerings (a large deer antler lying directly on top of one of the Qafzeh skeletons and a complete boar's jaw said to be "clasped in the arms" of one of the burials at Skhul). Secondly, that, at least in the case of the Qafzeh burials, the remains were associated with a number of deliberately perforated seashell ornaments, together with large quantities of used and apparently heat-treated fragments of red ochre, almost certainly used as coloring pigments. And, thirdly, that, despite these clearly "symbolic" aspects of the archaeological material, the stone tool assemblages found in association with both the Skhul and Qafzeh remains were

of typically Middle Palaeolithic or MSA in form, without any trace of the distinctively modern or Upper Palaeolithic technological features recorded at the later African MSA sites of Klasies River, Blombos, and elsewhere.

It may be that as early as one hundred thousand years ago, give or take a few years, "anatomically modern *Homo sapiens*" practiced some sort of ritualistic burial. It is still possible that these were just examples of honoring the dead, with no spiritual recognition. By the time of the ornate burials in Europe at thirty thousand years ago, give or take a few years, it appears that a more spiritual side was present.

Although it is later, one site is perhaps of special interest. That would be Göbekli Tepe or Gobeklitepe, in modern day Turkey (Figure 95). It has been declared to be "the world's first temple" (Gobeklitepe 2009). Here, approximately twelve thousand years ago, a full pagan stone temple was built. The temple is interpreted to have been built by hunter-gathers, before agriculture (Mann 2011). Archeologists seem to be learning that one of man's fundamental characteristics is that he is religious. Today, many have atheism as their religion, but they are religious nonetheless. This site provides a useful point of reference in the Middle East.

Figure 95 Göbekli Tepe or Gobeklitepe, in modern day Turkey, a pagan temple built circa 12,000 years ago (By Teomancimit - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=17377542)

Figure 93 shows various discoveries ranging over a wide period of time with particular significance from about eight to eighty thousand years. Many researchers are convinced that there was a relatively short period of time when dramatic advances were made. This period is known as the "Upper Paleolithic Revolution" or to use terminology from Mao Tse Tung, the "Great Leap Forward." The evidence for this revolution and the views about it impact all the lines that I am considering: fossils, artifacts, genetic analysis, and language. For this reason, I will hold off on discussing it until the language section.

Genetic Analysis

DNA analysis did not exist a few years ago. "DNA fingerprinting" was born in 1984 and has exploded since. Today, it is a vital part of criminal investigation. Most people are aware that it can be used to establish paternity and family relationships. The patterns in our DNA provide clues about family linkages extending well back into the past. *National Geographic* is studying these patterns and will sell you a kit for two hundred dollars that will allow you to send a swab back to them and be told a great story about how you individually link back eventually to a single woman and a single man that we are all related to. (http://shop.nationalgeographic.com/browse/productDetail.jsp?productId=2001246andgsk). It is fascinating that geneticists agree that all humans have a single common female ancestor and a single common male ancestor. These are even referred to as Mitochondrial Eve and Y-chromosomal Adam. Those that developed this story definitely did not equate these with the biblical Adam and Eve, but the findings are important for theology as well. Confirming that all humans share the same ancestry means that we are all related. There is no basis to claim that a European stock arose and was possibly higher or better than the rest. The story of the fall of Adam and Eve relates to all of mankind. No one can claim that their lineage is different.

I will try to tread softly and tentatively because of my lack of expertise in this area. Reading a couple of books does not an expert make. It is certainly a busy research area, judging from the number of articles and headlines written in the last few years. Christians such as Dr Fazale Rana of Reasons to Believe and Michael Behe provide valuable resources that are helpful in looking at this area and trying to sort through and decide what to trust. Genetic analysis impacts our understanding of the history of humans in several ways including these four:

1. The interpretation of the timing and impact of Mitochondrial Eve and Y-chromosomal Adam on our understanding of the biblical Adam and Eve
2. Clues as to the location where the earliest humans lived
3. Interpretations of the migration routes that populations followed
4. Interpretations of early population sizes and possible "bottlenecks"

Some workers have reported *Homo sapiens* extending back beyond two million years ago based on genetic analysis, but there seem to be widely varying definitions of the species *Homo sapiens* (Hawks 2000). Genetics and the fossil evidence shown in Figure 92 are often reported to have similar conclusions. Here are two examples:

> Genetic and fossil evidence supports a single, recent (<200,000 yr) origin of modern Homo sapiens in Africa, followed by later population divergence and dispersal across the globe (the "Out of Africa" model). (McEvoy et al. 2011)
>
> Collectively these studies indicate that humanity originated recently (around 150,000 years ago, though there is significant uncertainty in the date), from a relatively small population (perhaps as small as a few hundred) from a single location (East Africa). (Rana 2012)

This comment from Dr. Rana helps to understand the precision and significance of dates provided by genetics.

> It is also important to keep in mind that dates for humanity's origin derived from coalescence analysis and molecular clocks are notoriously imprecise. Calibration of molecular clocks is extremely difficult, if not impossible, to accomplish. Researchers simply cannot determine with any real accuracy mutation rates and changes in these rates over time. Scientists typically must estimate the likely high and low values for mutation rates. The dates for humanity's origin extracted from genetic data of human population groups must be regarded as crude estimates, not ironclad conclusions. One researcher noted that molecular clocks are best thought of as "sun dials" not "stopwatches." (Rana 2012)

Recognizing the lack of precision provided by the dates, it seems reasonably certain that some sort of "anatomically modern" hominid appeared about 150,000–200,000 years ago. It is also clear that the genes of modern humans share strong affinity with these hominids. The pattern of distribution of human DNA tells that the humans spread out from a small area with a small population. The pattern tells us that the African populations are most closely tied to their ancestors and others all are tied to them. Put together with the oldest fossil and artifact finds, the "out of Africa" hypothesis postulates that modern *Homo sapiens* originated in east Africa and spread out from there.

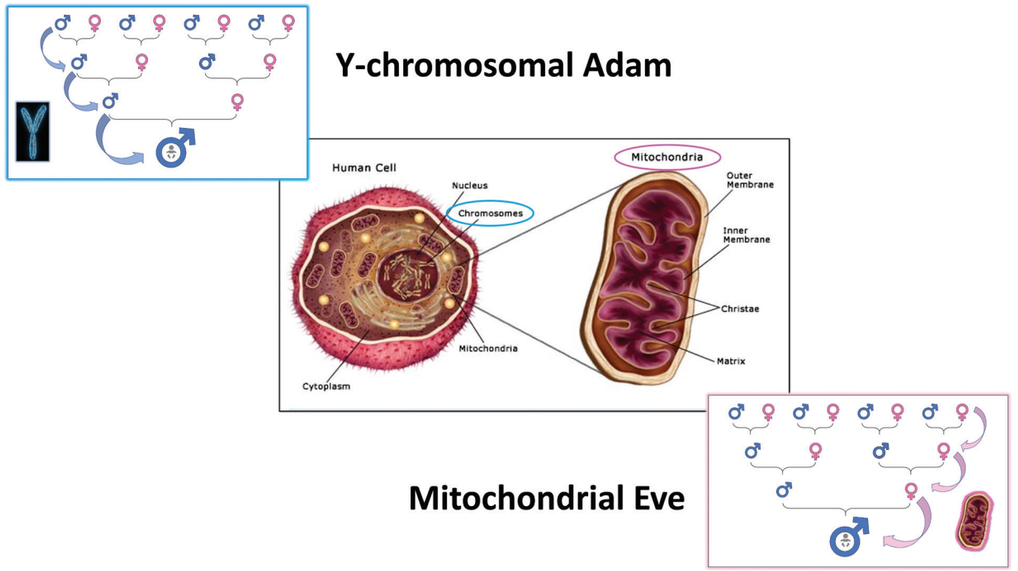


Figure 96 Human cell showing the mitochondria that is inherited directly along the maternal line and the Y-chromosome that transmits information from the paternal line.

Genetic studies of the DNA in the mitochondria demonstrate that this DNA is passed along the maternal line (Figure 96). They also demonstrate that all humans share a common female ancestor, called "Mitochondrial Eve." The name is obviously a biblical allusion, but the data does not prove that there was only one woman alive at the time. Genetic studies of Y-chromosomes demonstrate that the DNA within them is passed directly along the paternal line. Studies also demonstrate that all humans share a single common male ancestor, called "Y-chromosomal Adam." Again, the name is deliberately biblical, but geneticists typically reject the concept of a single first human. Most age estimates tend to make this "Adam and Eve" to have each lived in different times. This type of interpretation seems to be very linked to the assumptions of the investigator and the model algorithms that they have set up. Is it possible that given different assumptions, the data might allow or even demand a single couple at the same time? That is the interpretation given by Christian biochemist Dr. Fazale Rana who says,

> I also argue in Who Was Adam? The fact that all humans can trace their ancestry to a single mitochondrial DNA sequence indicates that humanity originated from a single woman. That is Mitochondrial Eve was the biblical Eve. (The corresponding reasoning would also apply to Y-chromosomal Adam.)

Others have challenged this interpretation, however, arguing that the genetic data indicates that humanity arose from thousands of individuals, not two. "The chief basis for this claim comes from estimates of the ancestral population size of humans based on genetic diversity." (Rana 2012, Who Was Adam? An Old-Earth Creation Model for the Origin of Humanity)

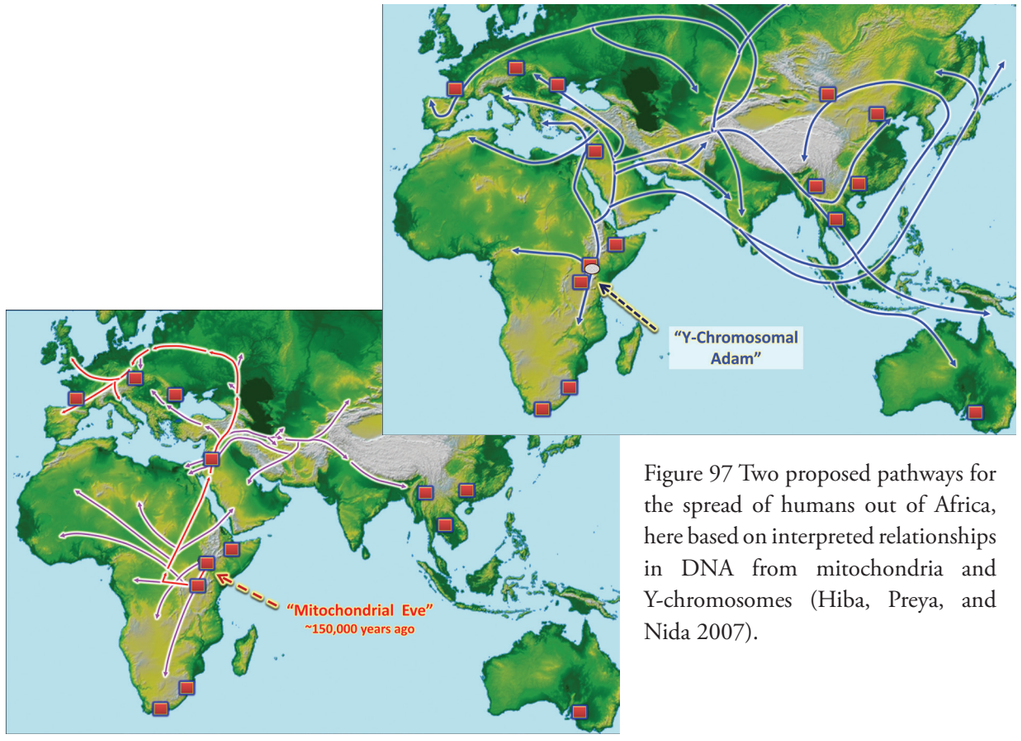


Figure 97 Two proposed pathways for the spread of humans out of Africa, here based on interpreted relationships in DNA from mitochondria and Y-chromosomes (Hiba, Preya, and Nida 2007).

I would speculate that few geneticists that publish would be open to considering the biblical model and would consider putting in the effort to evaluate the viability of any such options. They would have to be radically forced to this by the data, and so far, that has not happened. My personal opinion is that a single couple has not at all been ruled out by the data and as I will discuss later, a biblically based model still might look different than what we typically have been taught.

As noted earlier, DNA data is also interpreted to demonstrate migration linkages that show how humans spread from an origin in East Africa (Figure 97). Many theories are published. Some are based strictly on DNA. Others are derived based on fossils and artifacts, while others try to combine as much data as possible. There are many differences in the details, and some of these are not particularly small details. Can any of these be reconciled with Genesis? Stay tuned.

Fossils and artifacts provide great information about various specific locations scattered through time. Such data gives no real information about the overall population size through time. Genetic analysis does provide information that is related to the population size. Analysis involves assumptions and actual dates are at times in considerable question, but it is demonstrated that human genes have changed over time and the general observations seem valid. Again, a quote from Dr. Rana is useful.

> It is possible to estimate the effective population size of any ancestral group from genetic diversity of present-day populations if the mutation rate is known. As discussed in Who Was Adam?, a number of these types of studies do indeed indicate that humans stem from a small population, on the order of a few hundred to a few thousand. (Rana 2012)

Such sudden drops in population are referred to as "population bottlenecks" and generally these are explained as to have resulted from a sudden change in the environment, such as a rapidly forming ice age. Supporting evidence would typically be computer models that show a sharp decrease in the variation in the gene pool because few survived to pass their genes on. Several such bottlenecks have been reported. Rana reports one bottleneck that could have taken place "perhaps as recently as 150,000 years ago" (Rana 2012). Others have reported drastic bottlenecks that took place more recently. *Science Magazine*, the academic journal of the American Association for the Advancement of Science, reported this:

> Picture a frigid, overcast dawn, 65,000 years ago. A small band of human ancestors is leaving its campsite in Africa in search of food, scavenging their arid valley for fresh carcasses or small animals they can ambush. But times are tough, perhaps because the bone-chilling cold of the last Pleistocene Ice Age has made it difficult to find food and shelter. Whatever the reason, these early humans are suffering. While there may have initially been 100,000 of them, only 10,000 survive – making them an endangered species. "Our ancestors survived an episode where they were as endangered as pygmy chimpanzees or mountain gorillas are today," says Pennsylvania State University anthropologist Henry Harpending. (Gibbons 1993)

That was written in 1993, but the Smithsonian's Human Evolution Web site gives a similar assessment, as quoted here:

> About 74,000 years ago—Near extinction!
>
> Modern humans almost became extinct; as a result of extreme climate changes, the population may have been reduced to about 10,000 adults of reproductive age. (Smithsonian Human Evolution Research, n.d.)

Several studies try to relate this bottleneck to the massive explosion of the Toba volcano at approximately that time (Gathorne-Hardy and Harcourt-Smith 2003; Chesner et al. 1991). Of course, for every article relating the bottleneck to the volcano, there is another saying that the two are not linked. In any case, the possible bottleneck is interesting in understanding early human history and may possibly relate to the biblical account as well. The science points to dramatic changes in human behavior and distribution following an event that took place at approximately this time. Dr. Paul Mellars reports an episode of rapid population growth *ca.* 60,000 to 80,000 years ago. He speculated on the cause:

> First, we could suggest, as Klein has done, that the emergence of distinctively modern patterns of culture and technology was due to a sudden change in the cognitive capacities of the populations involved, entailing some form of neurological mutation (although, according to the model advanced here at 80,000 B.P. and not at *ca.* 40,000–50,000 B.P., as Klein himself has suggested). Or alternatively (and more prosaically), we could look for an interpretation in terms of some major shift in the adaptive and selective pressures to which the human populations were subjected, perhaps precipitated by some major episode of climatic and environmental change. (Mellars 2006)

Is it possible that such a key change in the cognitive capacity included a spiritual dimension? Is it possible that God brought about such a sudden change by creating Adam?

Study of Human Languages

Language is a totally unique characteristic of humans. We are genetically hard wired with the capacity for language. Not surprising, as we were designed to communicate with God. Parrots can mimic human voices and may even develop some understanding of the linkage between the sounds and the objects. Many mammals develop this. Our dogs have quickly learned what words like *snack* and *toy* mean. Our Westie understood the word *bath* very well and hid when she heard it. Human language is far beyond this. No other creature comes close. Earlier McBrearty and Brooks (2000) were quoted with a list of behaviors associated with modern humans. It is interesting that language is missing from the list. Part of the problem is that it is decidedly difficult to find proof of language from either bones or early artifacts. No early cassette tapes or even 78-rpm records have been dug up. When did language develop? Dr. James Hurford gave this opinion. "'The timing of the origin of language is anyone's guess' (Richards 1987:205). This assessment is near the mark, if not wholly right. The nature of the dating problem is to fit a series of vaguely and controversially hypothesized stages in

the evolution of language around a handful of approximate (and also controversial) dates for key non-linguistic events in human evolution" (Hurford 1999).

Symbolic behavior is often given as an indicator. It is hard to imagine complex symbology being communicated without language. Just think about trying to arrange a complex funeral without using language. Findings noted on Figure 93 suggest that language must have been in existence seventy to eighty thousand years ago. Dr. Jerry Hobbs gave this opinion: "Finally, fully modern language probably emerged simultaneously with Homo sapiens, and is what gave us a competitive advantage over our hominid cousins. We were able to construct more complex messages and therefore were able to carry out more complex joint action" (Hobbs 2005).

Others have the opinion that the early *Homo sapiens* did not actually have language but had "language readiness." It is worth thinking a bit about how language could develop by a naturalistic mechanistic process. At first glance, it might seem like an obvious progression from the grunts and gestures of a chimp to human language. However, it is far more complex than that. Physical and mental capacities are necessary. In fact, Hurford (1999) lists a number of factors that all must be present before even the capacity for language exists. These "preadaptations" include a series of cognitive capacity changes, social requirements, and physical changes. Hurford begins his list in this way:

> I give below a brief survey of some traits which have been suggested as preadaptations for language. The ideas briefly reviewed below are a small selection from many found in the literature. For each of these, it has been suggested that its presence was a necessary precondition for the emergence of Language. There is seldom, if ever, any serious consideration of the relative chronology of the various proposed preadaptations. Thus, each of the `preadaptations' reviewed below might be seen as the last and crucial step that gave us Language, or it might be one of an accumulation of necessary characteristics preceding that final step. (Hurford 1999)

Naturalistic evolution demands that each step along the development of each adaptation had to lead to some sort of reproductive advantage with no view of an end goal. It is a matter of faith that these existed because no one can describe such scenarios and, like the examples that Behe gives for "irreducible complexity," it would be easy for some of the changes to have put such beings at a disadvantage until all were present. Even then, having the prerequisites for language would not guarantee that it would appear, let alone demonstrate how or when it did. However, it is not difficult to consider these capacities as gifts that God provided to allow His people to experience and share a relationship with Him. Is it possible that language is an irreducibly complex gift handed to Adam and Eve as a completed work? Certainly, Genesis implies this.

Large amounts of study have gone into understanding modern language development and into what archaeology has revealed of ancient languages. We experience changes in language over our lifetimes. We see the effects of language change over somewhat longer periods just by observing the difference in English between England and the United States. For instance, some older verbs

continue in modern America that started in England but are no longer used there. Linguists have developed extensive genealogies for the development of modern languages using such clues. It would have been reasonable to predict that language would have developed separately by populations that were widely separated. However, after studying the syntax from over two thousand key languages from all over the world (Gell-Mann and Ruhlen 2011) demonstrated quite the opposite. They report the following:

> Recent work in comparative linguistics suggests that all, or almost all, attested human languages may derive from a single earlier language. If that is so, then this language—like nearly all extant languages—most likely had a basic ordering of the subject (S), verb (V), and object (O) in a declarative sentence of the type "the man (S) killed (V) the bear (O)."

That is another demonstration that all of humanity descended from a single group and they shared a common language. When compared to multiple language starts, Hobbs declared, "On the contrary, fully modern language has very likely been, more than anything else, what made us human right from the beginning of the history of our species" (Hobbs 2005).

He argues that *Homo sapiens* had this capacity at 150–200,000 years ago. Others feel that this was part of, if not the main driver for the "Upper Paleolithic Revolution." This 2011 quote reflects that view:

> Archeological evidence points to the sudden appearance of strikingly modern behaviour in humans around 50,000 years ago in the form of sophisticated tools and art like painting, sculpture and engravings. A possible reason for this could be the development of a fully modern human language, the protolanguage that eventually gave rise to all the current languages. (Sciencebyte 2011)

This "revolution" is hotly debated in archaeological/anthropological circles. Many see that over a relatively short period of time, dramatic changes took place in humans, as reflected in the quote above. Many argue with the dates involved, what technologies or behaviors are included, what areas were impacted, and what were the causes. Others argue that the changes weren't revolutionary at all but involve an accumulation of gradual changes. This view is reflected in the title of the McBrearty and Brooks article: "The revolution that wasn't: a new interpretation of the origin of modern human behavior" (McBrearty and Brooks 2000).

Whether it took place suddenly or over a somewhat longer period of time, new behaviors appeared that indicate a different level of sophistication. Dr. Ofer Bar-Yosef listed the following eleven changes in the archaeological finds that can be attributed to the "revolution" (Bar-Yosef 2002):

1. Systematic production of prismatic blades, and only rarely is flake production dominant
2. High degree of standardization and morphological variability prevails among tool types

3. Exploitation of bone and antler as raw material
4. Systematic use of grinding and pounding stone tools
5. Systematic use of body decorations—beads and pendants
6. Long-distance exchange networks in lithics, raw materials, and marine shells reaching several hundred kilometers
7. Invention of improved hunting tools such as spear throwers, and later bows and arrows and boomerangs
8. Human and animal figurines, decorated and carved bone, antler, ivory and stone objects, and representational abstract and realistic images, either painted or engraved, began to appear in caves, rock shelters, and exposed rocky surfaces
9. Storage facilities, generally known from northern latitudes where underground freezing kept food edible
10. Structured hearths with or without the use of rocks for warmth baking and parching activities
11. Distinct functional spatial organization within habitations and hunting stations such as kitchen areas, butchering space, sleeping grounds, and discard zones

Such changes show that man had at least entered into a new phase. It is uncertain exactly over what period of time the changes took place. All dating methods currently used carry uncertainty ranges and other new methods are likely to appear over time and some of these may be more accurate.

Archaeology is always just one find away from a very different picture than what is currently developed, and the "gradual" appearance of changes may over time collapse. Various numbers are quoted that range from thirty to seventy thousand years ago. This seems to correlate well with the genetic changes that we saw with population bottlenecks in the range of fifty to eighty thousand years ago. Many believe that the earliest changes took place in Africa, but that is also in question. Again, the lack of precision in the age measurements makes it impossible to be scientifically sure.

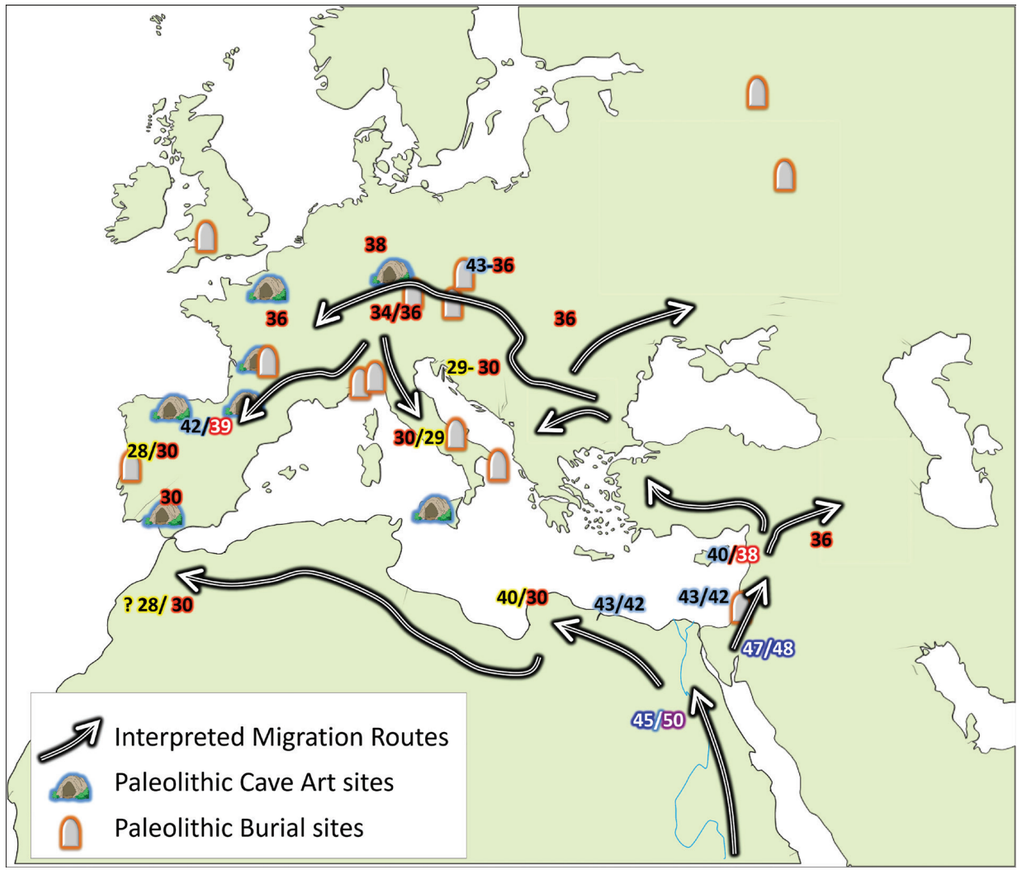


Figure 98 Map showing an interpretation for how "Upper Paleolithic revolution" technologies and presumably people migrated. Key cave art and burial sites taken from various publications are also shown. (Bar-Yosef 2002)

Figure 98 shows the interpretation of Dr. Bar-Yosef of Harvard (2002) in his summary paper of how the "revolution" spread across northern Africa and Europe. Is there some clear scientific reason for why so many major cultural changes took place in a short time? If there is, then scientists sure have not agreed on what it is. Rapid technological changes, emergence of a human culture, common use of symbols including evidence of religion, and long-distance alliances all took place at approximately the same time. Many believe that they took place effectively simultaneously across broad areas. Does language come into play? Most seem to think so. "All scholars agree that language plays a major role and that it probably evolved in time [Wynn 1991, Trask et al. 1998]. Communication

facilitated everything from transfer of technologies to long-distance exchange. This in turn had effects on subsistence economy and therefore led to population growth" (Bar-Yosef 2002).

Is it possible that the *Homo sapiens* brain needed just a bit more final genetic development to be able to handle language, cope with widely varied environments and create the technologies and tools that would grow human culture? That certainly is proposed if not agreed upon. It has been suggested by a number of works that language demanded a change in the brain and some insist that real genetic changes formed a fundamental cause for the "revolution." Bar-Yosef sums up this position this way:

> The main proponent of the need for an additional mutation, a neurological change in the human brain to explain the capacity for modern behavior, is Klein (1995, 1999, 2001a,b). In his view only this change brought about the socio-economic restructuring that is documented in the archaeological records across the continents. His explanation takes into account what was earlier called "Out of Africa 2" (Stringer and Gamble 1993), which posits that modern humans dispersed from Africa some 60,000–50,000 years ago. Hence, according to Klein it was only after 50,000 years ago that humans possessed and expressed the markers of modern behavior.
>
> By reference to contemporary studies of general trends in human brain evolution it was proposed that a complex internal circuitry evolved between the separate sections of the brain, mainly in order to increase efficiency in the social information processing that was essential for survival in variable environments under fluctuating climatic conditions. Among the most effective means would be language, and not surprisingly the emergence of language is seen as a determinant factor. Whether following Chomsky or Pinker in their views of genetically programmed "universal grammar" or "language instinct," the question that remains open is whether it was a one-time biological change or a long building process. (Bar-Yosef 2002)

To summarize, the scientific data are varied both in terms of the type of data, the confidence in it, and the dates represented. No single scientific story exists for how, where, and when modern humans originated. Many different interpretations are held and a case can be made for each. Some generalities seem to be consistently pointed to. Here is a list that impacts our concerns in this document:

1. The oldest "anatomically modern" *Homo sapien* evidence comes from Africa and dates approximately from 150 to 200,000 years ago.
2. Humans are all related, sharing a common female and a common male ancestor and come from one small group.
3. DNA evidence indicates that there have been sharp "bottlenecks" in human population size with one occurring approximately fifty to seventy-five thousand years ago.

4. The capacity for symbolic thinking and human culture may have arisen in a relatively short time in the "Upper Paleolithic Revolution."
5. This "revolution" may have started in the Middle East around the same time as the "bottleneck."
6. A spiritual dimension could have appeared at the same time, with the earliest evidence reported approximately seventy-five thousand years ago with "snake worship" in
7. Botswana. Human languages all can be traced back to a single human language.
8. It is proposed that changes such as the "Upper Paleolithic Revolution" and the appearance of language were related to some sort of genetic change that appeared at that time.

How Do They Correlate?

How can we correlate the Bible's version with the scientific data? Is that even possible? This quote from Ostling's article "The Search for the Historical Adam" in *Christianity Today* shows that some evangelical Christians have real problems with this: "In a recent pro-evolution book from InterVarsity Press, The Language of Science and Faith, Collins and co-author Karl W. Giberson escalate matters, announcing that "unfortunately" the concepts of Adam and Eve as the literal first couple and the ancestors of all humans simply "do not fit the evidence" (Ostling 2011).

Admittedly there is no definitive scientific proof that demonstrates a historical Adam and Eve or when they lived, but we probably should not expect it. Genesis and modern scientific data interpretations were written thousands of years apart and are different in terms of purposes, levels of detail, and spiritual insight. One problem is that, at this time, there are a number of opinions as to how to interpret both the Bible and the scientific data. Table 2 lists some of the views held by those who try to integrate the scientific data with the Bible. For comparison, naturalistic evolution is included. It is a sharp contrast to the other views.

It is clear that even Christians who do try to work with scientific data come to different conclusions. There are multiple options to consider. Think of these as separate hypotheses proposed that need to be examined. Geologist T. C. Chamberlin advocated working multiple hypotheses simultaneously as a way to keep from landing on a favored answer too quickly (Chamberlin 1890). Perhaps this is a good place to try that methodology. Perhaps that is why Dr. Davis Young, a geologist from Calvin College, treated the problem in terms of three different hypotheses in his 2005 article, "The Antiquity and the Unity of the Human Race Revisited". Chamberlin advises that the "The effort is to bring up into view every rational explanation of new phenomena, and to develop every tenable hypothesis respecting their cause and history." As Christians, it is certainly difficult to stand back from all the Sunday school lessons and sermons that we have heard and really speculate on other options, let alone seriously consider them. Nevertheless, it is important to open up as many hypotheses as possible. Next, we can consider each. Some may be eliminated on examination.

Those left remain possibilities with assorted strengths and weaknesses. If this were an oil exploration prospect, we might use a system to assign probabilities to those remaining and use those as a basis for our economic evaluation. Assigning probabilities, even in the oil industry involves subjective decisions. In this case, we may consider those with the most support to be more probable, but we should recognize that human interpretation is not perfect and one of the other hypotheses could be true or the answer may be one that we did not even think of. In this report, two assumptions will be made. First, the Bible is God's word and hence presents truth. My reasons for assuming this were presented earlier. Considering Adam and Eve, this assumption rules out the naturalistic evolution position because the story of Adam and Eve is far more than a Hebrew fable. The second assumption is that the scientific evidence is generally true. This evidence does include interpretation, and the absolute ages are sub- ject to revision but in general, it is not going away. Dembski may be right that Genesis is basically written in God's time (kairos), but in our time (chronos), the scientific findings must be explained to understand the origin of humans and understand the historical interpretation of Adam and Eve (Dembski 2006).

Table II Comparison of views regarding how complex life developed and interpretations of Adam and Eve. Intelligent design is more of an alternative to naturalistic evolution than a view of scripture.

Creation Position:	Naturalistic Evolution	Intelligent Design	Theistic Evolution	Progressive Creation or Old Earth Creation
Driving cause:	Accident	God or other intelligent designer	God	God
Key Mechanisms:	Mutation Natural Selection Historical contingencies (accidents)	Mechanisms may have varied but natural selection and mutation demonstrated to be inadequate	Mutation Natural Selection Historical contingencies (God ordered?)	Mixture of design and creation, Opinions vary about how much specific creation was involved
Associated terms	Survival of the fittest	Irreducible complexity	Fully gifted creation	Concordism
Adam and Eve:	Hebrew fable	Variable	Opinions range from non-historic to historic but not 1st humans	Typically viewed as historic 1st people in a literal Garden of Eden
Comments:	Inadequate explanation for origin of life	Demonstrates inadequacy of mutation and natural selection to explain life	Exaggerates the capabilities of mutation and natural selection	Man may be the only direct created lifeform
	Requires faith that the same mechanism that causes small changes can account for large changes	By itself, it cannot identify the designer	Difficult to reconcile with scripture	Believes God actively particpates with His creation
Leading proponents:	Richard Dawkins and many natualistic scientists	Michael Behe Phillip E. Johnson Stephen C. Meyer	Howard J. Van Till Francis S. Collins	Hugh Ross Faz Rana Davis Young

Hypothesis 1: Adam and Eve Are a Metaphor or Allegory

The first hypothesis is that God provided the spiritual truth that humans needed in terms of a story that they could understand but did not literally happen as we think of history. At the beginning of this section on Adam and Eve is a list of eleven specific details given in Genesis. If the Genesis accounts are to one degree or another a metaphor, this hypothesis does not really address these details as historical facts. The details are at least in part the tools that were used to build the story to teach important concepts such as these:

1. Humans are God's special creation.
2. Both men and women are equally designed for a personal relationship with God.
3. Satan tempted humans and they rejected God's ways.
4. This fall cost men their close walk with God and brought about their spiritual death.
5. God promised a cure and restoration that would one day come.

Jesus commonly communicated spiritual truths by means of parables, and this hypothesis would say that much of Genesis 1–11 is in the same category. Few Christian theologians would have entertained such a theory until the last two hundred years or so. However, a number of evangelical TE proponents accept this idea today. Many conservative Christians tend to condemn such ideas very strongly. They seem to believe that such a concession to liberal ideas would completely ruin the theology and beliefs of any Christian. Some caution might be advised. It would be hard to find a good book on Christian apologetics that does not include many quotes and strong influence from the English Oxford and Cambridge don, C. S. Lewis. However, he seems to have considered the biblical account of the creation of man in less than literal terms as reflected in this quote:

> For long centuries God perfected the animal form which was to become the vehicle of humanity and the image of Himself. He gave it hands whose thumb could be applied to each of the fingers, and jaws and teeth and throat capable of articulation, and a brain sufficiently complex to execute all the material motions whereby rational thought is incarnated. The creature may have existed for ages in this state before it became man: it may even have been clever enough to make things which a modern archeologist would accept as proof of its humanity. But it was only an animal because all its physical and psychical processes were directed to purely material and natural ends. Then, in the fullness of time, God caused to descend upon this organism, both on its psychology and physiology a new kind of consciousness which could say "I" and "me", which could look upon itself as an object, which knew God, which could make judgments of truth, beauty, and goodness, and which was so far above time that it could perceive time flowing past. This new consciousness ruled and illuminated the whole organism, flood-

ing every part of it with light, and was not, like ours, limited to a selection of the movements going on in one part of the organism namely the brain. Man was then all consciousness.

We do not know how many of these creatures God made, nor how long they continued in the Paradisal state. But sooner or later they fell. Someone or something whispered that they could become as gods. (Lewis 1940)

The nonliteral view is reflected in this quote from Denis O. Lamoureux (born 1954):

Real history in the Bible begins roughly around Genesis 12 with Abraham. Like many other evangelical theologians, I view Genesis 1-11 as a unique type of literature (literary genre) that is distinct from the rest of the Bible. (Emphasis from source). (Lamoureux 2013)

Lamoureux and others holding such views consider that God knew that men were not able to comprehend a more detailed account. He accommodated them, inspiring the author of Genesis to present this early history in a way that man could understand. Every Christian should understand that God does accommodate us in order for us to understand Him. In the earlier illustration, General Grant simplified the story of the Civil War, accommodating it for a young boy, but he could make it simple, and historically accurate. Although Moses undoubtedly believed many things about science and nature that we know to be untrue today, these beliefs are subtle if present at all in the Genesis text. This in itself is evidence of God's sovereign control over the Biblical text. Taken to extremes, accommodation could be used to explain away any inconvenient statements through the Bible. Those holding this view must make their case convincing in ways that are careful to honor the historical narrative in which God's story is told.

Strengths. Perhaps the major strength of this interpretation is that it can never be disproven by genetic or archaeological evidence. The spiritual truths remain valid. Genesis does make many specific claims about humans and their character. These have been proven over and over again. To use again the aging general metaphor, this would be like the general looking down at the little boy in front of him and recognizing that if he told the lad the details, the boy just would not understand what he really needed to know. Instead he decided to tell a story that would tell what he really needed, but in figurative form. Proponents of this view might say that to claim that the only way a story can be true is if it is scientifically and historically true is a modern phenomenon. Perhaps that just really wasn't important to the author and his immediately intended readers.

Weaknesses. In beginning this section, I expressed my opinion that the Bible presents Adam and Eve as historical people, both in the Genesis account and through to the references of Jesus and Paul. This has been the traditional view of Christians expressed in confessions and in the writings of conservative Christian theologians for centuries. It is difficult to see that one would ever arrive at this first hypothesis based on a direct reading of the scripture. Perhaps the greatest concern is the

subjective nature of choosing what is figurative and what is literal. If this is a matter of convenience, then the Bible loses its authority.

What Might We Learn in the Future that Would Impact This View? The case for this hypothesis might be considered weakened if further discoveries are made that strengthen one of the other alternatives, such as in archaeology or genetics. It is possible that further biblical studies will provide more support for this interpretation, but this is interpretation of essentially the same data.

Hypothesis 2: Adam and Eve Are First of Abraham's ancestors

The Bible presents the Jews as God's chosen people, through whom He revealed Himself. It records how at one point, God took the form of a Jewish baby in order to grow up and to pay the price of sin so that man could have the personal relationship with his creator that both man needed and God desired.

Abraham is known as the father of the Jews, but in Genesis 2–11 and Luke 1, the genealogy of Jesus is traced back all the way to Adam. The biblical Jewish genealogy definitely begins with Adam and Eve. If the genealogical lists have no major gaps, then Adam would have been created approximately six to ten thousand years ago (MacArthur 2001).

Hypothesis 2 is that a historical Adam and Eve indeed were created in that time frame and were then the originators of the Jewish people. This corresponds approximately to Young's "recent representative" category (Young 2005). In this hypothesis, they were not however the first or the only humans. As Adam was a "type of Christ" (Rom. 4:12), he was also a "type of human." The experience of Adam being tempted in the garden would have been one example of the type of fall that happened to all mankind. Just as Adam's sin caused his spiritual death, the disobedience of other humans caused their need of a savior. Regardless of when or how literal the Adam of Genesis was, Christians should all recognize that he is also used in the Bible as a symbol to teach us about mankind. John H. Walton (b. 1952), professor of Old Testament at Wheaton College, considers Adam and Eve "archetypal figures" and sees that as their primary function, as in this quote:

In my view, Adam and Eve are historical figures - real people in a real past. Nevertheless, I am persuaded that the biblical text is more interested in them as archetypal figures who represent all of humanity. This is particularly true in the account in Genesis 2 about their formation. I contend that the formation accounts are not addressing their material formation as biological specimens, but are addressing the forming of all of humanity: we are all formed from dust, and we are all gendered halves. If this is true, Genesis 2 is not making claims about biological origins of humanity, and therefore the Bible should not be viewed as offering competing claims against science about human origins. If this

is true, Adam and Eve also may or may not be the first humans or the parents of the entire human race. Such an archetypal focus is theologically viable and is well-represented in the ancient Near East. (Walton 2013)

Walton sees this function as common in ancient Near Eastern literature though the biblical Adam and Eve are also significantly different both in terms of their roles and setting and in terms of the theology and lessons they represent. There is no evidence that they were copied or derived from any earlier tradition. Walton would not necessarily tie them to the time frame suggested here, but his views would be consistent with it.

How does this hypothesis compare to the specific biblical claims listed earlier? Here are my comments:

1. Humans were created differently than the other plants and animals
   Works for Adam and Eve but does not address other humans. Did He create them the same way?

2. Male and female were created on the sixth day of creation
   If the sixth day of creation was the final age of creation, then it works fine.

3. They were created in God's image?
   Again, what about other humans? Were they the same by analogy?

4. Adam was created first and then moved to a special garden in the land of Eden
   No Problem

5. Eve was made from a part of Adam to complete him and to be his partner in life.
   No Problem

6. Adam and Eve enjoyed an intimate relationship with God in the Garden.
   No Problem

7. A dark power took the form of or used an ordinary animal as a mouthpiece to deceive this pair and led them to disobedience (Collins 2006)
   No Problem (He is still busy that way.)

8. This disobedience caused humans to experience death
   Again, what about other humans? Were they the same by analogy?

9. God promised a cure for the curse that came upon them as a result of their disobedience
   No Problem

10. These two had sons and daughters
    No Problem

11. Three sons were named Cain, Abel, and Seth
    No Problem

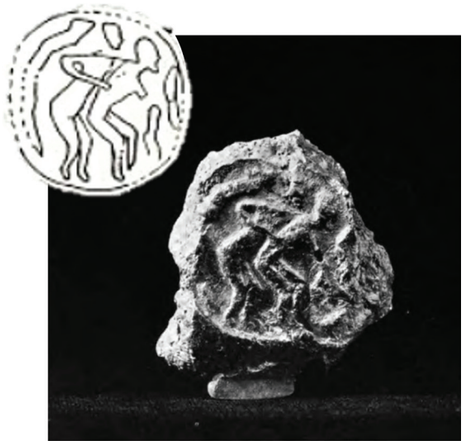


Figure 99 Seal from the Iraqi site of Tepe Gwara that shows a naked man and woman with a snake looking over their shoulder. Dated to ca 3500 BC (Speiser 1935)

Figure 100 Chaldean seal from the British Museum dates to ca. 2200-2100 BC. It shows a man and either a woman or a god. The man is reaching for a tree and there are obvious snakes over their shoulders. (Reproduced by permission of Associates for Biblical Research (ABR holds to a young earth interpretation of Genesis but have graciously allowed this use of their image.) (Associates for Biblical Research 2009)

Strengths. An obvious strength of this hypothesis is that it makes Adam and Eve and all the people in Genesis to be taken as historical people. The when and where of the fall are taken in literal sense. The Mesopotamian region has many stories about creation, flood, and early man. The contrasts between the Genesis account and the others are very stark, but there are some similarities. There are hints that even the story of Adam and Eve was known to the people of this region. (Custance 1988) The ancient seals in Figures 99 and 100 show that there was a very early tradition that involved snakes and trees, but we have no information about what the stories involved. Perhaps if God created Adam and Eve a few thousand years ago, their story survived in many forms, but Moses under God's direction was able to provide a correct answer. Another "strength" for this hypothesis is

that new discoveries in archaeology are not likely to provide problems for it. Presumably when Cain went off to marry, then in this scenario, he married another human that was not of Adam and Eve's seed. Perhaps Adam became the leader of the early population of man in that region, using John Collins's suggestion quoted earlier.

In this scenario, and in fact all the proposed scenarios, early pre-human hominids are found that could have had advanced minds. Some were apparently close to being able to mentally comprehend spiritual concepts. If they could, would that be a problem for these hypotheses? How did God deal with them? We can study and consider options for this for as long as we want, but I suggest that all we will have is theories and opinions. In this quote, C. S. Lewis considers the question of the spiritual state of animals:

> So far as we know beasts are incapable either of sin or virtue: therefore they can neither deserve pain nor be improved by it. At the same time we must never allow the problem of animal suffering to become the centre of the problem of pain; not because it is unimportant—whatever furnishes plausible grounds for questioning the goodness of God is very important indeed—but because it is outside the range of our knowledge. God has given us data which enable us, in some degree, to understand our own suffering: He has given us no such data about beasts. We know neither why they were made nor what they are, and everything we say about them is speculative. (Lewis 1940)

Just as the spiritual state of animals has not been revealed to us, God has not revealed to us the type of relationships or requirements that God had for the pre-spiritual hominids. By the way, if God created higher lifeforms in other parts of the universe, they would fall into the same category.

In this hypothesis, we are simply not told how other humans were created or if they sinned. Using again the analogy of General Grant and the civil war, imagine that he tells his grandson about the curse of slavery, about the great battles at Gettysburg and Antietam and about Lee's surrender at Appomattox. The young boy goes off, having learned valuable lessons about the price of freedom and how the Union was preserved. Later, when the boy is much older, he is told about the naval battles that were fought. He is shocked and dismayed that his grandfather failed to tell him about them. He goes up to the aging general and says, "Grandpa, you didn't tell me about ships or navies. I can't believe what you said when I was just a young and innocent boy." Maybe some modern Christians are like this young man. God thankfully spared us from a detailed historical and scientific account but provided us with those portions that teach us the key lessons that we needed. In this hypothesis, the story that would ultimately lead to Jesus was the important portion that God chose to provide. We would then have to trust that God dealt with other beings that existed justly and would eventually through Jesus provide the justification for their sins.

Weaknesses. The view that Adam and Eve were not the literal ancestors of all humans is still very much a minority view among evangelical Christians. Does scripture demand it? Genesis 3:20 refers to Eve as "the mother of all the living." In Acts 17:26, Paul reported, "From one man he made every

nation of men, that they should inhabit the whole earth; and he determined the times set for them and the exact places where they should live." Hypothesis 1 considered much of the story of Adam and Eve to be metaphorical. Hypothesis 2 demands that verses such as these two must be speaking metaphorically or "archetypally." It is not hard to find evidence that all humans are spiritually equivalent. All evidence that I have seen indicates that all people, regardless of race or nation, begin in a state of separation from God. They have sinful natures as abundantly evident by their actions. People of every nation have been reported to experience the spirit of God drawing them to himself and to experience the Holy Spirit coming into their life. Symbolic or literal, Adam and Eve were the first humans as evidenced by the spiritual state of modern man. It does not seem particularly likely that other humans waited for Adam to come along to sin. Hypothesis 2 offers no link to archaeology or the genetic mitochondrial Eve or Y-chromosomal Adam. This view also would be typically linked with an interpretation of Noah's flood that is both local and did not involve all humans. This topic will be discussed further later.

What Might We Learn in the Future that Would Impact This View?

Like hypothesis 1, the case for hypothesis 2 might be considered weakened if further discoveries are made that strengthen one of the other alternatives, such as in archaeology or genetics. Archaeological finds that anchor Genesis 1–11 in the time frame of the last ten thousand years do strengthen this case. Perhaps theologians will be able to present convincing means to understand the implications concerning other humans. No more scripture will be forthcoming, but over time God does seem at times to provide new ways to look at the scripture. Certainly, Dr. Walton's work is a helpful example.

Hypothesis 3: Adam and Eve Are First "Anatomically Modern Humans"

Both of the next hypotheses consider Adam and Eve to have been created as the first "biblical humans" but farther back in time. Thus from a theological basis, they tend to have some similar strengths and weaknesses. The differences between them involve how to integrate them with the archaeological data. These might be considered analogous to Young's "Adam and Eve as Ancient Ancestors" category (Young 2005).

Integrating either proposal with the biblical view involves pushing the historical Adam and Eve back well beyond what a simple reading of the genealogies implies. I have already noted that biblical scholars recognize that biblical genealogies cannot be taken as given and interpreted to represent a simple timeline the way that moderns wish. Forcing them into that mold represents an interpretation pitfall to be avoided. A number of scholars have concluded that it is simply impossible to deter-

mine the elapsed time based on the genealogies. This is not a new discovery. William Henry Green studied biblical genealogies in great detail, and in 1892, he concluded this:

> On these various grounds we conclude that the Scriptures furnish no data for a chronological computation prior to the life of Abraham; and that the Mosaic records do not fix and were not intended to fix the precise date either of the Flood or of the creation of the world. (Green 1892)

Their primary purpose was typically to document relationships. Matthew 1:1 summarized the genealogy of Jesus like this: "A record of the genealogy of Jesus Christ the son of David, the son of Abraham."

Perhaps some of the Genesis genealogical relationships are similar.

Even so, pushing Adam and Eve back further than approximately ten thousand years makes it worth considering just what possible sources in human terms were used by the author of Genesis. Modern society probably does not appreciate the methods and accuracy possible in transmitting oral traditions, but still if very long amounts of time are involved, it becomes more doubtful that facts would have come through by this method alone. The author, regardless of who he was, had to have some source or sources for the information in the book and this is relevant to these hypotheses. Where would Moses have gotten his information? One possibility would be that all of the leaders in the godly line, including Adam and Noah and more obscure people such as Arphaxad (Gen. 11:12), etc., led the people to learn the history that was eventually recorded by Noah. Other people in the region might have remembered pieces of the story but not most of it. This would seem more likely if less time were involved.

Another possibility might be that Moses took stories that the people of his area and era were familiar with and through divine guidance, recast them into the present monotheistic form. This implies that shreds of truth would have been remembered in early civilization but that God inspired (inspired = God breathed) Moses to pen them accurately. This would seem to be more plausible if one accepts a more metaphorical interpretation.

Another option would be more direct revelation. Consider, how would Moses have known about events that took place before Adam was created? If God revealed this history to him, perhaps much more came from revelation. Perhaps much of the history from the first eleven chapters of Genesis came this way. We have noted that the author writes as if he were recording what was general knowledge for his readers. Perhaps, the original divine revelation was to Abraham or some other person before. The book doesn't say. Cassuto, the Jewish commentator, believed that the author of the Torah drew on the "epic poems" current to the Israelites at the time. He wrote,

> Among the Israelites, too, there existed, prior to the Biblical account, narrative poems about the creation and the beginning of the world's history. Although these poems have not come down to us, having perished in the course of time, evidence of their existence is to be found both in this section and in other parts of Scripture. (Cassuto 1944)

If God revealed the story of creation to someone earlier than Moses, one possibility would have been for that person to have presented God's revelation by way of epic poems, making them easier for the Israelites to learn. Many have noted similarities with other ancient Middle Eastern stories. Perhaps some of the stories that God revealed were told widely in this region. This might be a way to explain similarities to other ancient writings such as the Babylonian Gilgamesh narrative that will be discussed later. If Adam and Eve lived thousands of years ago, such as in the time spans demanded by Hypotheses 3 and 4, then perhaps these epic poems were part of how God transmitted His message through generations to later man.

Hypothesis 3 is that Adam and Eve were the first "anatomically modern" humans and ancestors of those found by anthropologists. Figure 92 shows that the current dating would then mean that they would have lived earlier than two hundred thousand years ago. Let's look at what this might mean for the eleven specific biblical claims listed earlier with comments about how this hypothesis would relate to them:

1. Humans were created differently than the other plants and animals
   Adam and Eve would have been created just as the Bible said. Perhaps the dust of the ground in Genesis 2:7 contained DNA from previous hominids. It is fair to say that we all come from dust and will return to dust (Ps. 103:14, Eccles. 3:20). God took this biopsy and modified it to create Adam. This genetic linkage to all of life means that today we learn from them how to save lives. That is why doctors can test medicines on lab rats and other animals before actually using them on humans. He then took a biopsy from Adam to create Eve. This would definitely constitute a different type of creation.

2. Male and female were created on the sixth day of creation.
   The sixth day of creation was the final age of creation, and this model works here.

3. They were created in God's image?
   With Adam and Eve as the parents of all mankind, this is consistent with this hypothesis.

4. Adam was created first and then moved to a special garden in the land of Eden.
   I see no real conflicts with this. It does bring up the question of where Eden was. More on this later.

5. Eve was made from a part of Adam to complete him and to be his partner in life.
   No problem as noted above.

6. Adam and Eve enjoyed an intimate relationship with God in the Garden.
   No problem

7. A dark power took the form of or used an ordinary animal as a mouthpiece to deceive this pair and led them to disobedience (Collins 2006).
   No problem

8. This disobedience caused humans to experience death.
   No problem

9. God promised a cure for the curse that came upon them as a result of their disobedience.
   No problem

10. These two had sons and daughters.
    No problem

11. Three sons were named Cain, Abel, and Seth.
    Here, things do get interesting. It will be worth examining what we know about these sons to see about what it potentially says about the timing of Adam and Eve.

Strengths. This alternative has much to offer on the theological side in the sense that Adam and Eve are created special as the first humans. Some might be uncomfortable with stretching the biblical genealogies out as far as two hundred thousand years, but there does not seem to be a specific logical objection to such a long period even if it is a stretch.

Weaknesses. On the scientific side, there are genetic concerns that must be considered. The geneticists agree that their data indicates that humans arose from a population rather than from two individuals. Dr. Rana argues that the genetic diversity that leads to this conclusion can still be reconciled with an origin from two individuals, the biblical Adam and Eve (Ross and Rana 2005). How can this be? Can scientists disagree? No doubt! Geneticists make assumptions about the rates of mutation and use them to derive an "effective population size." Many estimates have been made and admittedly all would give population sizes well beyond two. Would we even understand what assumptions to use for the computer models to test the biblical hypothesis? It is reasonable to assume that God designed humans to have a wide diversity, but how he would have arranged for the genetic diversity is difficult to know. In my opinion, the jury is still out on the starting population size.

The genetic challenge is not the only question to be answered. On the theological side, there are questions as well. As alluded to above, Cain and Able as presented in Genesis 4 are not as easy to understand in those older ages. How are we to understand the beginnings of civilization as we see it in Genesis compared to our archaeological finds? If Adam and Eve were created 150–200,000 years ago, then why don't we find evidence of civilization until much later? Dr. Young described the issue like this:

> I suggest that intriguing scientific challenges still remain for this historic view of human origins because of the data contained in Genesis 4. There Cain is evidently the firstborn son of Adam and Eve. As befitted one who "worked the soil" brought an offering of the fruits of the soil. He sounds like a farmer, not simply a person who gathered wild fruits and vegetables. His brother Abel "kept flocks," and so brought an offering "of the firstborn of his flock." He sounds like a shepherd. After Cain killed his brother, he escaped to the land of Nod, fathered his son Enoch, built a city, and named it after his son. At the very least he established some sort of permanent settlement. Within a few generations, the descendants of Cain were using musical instruments, working metal, and engaging in the nomadic herdsman lifestyle. Genesis 4 seems to describe the cultural achievements associated with the Neolithic revolution, evidence of which is preserved in archeological sites throughout the Near East. (Young 2005, The Antiquity and the Unity of the Human Race Revisited)

Dr. Young described the "Neolithic revolution" as having taken place approximately 8000 to 7500 BC. That is a long way from two hundred thousand years ago when anthropologists date the first "anatomically modern humans." Genesis 4 doesn't leave a lot of room for making Cain and Abel some sort of much later descendant of Adam, so either archaeology has just not discovered this earlier civilization or else it actually looked much different than we imagine and just doesn't correspond at all to the "Neolithic revolution." Figure 93 illustrates that evidence of the components of civilization, including spiritual aspects existed much earlier than the date Young used. It is conceivable that the date could move back, but it is a stretch to move back to two hundred thousand years ago. Perhaps our aging General Grant metaphor would again be useful. Maybe the wise old general would have talked to the child using terms that he would understand to allow him to connect to those back in the war. Perhaps when God revealed the history of early humans to man, it was in similar ways. Perhaps Cain and Abel's agricultural lives were just not what we think of. Perhaps evidence of that older civilization was taken out by Noah's flood. Is it possible that after the flood, civilization actually degraded for a time? Perhaps that is one effect of dispersal after Babel.

Another question to consider is how does the biblical Eden relate to the "out of Africa" proposal from genetics and bones? The Bible describes a region known as Eden with a garden area located in it. It doesn't tell us how large the garden was or how large Eden was. Genesis 2:10–14 names these four rivers: Pishon, Gihon, Tigris, and Euphrates. The last two are in Iraq, but no one really knows where the other two were (Figure 101). Many commentators conclude that they are probably in the same region. That is not the only option however. Here is another opinion:

> Alternatively, the Pishon and Gihon may be references to the Blue and White Nile. Part of the support for this view comes from Genesis 2:13, which states that the Gihon "winds through the entire land of Cush." In the Old Testament, Cush (the land) equates to Ethiopia, but it can also refer to Kassites,

descendants of the patriarch Cush. The Kassites lived in Mesopotamia. (Rana and Ross 2005, Who Was Adam?)

At this point, it is fair to say that we don't know exactly where Eden was. It potentially may be more important to learn how mankind spread after Noah's flood than where Eden was. That will be discussed later.

Figure 101 Shaded relief map of Middle East (map by Kenneth Townsend, PA, USA)

What Might We Learn in the Future that Would Impact This View? Future genetic studies will no doubt propose new dates and options. It would strengthen the case for this hypothesis if options are recognized that would open up the possibility that humans began with one couple. It is more likely there will simply continue to be reasonable objections to models that are proposed by geneticists that demand larger populations. On the archaeological side, it is very possible that finds will discover indications of agriculture in earlier times. It is not impossible that some ancient document will be

discovered that helps to understand the rivers named in Genesis 2. On the theological side, convincing arguments may be developed that help with the concerns about Cain and Abel.

Hypothesis 4: Adam and Eve Represent a Dramatic Population Bottleneck Fifty to Seventy-Five Thousand Years Ago

Is it possible to be physically a man without being human? Men can certainly be inhumane, but in this case, I mean that there were those who were physically human but without capacity for spiritual relationships. Hypothesis 4 says that this was the case in the past. Anthropologist will never be able to discover a bone or DNA signature that proves the presence or absence of a spirit within their finds.

Figure 93 documented a number of evidences that suggest that the spiritual dimension existed over the last fifty to seventy-five thousand years. It has got to be at least ironic in view of the serpent in Genesis 2, that today's oldest evidence of worship is the snake worship reported in Botswana (Vogt 2006). As of today, it is hard to point to any clear evidence of modern human behavior or a spiritual dimension in any hominids before that point.

One scenario that would fit this hypothesis is that pre-human *Homo sapiens* existed from approximately two hundred thousand years ago. Then most or all of these hominids disappeared, perhaps catastrophically. At this point, God chose to create Adam and Eve as spiritual beings. We simply do not have any data to tell us what happened to the other hominids or what relationship with God they may have had. Adam and Eve had children who had some form of agriculture, but we are not told what that looked like. Again, it might have looked quite different than what we typically envision. We are told about a flood that may have destroyed evidence but more about that in the next section.

Now here is how this might relate to the eleven specific biblical claims listed earlier:

1. Humans were created differently than the other plants and animals.
   Again, Adam and Eve would have been created just as the Bible said. Just like for the last hypothesis, God may have modified the DNA from the dust of the ground from previous hominids. He also could have simply duplicated it by creative fiat.

2. Male and female were created on the sixth day of creation.
   The sixth day of creation was the final age of creation, and this model works here.

3. They were created in God's image?
   Adam and Eve would have been the parents of all mankind, and this is consistent with this hypothesis. Other Homo sapiens *were either dead or in some other category.*

4. Adam was created first and then moved to a special garden in the land of Eden.
   Similar to the previous hypothesis, we can speculate about Eden.

5. Eve was made from a part of Adam to complete him and to be his partner in life.
   Again, the "rib" as translated into English was basically a biopsy that He used to create Eve.

6. Adam and Eve enjoyed an intimate relationship with God in the Garden.
   No problem

7. A dark power took the form of or used an ordinary animal as a mouthpiece to deceive this pair and led them to disobedience (Collins 2006).
   No problem

8. This disobedience caused humans to experience death
   No problem

9. God promised a cure for the curse that came upon them as a result of their disobedience
   No problem

10. These two had sons and daughters
    No problem

11. Three sons were named Cain, Abel, and Seth.
    The archaeology has not shown agriculture this early, but it seems possible that some sort may have existed.

What Might We Learn in the Future that Would Impact This View? Cases for Hypothesis 3 and 4 will both be strengthened if genetic options are recognized that would open up the possibility to begin with one couple. It certainly would favor this hypothesis, if genetic dates are younger than the *Homo sapiens* fossils. Such models might not even be considered. If archaeological finds continue to demonstrate evidence of culture beginning in the fifty to seventy-five thousand years, this would support hypothesis 4. Where might such finds be located? Maybe they will be found where it is difficult to study today. Archaeologist Jeffrey Rose has pointed out that about seventy-four thousand years ago, the Persian Gulf looked much different than today (Rose 2010). Sea level was lower and no saltwater-filled gulf existed. The overall climate in the area was much drier. He theorizes that there was a "Gulf Oasis" approximately seventy-four thousand years ago. Humans may have lived here and spread out of it. Today, it is a bit dangerous to do detailed studies there, but perhaps someday, studies will help test this hypothesis further.

I have presented four hypotheses for how Adam and Eve might fit into our "chronos." I do not believe that I can completely eliminate any of them. Is it possible to assign some sort of "probability

of occurrence" to them? One's view of that probably depends on one's relative confidence in factors such as the genetic evidence that mankind arose from a population numbering in the thousands and one's comfort with less literal interpretations of Adam and Eve as the first humans. Evangelical Christian views run the gamut on these and other factors. This author finds it more probable that the interpretation of the genetic data could be flawed than that Adam and Eve were not historically the ancestors of all humans. Even so, the next question also is important to harmonizing Genesis and science in our time, "chronos."

3 Noah and the Flood?

My wife and I moved from Dallas, Texas to the Woodlands, Texas, in the year 2000. As we began to look for a home and look at areas, a key consideration quickly became, "What did this area look like during the flood of 1994." In October of 1994, storms brought up to twenty-eight inches (71 cm) of rain into the area and what has been called a "one-hundred-year flood" occurred. People still remember the flooding and the disruption of their lives. We knew that if a home was high and dry in 1994, then it was more likely to remain so in future floods. Many areas have historical floods that are important milestones in their history. Genesis claims that there was one ancient flood that was a key milestone for all of mankind.

The first part of this document looked at "flood geology" and its attempt to explain most of the geologic strata to have formed by that flood. If the "flood geology" theory fails, does that mean that the flood was a fable? The Bible presents it as a key milestone at least for the Jewish people. Did it affect all of mankind? This is the final question in this book to be addressed in looking at options to relate Genesis and science: Is the biblical account of Noah's flood a record of a real historical event and if so, what can we say about it?

Here, again, we will look at this in terms of a series of discrete questions. Answering these should help to understand the flood.

1. Does the Bible demand a literal flood?
2. When would Noah's flood have happened?
3. What was the extent of the flood?
4. What might the flood have looked like?

Does the Bible Demand a Literal Flood?

If skeptics write Noah's flood off as a fable, a huge miracle that sophisticated people should not even consider, does that mean that modern Christians should bury it? Genesis describes the flood in a historical narrative, not a poetic section. The literature genre is not ambiguous. If the flood was just a fable, that would have important implications for how we should treat the rest of scripture. Another problem with considering the flood just a fable is that Noah is referred to several times in the New Testament (Matt. 24:36–39; Luke 17:27; Heb. 11:7; 1 Pet. 3:18–20; 2 Pet. 2:4–5). As I noted earlier, Jesus' reference to Noah can be considered an eye witness account from an impeccable source.

What is more, other ancient sources also support the reality of a vast flood in the Mesopotamian region. Arguably all the most ancient historical narratives contain accounts of a major flood. Kitchen reports that there are three other ancient history narratives written in from *ca.* 2000 to 1600 BC. He states,

> Thus, within about 1900–1600, a firm tradition having the framework of creation, then crisis (flood), then to later times was to be found in three Mesopotamian works, with which in literary terms Gen. 1–11 belongs, as a fourth example, after which the genus is no longer cultivated, merely the existing pieces recopied. (Kitchen 2003)

Here the basic contents are common to both the Mesopotamian and Genesis accounts. So we have in both: a flood sent as divine punishment; one man enjoined to build an "ark"; he taking family and living creatures; and his survival. In detail, the differences are so numerous as to preclude either the Mesopotamian or Genesis accounts having been copied directly from the other. (Kitchen 2003)

So, an epochally important flood in far antiquity has come down in a tradition shared by both early Mesopotamian culture and Gen. 6-9, but which found clearly separate and distinct expression in the written forms left us by the two cultures. In terms of length and elaboration, Gen. 6:9–8:22 might be equal in amount to about 120 lines in Sumerian or Akkadian. Contrast the lengths of at least 370 lines in Atrahasis II–III, some 200 lines in Gilgamesh tablet XI, and the roughly 150/200 lines in the Sumerian account. Genesis thus offers a more concise, simpler account, and not an elaboration of a Mesopotamian composition. As to definition, myth or "protohistory," it should be noted that the Sumerians and Babylonians had no doubts on that score. They included it squarely in the middle of their earliest historical tradition, with kings before it and kings after it, the flood acting as a dividing point in that tradition, from long before 1900. (Kitchen 2003)

The simplest explanation is that Noah's flood was a historical event. With Adam and Eve, I made the assumption that the Bible is God's word and hence presents truth. The same can be said of Noah's flood. A fable explanation doesn't work for this writer.

When Would Noah's Flood Have Happened?

We do know one thing for sure about the date of the flood. It was after the biblical Adam and Eve. Genesis 5 records the generations from Adam to Noah with lifespans that were incredibly long. The chronology yields a total elapsed time of 1,656 years, if they are taken at face value and no gaps are present. That can be considered a minimum timespan from Adam to the flood. Of course, the problem with this plan is that I spent the last section showing that there are several options for when Adam and Eve lived. That leads to at least three ranges of options for dating the flood as shown in Figure 102. If Adam and Eve were the ancestors of all people, then the flood had to have been early. If not, then it could have taken place much later.

What Was the Extent of the Flood?

The first part of this document was spent evaluating the "flood geology" interpretation that most of the stratigraphic record resulted from Noah's flood. I concluded that the rocks unequivocally just do not fit that explanation. Does that mean that Noah's flood was not global? If you went to church as a child, there is a good chance that your teacher told you that the flood covered the entire world. It is probably safe to say that none of them came to that conclusion based on science alone. What is the biblical evidence that leads to that interpretation? Here are five biblical reasons often given to believe that the flood covered the whole globe.

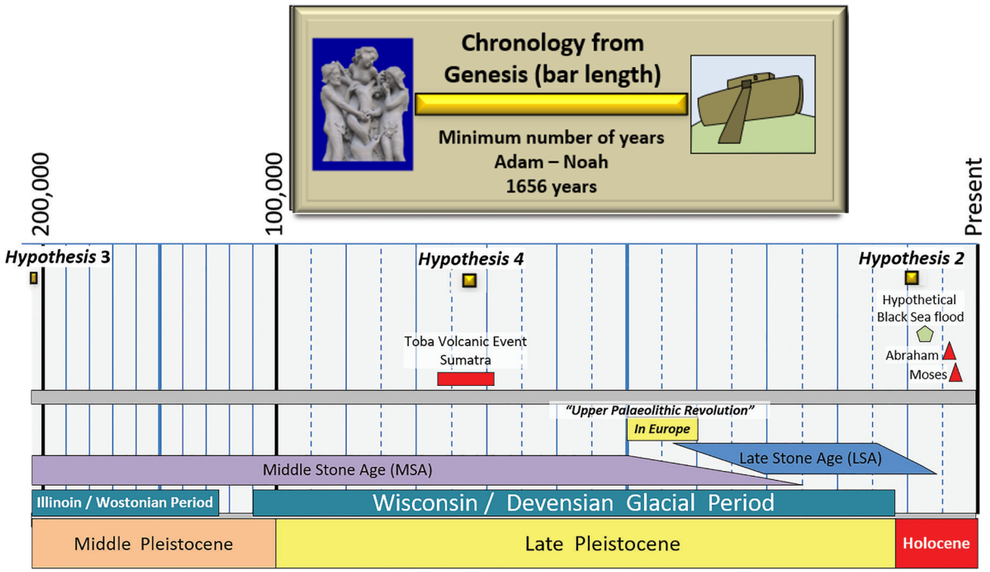


Figure 102 Options for dating when Noah's flood might have occurred based on the Genesis genealogies. (International Stratigraphic Commission 2010)

1. *Matches Simple Reading of Text*

Here are examples of verses that are used to prove the flood was global:

> For behold, I will bring a flood of waters upon the earth to destroy *all flesh in which is the breath of life under heaven. Everything that is on the earth shall die*. Gen 6:17
>
> For in seven days I will send rain on the earth forty days and forty nights, and *every living thing that I have made* I will blot out from the face of the ground. Gen 7:4
>
> The flood continued forty days on the earth. The waters increased and bore up the ark, and it rose high above the earth. The waters prevailed and increased greatly on the earth, and the ark floated on the face of the waters. And the waters prevailed so mightily on the earth that *all the high mountains under the whole heaven were covered*. The waters prevailed above the mountains, covering them fifteen cubits deep. And *all flesh died that moved on the earth, birds, livestock, beasts, all swarming creatures that swarm on the earth, and all mankind. Everything on the dry land in whose nostrils was the breath of life died.* He blotted out every

> living thing that was on the face of the ground, man and animals and creeping things and birds of the heavens. They were blotted out from the earth. Only Noah was left, and those who were with him in the ark. Gen 7:17–23

The Hebrew word *erets* is translated as earth and can simply mean ground. If it meant simply the local ground here, then the text could be simply describing a similar type of flood as happens periodically in the Mesopotamian region. Several flood deposits have been recognized and sometimes identified as deposits from Noah's flood. The Genesis phrases highlighted above demonstrate that this was no ordinary flood. Some have concluded that the text describes a purely natural event, but I would suggest God's judgment may have utilized miracles. It would have been the type of miracles where, from our viewpoint (chronos), the normal laws of nature were for a period of time superseded by God's direct action. Those actions probably would have looked like normal cause and effect from outside of chronos, i.e., kairos. Many commentators conclude that the language demands that the flood was global. For example, John Montgomery Boice writes:

> Verse 19 is important, for in that verse, the Hebrew work for "all" (kol) occurs not once but twice, in what can only be called a near-Hebrew superlative. The text says that the floodwaters rose greatly on the earth so that "all the high mountains under the entire heavens were covered." That means that the entire earth was covered. (Boice 1982, 1998)

I agree that the language indicates that this flood was totally unique in history, but the global interpretation needs to be examined more closely. It is worth thinking about what did the entire "face of the earth" mean to Moses in the thirteenth century BC. We can be pretty sure that neither Moses nor Noah thought in terms of a spherical earth or knew about Australia or North and South America or Antarctica. Moses wrote, "And all the countries came to Egypt to buy grain from Joseph, because the famine was severe in all the world" in Genesis 41:57 (NIV). In this instance, "all the world" certainly referred to a far more local area, not the whole globe. It is not difficult to find instances where words like "all" should not be taken to mean all in an ultimate sense. If a modern person were to have written the phrases in Genesis, we could be sure that they would have meant a global event. It is not so evident for Moses. Does it matter where he got his information? It has been suggested that if his information ultimately came from divine revelation, then that would mean that since God knew about the entire globe, then we can be sure that the words meant that the globe was covered. Why would we assume that God would not have revealed the flood in terms of reference that the people knew at that time? It would be thousands of years before this would even be an issue.

2. *Why Else Would Noah Bring All of the Animals?*

I have a vivid memory of riding home one day with my daddy in eastern New Mexico. Our car was meeting another car and a dog ran out in front of us. Daddy had to quickly choose whether to swerve to miss the dog and hit the car or whether to hit the dog. His decision saved my life but cost the dog's life. It was not a fun choice, but it was the right one. When God sent his judgment on mankind, it cost a lot of lives, but it was also God's love acting to save mankind. This judgment also cost many, many animal lives as well. There is no evidence that they were judged for any sin that they had committed but died in order that God's judgment on man could take place. If Noah's flood was a local flood covering a particular region, then why didn't He just cause the animals to migrate away? Genesis uses phrases such as "every creature that has the breath of life in it" and "men and animals and the creatures that move along the ground and the birds of the air were wiped from the earth." Francis Schaeffer stated the concern this way, "Another difficulty arises if the flood is not universal, and I don't see how anyone can quite get around this factor. If a flood occurs in a limited area, a lot of animals can be drowned but not all of them. There is no way you can eliminate all of them unless they are all in a sealed canyon. When a forest fire or flood comes, the animals take off" (Schaeffer 1972).

What types of animals were involved? It sounds like every land dwelling living thing in English. The Genesis text uses seven Hebrew words to characterize them. Hugh Ross comments,

> All these words refer to birds and mammals, though some can be used a little more broadly. We see a high correlation between this list and the list of soulish animals God created on the fifth and sixth creation days, animals that held significance in the Preparation of Earth for humankind. Clearly, the survival of these creatures would be important to the restoration and survival of human society after the Flood. Nothing in the Genesis text compels us to conclude that Noah's passengers included anything other than birds and mammals. (Ross 1998)

Perhaps this helps answer the age-old question: Why did Noah bring along the mosquitoes? Probably at most, they were stowaways. The minimalist approach would be to say that Noah brought along the domesticated animals and those closely related to man. That interpretation seems difficult to reconcile with the text. Even if the flood was not global, then the scale suggested by the text still indicates that a large number of species of animals boarded the ark, including both those closely associated with man and those not normally associated. Some of the "clean" animals were needed for sacrifices, but many were not. One way of understanding this is to say that Noah brought together all of the creatures necessary to reestablish the flooded ecosystem or ecosystems after the flood. Mammals and birds may have been dominant, but such ecosystems typically include other animals as well. Again, the overall tenor of the text makes it clear that a very large area was involved and presumably many ecosystems would have been affected. If the flood was "local," then this local was

huge. God did not have them migrate away perhaps because they couldn't but also because God wanted a dramatic visual warning to humans of the coming judgement.

3. *Ark Landed on Ararat*

Noah's ark came to rest on the "mountains of Ararat" (Gen. 8:4). Does this mean that the ark came to rest on the mountain that is known today as Mt Ararat? If the flood covered the modern summit that is at 16,854 feet (5,137 m), then that makes an argument that the flood was global (Figure 103). After all, if sea level were to rise up anything close to seventeen thousand feet, little of the earth would be unflooded. Is that what Moses had in mind? Apparently not, as Cassuto discusses here:

> On the mountains of Ararat--that is, on one of the mountains of the land of Ararat. The name Ararat, in Assyrian Urartu, was the designation of a region north of Assyria; and after the Armenians had invaded that area and settled there (apparently in the sixth century B.C.E.), their country was called Armenia after them. (Cassuto 1949)
>
> However, none of the identifications of the Biblical Ararat with a specific mountain has any basis in the Scriptural text, for the expression on the mountains of Ararat, correctly interpreted, only connotes a mountain—unspecified—in the land of Ararat. (Cassuto 1949)

The text makes it clear that the waters covered something that were called mountains and that the ark landed in what were named the mountains of Ararat in biblical times, but that does not make the flood global.

Figure 103 Mt. Ararat located in modern Turkey, elevation 16,854 ft. (5,137 m). Image licensed from shutterstock,com

4. *Promise of the Rainbow*

When Noah and the ark's occupants came off the ark, God promised them, "Never again will all life be cut off by the waters of a flood; never again will there be a flood to destroy the earth" (Gen. 9:11). We know that flooding has caused the death of millions. In 1931, flooding along the Yangtze River was reported to have killed 3.7 to 4 million people, perhaps the most people killed in any natural disaster, at least since 1900. How are we to understand God's promise? Was He saying there would be no more floods? Obviously not. Was God promising that He

would never again flood the globe? Perhaps His promise was never again to intervene supernaturally to destroy almost all of mankind. At least it was this promise to Noah's descendants.

5. *Guarantees that All Humans Died*

If God chose to bring His judgment on all mankind and man had spread around the globe, then a global flood would have been required to destroy them. Christians debate both aspects of this. If one can argue that the description of earth is not global, then it is equally possible that the description of who was to be judged could be more limited as well. Bernard Ramm expressed this view as follows:

> The flood was local to the Mesopotamian valley. The animals that came, prompted by divine instinct, were the animals of that region; they were preserved for the good of man after the flood. *Man was destroyed within the boundaries of the flood; the record is mute about* man *in America or Africa or China*. The types of vegetation destroyed quickly grew again over the wasted area, and other animals migrated back into the area, so that after a period of time the damaging effects of the flood were obliterated. (Ramm 1955)

Many conservative Christian scholars conclude that even if the flood covered a more limited area, all of Adam's seed were destroyed except for those on the ark. If Adam and Eve were literally the first humans and lived before spiritual man had left the flooded region, then God's judgment over humanity would have been total. The Bible suggests that mankind remained in the Middle East as described by Hugh Ross:

> Biblical clues to the geographical limits on human habitation can be found in the place- names Genesis mentions or does not mention. In Genesis 1:9 the text mentions place-names only in the environs of Mesopotamia. From Genesis 10 onward, we encounter references (by name or direction) to places beyond Mesopotamia, in fact, to places covering much of the Eastern hemisphere. This sudden shift from narrow to wider geographical range after Genesis 10 strongly suggests that until the time of the Flood", human beings and their animals remained in and around Mesopotamia. Therefore, to fulfill His purpose in sending the deluge, God would need to flood only the Mesopotamian plain and perhaps some adjacent territories. (Ross 1998)

It is interesting that there are ancient legends of floods in the mythology of people all around the world. Many believe that these legends represent evidence of the historicity of the flood and its impact on people all around the world (Boice 1982, 1998). The stories vary significantly from the Genesis account but often have remarkable similarities. Even non-Christian authors have noted how

universal these flood myths seem to be such as in this quote from Leakey and Lewin, where they note a flood legend from the Yanomamos, an indigenous people from the Amazon valley in South America:

> The appearance of a devastating flood in the Yanomamos' origin myth is, incidentally, just one of many examples of a flood as an essential agent in a society's birth. Real floods can loom large in the worlds of many people, and often must have threatened their safety. *But ubiquity of flood myths-they can be found in societies on every continent-has convinced anthropologists that their origin is more fundamental, less tangible.* "I would ascribe these myths to that basic and clearly universal human longing—manifested less dramatically when a man changes his job or moves to a new house—to get rid of an unsatisfying past and start all over again," speculates the anthropologist Penelope Farmer. "Just so a world, post-flood, could be restored to innocence, to another Eden, all bitter experience laid aside, and the history of mankind begin anew." (Leakey and Lewin 1992; emphasis added)

This author finds it a much simpler explanation to recognize that they have a common origin in a historic flood. In general, the accounts seem to have more in common with the account in Genesis, the closer they come to Mesopotamia. One explanation would be that all of humanity carried the collective memory of the devastating judgment but that Moses had the added advantage of divine revelation, though it may have been revealed to one of his ancestors.

We looked at three different hypotheses that include a literal Adam and Eve. These include different age ranges for when Noah's flood might have occurred (Figure 102). If Adam and Eve lived in the last ten thousand years such as in hypothesis 2, then we can rule out that the flood killed everyone except for Noah's family. A more recent flood goes with a more limited extent both in terms of area and in terms of people included. If Clovis man lived in Eastern New Mexico eleven to thirteen thousand years ago, then a recent flood would not have impacted them.

6. *Comparison to Second Coming of Christ*

One evidence that is often sited to indicate that the flood had to be global is the analogy that Peter presented in 2 Peter 3:3–7 where the second coming of Christ is compared to the flood (Snelling 2009; Boice 1982, 1998; Schaeffer 1972; Whitcomb and Morris 1961). The argument is that Peter used Noah's global flood as an example of a judgment to be compared to the future global judgment that will be associated with the second coming of Christ. Noah's flood is undoubtedly a clear example of God's direct judgment as well as His provision and ability to deliver those who trust in Him. I can't see how that is changed if the judgment was for over all of Mesopotamia, particularly if all of mankind died except for Noah and his family. Just as Adam is a type of Christ and the

Passover Lamb was a picture of a greater truth, Noah's flood, regardless of its physical extent is an effective type of the judgment of God and deliverance by grace.

Problems with a Global Flood Interpretation

An infinite God certainly has the power to render His judgment. It is not a question of if He could have flooded the earth, but did He choose to do so? We can be sure that the reality of how He chose to do so is true to both the Bible and other real evidence, but data we have now has some important gaps. As Ramm pointed out in 1956, this is not a disagreement between Christian and skeptics because the skeptics don't believe in Noah's flood at all, at least as God's judgment. Christian scholars who believe that Noah's flood was not global believe that there are adequate answers to the objections and point to theological, geological, and biological issues to support their belief. Here are examples:

One theological issue that a global flood brings up concerns the nature of God's judgment. Consider other biblical examples such as Sodom and Gomorrah (Gen. 19) or Korah's rebellion (Num. 16). God destroyed the rebellious ones but those beyond that area remained. In the case of the Genesis flood, the judgment fell on mankind. Even if all of mankind was involved, it seems uncharacteristic of God's judgment to flood Antarctica or other uninhabited areas. It is not as though God is unable to control His power.

Three geological issues will be considered:

1. Where did the water come from?
2. Where did the water go?
3. Is there evidence of a global flood?

1. *Where did the water come from?*

The earth's surface is 70 percent covered with water. Perhaps covering the other 30 percent with water doesn't seem unreasonable. However, consider that Mt Everest is 29,029 feet (8,848 m) high. Literally covering all the mountains of the earth with water would have meant adding a vast amount of water to the globe. Think about an airline cruising above the earth and imagine that it is a boat up there. The deepest part of the ocean is in the Marianas Trench where the water depth is –35,994 feet (–10,971 m). A global flood would almost double the water depth in even such places. Bernard Ramm expressed the problem here:

> There is the problem of the amount of water required by a universal flood. All the waters of, the heavens, poured all over the earth, would amount to a sheath seven inches thick. If the earth were a perfect sphere so that all the waters

> of the ocean covered it, the depth of the ocean would be two and one half to three miles. To cover the highest mountains would require eight times more water than we now have. It would have involved a great creation of water to have covered the entire globe, but no such creative act is hinted at in the Scriptures. (Ramm 1955)

What if we included the water in the atmosphere, icecaps, and groundwater? Dr. Jeff Zweerink concluded that "the volume of water currently on Earth is only about 24 percent of the volume needed to cover Mount Everest" (Zweerink 2015). That leaves 76 percent to be accounted for from some other source.

Early readers may have pictured great subterranean caverns that emptied to flood the earth. Seismic surveys have conclusively demonstrated any such caverns are miniscule in terms of the water needed to flood the earth. If there is not enough water in the atmosphere or under the earth's surface, then where did it come from? Did God just make it appear and then go away after? Boice's Genesis commentary notes that no one feels comfortable relying on this method, although it still would be in the realm of God's ability. Boice comments:

> As to the creation of vast amounts of new water, so far as I know, no one currently holding to a universal flood would resort to this theory. Generally, it is assumed that the surface of the earth was not as irregular as it is today and that the land was covered with existing amounts of water. It must have reached its present form afterward, perhaps even as a result of immense disruptions that the flood caused. (Boice 1982, 1998)

Lack of mountains or deep oceans would seem to be one way around the problem. Similarly, "flood geologists" from Henry Morris to Andrew Snelling have proposed that the pre-flood world did not have the type of relief that we have today (Whitcomb and Morris 1961; Snelling 2009). However, modern seismic surveys and deepwater drilling have demonstrated that deep oceans have been a major part of our planet through at least the Phanerozoic and much of Pre-Cambrian time. The present configuration of the continents has been slowly developing since the Triassic period, typically dated around 250 million years ago. "Flood geologists" have proposed that "catastrophic tectonic" processes caused the mountains to rise up and the ocean basins to sink, giving us the present day extremes in topography and bathymetry. However, the evidence is conclusive that such events just did not happen either early in the earth's history or specifically in the Pleistocene to recent time period, when the biblical flood might have occurred. I have personally looked at thousands of profiles across the margins of the Atlantic Ocean. The structural and stratigraphic patterns vary tremendously around this one ocean. However, it is very clear that no fault or fold system is present that might have been utilized to cause the ocean basin to have either suddenly deepened or moved to expel water onto the continents (Figure 104).

Is there some other deeper source of water? In 2014, press releases announced that scientist had discovered that the earth's interior does indeed contain a lot of water (New Scientist 2014). Some seeking support for a global flood have asked if this could have been the source for the water. The deep water that is referred to is in microscopic holes within crystals of the mineral, ringwoodite. Removing water from enough of these crystals and then putting it back would probably have been a larger miracle than for God to have created it outright.

2. *Where did the water go?*

If a large amount of water did somehow flood the entire globe, where did it go afterward? Just as we have nowhere for the water to come from before the flood, we have nowhere for the water to go afterward. The only explanation that I can think of is that God miraculously "uncreated" it over the course of the time when the waters receded. Genesis 8:3 says, "The water receded steadily from the earth." Wenham comments,

> The waters . . . receded," reversing 7:17, 24. Exactly the same description is given of the Red Sea returning to its place in Exod. 14:26, 28, and the Jordan likewise, in Josh 4:18, the other great saving acts associated with water in the OT. *Here the waters are pictured as returning to their normal place, above the sky and below the earth.* (Wenham 1987; emphasis added)

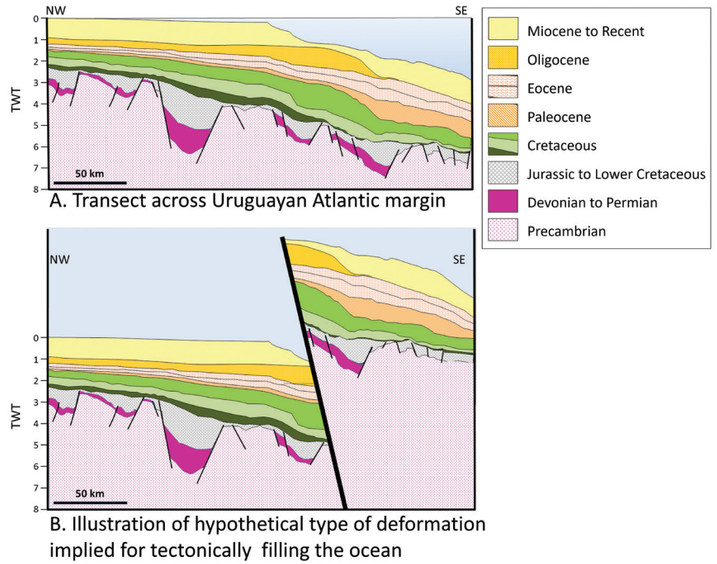


Figure 104 Profile across Uruguayan Atlantic margin. It illustrates the evidence that showing that God did not supernaturally raise the ocean floor during Noah's flood. Such a process would have involved some sort of faulting or folding. After the flood, one might could speculate that such faults would have been reversed back to normal position. However, no such fault or series of faults exists around the ocean margins. Faults are common but not that might have been activated the way such "catastrophic tectonics" would demand. Most are older and buried such as the ones on this line. Some local areas have faulting that cuts through all the older rocks, but local movements would not have significant impact (Penn, Scaife, and Spoors 2012).

From at least my perspective, sea level was far below the land where the ark landed. Therefore, it was "below the earth" for Noah. Waters returning to the ocean were returning to their normal place.

3. *Is there evidence of a global flood?*

If God had miraculously flooded the entire planet with an additional almost twenty-nine thousand feet (9,000 m) of water, then one might expect this to leave a major erosional and depositional event that would be easily correlatable around the world. Geologists certainly have not recognized any such event, let alone in the last two hundred thousand years. Just the pressure from the weight of all of that water would have been destructive to life in a unique way and left a distinctive global deposit but such a deposit just has not been recognized. Later we will consider further details about what Noah's flood would have looked like, but clearly geologists have not recognized a global flood deposit so far. Early geologists often pointed to various sediments deposited chaotically and declared them

to be deposits from Noah's flood. These turned out to have formed at many different times. Many famous ones turned out to have been deposited by glaciers, not flood waters. Imagine the effect that global flood waters would have had on Antarctica. Ice cores there have been dated to 750,000 years ago (Pokar 2003). How did the ice survive the flood? Surely at least a major melt event would have been caused by a water column that was miles deep covering the area. We would expect to see such an event in the other major ice columns such as in Greenland. However, no such event has been recognized.

Many biological issues have been recognized that present difficulties for a global flood as well. After all, in a global flood, Noah's ark had to provide safe passage for every modern animal species on earth. Few species of the higher animals have arisen by anybody's scientific evolution model in the last two hundred thousand years. We have no scriptural basis for expecting many animals to have been created since the flood. Therefore, the ark had to take care of them all. The global flood model would have to include insects and many microscopic lifeforms as well, given that many would not have made it through a year with miles of water on top of them. How about cactus? They would have all been dead after a year of flooding. Did the ark include seeds for all the plants? How would they have been distributed afterward?

One basic consideration would have been getting the animals to and from the ark. The time when the continents were together had long passed and the continents were not far from where they are today. Many authors have considered the issue of the marsupials of Australia. Imagine what this must have looked like. God knew the future, so perhaps he started a population from Australia, beginning millions of years before the flood (Beck et al. 2008). Maybe he supernaturally got them onto a floating vegetative raft to bring them to Mesopotamia or wherever Noah lived. Such "rafts" had to have come from all over the world, miraculously passing across what are normally treacherous waters, bringing entire populations. After all, the animals had to eat along the way. Many of them have very specialized diets. The starting populations had to be quite large for the carnivores to eat along the way. Of course, only two had to make it to the ark.[25] Then the animals had to get back to their own specific locations. How long would that have taken? Were the continents basically devoid of animal life for long time after the flood? Imagine that God preserved seeds of all the plants below the water column so that they could start growing after the flood waters receded. After the flood, they could have started growing, but many flowering plants require help to distribute their pollen. However, the insects were on the ark and would not be back for a long time. Perhaps insect eggs were made to survive buried for the year, but the pressure from the weight of the water column would have made this miracle larger than you might first imagine. Once again, none of what would have been required would have been impossible for God, but one would have expected to have seen evidence of a dramatic change in life above and below the flood event everywhere around the world.

A second issue that is often raised is care for the many kinds of creatures while they were on the ark. The basic space for the animals had to be a challenge. The logistics of storing food and feeding the animals would have been an incredible job. Storing and keeping the food would have

[25] Animals that would have been considered ceremonially clean would have had seven taken aboard (Gen. 7:2).

been problem in itself. How would Noah and his family have known how to care for all these strange creatures? There would have been no room for error, because each fatality was an extinction. Perhaps God placed them in sort of suspended animation. It starts to sound more like a science fiction movie more than a historical story from the Bible. Even if God suspended the animal feeding problems, Noah and his family apparently were awake. I wonder, what did they eat? Perhaps God provided them with manna. He has been known to do that, but the Bible does not suggest any such.

The difficulties for the terrestrial animals may have been simpler than those presented by the saltwater aquatic animals, if we assume that the flood waters would have been fresh. If they were dominantly saltwater, then the problem just shifts to the fresh water aquatic species. At least the terrestrial animals were on the ark. Once again, Bernard Ramm's statement of the problem is useful:

> The mixing of the waters and the pressure of the waters would have been devastating. Many of the saltwater fish and marine life would die in fresh water; and many of the fresh water fish and marine life would die in salt water. An entire marine creation would have been necessary if the waters of the earth were mixed, yet no such hint is given in the account. Furthermore, the pressure of the water six miles high (to cover the Himalayas) would crush to death the vast bulk of marine life. Ninety percent of marine life is within the first fifty fathoms. The enormous pressure of six miles of water on top of these forms (most of which cannot migrate, or migrate any distance) would have mashed them. (Ramm 1955)

It is hard for me to get around these types of problems. It seems likely that God could and would have accomplished His goal by much simpler means. It seems more likely that the biblical text is not describing a global flood with waters that rose up twenty-nine thousand feet, especially when that text is interpreted in the context of the human author and the perspective of his primary intended readers.

What might the flood have looked like?

I would like now to give you a clear description of what the Genesis flood actually looked like in terms of a historical event. I really would love to be able to do that. However, I do not know enough to even to provide a single unique scenario that answers all my questions. I am convinced that Genesis records a historical event where the significance and meaning for us is clear and remains immense. However, it remains uncertain how it fits into specific historical context. Descriptions in modern literature have explanations that incorporate a wide range of God's supernatural power. Explanations range from those that make the flood essentially a natural event whose timing was orchestrated by God to an event that is overwhelmingly miraculous, where God totally set aside the normal laws of nature in order to bring about this judgment. This author, like many, believes that the historical event was between these two extremes. I will present three scenarios that illustrate options for how

the flood might have fit in historically. The options all have strengths and weaknesses but seem to be viable at this point in time.

If the flood was a historical event, then there are biblical details that should be present. Here are some of the key biblical details, some of which help to constrain scenarios:

1. Adam and Eve were created as the first spiritual humans
2. Humans became an evil, violent people who required God's drastic judgment in order to become what God planned for us
3. God revealed his plan for judgment to a literal Noah along with His plan to provide a means of escaping that judgment
4. The judgment took the form of a flood that occurred at least 1,656 years after Adam's creation.
5. Noah built an ark, a large vessel designed not for moving across a body of water, but for preserving its occupants through the flood.
6. Noah loaded into the ark a set of animals that represented the critical pieces of the ecosystem for the flooded region.
7. A vast flood occurred that destroyed all of mankind (or at least all in that region).
8. Two sources for the waters are noted: rainfall and "the great deep."
9. The flood covered all mountains in the flooded area.
10. After 150 days, the ark grounded on a mountain in the region known in Moses's time as Ararat.
11. Noah and his family left the ark after 371 days.
12. Mankind spread out from this point to fill the earth.

First, it is worth considering this question: If the flood did not cover the whole globe, then how big was it? What does local mean? If the flood was essentially a local event timed by God, then we can look at flood deposits in the area and consider what might be the largest of these. However, if the flood included God's supernatural work, then it is very likely that the Genesis "local" flood covered a dramatically larger area. We can only guess how God would have acted or which normal processes and laws He chose to set aside. We can, however, think about some of the options.

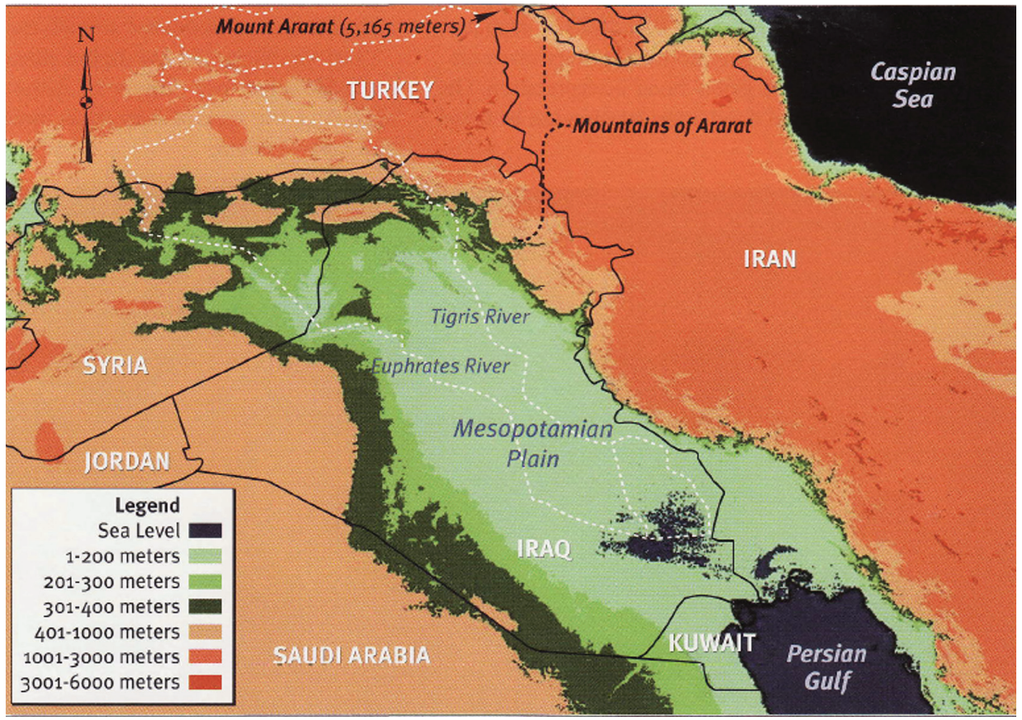


Figure 105 Map illustrating the Mesopotamian topography that would have been flooded by various sizes of floods (Sarigianis 2002; Reproduced by permission of Reasons to Believe [RTB]).

What if God used normal processes and laws but chose to use them to a much greater extent than normal? The result might have been a super-sized normal flood. Christian research engineer, Steve Sarigianis looked at this type of scenario (Figure 105), and this quote reflects one example of this view:

1. The topography of the Mesopotamian region forms a huge U-shaped bowl that stretches 600 miles from the Persian Gulf to the northwest. Steep escarpments that rise quickly from less than 200 meters to 1,000 meters set boundaries for the Mesopotamian Plain on the north and the east. Terrain that rises gradually, but consistently, to heights above 400 meters forms the southern and western boundaries. Elevations above 400 meters fully contain the Mesopotamian Plain except where it meets the sea.
2. The biblical flood account refers to extraordinary geophysical events. Huge underground aquifers ("the springs of the great deep" in Genesis 7:11) suddenly "burst forth." In addition, Genesis 7:12 states that "the floodgates of the heavens" opened, and rain fell for 40 days and 40 nights. In other words, hard rain fell in the region continuously for 40 days.

Meteorologically, these factors constitute an unprecedented rain event in a region that averages only 10–20 inches of rainfall per year. No natural explanation exists for a storm so large, intense, or persistent in this region.

A super-storm of this unprecedented magnitude would have produced an enormous surge in the Persian Gulf. During a storm surge, the force of the winds circulating around the storm's low pressure center pushes water ashore. A large hurricane can cause storm surges 50 miles wide and 25 feet deep. Shallow coastal waters like those in the Persian Gulf only amplify a storm surge (see figure 1). And, greater storm surges are observed with slow-moving storms. The Genesis super-storm remained stationary for at least five weeks; so the height of the storm surge must have been larger (by some incalculable amount) than any Earth has experienced since that time. A storm surge that reached 200 meters deep certainly would have been sufficient to sustain the destructive flood levels for the length of time Genesis records. (Sarigianis 2002; Reproduced by permission of Reasons to Believe [RTB])

God in control of the weather? Jesus demonstrated His ability to command the winds and waters on Sea of Galilee while on earth. Sarigianis did not specifically state how high the water rose due to the rainfall or the storm surge. He did refer to a storm surge that was two hundred meters deep. Such a surge would have spread out to flood a huge area as it dissipated. Would such a flood have kept the ark above the mountains for 150 days? Would mountains in the Ararat region have been covered with water as long as Genesis records? Would this flood have destroyed a large enough area that the animals had to be on the ark to re-establish the ecosystem? The Sarigianis's explanation is a supernatural convergence of events whose result is beyond disasters that are wholly natural and thus recognizes God's direct intervention. It is however just one hypothesis.

What if the scale were even larger? If Noah's flood filled the Mesopotamian region with 1,300 feet (400 m) of water, a 280-by-700 mile (450 × 1,100 km) area would have been flooded. As I wrote this initially, I was in Stavanger, Norway. Out our window, I looked out over a fjord. I saw beyond it a small mountain named Dalsnuten that rises from sea level to 1,063 feet (324 m). Imagining a flood that covered it would be awesome indeed. In a low relief area such as Mesopotamia, it would have been even more impressive. Is it possible that God could have raised water to this extent? What might that have looked like? Such a flood would slide even further down the scale from the natural to the supernaturally dominated.

Scenarios

Scenario A

Scenario A will describe a scenario where God directly intervened dramatically and on a larger scale than envisioned in the Sarigianis description. The date of the flood would have been somewhere between 60 and 220,000 years ago, as illustrated in Figure 102. The scale of the flooded area and the depth of the water would be the 1,300 feet (400 m) case considered above. The exact depth is not important, but larger scale implies that a larger area was flooded. A larger area and deeper water column makes it even more likely that a year was required for the waters to recede and that the ark came to rest on a mountain in the Ararat region. The lowlands of Mesopotamia would have been home to an entirely different range of fauna than lived in the highlands surrounding it. The species that Noah and his family depended on for food and clothing would have been particularly at risk. The larger the flooded area, the more species would have been impacted and the greater the need for the ark to provide safety for them. The area would have looked a bit different at that time in some ways. Mountains probably were not quite as high and the Mesopotamian valley would have been just a bit wider. Geologists recognize that plate tectonic movements are causing the Arabian Peninsula to move toward Asia and this collision is what has caused the Zagros Mountains (Figure 106). It is interesting that geologists have been able to document the rate of this plate motion with modern GPS technology and find that it is moving today at up to nine-teen millimeters per year, one of the highest rates of plate movement on earth (Hessami, Nilforoushan, and Talbot 2006). That suggests that these plates were one to four hundred meters farther apart during the times for Noah's flood in this scenario. That may have made the flood area wider, but unlike YE predictions, this was not a major impact. Movements of the earth's plates have nothing to do with the flood.

Figure 106. Map based on reconstruction of the plate motion that has brought the Arabian and African plates against Eurasia. This resulted in large scale compression and the uplift that formed the Zagros Mountains. Reproduced by permission of GEO ExPro (Sorkhabi 2012)

Where would the water have come from for this flood? The biblical sources would have been adequate. Rainfall would have been responsible for some of the water but alone would not have caused the water level to have risen nearly enough for the scale described in this scenario. Perhaps the rain was a byproduct of the other processes and a means God used to judge humans that had moved to higher elevations. It is likely that no structures that man could have built in these early times would have given much protection from such a downpour. The second biblical source of the water was the "springs of great deep" (Gen. 7:11). Writers ranging from John Whitcomb and Henry Morris and Andrew Snelling to Hugh Ross all attribute these at least in part to subterranean springs, perhaps some sort of supercharged artesian fountains (Whitcomb and Morris 1961; Snelling 2009; Ross 1998, The Genesis Question). Such fountains may have been visually very powerful and impressive but may not have contributed dramatically to the amount of water. They may even have formed as a result of hydrostatic pressure in response to the final source of the water.

The Hebrew word translated "the deep" often refers to the sea (examples include: Gen 1:2, John 2:3, Ps. 36:6, Prov. 8:28) (Lockyer 1986). This scenario would interpret that to mean that vast amounts of ocean water flooded into the region. This would definitely have been a supernatural occurrence. No natural process would bring water to such a level. Certainly, God has this within His power. Water is normally constrained by gravity to seek a common level and sea level ultimately is the ultimate base level. Sea level goes up and down over geologic time but not within a few months such as in Noah's flood.

However, God can choose to overrule the power of gravity over water. Joshua 3:14–17 records the amazing story of how the Children of Israel crossed over the Jordan River to enter the Promised Land. The water in this case was said to have "stood and rose up in one heap" (Josh. 3:16, NASB). This was one river. A larger scale of control happened at the Red Sea. In Exodus 14:21–22 (NIV), we read, "Then Moses stretched out his hand over the sea, and all that night the Lord drove the sea back with a strong east wind and turned it into dry land. The waters were divided, and the Israelites went through the sea on dry ground, with a wall of water on their right and on their left." God miraculously caused water to ignore gravity to allow His people to cross over safely. When God chose to once again allow gravity to take its normal course, the waters receded and the Egyptian army perished. Similarly, this flood scenario suggests that God miraculously brought water into the Mesopotamian region, piling it up to the level that He chose, and held it there until it had accomplished His purpose and then allowed it to go back to its normal position. The Persian Gulf itself does not contain enough water to accomplish this scale of flooding. It has a maximum depth of 295 feet (90 m) and an average depth of 164 feet (50 m). If global sea level happened to be lower, then this area might have even had less water. Thus water would have had to come from the Indian Ocean through the Strait of Hormuz. It would be interesting to look for erosional surfaces there.

What would such a flood look like to a geologist? Is it possible that such a huge event could have taken place anywhere and not have been discovered? First consider the rainfall. How much impact would forty days of rain have had on the area? Rain does erode, but most of the actual erosive work is done by running water after it has fallen. Consider how many total days of rain must have hit Hadrian's Wall since it was erected approximately 1,900 years ago or the Great Wall of China since it was built

approximately 2,200 years ago. These are located in rainy areas and though there are parts that are in bad shape that is not primarily due to rain. Erosion due to the expansion of rivers and streams due to the rainfall would have been substantial, but as flood waters rose and covered the area, that erosion would have ceased. We would not expect to see large amounts of impact from the rain itself.

This scenario would include forty days of powerful rainfall moving sediment basinward and then perhaps three months of waters coming into the area while the flood prevailed. The waters coming in would have transported sediment landward. Both the rainfall and the landward transport would have been strong processes. Given that it apparently lasted longer, the landward transport might have had the strongest impact. One would expect that a large chaotic deposit that included deeper water sediments would really stand out. However, then the waters began to recede and erode out the deposit. Over the course of time, one would have expected much of the loosely consolidated sediment to have eroded away. It would seem reasonable that terraces of flood debris would have remained. Several sets of Pleistocene terraces have been mapped along the Tigris and Euphrates Rivers just as they have along most rivers in the world (Yacoub 2011; Demir et al. 2007; Kuzucuoglu, Fontugne, and Mouralis 2004). Work to date makes these seem to be normal terraces. Yacoub described the lithology: "Pleistocene sediments of the Mesopotamia Fluvial Basin comprise rather complicated interbedding of pebbly sand and sandy gravels, sands, silts and silty clay, where the sands are prevailing, followed by silts" (Yacoub 2011).

Although the relative age of the terraces has been worked out, their absolute ages are not known except in general terms. River terraces typically form due to significant changes in discharge or a water level where the rivers ultimately flowed into. The timing of the development of terraces can often be related to climate or sea level changes. One could speculate that some portions might have originated during the flood, but that is not even hinted at in the literature. Most attempts to identify deposits as related to Noah's flood have concentrated on the sediments from the last five to ten thousand years. Was there a massive earlier flood that has not been recognized because it was stratigraphically too old and the character was confusing? Perhaps until we have a better understanding of human habitation under the Persian Gulf, we will not understand what Noah's flood looked like (Rose 2010).

Would such a scenario destroy all the humans? It is hard to imagine that any humans in the flooded area would have survived without divine preservation. The pre-Flood humans (antediluvians) probably lived along bodies of water. Structures that they built and other artifacts would have largely been destroyed by the flood. The population from the time of Adam to Noah in a minimum of 1656 years could have been very large (Ross 1998; Boice 1982, 1998). Even so, it is entirely possible that this population was destroyed and left no sign that modern archaeologists can be expected to decipher.

Scenario B

The description by Sarigianis will be considered scenario B. He describes a two-hundred-meter storm surge that would have destroyed a large part of the Mesopotamian region. Mankind in this area would have been destroyed. One interesting aspect is that this scenario uses normal processes that are scaled up under supernatural influence and timing. Noah was warned and built the ark to

prepare for this hypothesized "perfect storm" of processes that formed the largest flood in history. A major concern is deciding if it can match the biblical details. The flood would have had its apex with the storm surge and then begun to wane. Water from a flood of this magnitude would have remained for an extended time after the surge. Two questions come to mind. First, if the Genesis account is interpreted to mean the floodwaters did not begin to recede until 150 days after the rains started, then would this process fit? Secondly, would a flood where the waters began to recede following the storm surge leave the ark up in the Ararat region after 150 days? It is impossible to categorically answer the questions, but they are questions to consider in evaluating the option.

Scenario C

Scenario C to be considered is that of a local flood that occurred five to ten thousand years ago. Many hypotheses might be and have been considered even for this more recent event. One of the more famous was announced by Sir Charles Leonard Woolley (1880–1960). His excavations in the ancient city of Ur documented a major city that was the ancient home of Abraham (Woolley 1929). Deeper down in the excavation, he discovered a layer of water-deposited sediment that he considered to have been the result of a local flood that he equated with Noah's flood. He described it as "400 miles long and 100 miles wide; but for the occupants of the valley that was the whole world." His discovery made headlines around the world but the actual flood deposit that he discovered apparently did not cover as large an area as he anticipated. Few would identify these deposits with Noah's flood today.

Figure 107 Location of Black Sea and Strait of Bosporus through which it is hypothesized that the Black Sea catastrophically filled with sea water approximately 7,500 years ago (Map from Google Maps).

More recently, a new theory has been proposed by geologists William Ryan and Walter Pitman. These two well-known and respected geologists went out deliberately looking for the flood (Brown 1999; Mitchell J). Though they did not particularly believe that the flood represented God's hand, but they recognized that tales of an early flood with many similarities were common in the early civilizations. It made sense to them that they stemmed from a historical event. They examined the Persian Gulf and Red Sea but did not recognize any candidates. Then they looked at the Black Sea (Figure 107). They found evidence there of an abrupt change in the sediment caused by a sudden change from fresh water deposition to saltwater deposition.

> They surveyed east of the Crimea from off the shelf edge onto the shelf, finding "up to four-meter layers of sediment that covered everything like dust," he said. "It went right down valleys and up the other side, the same sloppy, highly saturated sediments the Russians had described earlier." A shell hash overlay hard, very compact deltaic-type sediments with mud cracks.
>
> Carbon dating of the transition break placed its age at 7,550 years. Before that time, Ryan and Pitman say, the Black Sea was a fresh-water lake draining into the Mediterranean. When the sea level rose, pressure built up on the natural dam of the Bosporus. Eventually, water began to pour into the Black Sea basin with enough force to scour out the Bosporus channel to a depth of almost 500 feet.
>
> Water rushed in at a rate of 50 cubic kilometers a day—about 200 times the rate of flow of Niagara Falls, Pitman said. "It would have been a very exciting thing to see," he marveled, "from a distance." (Brown 1999)

Other geologists dispute that the change was anything near as dramatic as the "Black Sea deluge hypothesis" proposes. Nevertheless, work has continued to go on investigating this theory. Oceanographer Robert Ballard has documented evidence of human occupation in the area that is now underwater (Watson 2012).

Is it possible that Noah lived along the Black Sea? The story still sounds far different than the biblical account. However, it does show that there are possibilities that might be outside of where we typically look. It also shows that further work may completely change the way we look at the history of these times. Ballard points out that most of what may have been the most significant sights for early man are located in areas that are completely drowned by the ocean today. Is it possible that God brought about dramatic rainfall that added to the dramatic flooding of the Black Sea to destroy a violent civilization? Did word of this dramatic judgment spread around to all the people around the occupied world? Perhaps a more complete picture may be developed in the years to come that will make it more possible to reconcile the Bible with a recent flood.

This Author's Favored Interpretation

This book has presented much information and several hypotheses regarding the origin of man, the biblical Adam and Noah's flood. Some take these biblical stories as not historically true but given to teach spiritual truths. Deciding when and where to apply this type of explanation to scripture seems to be a judgement left ultimately to the individual reader. Just as with creation week, I believe that ultimately concord exists between the biblical record of Adam and Noah and historical events demonstrated by correctly interpreted physical evidence. What did the biblical stories look like in terms of physical history? Again, I reserve the right to change my views as new information comes to light.

Given my understanding now, perhaps the history might have looked a bit like this:

God, the ultimate master designer, prepared the genetic code that he would use for the creature that would be spiritually aware. Over the last two million years, a series of hominids were created, lived, and died. Each served the purpose that their creator had for them, though He has not revealed these purposes to us. Their DNA became successively closer to ours. Around two hundred thousand years ago, beings appeared that were essentially like us physically. They made tools and were smarter than those before. They buried their dead. After all, they were smart enough to know how to stop the odor caused by a decaying body. Just as animals today are capable of love, so were these pre-Adamic hominids and that love may have been stronger than those that came before.

Sometime around sixty to seventy thousand years ago, one or more disasters struck, and most of these creatures died. Perhaps in some way that we cannot know, they rejected God and were judged. This population bottleneck created a vacuum. In this case, God chose this point to create the special pair that we know as Adam and Eve. Their DNA was almost identical to the previous hominids, but God added the special changes that made them human. The pair were created with language as that would be critical for the purpose God had for them. They were created as spiritual beings and enjoyed a close relationship with their creator. God placed them in a special garden in a land known as Eden. God gave them free will, and at first, they chose to love God. Both love and free will are meaningless when there are no other options and God provided a meaningful choice. They chose to love themselves over God, much as we do today. The natural consequence of sin was death, and they then began to die physically. Cast out of the garden, life was hard and death reigned. The human population grew but remained relatively small. Man lived along the coastlines and lowlands of the day, though these may have been largely beneath the modern Persian Gulf today. Over the next 1,656 years or more, man grew more and more sinful in a tightly bound, violent, corrupt society. While most may have had short lives, a least one line, the godly line of Seth did have long lives by our standards. God has always had a people. When no one would be left that followed God, God acted in judgement and all perished but one family. God sent rains and miraculously caused vast amounts of water to flood into the Persian Gulf and caused the waters to remain there for a whole year. This

represented the whole earth in terms of the known earth and the whole of mankind perished, except for Noah and his family.

Following the flood, these humans spread over the world. It is amazing to see how fast and far mankind spread, even with just the information that we have today. Earlier and earlier evidence of forms of sheep herding, metal work and such activities may come to be documented by archaeology. Perhaps as man spread out quickly into harsh environments, much of the earlier knowledge of agriculture and simple industry may have been forgotten. More evidence of spiritual worship will also be found, but no evidence will turn up prior to Adam, perhaps sixty to eighty thousand years ago. Only Adam's descendants had the real "God gene"—the spiritual dimension.

Eventually only remnants of the memories of the flood remained in the collective memory of man. Those geographically closest to the event had more complete stories. Eventually God revealed to someone, such as Abraham or Moses, the account that we now have recorded in Genesis. This account reveals truth without error but does not contain information to answer many of the questions we have today. Discussions and debates will rage for a long time about the interpretation of this portion of the Bible. The above scenario may or may not be confirmed in the future. It may sound somewhat different than what you pictured from Sunday school. Truth can often be more complex than we expect. The more details we learn about history, often the more complex it is. The biblical account is interpreted here to demand a literal event involving real people. It is not possible today to geologically point to a deposit that resulted from Noah's flood or to demonstrate its extent or the processes involved. This may be in part due to the flood being older than what has been looked for. It also may be due to the processes being different than we typically picture and much evidence may have been removed by later erosion. The degree to which supernatural miracles were involved is uncertain as well. It is the opinion of this writer that geological studies to date have not at all demonstrated that such a flood did not occur. The stories of Adam and Noah should be taken as ancient historical accounts that are true, even though many details are uncertain.

Conclusions and Applications

The first part of this book evaluated the "flood geology" proposal to explain the geologic record. We looked at the assumptions that form the basis for "flood geology." A series of predictions based on these assumptions were then evaluated using the study area of Texas and New Mexico. This author concluded based on this area and other examples from around the world that the "flood geology" proposal is not viable as an option to consider for the geologic record. The rock record cannot be explained by the processes demanded by this proposal or in its timeframe. Both "flood geology" and the related proposal that the earth is relatively young (six to ten thousand years old) just do not fit the data based on many different evidences. An obvious question would be: so what? Does it matter? Truth matters. This particular truth does not impact everyone equally or all of the time, but it does have real impact on everyone.

Starting with the obvious, look at the impact this has on scientific pursuits. Would it really be possible to work as a geologist using YEC "flood geology"? There are very few who try. Petroleum geology would suddenly become difficult and unworkable for me. Trying to explain and predict the rock distribution that we observe from global flood processes for the Paleozoic and Mesozoic rocks would be a fundamental change. Imagining the processes involved in depositing the Cenozoic in a few hundred years is unthinkable. The understanding that we have today of stacks of ancient deltas or deepwater deposits or reefs has been extremely successful. It enables geologists to make and test hypotheses on many different levels. It works to understand the larger basinwide scale that is particularly important in deciding where to explore for oil and gas. It works at the next scale down, subregional studies that are critical to understand where and how to drill wildcat wells to discover new fields. It works a smaller scale, once a discovery is made and we need to plan how to place wells to develop the field. It also works at finer scales, when we are describing fields in detail to understand how they perform and how oil and gas move through them. If you use petroleum products, the success of the modern understanding of stacked ancient systems has impacted your life, whether you were aware of it or not.

How about astronomy? What would it mean if the universe were only six to ten thousand years old? We should be looking only at stars whose light would have reached us in that amount of time.

How would we explain all the other stars? What would be the point of studying them? Could we really believe anything that we learned about space or stars out there?

Many Christians choose to believe the YEC and "flood geology" interpretations. God is a God of truth and we agree that this means that His word is true. We cannot pick and choose what we believe and what part we don't. How we understand creation is important to how we understand the Bible. The YE believers are very right about that. I appreciate their desire to honor God by trusting in His word. It is sometimes difficult to understand how the Bible history fits together with historical and scientific accounts, especially when the last two are constantly developing over time. This book attempted a non-expert's look at three basic questions that the "old earth" concept impacts. First, we considered: can the Genesis 1 account of creation over seven days be reconciled with the scientific understanding? It is the opinion of many Christians, including well-respected evangelical Bible scholars, that this is very possible. In fact, there is good biblical evidence to suggest that this is the best primary interpretation, not just an obscure option. Given the weight of the scientific evidence, it is difficult to see why one would not choose one of the proposed biblical interpretations.[26] God could have given us a detailed scientific account but chose to give us the summary version. It describes events occurring in seven time periods that in human terms took billions of years. We can clearly understand that God and God alone was the creator. We are His workmanship, created to serve Him.

Secondly, this question was considered: Can the biblical account of Adam and Eve be reconciled with scientific data? The Bible teaches that God created two historical people, Adam and Eve. We see the origin of our sin in their rejection of God's instructions. We saw that science recognizes that all of humanity shares a single common male and a common female ancestor. We saw that all language derives from a single common language. Modern discoveries are difficult to reconcile with all humans descending from a single human couple, but it is this author's opinion that further discoveries are likely to point more and more clearly to this scenario. Some evangelical Christian scholars consider that Adam and Eve were used as an illustration of the type of rejection of God that caused all of man to sin and fall short of the glory of God. The less literal interpretations seem unlikely to be what Moses had in mind when he wrote. The important consideration is: what did God intend? The most logical and consistent interpretation seems to demand a literal Adam and also a literal Noah. However, the thought still occurs to me, what if God provided something different in these passages than what I understand? It is definitely possible that God could have provided something different than what I understand, and it would still be 100 percent consistent with His nature—true, just, and loving. We don't get to choose how God reveals himself to us. We might stamp our feet and declare that God absolutely had to do it our way but He is right. My understanding remains more literal, but I recognize my human fallibility and the fact that the first eleven chapters of Genesis are difficult to understand and reconcile with archeological finds to date.

[26] This book has not attempted to evaluate the various proposed ways proposed to interpret Genesis. I would recommend reading one of these books to get an overview of the strengths and weakness of the various ideas: The Bible, Rocks and Time by Young and Stearley (2008), Genesis, Volume 1–Creation and Fall (Genesis 1–11) by Boice (Boice, 1982, 1998) or The Doctrine of Creation by Vestal (1989).

Lastly, the question was: Is the biblical account of Noah's flood a record of a real historical event, and if so, what can we say about it? Genesis presents this event as historical, with one of the most detailed event chronologies in the Old Testament. Flood stories are common in the ancient literatures and oral histories of many peoples, and this is most easily explained by them having drawn from a common historical event. Archaeologists and geologists have not recognized a deposit that can be identified firmly as the flood deposit. History has had many failed attempts to label strata as deposits from Noah's flood. Part of the problem with more modern attempts may be because they have been looking for too recent an event and because the mixture of miracle and nature may make the event appear different than we have typically expected. I have suggested that it is possible that the flood could have been closer to either seventy or two hundred thousand years ago. If the flood were in one of these time frames, then over time more discoveries will show that human population, technologies, and religious symbols dispersed following it. Perhaps as Rose has suggested, the earliest records of civilization in the Middle East are currently under the Persian Gulf.

At this point, science has not confirmed Adam and Eve or Noah. It also has not proven that they did not exist. The absence of proof is not the proof of absence. Their physical timing remains an issue that we cannot resolve now and may not be able to in the near future. I believe the Bible because it has proven itself to be authoritative and reliable on many levels. Believing in these early stories is both a matter of reason, based on the Bible's demonstrated reliability as a historical document and faith because I believe that its ultimate author is God, who is totally trustworthy. Believing this does not require me to reject the data presented by scientists, many of whom are nonbelievers. Many of them are fanatical about the integrity of their data. There may be factors that they have not considered and the range of uncertainty inherent in their data may be larger than they envision and even that alone can give room for biblical answers.

Atheists often accuse Christians of always appealing to the "god of the gaps." The accusation is that Christians take something that science has not quite answered and claim that the answer is God. Then, when science does provide an answer, Christians simply move God to a new gap. Is that what this report does with creation and the flood? The appeal to God as the cause of the Big Bang seems to this author as far more logical than any other proposal on the table. Accounting for the string of "coincidences" required for complex life to exist on earth seems to require tremendous amount of faith from the atheist. The tendency seems overwhelmingly to be that the "gaps" are increasing rather than being filled. Perhaps it is a case of the "atheism of the gaps."

The claim that the leaders in the intelligent design community are just appealing to the god of the gaps is a great misunderstanding or misrepresentation of the argument for design presented by these scientists. This is not a situation where creationists are claiming that just because evolutionists cannot document every "missing link," God must have jumped in and miraculously animals appeared. The processes of natural selection and mutation are valid processes. The point here is that they just are not even close to understanding the origin of life or modifying that simple life with the degree of engineering that is evident in life on our planet. At the 2013 Goldschmidt Conference of the Geochemical Society, a paper was presented that hypothesized that life must have originated on Mars and then traveled from there to earth (Redfern 2013). It seems that any scenario that is iden-

tified that might actually have some chance of allowing formation of RNA, DNA, and the proteins required for life would require conditions that evidence indicates just did not happen on ancient earth. Notice that no one, after decades of intelligently designed experiments, has actually formed any of these compounds. Even if they had, it would be one thing to form them and quite another to have formed them under realistic conditions such as might have existed on earth. The point is that science today has no realistic proposal for how life might have formed without a designer. Vast major genetic changes occurred during the "Cambrian explosion" when so many complex lifeforms appeared in an amazingly short period of time, perhaps even less time than estimated by paleontologists. The limits demonstrated for natural selection and mutation seem to have been far exceeded and intelligent design is the warranted conclusion. Intelligent design seems fit the data much better in my opinion. "Evolutionary creation" also demands an intelligent designer for life's changes but makes the case that the designer used natural selection and natural mutation as his tools. No designer, no evolution.

I have tried to avoid a "gaps" approach to Adam and Eve and Noah's flood. I have tried to show that there are multiple options that are viable today and that still honor the biblical text. I freely admit that I do not have a firm answer to tie either of these to our own chronos. Others certainly have more detailed knowledge of the Middle East geology and anthropology than I have. They may be able to demonstrate that some options that I consider possible are far less likely than I see them to be. Others certainly have more theological training than I have and more knowledge of the ancient biblical text and other ancient literature. Even so, I expect that all will learn much more as time passes.

The last three hundred years of geological investigation have firmly demonstrated that the earth is quite ancient. Future learnings and theories will change ideas about things, but this one seems extremely unlikely to change. Jeremiah declared, "But God made the earth by his power; he founded the world by his wisdom and stretched out the heavens by his understanding" (Jer. 10:12). If we learn that the universe and the earth are truly ancient, what does that teach us about its creator? God asked Job, "Where were you when I laid the earth's foundation? Tell me, if you understand" (Job 38:4). God's understanding is far beyond ours. Our understanding does begin with Him. Knowing the truth should lead us to further understanding of Him.

Think about how knowledge in general and scientific knowledge in particular has grown since New Testament times. Even then, men had mapped the constellations and could look up in wonder at the stars. Copernicus suffered because he showed that the earth was not the center of our planetary system. Perhaps we were not as large as we thought. In 1923, Edwin Hubble trained the Hooker telescope on a hazy patch of sky called the Andromeda Nebula. He discovered that that nebula was not just a cloud of dust but was actually what we know now as the Andromeda galaxy. He discovered that our Milky Way was not the universe, but one galaxy among many. Our world just became much smaller and man seemed tinier. The creator of such a vast universe was even greater than we could have conceived.

At one time, the atom was supposed to be the smallest unit of matter but now we recognize thirty-six subatomic particles. The last one hundred years have also allowed mankind to develop

microscopes and electron microscopes and other tools to probe incredibly small intricacies of nature. In Darwin's day, one-celled animals were just blobs of protoplasm. Today we know that they are incredibly intricate and well-engineered. Designing such a system that would function and self-replicate required the concern and care of a truly amazing God. Taking these complex cells and eventually bringing them together to form a creature that had the capacity to reason and love required a creator who was not distant and impersonal but one who was intimately involved in his creation.

Over the last three hundred years, man has become smaller, not just in terms of his power or his intelligence but in the time of his existence. Daniel referred to Jesus as the "Ancient of Days" (Dan. 7:9). When we recognize that even in terms of our own timeline, God created the universe not just a few thousand years before but perhaps thirteen billion years ago, "Ancient of Days" becomes even more real and impressive. Once again, we become smaller because He is greater. David wrote, "Show me, O Lord, my life's end and the number of my days; let me know how fleeting is my life. You have made my days a mere handbreadth; the span of my years is as nothing before you. Each man's life is but a breath" (Ps. 39:4–5). The geologist's recognition of the age of the earth has provided emphasis for this and a greater understanding of how tiny is our time in this life.

Gary Chapman's book *The Five Love Languages* explains that for many people, quality time is their major way of expressing love. In creating the universe and earth over billions of years, once again, God has demonstrated His love in a way far beyond what we deserve. This does not mean that man was God's only or perhaps not even His main reason for creating the universe. We do see the importance of man to God, both in the Bible and in the care that science shows that God has used in bringing man into existence. It seems clear that one purpose that God had in mind as He engineered our position in time and space was so that we would one day learn of His majesty and wonder. He has given us the ability to develop the technologies to discover the galaxies. He positioned our planet in a solar system that circles a star located in one of the few places in our galaxy from which we can actually see other galaxies.

Imagine Adam looking out at night if the world were created just a few days before. It would have been a very dark night. The only stars visible would be those whose light could have reached earth quickly. Over time, more would have been visible, but relatively few. It is like God intentionally gave us the ability to see far into space in order to allow us to see back to the earliest galaxies after creation. He has given us tools and techniques that allow us to recognize how long ago He created the earth. The earth's natural resources are His provision, planned for us billions of years before our needs. We are responsible to Him for their wise use. We learn to recognize that God, from outside of our time, knew all that would be. Geology can help us appreciate this. The hills around Jerusalem are Cretaceous in age. This means that ninety million years ago, God could see the Cretaceous seas and know that those lime muds would someday be Golgotha. He could see that as well. Knowing this is another way to appreciate God's love and also what eternity means.

Recognizing that God has acted over billions of years to bring about His plans for us can also help us to learn more about the way God works in other areas as well. Christians learn to see God's hand at work in three distinct ways. One way is through the normal laws of nature. The Bible reveals God as the creator who established the earth (Ps. 119:90) and who sustains the earth (Col. 1:17).

He set the stars and moon in place (Ps. 8:3–4). Creation is orderly because He made it so. Scientific pursuits are worth pursuing because the universe is God's handiwork. Geology is useful because it studies His handwork because, after all, it was He who formed the mountains and created the wind (Amos 4:13). Most of the geologic record reflects that form of God's activity. It is perhaps not as dramatic as the miraculous, but it is still His hand.

We also learn to recognize that God works through circumstances. We must learn to see that He is at work in our lives in our circumstances. He is personally arranging our circumstances for His purposes. It takes a careful eye of faith to understand how to interpret His hand in such matters. The Christian may see the set of circumstances that come together in unique ways that answer prayers given. The skeptic will see just coincidence, but the Christian will often feel the warm presence of God. Examples of this type of working are also common in the Bible. Remember when Mordecai pointed out to Esther, "And who knows but that you have come to royal position for such a time as this?" (Esther 4:14). He was pointing out that God arranges circumstances to protect His people. Interpreting circumstances takes wisdom and care because as humans, we are fallible and often are mistaken when we interpret God's will through circumstances. By the same token, God seems to have worked in amazing ways to bring about the circumstances that formed life on earth. Scientists theorize that "fortuitously" our moon was formed when a large object hit our planet and a portion of earth broke off to form the moon (NASA, n.d.). However, it formed, it is very "lucky" for us in many ways. For instance, without the lunar tides, complex life would not be possible. Our earth has a tiny wobble, related to the moon that actually is critical to marine life (Zandonella 2013). Remember that most oxygen generation is the result of algae in the ocean. We see God arranged the unique circumstances that allow life to exist on earth. It is unclear what physically occurred to modify the DNA as life developed on earth. Many of the modifications that happened to DNA probably reflected more of God arranging very unique circumstances than the use of direct miracles as He directed the process that brought about the animal kingdom that we see today. The skeptic may claim coincidence, but the mechanisms of natural selection, mutation, and unguided accidents are totally inadequate.

The third way that we see God work is through direct miracles, His temporarily setting aside the laws of nature to bring about His plan. The Bible records a number of direct miracles where God acted to bring about His plan for mankind. Christian scientists who believe that the earth is old are not at all saying that God does not work miraculously at times. Young and Stearley comment, "We suggest, however, that God is economical with miracles and that He has employed them mainly in the service of redemptive history" (Young and Stearley 2008). Even a Christian geologist will not provide an interpretation invoking a miracle without a very clear demand for it. A biblical account of a miracle that would have geologic significance is perhaps the only case where I can imagine considering that explanation. Hence, I have suggested miracles in the creation of Adam and Eve and in Noah's flood.

Recognizing how God has worked in the past is useful in how we look at life today. We should recognize that it is God's hand that sustains the laws of nature. We should honor God accordingly.

This is reflected in this scripture: "Worthy are you, our Lord and God, to receive glory and honor and power, for you created all things, and by your will they existed and were created" (Rev. 4:11).

We recognize that God works through circumstances far more often than through the miraculous. Hence, we should pray asking God to act. Yet we know that while He is able to work miraculously, it is not wrong to go to the doctor because He often will choose to work through circumstances and natural processes. Those also can be answers to prayer.

Recognition that the universe is old helps Christians gain a better perspective on God's view of time. It has been said that God never hurries but is never late. Often, I have difficulty keeping perspective of God's timing. If you have ever taken a long road trip with a small child, you probably remember that limited perspective that they have makes it difficult for them to be patient. While the adult
may begin to think "we are almost there," the same amount of time can seem like an eternity to the young child.

Christians have a similar problem with God's timing. It is apparent that the apostles and early believers expected Jesus to return in their lifetime. They were living in what Old Testament prophets such as Isaiah, Hosea, Amos, and Micah referred to as the "last days." They probably never considered the possibility that we would still be waiting and watching almost two thousand years later. God however had a bigger plan. If Jesus had returned in the first century, think how many fewer believers there would have been.

Just as Peter and John were living in the last days, so are we today. In high school and college, I became very interested in studying about Jesus' return. I read many books, such as Hal Lindsey's *Late Great Planet Earth*, pointing to Jesus return in a very short time. I eagerly expected Jesus to come back soon. What an amazing event that will be! Well, He did not come back as early as I had anticipated. I recognized that Jesus made it clear that no one would know the exact time of His return, but we are told to be ready and to watch the seasons.

I still hope that Jesus will return in my lifetime. However, I recognize more clearly that perhaps God still has a bigger plan for this present earth. Knowing that this earth is over four billion years old helps to give me the perspective that two thousand years later is still very literally in the "last days." If spiritual humans were created between forty and two hundred thousand years ago, then perhaps it is very possible that Jesus' return will be two thousand more years away or perhaps even twenty thousand years. A geological perspective helps one realize that God's view of time may be considerably longer than we tend to envision. This can have very real importance in how we live our lives. I have talked to believers who seemed to think that saving for retirement is a waste. They need a longer perspective.

Perhaps more disturbing is that it has been expressed that a Christian who believes in a literal return of Jesus is the wrong person to be involved in processes such as peace negotiations between governments. Admittedly, I have talked to believers that were so convinced that Jesus' return is imminent that they questioned the value of trying to negotiate for peace in the Middle East. Perhaps the recognition that the last days may extend for a much longer time would help. Jesus said, "Blessed are the peacemakers" (Matt. 5:9). We should be leaders in making peace. Someday the Battle of Armageddon will come, but it is still very possible that a negotiated peace for today will bless lives

for generations to come. The recognition of geologic ages helps to give Christians the long-term perspective that we need to place value on improving conditions in the world that we live in now.

Another important aspect involves the way the antiquity of the earth affects the way Christians relate to the non-Christian world. It is obvious that it is important in how we relate to members of the scientific community but nonscientists also watch how we relate to one another and to those in the sciences. Most people are aware of the disconnect between modern scientific thought and what is often considered the only conservative Christian position on the age of the earth. If both the Bible and science point to an ancient earth, then those who insist that their interpretation of the scripture trumps all others are creating a conflict that need not exist between Christians and non-Christians who study the sciences.

If the world were young, then one would expect that all the hard work of the YE researchers would have identified valid proofs that demonstrate that it really is only a few thousand years old. In addition, the efforts of scientists would have over and over found the old earth model unworkable. Neither of these has happened. Those who insist that the earth is a few thousand years old and that Noah's flood accounts for geology present a Christianity that is out of touch with reality and demands blinders. So many areas for scientific study are just off the table. If I were a non-Christian, looking at religions and searching for truth, this type of faith would be waiving caution flags for me. I would wonder, "If these people have the truth, then what are they so afraid of?" Non-Christians who have examined any significant amounts of science are not likely to consider these believers' truth claims very long. Should they seriously consider a belief system that teaches that it is necessary to hold the earth to be a few thousand years old or that the light from stars was created to look like it actually traveled through space? The perception of Christianity becomes that of a faith out of touch with reality and truth.

Christians who live their faith are always considered strange by non-Christians. Biblical ideas are always unfashionable to the world's "movers and shakers." Often, Christians are considered odd for caring about people that are down and out or odd for being honest when it would seem obvious that it would be to their advantage to be a bit dishonest. Christians are identifying with Christ in these cases. Being odd for not accepting truth is another charge entirely.

If we were to follow the lead of some believers from the past and insist that the earth is the center of the universe or that it does not move, we would be placing our interpretation of scripture ahead of truth after that interpretation had subsequently been proven wrong. Scripture would have been true but the interpretation in error. Science over the last three hundred years has again proven interpretations wrong.

Scripture is still true, but the interpretations were subject to human limitation and have been proven wrong. Holding on to the error, regardless of how honestly it is held, has the real effect of creating barriers between Christians and non-Christians that shouldn't be there.

This situation reminds me of a common circumstance in the oil industry. An exploration geologist will try to put all the available information together to build a prospect, an opportunity to drill a wildcat well that will test for the presence of an oil accumulation that will produce oil or gas to make money. A presentation package is put together to convince everyone that there really will be oil in the

prospect. That package can be elaborate and can fit many kinds of data in great detail. Eventually if it looks good, the day will come to drill a well that will provide new information that the exploration geologist just did not have when he made his interpretation. One of my former exploration managers observed, "Nothing ruins a good prospect like a well." There are many limitations to our data, and we are always surprised to one degree or another. When we turn out to be correct in a fair amount of detail, then we are really surprised. The interpretation of Genesis is similar in this sense. Early Christian believers just did not have access to the type of information that we have today. They did not have the scientific data that proves that the universe is old. They also did not have access to all the older texts that we have of the Old Testament or the other Middle Eastern literature that helps to understand how to interpret the literary styles of ancient times. Nothing would be worse in the oil industry than for a geologist to go around trying to convince people to invest in a wildcat well that had already been drilled and proven to be a failure. Often, once an unsuccessful wildcat (a dry hole) has been drilled, that data can be incorporated into the previous work and sometimes it is found that there is a new prospect to be considered. It may actually be better than the first because the data from the first well can help make the new interpretation better. Here again, this is similar to the interpretation of creation. Christians should not try to convince the world that the new data doesn't exist or is false. With the new data, we can put together a stronger understanding of God and His ways. It will still be wrong in some details because we are still limited. However, trying to get unbelievers to invest in an understanding that has been proven wrong is something that we should not be guilty of. If the YE model has been proven to fail, then presenting it as true, cannot be right.

Christians are rightly concerned about the teachings of a naturalistic or humanistic worldview to our children. The children and young people need to be provided an education that equips them to live in the modern world. The education must include science. Children who attend public schools (or state schools, for the British) are educated in an environment that is often hostile to the Christian faith. Some look back with longing on days when Christianity was openly assumed, prayer was in school and faith was more acceptable. Some act as if the Christian faith should be taught in school but that is not legal, at least in the US. Having the nonbelievers present a Christian faith that they do not believe would not help. It should be that the playing field should be level, and the program should not be set against Christianity. Christian answers should not be singled out for mockery. Many teachers are Christians and seek to be faithful in this environment but it is often not easy. Some believers continue to try to have the creation option presented in science class. Courts have ruled against these cases in Kansas, Delaware and Pennsylvania. The creation envisioned is usually tied to YE assumptions and "flood geology." These ideas will not and should not be brought in as science in the schools. They are based on one interpretation of the Bible and not on science. "Flood geology" proponents are organized and are unlikely to stop their political agendas soon. It will be a long time before intelligent design has the scientific credibility necessary to be seen as separate from YE creationism.

Children and young people must be prepared to live in our world where Christian assumptions are the exception, not the rule. These young people do not have to simply accept the naturalistic assumptions. The challenge for Christian parents and other adults involved with young people is to

teach them to dig deeper. They can learn to recognize and question naturalism. Recognize that they will also often question the Christian faith, but truth is not afraid of questions. It is a challenge to provide answers, but there are many good resources. Christian young people are going to recognize that many scientists are passionate about the integrity of their work. It would be much better for Christians to share how the God who designed the universe really cares about them. It is worth remembering that the non-Christian scientist also needs to know God as well. It is not necessary to vilify the scientist who believes in evolution. Most of these are presenting their understanding of truth. Surely there are ways to show them that God is true and real and can help them.

Final Thoughts

Christians disagree about many things. That is not surprising nor does it have to be a problem. We can be clear and passionate about our beliefs and still be loving. This book has made case that some Christians present a wrong interpretation of nature and scripture. It is not its purpose to question the faith of these fellow believers. Thankfully God does not require us to be correct in all of beliefs and ideas in order for Him to love us or choose us. It is not even necessary for us to always be correct for Him to use us to perform His work. An old Gaelic saying goes, "God strikes straight blows with crooked sticks." Although I am confident in the major conclusions presented here, there will be weaknesses and flaws here as well.

This book has not presented simple obvious answers to some important questions about how Adam and Eve or Noah fit into history. Sorry about that. We will have to wait to learn more. There is much to gain from the study of God and the study of science. Writing the introduction to Sir Isaac Newton's *Mathematical Principles of Natural Philosophy, 2nd Edition* (Newton 1713), Roger Cotes wrote,

> Therefore we may now more nearly behold the beauties of Nature, and entertain ourselves with the delightful contemplation; and, which is the best and most valuable fruit of philosophy, be thence incited the more profoundly to reverence and adore the great Maker and Lord of all. He must be blind who from the most wise and excellent contrivances of things cannot see the infinite Wisdom and Goodness of their Almighty Creator, and he must be mad and senseless who refuses to acknowledge them.

God has wired each of us in different ways to know Him and experience Him, and some will experience Him more deeply through nature than others. Moses experienced many miracles but still asked God to show him His glory (Exod. 33:18). As we learn more about God's creation, we come to know His glory in new ways. We have a great God and we can learn much about Him from nature but nature alone still misses so much. The key remains as a favorite saying in my office read, "For what does it matter if I know all of geology and know the ages of all rocks, if I do not know Jesus, the rock of all ages."

Biographical Sketch

I was born the second time in 1965 in a small church in the small eastern New Mexico village of Dora. I was nine years old. I had been in church regularly since soon after birth, but I understood that that did not make me a Christian. When I knelt with our pastor, I prayed and invited Jesus to come into my heart. I was young, but I had already been collecting rocks for at least three years. Through my elementary and high school years, my interests in science and my Christian faith deepened. In high school, I was aware of the conflict that many saw between the two, but I was encouraged to pursue both. Scholarships, government grants, and work/study programs make it possible for me to go to college at Eastern New Mexico University in nearby Portales where I immediately chose to major in geology. There I dated an amazing young Christian lady named Karen Ridgley, and soon we were married. I graduated from ENMU, and after a brief period working for Gulf Oil Company, we moved to El Paso, Texas. I completed a MS in geology at the University of Texas at El Paso.

When I graduated, my wife and I moved to Houston to take a job exploring for oil and gas with the Mobil Oil Company. Over the next twenty years, we lived in Houston, New Orleans, London, and Dallas. When Exxon and Mobil merged to form ExxonMobil, we moved back to Houston. I continued to work for ExxonMobil, writing drafts of this while living in Stavanger, Norway. My career allowed me to study the geology of many parts of the world. I have been involved in exploring for new fields, developing fields that have been discovered and in creating detailed geologic descriptions of existing fields in order to recover more oil and gas. I have now retired and in living back in the Houston area.

Karen and I have been active members of churches in every place that we have lived. This has included teaching Bible classes to children, young people, and adults. I believe getting into God's word is essential for every Christian and that small group Bible study is an important part of Christian discipleship. I have also served as a deacon in four churches as we moved around. We have two grown sons who are Christians and are active in local churches as well. We now have the joy of helping our grandchildren learn about both God and science as well. God has designed each of us in special ways to be able to see and experience an individual close relationship with Him. Each can experience God differently.

Regardless of how else our grandchildren learn to know Him, I hope that they will also learn to know God as their creator through both science and the Bible.

Appendix Radiometric Dating

When a murder has been committed and a medical examiner arrives at the scene, one of the most important questions that he has to answer is: When was the time of death? The TV programs show over and over again that measuring the body temperature is one method that is used. If the death was recent enough, its temperature may still hold remnants of its temperature from life. That temperature often will decay at a predictable rate: 1.5° (2.7°F) per hour until it reaches the temperature of its environment (Claridge 2015). TV detective shows also point out that murderers have numerous ways to trick the medical examiners. The basic predictable rate requires that the conditions be right for the measurement to be accurate. If the body is put in extra cold conditions, the temperature will drop more quickly. Smaller bodies cool more quickly than larger bodies. The fact that there are situations when this method does not work does not mean that the method is not useful. The time of death based on the decay in body temperature uses very straightforward measurements of physical properties and changes that are well understood and the method has been tested repeatedly. One can be confident that if the proper conditions existed, this measurement will give a trustworthy answer. Even in the best of cases, the examiners recognize that the measurements are not perfect and the ambient conditions were variable to some extent. There is always a time range given because the measurements just cannot be precise enough to tell the precise moment of death.

The forensic medical examiner is quite analogous to the physicist using radiometric dating. Certainly, the time ranges that they are attempting to measure are radically different. Instead of hours, the physicist uses different methods to date things that might be hundreds or even billions of years old. Fortunately, normally knowing the exact year for rocks is not that important in most cases. Both are using physical measurements of properties that varied over time. In each case, the process that leads to the change is well understood. Although the decay in body temperature may be easier for nonscientists to understand, radioactive clocks should give more consistent answers for the time ranges that they are trying to measure. This may seem surprising but they are just less susceptible to environmental changes and thus more predictable as clocks. Without giving in any sense a thorough explanation, I will give my perspective on this valuable scientific approach.

How does a radiometric clock work? First it is important to understand what radioactivity is. Atoms of the same element all have the same number of protons and electrons. However, they can still be different, based on the number of neutrons. Thus, elements may take different forms, known as isotopes, based on differing numbers of neutrons. Some isotopes are stable for long periods of time, but others are unstable. The unstable atoms break down, emitting radiation and in the process, change into other elements that are also usually unstable, a process known as decay. From a human standpoint, it is impossible to say when a particular atom will decay and change into another element. That would seem to make such a process particularly badly suited for use as a clock. However, what is totally unpredictable for one particular atom turns out to be extremely consistent for large populations of atoms. For large sets of atoms, each isotope will decay at an average rate such that for a particular time, known as the isotope's half-life. Half of the atoms will decay, emitting radiation and changing from one element to another. Isotopes that decay faster have shorter half-lives. The most common isotope of uranium, ^{238}U, is unstable. It decays, sending out an alpha particle and changes into the thorium isotope, ^{234}Th. It is not a fast process. We still have ^{238}U around. If you had one gram of ^{238}U, then 4.468 million years later, you would have 0.5 grams of ^{238}U. The rest would have decayed into ^{234}Th. The thorium isotope is also unstable, so part of it would have decayed into protactinium. Unstable ^{238}U is transformed through fourteen steps into lead, ^{208}Pb (Figure 108).

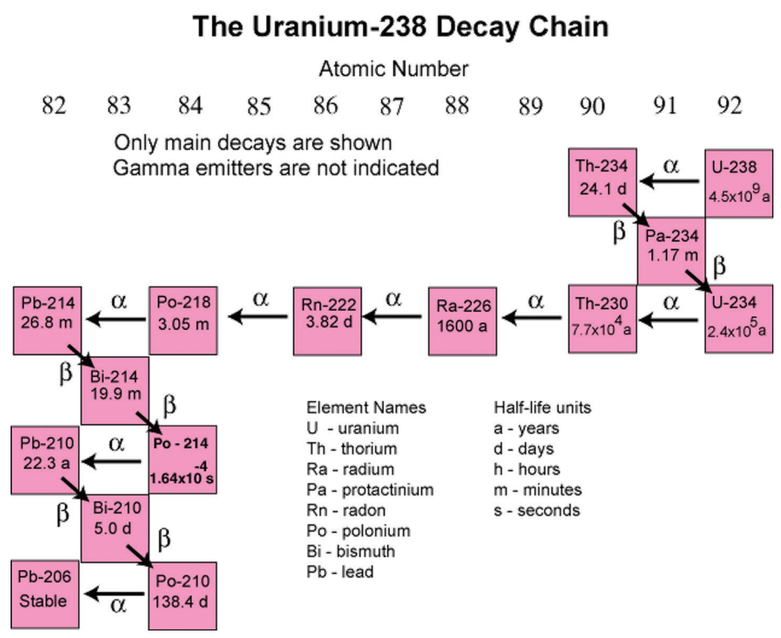


Figure 108 The decay series for ^{238}U, showing the element isotopes, the decay half-lives and the type of radiation emitted at each transition (Duval et al. 2004).

Such reaction chains have been developed for many different radioactive isotopes. In fact, many different chains are documented and are candidates for use as radiometric clocks.

A fair question might be, do we understand the physical decay process well enough to consider radioactive clocks reliable, even theoretically? Could this be some sort of "black box" where an analysis is performed and numbers generated, but scientists are really totally wrong about what is happening? How stable is the process of radioactive decay? Many experiments have been devised to evaluate the constancy of the rate of decay. Probably many investigators wanted to be the first to find the exception, the situation, or conditions that would give a different answer. It would have been much more exciting to be able to announce that they had discovered a way to slow or speed the decay rate. The actual result was to confirm that the decay rate is very constant regardless of extremes in temperature, pressure, electromagnetic field or gravity field. Why? Dr. G. Brent Dalrymple, a recognized expert on radiometric dating, helps with this explanation:

> There are two basic reasons why significant changes in rates of decay are not expected. First, the nuclei of atoms are extremely small and well insulated by their cloud of orbiting electrons. These electrons not only separate nuclei sufficiently that they cannot interact, but also provide a "shield" that prevents ordinary chemical or physical factors from affecting the nucleus. Chemical activity in an atom, for example, occurs almost entirely among the outermost electrons and does not involve the nucleus at all. Likewise the "compressibility" of a substance may result in slight changes in the configuration of electrons but has no effect on the nucleus.
>
> Second, the energies involved in nuclear changes are 10^9 times greater than those involved in chemical activity and 10^4 to 10^5 times greater than the energies that bind the electrons to the nucleus . . . Except for nuclear reactions, such energies are generally unavailable in natural processes such as those that form, change, and destroy rocks on the earth and in the Solar System. (Dalrymple 1991)

Overall, it seems that the physics required to explain radiometric dating is well understood and is constantly used in many other processes. The rate of decay has been experimentally tested rigorously for variations based on natural changes and found to be constant. We see good theoretical explanations for why the experimental data should be this way. If there are problems with this clock, they must come from somewhere other than the theory.

Does this prove that radiometric dating is valid? Hardly. Not all theories work in the real world. It is conceivable that one could theoretically date materials using some physical change, but it might be practically impossible to make meaningful measurements. For example, real measurements might be made useless because the measurements would be too difficult to make, or technology might not be available to measure the properties consistently. It also is important to look at what assumptions are necessary for the methodology to give meaningful measurements. It could be that the necessary

assumptions would be so unjustified and untestable that the results could not be believed. Let's look at radioactive decay and consider its methodology.

The first test of radiometric dating was published by Ernest Rutherford in 1905. He recognized that helium is a byproduct of radioactive decay and that it would otherwise be virtually absent from many minerals. His early measurements were encouraging but demonstrate some of the concerns. He proposed that by knowing the rate of helium production and the amount of helium in rocks, one could calculate an age for a rock. Measuring equipment at the time was far less accurate and reliable than today, but that was perhaps the smaller problem. He had to make the assumption that all the helium generated by radioactive decay stayed in the rock. He recognized this concern, knowing that helium, as an inert gas, is just too mobile. Rutherford published a date of 497 Ma (millions of years ago) for a fergusonite mineral for his first published example and called it a minimum age. The assumption that all the helium remained was not necessarily valid and could not be proven. If some of the helium escaped the rock, then the ratio of uranium to helium would be higher and the rock would seem younger than it actually is. At best, this could only be used for a few pristine igneous rocks where one could make the case that they had been undisturbed since formation. Rutherford's analysis also had the problem that as one standalone measurement, there was no way to validate it by comparing it to other methods. If no other possibilities had come forward, radiometric dating would have been of limited value and its conclusions been controversial and often unaccepted.

I will not try to give a technical explanation for the many techniques used in modern radiometric dating methods. Good resources for such would include *The Age of the Earth* by G. Brent Dalrymple, the University of Wisconsin Green Bay PowerPoint: https://www.uwgb.edu/...PPT/340Ra...; *The Bible, Rocks and Time* by Davis A. Young; and Ralph F. Stearley, *The Dynamics of Dating* (http://www.reasons.org/articles/the-dynamics-of-dating) and *Radiometric Dating: A Christian Perspective* (http://www.asa3.org/ASA/resources/Wiens.html) by Roger C. Wiens. The last three are particularly good because they are by Christians and give good Christian perspectives. This is useful for those who have concerns and difficulties when reading answers from scientists that are not Christians.

We recognize that there are many reasons why radiometric dating might not work for a particular rock. Many rocks have had complex histories that may have involved partial melting, alteration that occurred as groundwater and other fluids percolated through them and other processes. With so many things that could go wrong, is it possible to really trust this methodology? Here are some simplified points to consider when evaluating the validity of the methodology used to date rocks using radiometric techniques.

1. Over forty different measurement techniques are used. In many cases, the same rock can be dated using multiple independent methods. Such cross-checks provide strong validation that such dates are valid.
2. Today's instruments are extremely precise and capable of measuring isotopic concentrations in tiny, microscopic minerals. This helps both in terms of the precision of the measurement and by allowing measurement of elements within the lattice of crystals that are far less altered and more pristine than were available in earlier days. Zircon is the favorite mineral because, though it forms as only traces in most rocks, it is very durable and typically has uranium and thorium incorporated into its crystal structure. Isotopes within tiny crystals of zircon can be measured today and provide valuable data.
3. Techniques are available that do not demand major assumptions about the original isotopic composition of the rocks. The assumption that we know the original composition is usually difficult to test. Removing this assumption raises confidence in dates. One way is to measure the isotopic ratios in different minerals within the same rock and from different rocks within a given igneous body. When no other processes have intervened, the ratios can be plotted to align and point to a date without knowing the original composition. If they do not align, this provides clues about what other processes have occurred.
4. Several techniques are self-checking. That is to say that when the data are plotted, bad data can be identified and often corrected.
5. Most alterations tend to make a rock appear to be younger than it is. Many of the "daughter" isotopes, those that result from decay, tend to be somewhat more mobile than the original isotope. If less of the daughter is found, then the resulting ratios will tend to be enriched in the parent isotope and make the rock look as though less time has elapsed than really did. This was the case with helium in Rutherford's early work.

What might make rocks look older than they are? In this case, we are talking about not just a bit older. We mean radically older. What would make a rock that is only ten thousand years old have measurements that appear to be one hundred million years old? YEC scientists have spent much effort trying to identify any possible explanations. They dug into every aspect of the theory and the methodology. YEC geologist John Woodmorappe has extensively searched the literature for examples of radiometric dates that are questionable (Woodmorappe 1999). It is common for scientific writers to express concerns and uncertainties about their data and interpretation. Woodmorappe has a large collection of such comments and other inconsistencies. It would be quite a job to investigate each of his interpretations.

The most extensive YEC study was the "Radioisotopes and the Age of the Earth" (RATE) study initially published in 2000, and then in 2005 as a final report (Vardiman 2000; Vardiman 2005). Did the studies demonstrate any serious problems with radiometric dating assumptions or methodology? A reader might ask, did the RATE investigators come into study their with open minds to learn whether or not the method was valid? Perhaps it is more likely that, given their interpretation of the Bible, that their conclusions were forgone. They certainly gave their financial contributors a lot of material as each report is over six hundred pages long. I suspect that those convinced that the earth is young prior to the report were thoroughly pleased. Scientists in general and particularly those who are experts in nuclear physics were not impressed. Perhaps more telling, there does not seem to be any evidence that technically minded individuals with no prior position see the RATE report as raising any particular doubts in radiometric dating.

In my opinion, they have not found any evidence that really causes any substantial doubt in radiometric dating. A number of Web sites are available that provide specific critiques of their report.

For example, Jeff Zweerink of Reasons to Believe here: http://www.reasons.org/articles/comments-on-the-rate-project and Randy Isaac of the American Scientific Affiliation, an organization of scientists who are Christians: http://www.asa3.org/ASA/education/origins/rate-ri.htm

The researcher's extensive efforts in effect demonstrate several positive points that support conventional dating:

1. *Large numbers of measurements have been made from around the world consistently point to the dated rocks being much older than the YEC time frame allows. These are not flukes. They are the rule not the exception.*
2. *Most measurements are stratigraphically consistent. They are not randomly distributed.*
3. *No easy errors in either the theory or methodology exist that invalidate this methodology. The hope for an Achilles' heel that will make radiometric dating just go away does not seem to be coming.*

For example, DeYoung (2000) lists the following proposals to address the problem of these old dates:

1. Conventional assumption: Constant rate of decay in the past. If one assumes that today's rates worked in the past, then this is a major problem, given the preponderance of older dates.

   DeYoung proposal: a dramatic temporary increase or increases in decay at some point in the past, creating a large rapid increase in daughter products (during creation and Noah's flood). This would be a bit more tenable if (a) the earths strata supported such a flood interpretation, but the first part of this book demonstrated that they do not and (b) there was physical evidence consistent with such an increase, such as melting or evidence of the heat associated with such rapid decay. Most radioactive dating of rocks commonly uses igneous rocks such as granites. Even so, potassium feldspars are major components of arkosic sandstones. If such a dramatic increase in radioactivity occurred in them, then these sedimentary beds would show dramatic evidence of the associated heating.

2. Conventional assumption: Isotope composition has not changed by fractionation over time. There does not seem to be any physical explanation for why we should expect isotopes to be fractionized significantly, let alone routinely. If they are not, then it is fair to assume that radioactive decay is the major mechanism responsible for today's isotopic composition.

   DeYoung proposal: isotopes ratios altered, not just by decay but by fractionation. Evidence for this significant fractionation is apparently missing, but it would be necessary for the

   YEC timeline. There seems to be no particular logic to use to assume that ages that fit the stratigraphic order are due to fractionation.

3. Conventional assumption: It is possible to find rock samples that have been closed systems for eons of time. That is not to say that all rocks were closed or even that they were closed for all elements.

Geochronologists do say that it is possible to identify clean, unaltered samples and their analysis give valid results and that it is also possible to distinguish between valid and invalid results.

DeYoung proposal: parent or daughter atoms have moved into or out of rocks. Again, all recognize that many processes alter rocks. The geochronologist's assumption is that samples and scenarios can be identified that give meaningful results. The YEC proponent must believe that all the scenarios identified are off in major ways.

Radiometric dating methods have been through heavy scrutiny both by the regular scientific community and YEC skeptics. There seems no consistent reason to doubt its general credibility. So far, ^{14}C dating has not been discussed here. Is it to be believed? Many nonscientists think of this method as the only form of radiometric dating, while in fact, it was not even discovered until 1949 and not used for dating until the 1960s. The method recognizes that living plants and animals have nearly constant ratios of ^{14}C and ^{12}C and that ratio is fixed at death. At that point, the radioactive ^{14}C begins to decay and the ratio begins to change. With a half-life of 5,730 years, ^{14}C dating does not help much for most of the geologic column. It can be used only for samples younger than fifty to sixty thousand years. While that is old enough to be a significant problem for YEC positions, it does not hit much of the geologic record by the conventional timeline. This method has a well-known set of possible problems that can invalidate it, but it offers opportunities for testing it with material of known dates. While not every analysis has proven to be correct, even YEC geologist, Andrew Snelling admits that "radiocarbon 'dates' for the last 2,000 years seem to show a generally good correlation with historically verified artifacts and specimens" (Snelling 2009). It seems a bit convenient to me for a technique to be valid until it begins to give problems for the YEC position. Snelling again appeals to accelerated decay during creation and the flood.

It is the position of this book that the geologic record alone, without any of the radiometric dating demonstrates that the earth is far older than the YEC position demands. Radiometric methods do not rely on standard geologic methods. They are independent evidence for the antiquity of the earth. The RATE study recognized two problems for which they have no answers for today: the heat and radiation that their accelerated radioactive decay model demands. Such heat and radiation would not just leave evidence; it would end life on the planet. It is as always recognized that it is not beyond God's power to decay elements rapidly and make the world appear old radiometrically. However, so far it looks like the only purpose would have been for God to have made the earth appear old. Such effort at deception seems far out of character for the God of the Bible.

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Glossary

Anhydrite. A mineral composed of calcium sulfate ($CaSO^4$), typically white to gray. It commonly forms masses known as nodules in arid sabkha environments such as are found in the Persian Gulf today and in many ancient rocks as well. When anhydrite weathers near the surface, it usually gains water and changes to the mineral gypsum. Gypsum is used to make sheetrock, among other things.

Beds. Just as people lay in beds, sedimentary rocks are laid down or deposited in beds. Sedimentary beds can vary widely in thickness, typically from a few centimeters to few meters in thickness. In a few rare cases, individual beds can be many meters thick. They have limited areal extent as well. Individual sandstone and shale beds were typically deposited over the course of minutes to weeks. Carbonate beds sometimes took many years to form.

Bioherms. A mound shaped rock unit that was formed by organisms that grew in place. Reef deposits are a form of bioherm.

Carbonates. Sedimentary rocks composed largely of calcium or magnesium carbonate. The most significant are limestone and dolomite. At one time, many proposed that carbonates might have precipitated from sea water, but many studies have demonstrated that the material in carbonates was virtually all formed by debris and material from living organisms.

Clastic. Sedimentary rock formed from material derived from the erosion of older rocks. The size of such material ranges from boulders to fine clay. Examples include breccia and conglomerate made up of angular and rounded pebble size fragments, sandstone from sand sized fragments and shale and mudstone, made up of clay-sized particles.

Correlation. The establishing of the equivalence of two or more geologic units. In this book, we are primarily concerned with establishing that two units are stratigraphically equivalent. This means that they were deposited at approximately the same time. Approximately the same time is typically in terms of the geologic relative time scale rather than absolute age.

Cristobalite. A silicon dioxide mineral that forms at high temperatures. Opal forms at low temperature, often in some protozoa such as radiolaria. As the sediments are buried, they become hotter and the opal is no longer stable. Gradually it progressively changes to cristobalite which further changes to another mineral, tridymite and later into the mineral quartz. These conver-

sions take place over long periods of time but demonstrate the temperature to which the rocks were subjected to.

Cross-bedding. Many sedimentary rocks contain laminations that formed from moving water. Bedding and laminations that are not parallel are called cross-bedded, reflecting changes in the flow of water during deposition. Many different schemes have been used to name the various types and some types are diagnostic of the depositional setting and the water velocities involved.

Depositional belt. Repetitive sets of sedimentary facies are found in many basins around the world. When these are roughly linear, they are known as depositional belts, as similar processes repeated over and over through time.

Depositional shelf edge. The seaward limit of shelf depositional processes along a basin. This is term is used when this limit forms a bathymetric break in slope and the water depth deepens sharply into the basin (Figure 1). In clastic depositional areas, this break develops at a depth that is usually between 50 and 130 feet (15–40 m) below sea level. This point, known as "storm wave base" represents the deepest depth that waves can move sands and coarser sediment. Basinward, all movement of sediment coarser than clay size, is by gravity driven processes, not wave energy.

Depositional systems. A set of depositional processes that are linked in that they are typically found together. Such depositional systems might include deepwater clastic, fluvial, or aeolian systems. Recognizing the system allows geologists to predict many things about the geometry of the rock units and their properties and what type of rocks were deposited around them.

Debrites. A sedimentary rock deposited by a "debris flow." A debris flow is a gravity driven slurry of sediment moving down a slope. The resulting deposit has a very chaotic fabric with no internal organization. Debris flows are often started in marine settings by sediment collapses and reflect rapid deposition.

Diapir. Rock formations where lighter, less dense material rose up through heavier, denser rocks. Both salt and shale can form diapirs in sedimentary settings. We can now demonstrate that salt and shale diapirs typically developed passively as the heavier sedimentary rock were deposited around lighter rocks. Salt masses are particularly noted for complex histories related to salt movement at times and at other times having been eroded.

Environment of deposition (EoD). The setting where sedimentary rocks were deposited. Different settings or environments were characterized by different energy levels and thus different grain sizes, often by different biologic components such as reef forming organisms or plant roots and by many other different features. When many features found in one area are considered along with the features in nearby areas, it is normally possible to recognize the environment of deposition with confidence.

Facies. A body of rock that can be characterized by distinct features that distinguish it from other adjacent rocks. Many types of characteristics are used such as lithologies, chemical characteristics, or fossil assemblages. Often the facies are mapped to help understand the depositional setting and its characteristics and extent.

Fenestral texture. Texture of limestones with many parallel open pores, often later filled with minerals such as calcite or anhydrite. The texture was formed by gas bubbles and sediment shrinkage in tidal-flat carbonates where the lime muds were exposed often.

Fluvial. Used in geology to refer to processes related to rivers and river deposits.

Flume. A physical model built to simulate natural flow processes. Geological flumes simulate sediment deposition under many different fluid flow conditions.

Geothermal gradient. The measure of how temperature increases with depth at a particular location. The rate of change or the gradient varies depending on factors such as the nearness to magma chambers or the local composition of the earth's crust and its local amount of radioactive material.

Hiatus. A period of time when little or no deposition takes place at a particular location. This term is generally used when little erosion is recognized, despite evident passage of significant time.

Hydrodynamic sorting. The dropping of materials out of suspension where the order of is determined by their size and density. Bigger and denser sediments settle first. Last to settle out are small mud and clay particles. The shape of particles also affects the rate of settling, such that less compact shapes also settle slower. Today computers are able predict sorting characteristics quite accurately.

Index fossils. Fossils from distinct animal or plant species that lived over a broad area, but not for a very long time. Often these are species of animals or plants that were very adaptable in terms of environments but that evolved quickly by changing in small but distinct ways.

Law of Superposition. The recognition that rocks that are deposited on top of other rocks or layers are younger than those they are deposited on. When rocks have been deformed by later structural activity, it can take some investigation to determine which way was up, but once we know which way was up, it is clear which beds are older, using this simple law.

Levee. Topographic highs along the margins of channels. The channels can be either river or submarine channels. Levees typically form as floods or large flows deposit fine grained sediment along the channels. The fine-grained sediments don't erode easily and help to confine normal flow. Later, floods or large flows again deposit layers of fine sediment over the earlier deposits building them higher and further confining the flow of the channel. Thus, over time, with many flows, levees can build to be very significant features that restrict rivers and submarine flows strongly to the channel. Levees are usually easily recognizable by the shape as they parallel a channel and are thickest near the channel and thin away from it.

Meander. A curved portion of a winding, sinuous channel. Both river and deepwater systems form meandering channels. Predictable sediment patterns (facies) are found in meandering systems. Water flowing along highly sinuous channels uses much of its energy eroding into the outer banks of meanders. Hence such systems do not downcut into older strata but aggrade as subsidence deepens the area. For information on the formation of meanders, this Web site is useful: http://hydrotopics.wordpress.com/2010/10/05/how-and-why-rivers-meander/

Measured section. A description of the strata at one location that has been measured and described by a geologist. This records that portion of the geologic column that has been preserved at one

location. It generally includes the lithologies and depositional features that are found there. Such descriptions can be put together in a region to help understand the geologic history of that area.

Megabreccia. A sedimentary rock made up of very large boulder sized clasts, most of which are angular. A breccia always has angular clasts, indicating that they were not smoothed by the long periods of erosion that form rounded pebbles. Megabreccias form in when a large amount of sediment is deposited rapidly as a very high energy deposit near to where the clasts originated.

Mudstone. A sedimentary rock largely composed of fine, mud-sized particles, too small to see without a microscope. These sediments settle out last in a sediment flow, in the quietest water available.

Ooids. Carbonate grains approximately two millimeters around and composed of many layers. Usually the layers were originally tiny aragonite needles that nucleated around a sand grain or shell fragment. Ooids are actively growing today in the Bahamas. Radiocarbon dates show that those at the surface have been growing for the last 1,000 to 2,800 years (Duquid et al. 2010). They show evidence of many phases of growth including periods where microbes corroded them. Ancient ooids were the same. Rocks formed dominantly of ooids, known as oolites, probably took thousands of years to form.

Period. A geologic unit of the time it took for a particular set of strata to be used. Conventional geology interprets periods to have lasted tens of millions of years. Each period is characterized by unique fossil types that can be correlated globally.

Playa. A very flat depression in arid areas that does not drain into other systems. Ephemeral lakes develop in playas during rainy periods and dry up during dry periods.

Porosity. Holes and spaces within rocks, known as pores. Usually porosity consists of tiny holes though larger pores are found such as caves. Oil and gas are held in rocks within pore spaces.

Progradation. A common stratigraphic pattern that develops as sediments fill in a basin. In prograding sediments, the rate at which sediment is brought to the basin is faster than the rate at which the basin subsides. As a result, sediment facies patterns advance across the basin much faster than the patterns deepen from subsidence (See Figure 12).

Reef. Originally this word was used to represent a positive feature that represented a hazard to ships. This book uses the term for a localized buildup of carbonate sediment that formed from organisms growing in place. (See pages 132–136.) Reefs have been formed by many different types of organisms and many more specialized terms are used in geology. For the purposes of this book, it is important to distinguish what is not here considered a reef. In particular, a carbonate mound or accumulation that formed by wave or current energy, such as a carbonate sand bar would not be a reef. An accumulation of carbonate debris from storms such as hurricanes or floods would not constitute a reef. Both ancient and modern reefs would be likely to include features shaped by storms or have sand bars along them, but the presence of an organic community that developed in place is key to considering a deposit as a reef in this book.

Reservoir rocks. Rocks that can hold oil or gas and having properties that will allow them to be produced at economic rates. This term is used in the oil industry to distinguish rocks that represent

potential targets to drill wells into. Reservoir rocks must have porosity and the pores must be connected enough for fluids to move through them.

Sabkha. A depositional environment that develops under arid to semiarid conditions above the normal high tide, where minerals such as gypsum, anhydrite, and halite (salt) crystallize near or at the surface as a result of evaporation and other processes.

Seismic. Term used in this book for reflection seismic surveys. These surveys utilize a source that generates sound waves that propagate down into the earth. As the sound waves go down through the earth, part of the energy is reflected back to the earth by the rock layers. Sound receivers record the sound, and this is then processed by computers to give an image of layers below.

Sinuous. A winding pathway commonly found in rivers, streams, and other channels such as in deepwater settings

Spiderweb anhydrite. A common form of anhydrite where the growth of white anhydrite has pushed and concentrated impurities away, forming black outlines through the anhydrite (see Figure 40)

Shelf. In this book, used as a general term to describe a depositional setting characterized by shallow marine processes.

Stratigraphy. The branch of geology that studies stratified sedimentary rocks, including the processes by which they were formed, their classification, organization, and distribution

Stromatolite. Finely laminated sediment in which the layers were microbial mats formed my blue-green algae (also known as cyanobacteria). These mats form during tidal cycles.

Subaerial. Referring to events or deposits that formed on land, above a standing water level such as sea level or lake level.

Subducted. Used in plate tectonics for when two of the earth's plates collide and an oceanic plate is denser and is pushed down beneath a continental, less dense plate.

Subside. The geologic process by which portions of the earth sink deeper. Several different processes can drive this, including some caused by man. One effect of a basin subsiding is to create space for sediments to be deposited in.

System. The geologic term for the set of rocks deposited during the unit of time known as a "period." Periods are conventionally viewed as lasting tens of millions of years. Regardless of the length of time, the correlative rock units would be described as a "system."

Tidal deposits. Sediments laid down by processes dominated by tide action. Many criteria are used. Often such sediments have distinct bundles of high and low tide deposition. Overall cyclicity corresponding to lunar cycles is recognized in some cases. Some sections show the reversing of the current direction with the changes of the tides.

Tridymite. A silicon dioxide mineral that forms at high temperatures. Opal forms at low temperature, often in some protozoa such as radiolaria. As the sediments are buried, they become hotter and the opal is no longer stable. Gradually it progressively changes to another mineral, cristobalite which further changes to the mineral, tridymite and later into the mineral quartz. These conversions take place over long periods of time but demonstrate the temperature to which the rocks were subjected to.

Turbidite. The deposit of sediment that results from a mix of sediment and water moving down a slope in a body of water. The flow that deposits the turbidite is known as a "turbidity current." Turbidites have a predictable set of sedimentary features that develop in the same order though they are dependent on the type of material available. Deposits from turbidity currents make up much of sediment deposited in deepwater settings.

Unconformity. An erosional surface between two bodies of rock. The term itself does not imply how much erosion took place or how much time went by before the younger rock was deposited over the surface. It does demonstrate that some time is not represented by rock.

Well Log. A record of what was encountered down a well, such as an oil well or water well. Sample logs record the types of rocks drilled and other characteristics using bits of rock that are brought up in the drilling process. Electrical tools are lowered down the hole on wires or attached to drill pipe behind the bit. These record many properties of the rock such as its density, natural radioactivity, how fast sound travels through it. These logs can be used to accurately determine the lithology, porosity of the rock, and the type of fluid that the rocks pores are filled with.

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About the Author

Stephen Mitchell (MS, University of Texas El Paso) is a recently retired petroleum geologist and a Christian. He spent thirty-eight years working for major oil companies, exploring for new oil fields, helping develop major discoveries and optimizing production of existing oil fields. In geology, he has strong expertise in stratigraphy, sequence stratigraphy, regional geology, and reservoir geoscience. He accepted Jesus as his savior at the age of nine and continues to experience God through the Bible and through His creation. He and his wife, Karen, have been active in teaching Bible classes to children, young people, and adults in the churches where God placed them around the world. He has served in many leadership positions including in their current church in Spring, Texas.