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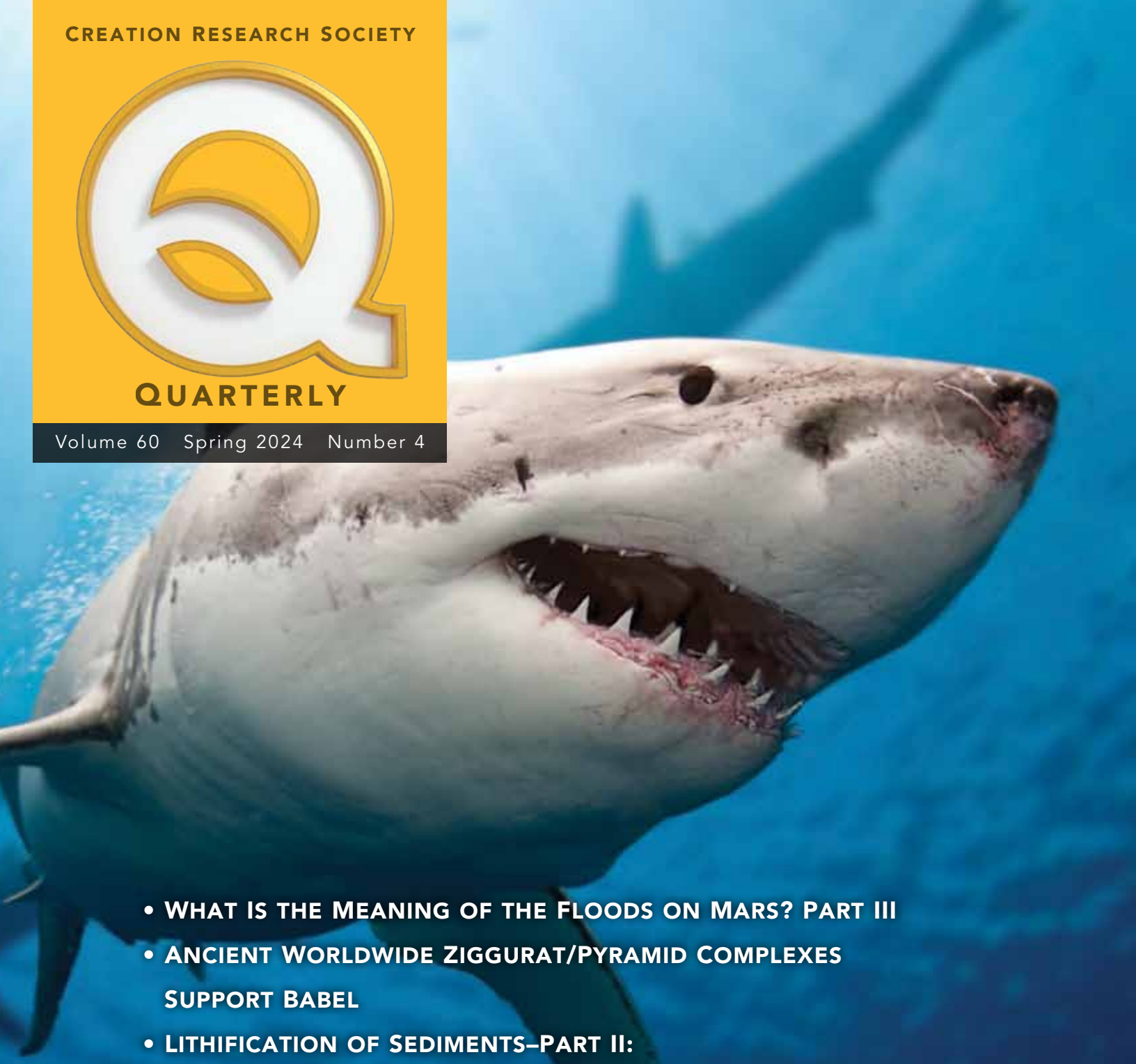

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Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh.—Exodus 20:11

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Editorial

Why Christians Should Conduct Research

There are Biblical reasons, cultural reasons, and financial reasons to conduct research as a Christian. What defines Christian research versus non-Christian research? Essentially, it is the frame of reference in which a person will view the information, data, and results. Evolutionists will find a fossil today and make up a story with its associated timing of what happened in the past. If they examined a wrought metal fatigue specimen after it fractured, they might logically suggest that most of the life was spent in the large surface roughness region or the smaller "thumbnail" region of the fractured surface as shown in Figure 1, because those are the two obvious regions that one can see on the surface. However, both guesses would be wrong as 99% of the cyclic life was spent in a region that nucleated the crack that one cannot see on the specimen (on the order of a couple microns). In other words, one cannot predict the past by just examining the current state of a material or structure. One needs to know the history of the entity to really develop a good theory about what happened. Figure 1 illustrates an example of how one cannot just examine the specimen in the final state and determine its history. Our claim as creationists is that we have clues about the history because the Bible has accurately documented them for us. Evolutionists are examining fossils today and speculating about the past without knowing the actual history. Hence, Christians need to conduct research in order to address false claims about science.

Several Bible verses provide the impetus for one to *conduct research* to garner knowledge:

- **Psalm 111:2** (ESV): Great are the works of the LORD *studied* by all who delight in them.
- **Proverbs 25:2** (KJV): It is the glory of God to conceal a thing: but the honor of kings is to *search out* a matter.
- **Ecclesiastes 1:13** (KJV): And I gave my heart to seek and *search out* by wisdom concerning all things that are done under heaven: this sore travail hath God given to the sons of man to be exercised therewith.
- **Ecclesiastes 7:25** (KJV): I applied mine heart to know, and *to search, and to seek out wisdom*, and the reason of things, and to know the wickedness of folly, even of foolishness and madness.
- **Proverbs 15:14** (KJV): The heart of him that hath understanding *seeks knowledge*: but the mouth of fools feeds on foolishness.
- **Proverbs 18:15** (KJV): The heart of the prudent *gets knowledge*; and

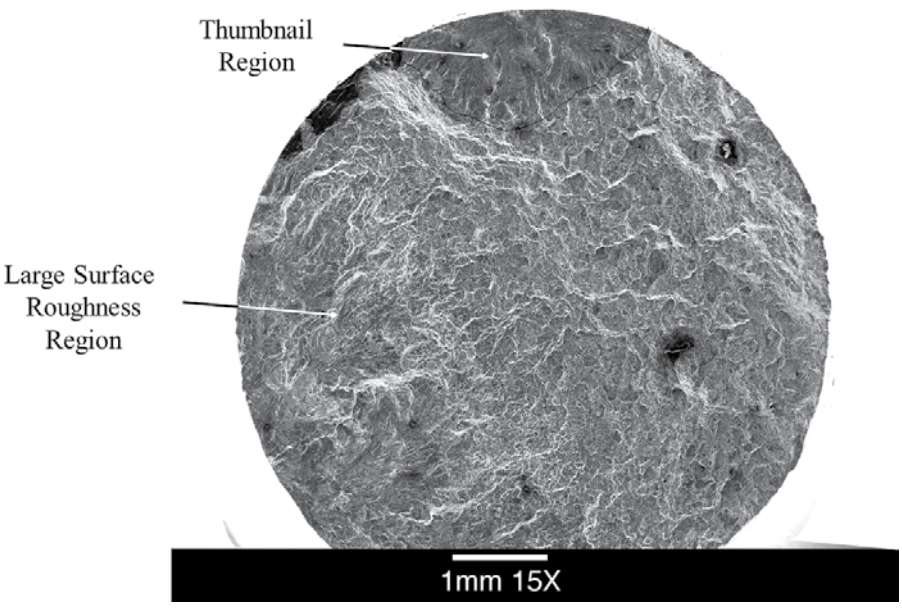

Figure 1. Fracture surface of an aluminum alloy illustrating different regions where different physical mechanisms dominated the regions under a mechanical cyclic fatigue loading environment.

the ear of the wise *seeks knowledge*.

- **Deuteronomy 29:29** (KJV): The secret things belong unto the LORD our God: but those things which are *revealed* belong unto us and to our children for ever, that we may do all the words of this law.
- **Romans 1:20** (AMP): For ever since the creation of the world His invisible attributes, His eternal power and divine nature, have been clearly seen, *being understood through His workmanship [all His creation, the wonderful things that He has made]*…

It is interesting that Romans 1:20 reveals that we can understand God more from the things that He creationeered®. Although one motive is to increase knowledge by using the scientific method, Romans 1:20 indicates that the ultimate motive is to learn more about God by conducting "reverse engineering" analysis of His creation. As a Christian, this elevates the motivation because "knowledge of God" is on a greater plane than gathering knowledge for one's own sake or for a corporation's sake.

Several cultural reasons exist that should encourage a Christian to partake in research endeavors. One is that researchers write the books that influence our academic and national culture; if Christians do not engage in research, then the "opportunity loss" to impact our culture would be great. Atheists and agnostics seem to have recognized this fact and have written many science and engineering books. Martin (1992) summarized the philosophical basis for atheism and noted that 210 million atheists and 805 million agnostics reached about 21% of the world's population in 1982. Dawkins (2006), Hitchens (2007; 2019), and Hawking (2009) popularized atheism around the world. In 2022, approximately 450 to 500 million atheists and agnostics self-identified worldwide (7% of the world's population) according to Keysar (2017) with China alone accounting for 200 million people of that demographic. The reason that China is predominately atheistic is due to communism, the totalitarian political structure declaring that the "state" can take care of society, not God. Hence, no God is claimed to be needed. However, it was Darwin's book (1859) that was the watershed for widespread belief in atheism, since he hypothesized that pure materialistic means of evolution controls the origin of species, meaning that the minor species variations that we observe in nature give rise over time to all different species. This leads to a purely naturalistic premise that all life does not need a Creator God nor a current controlling or influencing God in the universe.

Another cultural reason to conduct research is that it is useful and helpful for humankind. President George Washington (1790) said that research was a foundational issue of our country. When addressing Congress in his State of the Union Address, he urged Congress to create institutions of learning for "the promotion of patronage of science (re-

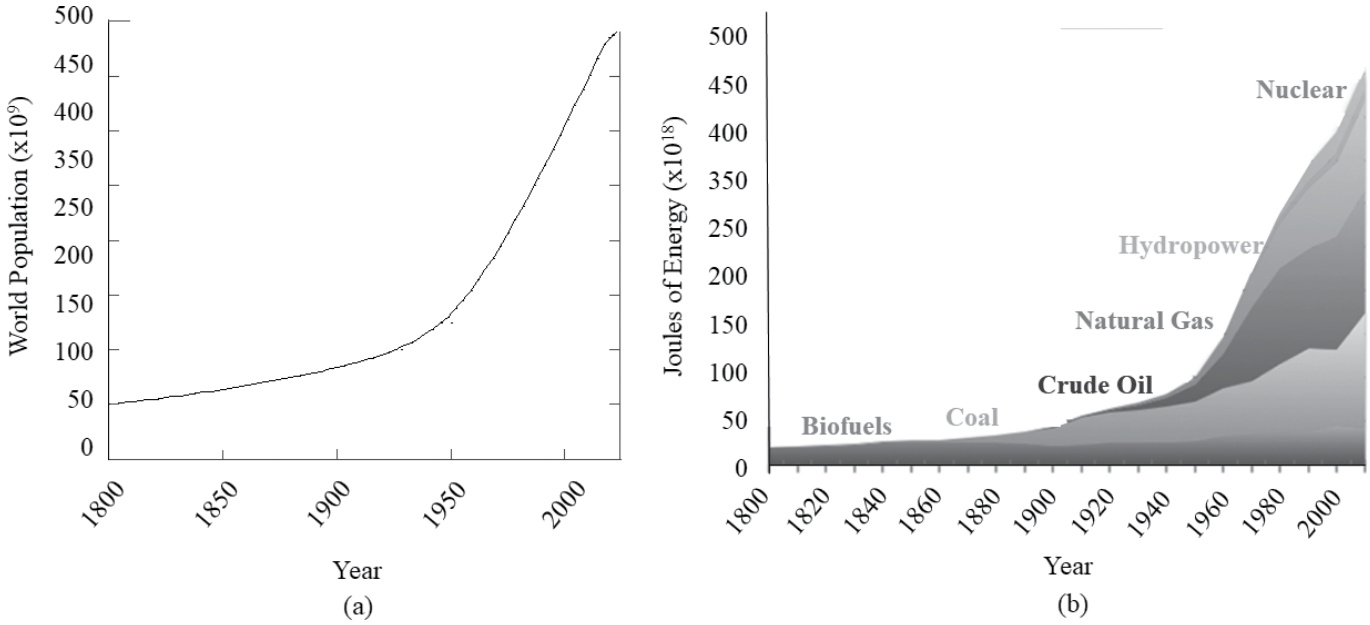

Figure 2. (a) World population (ourworldindata, 2024) increase over the years increased the need for energy and (b) the amount of energy required (Smil, 2010) and the associated different energy technologies that arose from research endeavors to sustain humanity.

search) and literature: Knowledge is in every Country the surest basis of public happiness." He tied together the causal relationship of knowledge-gathering to happiness.

One final cultural reason for research is related to the social and economic pressures that have produced societal problems like energy, starvation, and water problems related to the world population increase in the past 50 years. It was scientific research that has produced newer, more efficient energy methods (see Figure 2). It was scientific research that created new efficient agricultural methodologies and new foods. It was science that has created new technologies for purifying water for human consumption.

Several financial reasons exist that should encourage the Christian culture to pursue research endeavors. Research is an exponential "growth stock" from a business sense as research funding pays not only for researchers' salaries, but its overhead pays for the growth and infrastructure needed. Research-technology industry growth increases the real estate growth and overall prosperity of a community (Hart, 2019) particularly when entrepreneurship can grow the technology (Goldstein and Renault, 2004). Research creates technical entrepreneurship opportunities and helps to fight through the valley of death to grow a local ecosystem (Drucker and Goldstein, 2007). The regional repository of research expertise heavily influences the regions' ability to attract and retain technology-intensive firms with higher-paying jobs. Research provides the regional labor force with modern knowledge skills. Finally, research provides the flexibility of shifting, uncertain, and rapidly changing economic circumstances.

In summary, research has an impact on individuals and groups of people as it affects cultures and finances of a society. In essence, research fulfills the general proposition of the "Dominion Mandate" of Genesis 1:28 to "rule" and "reign" on the earth. Individually, some parts of the body of Christ should conduct research as specific callings related to Ephesians 2:10. For example, some feel led with a holy calling to conduct research. Apparently, when King Charles II nominated Robert Boyle to be the highest-ranking person in the church, Boyle responded with "my ministry unto the Lord" is related to scientific research and not church work (to the amazement of King Charles II). Creation scientists should be encouraged that they are fulfilling God's mandate related to the aforementioned reasons when they conduct research. Creation science is ministry.

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Liberty University

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Why Ancient Worldwide Ziggurat/Pyramid Complexes Support the Biblical Babel Account

Anne Habermehl*

Abstract

Although the best-known feature of Babel in the Biblical narrative was the tower that Noah's descendants began to build in Shinar, the Bible says that they were constructing a "city" there as well. No details are included of either the Babel city or tower. However, as this paper will show, the Tower of Babel was likely a ziggurat (stepped pyramid), and the city that accompanied the Tower was most likely composed of temples and various other religious structures. We infer this because around the world we see many ancient pagan religious complexes consisting of ziggurats together with temples and other buildings. The archaeological similarity of these far-flung ziggurats has been noted by many scholars, both Biblical and secular. It appears that after the Babel dispersion, far from learning their lesson when God intervened by stopping the work and confusing their language, men went on to build ziggurats and temple complexes wherever they settled all over the world. It is proposed here that these complexes were patterned after the original one that they had started to build back in Babel. These worldwide pyramid complexes constitute witness to the truth of the Biblical account and are compelling archaeological support for the authenticity of the Biblical story of Babel. The rebellion against God by Noah's descendants at Babel cannot be overestimated in its profound effects on mankind. In showing evidence for taking the Babel story literally, as in this paper, the creationist worldview is supported.

Key Words: Biblical archaeology, city of Babel, pyramids, ziggurat/ pyramid complexes, ziggurats

Introduction

The worldview difference between young-Earth creationists and traditional evolutionists with respect to world history is nowhere more obvious than in the Biblical narrative of the city and Tower of Babel. Whereas creationists believe this account literally, the evolutionary view is that it never happened, but is merely a myth, as primitive early men could not have built a structure as advanced as the famous Tower. Evolutionists are therefore confronted with the problem of explaining the existence of the many ziggurats around the world that bear resemblances to each other (we will look further into this below). Creationists, on

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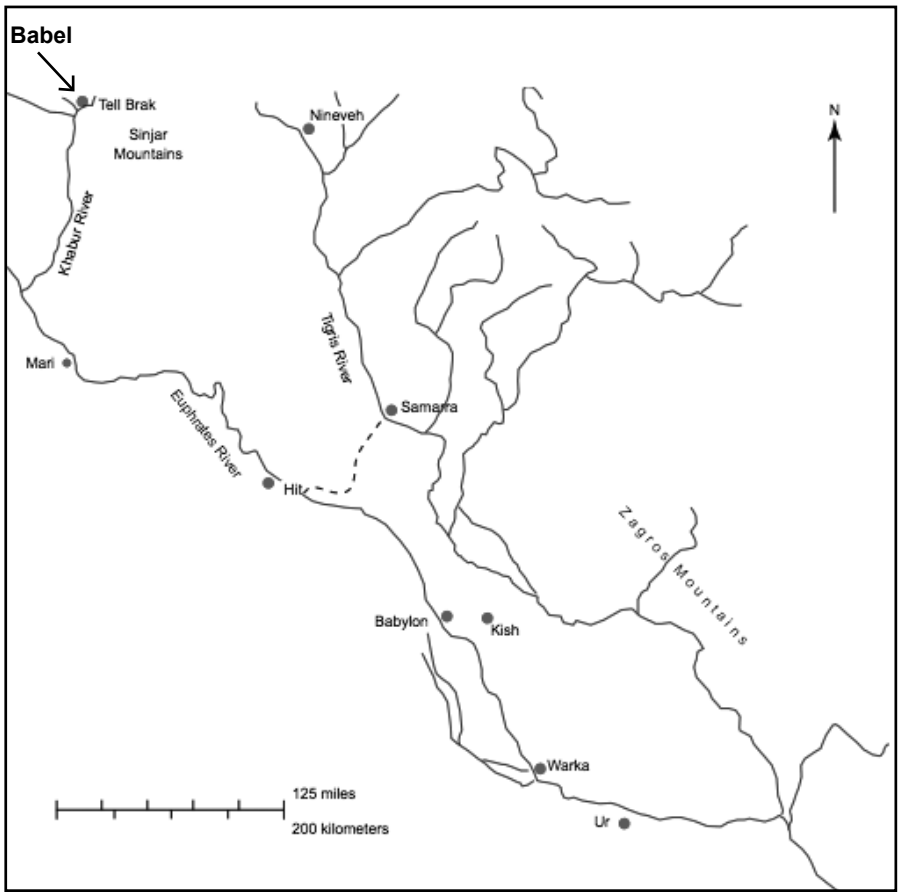

Figure 1. This map shows Mesopotamia, the land between the Tigris and Euphrates rivers. Babel was in Shinar, in the upper left corner near Tell Brak (see arrow). The dotted line is the escarpment that marks an ancient shoreline, dividing the north from the south. Babylon is in the south, in territory that was under water at the time of building the Tower of Babel. (Drawing is from Habermehl, 2011. Used by permission of *Answers in Genesis*.)

the other hand, can point to the Biblical narrative as a viable explanation for this similarity.

Background of the Babel Narrative

According to the Bible, God sent a worldwide flood that destroyed the entire Earth because of mankind's evil ways. Noah and his family came safely through the Flood in an Ark that God had instructed Noah to build (Genesis 6:11–22). After Noah and his family left the Ark, the group eventually migrated to a plain in the land of Shinar (Genesis 11:2). There they began to build the famous Tower of Babel and its city (Genesis 11:3, 4). From Shinar, God dispersed them abroad "upon the face of all the earth" (Genesis 11:8). Considering that God had taken extreme measures to stop the building project (Genesis 11:5–8), we might think that the people had learned their lesson and would fear further punishment from God if they ever tried such a thing as building another city/tower complex. But as we will show in this paper, quite the opposite happened. After the people spread throughout the world, they eventually built these structures wherever they went. History does not tell us details on this.

Where Babel Was Located and When the People Dispersed

It is from Babel in Shinar that the people scattered in all directions because God had confounded (confused) their language (Genesis 11:7). Shinar was most likely located in the Khabur (Habor) Triangle in North Mesopotamia near Tell Brak. For an extensive treatise supporting this location for Shinar, see Habermehl (2011). Two of the points made in that paper are that South Mesopotamia, where it is traditionally believed that Babel was situated, was under water at the time of building the cities in Shinar; and also that Babel and Babylon are two different places. This shows the importance of crossing over information between archaeology and other disciplines such as geography and geology. See Figure 1 for a map showing where it is argued that Babel was located in North Mesopotamia.

There is disagreement among Bible scholars as to when the Babel incident occurred. The birth of Peleg is usually considered to be the time of the Babel dispersion, because of the statement that "in his days the earth was divided" (Genesis 10:25; 1 Chronicles 1:19). Some scholars dispute this, on the basis that it was actually the physical land that was divided in Peleg's day, not the peoples. For a discussion of this subject, see Fouts (1998, pp. 17–21).

The Babel dispersion date also depends on whether we look to the MT (Masoretic) or LXX (Septuagint) genealogies. Although traditionally creationists have used the MT timeline, in more recent times there have been some who argue that the LXX is the version that we should use (e.g., Smith, 2018, pp. 117–132). Based on Peleg's birth, this

puts the Babel dispersion around 2250 BC in the MT, or 2570 BC in the LXX, a difference of just over 300 years between the two. See Habermehl (2018a, Figures 3 and 4), for diagrams showing these dates on the MT and LXX timelines. However, the conventional (also called the standard secular) timeline in those figures shows the Babel dispersion at least 1.76 million years ago. Those who use conventional dates to look for the Tower of Babel do not realize this.

Dating of Ziggurats and Pyramids

The difference between the LXX and MT does not apply to the dating of anything from Terah (Abraham's father) on, except for the 40-year difference in I Kings 6:1 between the two versions. What does apply is the divergence between the Biblical and secular timelines, which could also be called their misalignment. (The question of synchronization of Biblical dates and standard archaeologists' dates is debated in creationist circles. See Habermehl 2013a, 2013b, and 2023 for discussion of this.) Table I shows correlation of some secular Egyptian dates to Biblical dates in the historical period.

How the standard timeline relates to the Biblical timeline is significant in this paper, because all dates of monuments published by archaeologists are based on the standard timeline, not the Biblical one. As shown in Table I, the secular and Biblical timelines merge roughly at 600 BC, and after that the standard archaeological dates are the same as those of our Biblical timeline. This means that any ziggurats and other structures dated before 600 BC will have two dates—the secular one and the Biblical one.

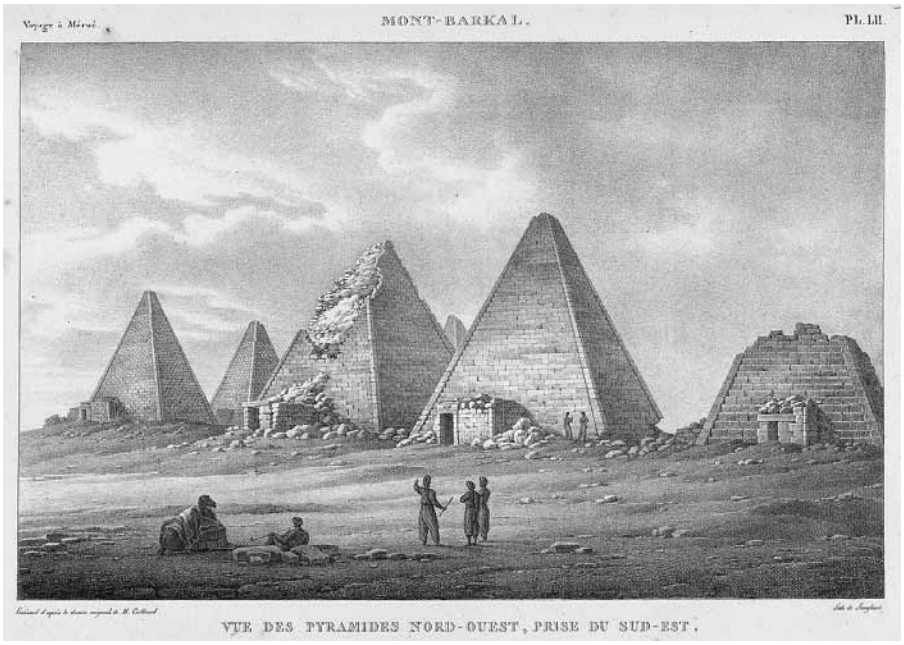

Figure 2. The pyramids at Jebel Barkal, Sudan (about two thousand years old), are examples of simple smooth pyramids. (Drawing: Frederic Caulliaud, 1826. Public domain.)

Figure 3. The Temple of Kukulcan (El Castillo) at Chichen Itza in the Yucatan, Mexico (built 600–1000 AD), is typical of a basic ziggurat, also called a stepped pyramid. The basic features are the layers of receding steps, with one or more stairways, and a shrine on top. Variations of this design are seen around the world. (*Wikipedia*: Photo by Pedro Marcano, August 2014.)

Are Ziggurats and Pyramids the Same Thing?

In this paper we will take the view that the two kinds of structures, smooth-sided and stepped, are essentially the same with regard to their meaning and their descent from the Tower of Babel. See Figures 2 and 3 for photos of a smooth pyramid and a ziggurat (stepped pyramid), respectively.

The common elements of the pyramid/ziggurat design are a square or rect-

Table I. Synchronization of Egyptian and Biblical dates. Because of the vagaries of the Egyptian/standard timeline, it does not correlate to the Biblical timeline in a straightforward way, as is shown below. There are two dates for the Exodus because the 6th and 12th Dynasties ran concurrently, and the Exodus takes place at the end of both dynasties (see Habermehl, 2013b). For a discussion of Solomon's date on the Egyptian timeline, see Habermehl (2018b). The timelines merge at the fall of Jerusalem, usually dated at 587 BC. Dates on the chart are approximate.

Person/Event	Egyptian (Standard) BC	Biblical Date BC
Abraham	3000	2000
Joseph	2650	1700
Exodus	2200/1800	1450
Solomon	1500	1000
Timelines Merge	600	600

angular base, with four sides oriented to the four cardinal directions. Unlike smooth-sided pyramids, ziggurats have multiple stories that get successively smaller toward their summit, one or more sets of stairs, and often a shrine on top. It is surprising how recognizable the basic ziggurat elements have remained up to fairly recent times, as we will see.

The world-famous (smooth) Egyptian pyramids at Giza are frequently cited as examples of pyramids; indeed, the definition of a pyramid is often given as an Egyptian pyramid. For example, Lehner (1997) claims right on the cover that his work is a complete book of pyramids, but he does not mention pyramids anywhere else in the world other than Egypt and Sudan. A ziggurat is often defined as a Mesopotamian structure, as an internet search of "What is a ziggurat?" will show. Oddly, ziggurats in other countries. (except the Saqqara stepped pyramid in Egypt) are not referenced by these sources.

"Pyramid" is used by some sources to refer to both the stepped and smooth structures. As an example, *Wikipedia*'s page, 'List of Mesoamerican Pyramids' (List of Mesoamerican Pyramids, 2022), lists 51 pyramids; most, if not all, are stepped, and are therefore ziggurats. The article says that "in most cases they are not true pyramids." The accepted definition of a true pyramid by this writer is clearly a smooth-sided structure. Understandably, this is confusing.

What this all means is that, if a structure is called a ziggurat, we know that it is stepped. If it is called a pyramid, it can be either stepped or smooth. But the real question is whether there is a difference in meaning between the two. This is doubtful.

It has been pointed out that the Egyptians, who built the most famous smooth pyramids in the world, built at least one stepped pyramid first (e.g., the Saqqara pyramid of Djoser) (Tyldesley, 2009, pp. 32–34), and continued to call their smooth pyramids "stairways to heaven" (Bertman, 2003, p. 197). It would seem that the Egyptians did not distinguish in meaning between pyramids and ziggurats (see Step Pyramid, 2018).

Also, the line between ziggurats and smooth pyramids is not always clearly drawn. As an example, the Pyramid of the Sun in Teotihuacan (Mexico) is stepped, but the sides have a gentle incline, and the steps are not sharply delineated (Phillips, 2009, pp. 54–55) (see Figure 4).

Figure 4. The Pyramid of the Sun at Teotihuacan, Mexico—an example of a ziggurat with sloping stepped layers that are not distinct. The stairs are on the other side and do not show in this view. (*Wikipedia:* Photo by Mario Roberto Duran Ortiz, 2015.) (HJPD 2011)

Where Are Ziggurats and Pyramids Found Around the World?

If these structures are descendants of the Tower of Babel, they should be found in far-flung places, because the people migrated from Babel to all parts of the globe.

Popular sources might lead us to believe that a limited number of ziggurats and pyramids are located in Egypt, South Iraq, and Central America. But these are only the most famous ones. There are as many as 30 countries where pyramids/ ziggurats are located, according to pyramid lists (see, e.g., Home In The Air, 2018).

This includes the United States, where secular scholars make an end run around the problem of pyramids by calling them "mounds." (However, see Pluckhahn et al., 2016, pp. 345–363, regarding the shell ziggurat on Roberts Island, Florida, claiming that some scholars are starting to change their minds, and are using the term "pyramid.") A well-known example of an American ziggurat is the enormous Monk's Mound at the Cahokia Mounds site in Illinois (George, 2008, pp. 48–49), as shown in Figure 5. This mound is somewhat over a thousand years old.

Figure 5. Monk's Mound, a Pre-Columbian Mississippian culture earthwork, located at the Cahokia site near Collinsville, Illinois. The concrete staircase is modern, but it is built along the approximate course of the original wooden stairs. (*EN.Wikipedia*: Photo by Skubasteve834, November 2007.)

How many ziggurats and pyramids are there worldwide? One pyramid hunter who has spent over ten years researching this question has come up with at least 1700 known ones (Yakovenko, 2014). However, he concludes that we don't really know how many there are because many more may remain to be discovered. In support of this conclusion, a vast jungle area of Guatemala has been surveyed by LIDAR (Light Detection and Ranging), and archaeologists claim that as many as 60,000 Mayan structures previously unknown are hidden under the canopy of trees, including an unknown number of pyramids (Gillan, 2018). Another pyramid has recently been discovered in Egypt (Hoare, 2020). For information on various kinds of remote technology that we now have for finding many more structures such as pyramids around the world, see Parcak (2019).

If we wonder how something like a pyramid could be still undiscovered, the answer is that it is easier for a pyramid to hide out than we might think. As mentioned above (Gillan, 2018), some are camouflaged by jungle. In some cases, pyramid-shaped hills are believed to be natural and not manmade; the Bosnian pyramids (Editors, 2017) are an example of this (more on these later). Some pyramids are buried; for instance, there is an underground pyramid in Peru that was discovered via satellite and other methods (Lasaponara et al., 2011). Some ziggurats are found beneath later religious structures built when conquerors brought a new religion with them. A famous example of this is the huge Mexican pyramid of Cholula that has a Catholic church, La Iglesia de los Remedios, sitting on top of it (McCafferty, 1996, pp. 1–17). This pyramid is by volume the largest in the world. Its base covers 39 acres (16 hectares), not including the complex of other structures around it. It is claimed that it was so big that the Spaniards did not realize that it was a pyramid when they built the church on what they thought was a hill.

This all makes it difficult to come up with the number of ziggurats/pyramids there actually are. We only know that there are a lot of them, and more may be discovered at any time.

One thing needs to be clarified: smooth pyramids are found only in Egypt and its southern neighbor, Sudan; these countries are therefore a small minority of the countries where pyramidal structures are located worldwide. Because the pyramidal structures in all other parts of the world are actually ziggurats, this leads us to believe that the original Tower of Babel was also most likely a ziggurat. The smooth pyramids were a later development in history, with the first Egyptian ones built in about 2600 BC on the secular timeline (Lehner, 1997, p. 15).

Other Ziggurats and Pyramids

Clearly in this paper we cannot discuss even a fraction of all the ziggurats/ pyramids around the world, so a few examples will have to suffice. There appear to be some pyramids that date as early as the Ice Age. One of these is Gunung Padang, on the island of Java, where scientists believe there is a very early pyramid at the bottom of the multilayered structure, dating as far back as 22,000 secular years (2100–2000 BC Biblical) (Deron, 2022). There are also

Figure 6. This modern Hindu Sri Siva Vishnu Temple in Lanham, Maryland, has a traditional gopuram tower with ziggurat characteristics over the entrance to the temple area. (*EN.Wikipedia*: Photo by Docku, July 2008.)

Figure 7. The Prasat Thom at Koh Ker, Cambodia, is a seven-tiered ziggurat. (*Wikipedia*: Photo by PsamatheM, December 2019.)

some large pyramid-shaped mountains in Bosnia that date during the Ice Age; we know that these are pyramids because they are oriented to the cardinal points, i.e., the four main compass directions (Editors, 2017).

These early men must have had a powerful urge to produce pyramids. Even shaped hills would have required an enormous amount of work, especially if faced with a hard material, as the Bosnian pyramids are claimed to be (New Investigation, 2019). Judging by the size of some of the pyramid-shaped mountains, we might wonder just how large the Tower of Babel was planned to be before God stopped its construction. There may be more meaning than we realize in the Biblical statement that the tower was to "reach up to heaven" (Genesis 11:4).

The gopuram towers of south India (built there in front of Hindu temples as late as the 17th century) (Kuiper, 2011, p. 317), show clear ziggurat characteristics. But this style of architecture lives on. A modern Hindu temple in Lanham, Maryland, USA, has a traditional Indian-style gopuram tower over the entrance to the temple area (Sri Siva Vishnu Temple, 2002) (Figure 6).

Two ziggurats that surprisingly look much alike are the 10th-century Prasat Thom at the Koh Ker temple complex in Cambodia (Figure 7) and the 8th-century Pyramid of the Niches at El Tajin in Southern Mexico (Figure 8). Built on opposite sides of the world within 200 years of each other, the similarity in their design has caused scholars to scratch their heads. There must be some connection, they are certain, but they cannot fathom what it can be. For more description of the Prasat Thom, see Zwegers (2008). For more on the Pyramid of the Niches, see Cartwright (2015).

Two further examples that are very similar but located geographically far apart are the 15th-century AD Candi Sukuh in Java (Figure 9) (Oey, 1997) and the seventh-century AD Temple of the Inscriptions at Palenque in southern Mexico (Figure 10) (Phillips, 2009).

Ziggurat/Pyramid Complexes

Although the story of the Tower of Babel is renowned, there was another aspect of Babel that is less widely known. This

Figure 8. Pyramid of the Niches at El Tajin, Veracruz, in Southern Mexico. This ziggurat bears a surprising resemblance to the far-away one in Figure 7. (*Wikipedia*: Photo by AlehandroLinaresGarcia, January 2010.)

Figure 9. The Candi Sukuh is a Hindu temple in Java, built in the 15th century, and is the main structure in the complex. This truncated ziggurat bears an inexplicable resemblance to Mayan monuments. (*Wikipedia*: Photo by Anton Leddin, December 2007.)

Figure 10. The Temple of the Inscriptions ziggurat at the Palenque complex of structures in Chiapas, Mexico, built in the seventh century BC. (*Wikipedia*: Photo by Lousanroj, March 2013.)

Figure 11. This is an example of a ziggurat complex. The great Templo Mayor (the ziggurat at upper center with two shrines on top) was part of the Aztec City of Tenochtitlan. The model shown here is at the National Museum of Anthropology in Mexico City. (*Wikipedia*: Photo by Thelmadatter, March 2008. Public domain.)

was the "city" that was being built in addition to the Tower (Gen 11:4). We note that in this verse it is the city that is mentioned first, giving it a degree of importance. The original Babel tower was not going to be a solitary structure. If the thesis of this paper is correct, that the people later on went everywhere and built ziggurats as memories of the original Tower of Babel, we should find a "city" of some kind along with these towers. What was this city?

Again, we need merely look at the ziggurats/pyramids around the world for our answer. We see that they are usually part of a religious complex of temples, shrines, altars, statues, and various other associated structures. We will choose some examples from the many available.

One of the ziggurat complexes in Mesoamerica is at Tenochtitlan, now

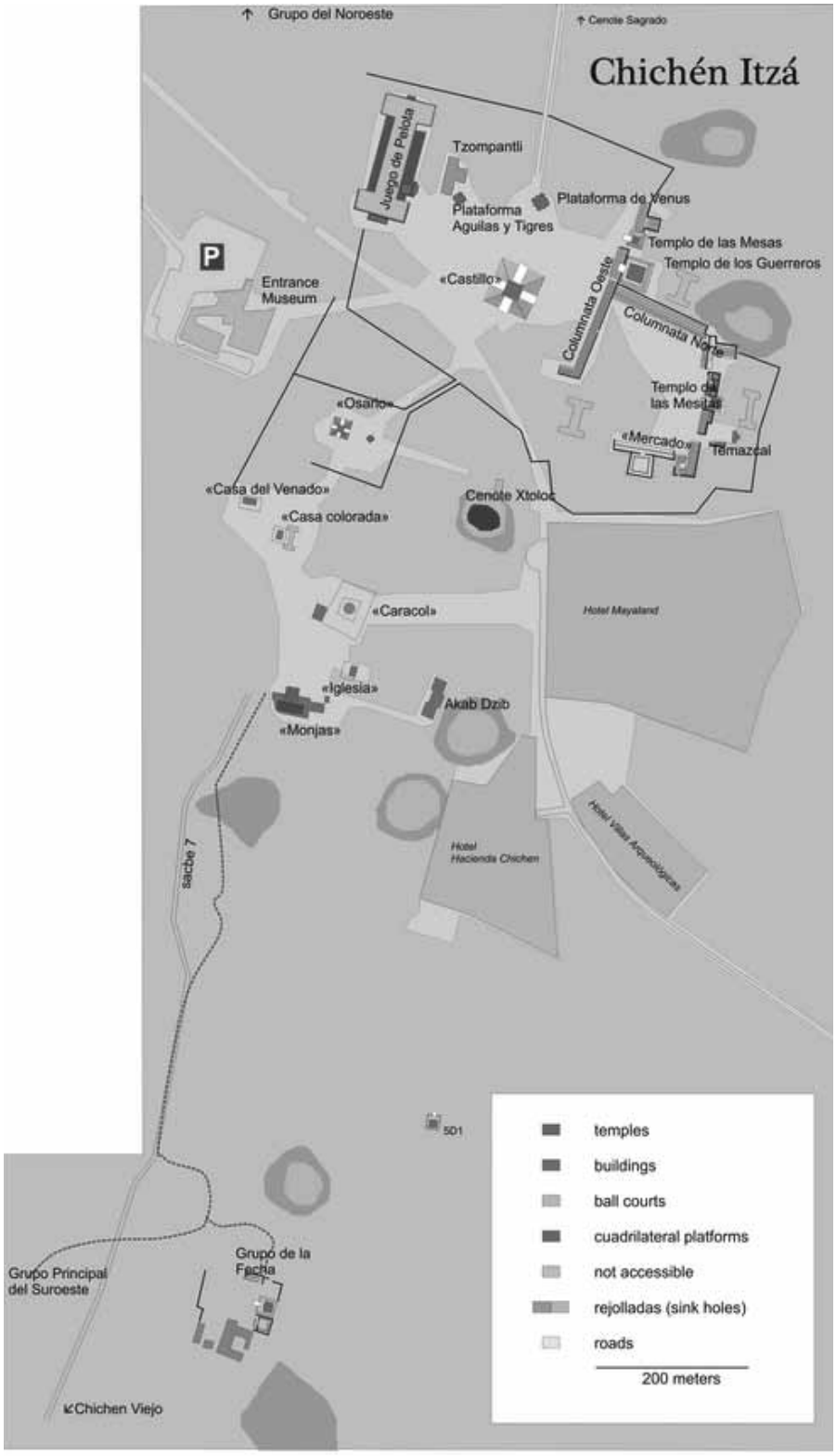

Figure 12. Diagram of Chichen Itza site complex, including the location of the famous El Castillo ziggurat shown in Figure 3.

in Mexico City, where the main structure was the Templo Mayor (see Figure 11) (Phillips, 2009, pp. 430–431). The other structures in the complex included several temples, a blood-drenched sacrificial stone, and other sacred structures. All of these were enclosed by a wall. Another example from this part of the world is El Castillo at Chichen Itza in Mexico, mentioned earlier, built about 9th century AD (Chandler, 2013, p. 254) (see Figure 10). It is located in a huge complex (see a map of the complex in Figure 12) that covers an area of at least 5 square km, packed with hundreds of smaller ziggurats, temples, and other buildings. Much of this site has not yet been excavated (Paxton, 2001, p. 98; Onstott, 2010, p. 338). The Caral pyramids of Peru are as old as the great pyramids of Egypt (about 2600 BC secular), and are considered to be part of the oldest civilization in the Americas; see Faram (2010) for information on this complex. In Guatemala, a large number of Preclassic Maya sites have recently been located by LIDAR, dating from 1000 BC (secular) (Hansen et al., 2022). The authors describe complexes consisting of a pyramid plus other structures throughout this area.

The nineth-century Hindu Arunachalesvara temple complex in the Tamil Nadu area of India is one of the many Indian temple complexes (see Figure 13) (Bajwa and Kaur 2008, p. 1069). Das (2001) describes 68 of these Dravidian Hindu temples of South India. However, the real number of these is claimed to be many thousands in the Tamil Nadu state of India alone, not including Kerala and other states (List of Temples in Tamil Nadu, 2022). These South Indian temple complexes all have the tall gopuram towers with the ziggurat characteristics (mentioned earlier). The Palace of Sargon II at Dur-Sharrukin contains a ziggurat that is part of his palace complex (Figure 14). See Mark (2014) for further information about Dur-Sharrukin. There are about 25 zig-

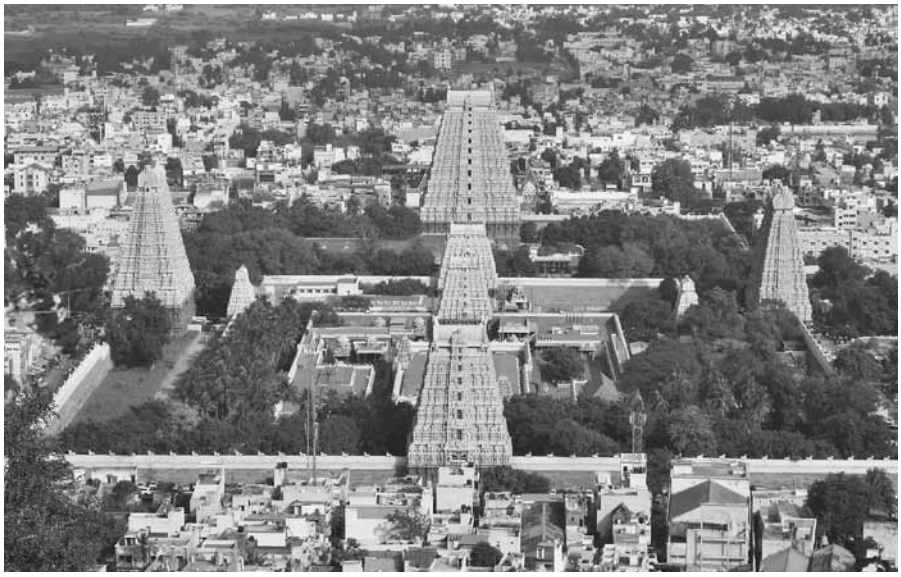

Figure 13. The nineth-century Hindu Arunachalesvara temple complex in the Tamil Nadu area of India is shown above with its six gopuram towers. The four large ones are over the four entrances; there are two smaller ones in the middle. These steep towers show characteristics of ziggurats with their stepped layers and shrine on top. (*Wikimedia Commons*: Photo by Adarsh Pidugu, February 2020.)

gurats known throughout Mesopotamia, dating from 2200 BC to 500 BC secular (Ziggurat Towers, 2020).

The extensive Giza complex in Egypt contains the famous smooth pyramids of Khufu, Khafre, and Menkaure. In his book, Lehner (1997, pp. 18–19) devotes space to describing a standard Egyptian pyramid complex: besides the main pyramid there was usually a mortuary temple, entrance chapel, storage areas (called magazines), courts, halls, causeway, valley temple, etc., all enclosed by a wall.

The highest pagoda of the Bagan complex in Myanmar (Burma) has a ziggurat style that greatly resembles the ones in Figures 7 and 8 (see Figure 15). The terraces of the ziggurat are very clear; the round stupa on top of them is the equivalent of the shrine on ziggurats in other countries. It is 328 feet tall. The vast number of other structures around it form the remainder of the huge complex (for a photo view of this stunning complex, see Bagan, Burma, 2007).

Among other examples of pyramid complexes are: The Holly Bluff site, also called Lake George site, in Mississippi (see Figure 16); the Etemenanki tower complex at Babylon (Parrot, 1955, p. 37); and the ancient complex at Ur (Ching et al., 2017, p. 35). Many more could be mentioned.

Wherever we look, we find that ziggurats/pyramids were accompanied by other structures that constituted a "city." Based on the pattern of complexes like those mentioned above, it follows that the builders of the original Babel ziggurat must have been constructing a religious complex of buildings to go with their tower. In other words, the "city" that accompanied the Babel Tower was not meant for people to live in, the way we think of a city today. The city with its tower would have been the religious center for the Babel kingdom.

Although the MT only mentions that they left off building the city in Genesis 11:8, we would expect that the tower also would not have been completed, as the tower was part of the city complex. In any case, the LXX more specifically says in the same verse that they "left off building the city and the tower." No indication is given as to how much of their build-

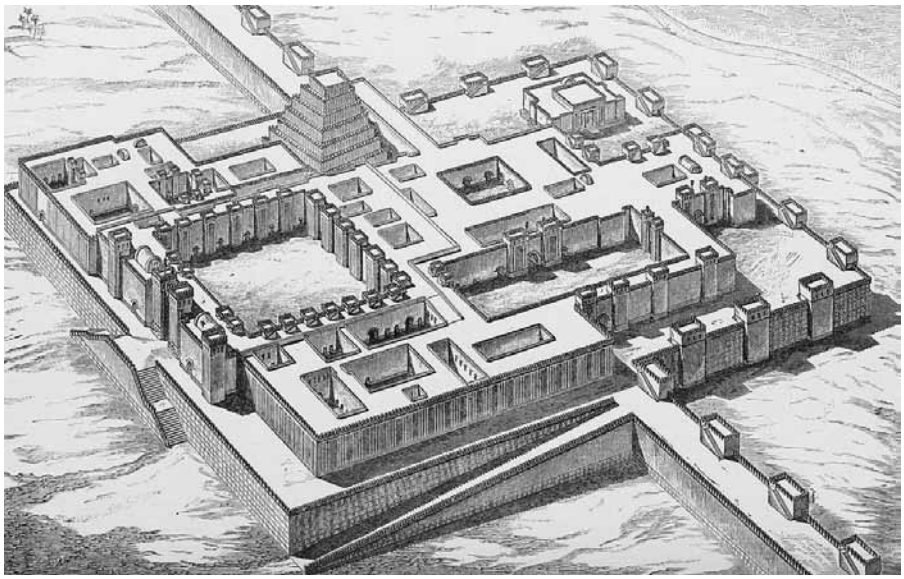

Figure 14. Drawing of the palace complex of Sargon II at Khorsabad, northern Iraq, with its ziggurat. (An Internet Archive Book Image, dated 1905. Public domain.)

Figure 15. The Shwesandaw Pagoda is the tallest of the 3500 pagodas, temples and other structures in Bagan, Myanmar (Burma), that occupy about 41 square kilometers. (*Wikipedia*: Photo by Jasoneppink, January 2013.)

ing project was completed before God interrupted it. This has implications for searching for the Babel ruins today.

The Religious Meaning of the Worldwide Complexes

God's displeasure with the Babel city-and-tower project is evident in the narrative of Genesis 11:5–9. He was concerned with what the people were planning to do, clearly actions that were against His wishes. A further clue is supplied by Nimrod (see Nimrod's mention in Genesis 10:8–10).

Although it is often stated that Nimrod was the original instigator of the people's rebellion against God (e.g., Josephus, 1988, p. 35; Pentecost, 1995, p. 49), this belief cannot actually be supported from the Biblical text. The Genesis narrative indicates that it was a group decision to build the Tower ("... let us build us a city and a tower...let us make us a name...") (Genesis 11:3,4). The driving force behind the building of the original Babel tower and city was therefore a group rebellion against God.

Before this rebellion took place, the people would have followed their ancestor Noah in worshiping God. The important indication here is Nimrod's name, which is widely claimed by scholars to mean "Let us rebel" or "We shall rebel" (Butler, 1991; Hendel, 2001, p. 218; Morris, 2003, p. 54). Nimrod would have received his name at birth as was the usual custom. The significance of his name had to do with something that occurred at the time he was born. We can conclude that the decision of Noah's descendants to rebel against God must have been made when Nimrod was born. From childhood, Nimrod would have grown up in the midst of the group's planning of the rebellion, designing of the city and tower complex, the beginning of its construction, and practice of their pagan religion. Eventually, when he became a mature adult, Nimrod became their leader (Genesis 10:10).

We would expect that the city they were building along with the tower was intended to support the ritual and administrative aspects of this religion. If so, this should be true of the many pyramid complexes in the world today.

And this is what we do see. Although it is outside of the scope of this paper to examine all the ziggurat/pyramid complexes around the world for their ties to religion, we will look at some here.

In Mesopotamia, the ziggurats were recognized as part of the religious complex that formed a sacred zone in the cities. The colors of their stories (from their base upward, white, black, red, purple, and blue) were considered to have religious significance. (See Margueron, 1965, p. 150; Oppenheim, 1994, pp. 172–173; Leick, 2001, p. 128.)

Egyptian pyramids were known for religious meaning. The king was a god, and the pyramid was the focus of a temple complex (Lehner, 1997, p. 20). In his classic book on Egyptian religion,

Breasted (1972, pp. 70–77) discusses the importance of the religious aspect of the pharaoh's pyramid complex.

In Mexico, an example is the site of Angamuco, Mexico, where LIDAR has uncovered a city under the jungle (Friedl, 2019). There are a couple of dozen pyramids; these are believed to be associated with various gods and goddesses, according to what is known of the religion of the Purepecha people who built them (Tompkins, 1976, p. 384). The Tucume pyramids of Peru had a mainly religious function (Heyerdahl et al., 1995). Multiple other examples can be cited.

Often writers somewhat confuse the issue by calling ziggurats 'temples.' Although many ziggurats do have a shrine of some kind on top, the temples are usually a separate structure in the complex. However, the basic religious significance of the complex is implied by this.

The sheer number of these structures, and the enormous amount of work that their builders put into them, tells us that ziggurats and pyramids were something important that was inherent in the worldwide pagan religions.

There is one more thing to mention here. One might suggest that a religion such as Buddhism could not have ziggurats that related back to Babel because the religion itself only developed later on, in the late 6th century BC (Vail, 2022). It appears that pagan religions developed religious structures from traditions that already existed in their various countries. The stupas of Myanmar (one is shown in Figure 15) are essentially the Buddhist-style dome sitting on a ziggurat base. That ziggurat base is most likely in the style of ancient structures in Myanmar or Indian history that have been lost to us (Buddhism originated in India). Indeed, we do not know how many very early versions of pyramids were built everywhere thousands of years ago, and have not survived. But logically we can expect that these must have existed; it is unlikely that the people built no ziggurats for thousands of years and then suddenly started to build them.

Figure 16. An artist's conception of the Holly Bluff Site, sometimes known as the Lake George Site, a Plaquemine Mississippian culture ceremonial mound site in Yazoo County, Mississippi. Note the flat-topped pyramid in the center of the complex, dated to about AD 1350–1500. (*Wikipedia*: Herb Roe, October 2016.)

How Do Unbelievers Explain Worldwide Ziggurats and Pyramids? (Not Very Well)

As noted earlier, explaining the architectural similarity of all these worldwide ziggurats/pyramids has been a problem for secular historians because of their belief that humans (*Homo sapiens*) evolved from lower species, most likely out of Africa (Rito et al., 2019). In the evolutionary worldview, the ability to design and build engineering marvels like these monuments has to have evolved along the way and only developed in relatively recent times in human history.

Ziggurats/pyramids do not fit into this mainstream worldview. That this feat of engineering should have occurred all over the world separately among the various peoples is off the edge of their scholarly thinking. They have been forced to resort to some rather far-fetched explanations for this phenomenon.

One idea is that a ziggurat is a natural concept that occurred to many peoples independently. A proponent of this concept is de Camp, who says that "if you set out to build an edifice several hundred feet high when architecture is in its infancy…you have to adopt a pyramidal form for the sake of stability" (de Camp, 1993, p. 62).

Another secular explanation is called the "diffusion principle;" i.e., if two peoples have the same idea, one group borrowed it from the other. This principle has been quite popular, presumably because it sounds good. Graf says that "…whenever we spot parallels and agreements in ritual and mythology, diffusion, however complex, is as likely an explanation as is parallel origin" (Graf, 2004, p. 5). A special form of the diffusion principle is offered by Schoch, who would have us believe that there were ancient seafaring ziggurat builders who traveled around the globe preaching the idea of building pyramids (Schoch, 2003, p. 3).

Because some countries with pyramids/ziggurats are not geographically far

apart (e.g., Egypt and Iran), we cannot prove that the idea of building similar structures in these places arose independently. But even then there are problems. The Saqqara pyramid in Egypt (dated 27th century BC secular) is considered to be Egypt's first pyramid. But was it? We cannot prove that there were no earlier ones, now ruined. The same argument applies to the earliest Mesopotamian ziggurat at Sialk, Iran, about 3000 BC in secular time (Raddato, 2021). There is also the question of the different religions practiced in these countries. As we have shown, religion was inherent in the meaning of the Tower of Babel.

It is understandable that scholars who deny the Biblical history of the Tower of Babel would look for explanations of widespread ziggurats like those cited above. This also helps us to understand the great resistance that has been shown by many modern secular archaeologists toward recognizing newly discovered pyramids/ziggurats as such, especially really ancient ones. While they recognize that men could build structures like ziggurats and pyramids within historical times, the more ancient ones go against evolutionary belief.

An example of this is the outright hostility that continues to be shown toward the huge pyramids that are being uncovered at Visoko in Bosnia. The *Wikipedia* page on these pyramids is written from an extremely biased point of view, quoting the European Association of Archaeologists who call these pyramids a "cruel hoax" (Bosnian Pyramid Claims, 2022). This same page even makes statements that are incorrect, such as that the excavations there since 2006 have shaped the main hill to look like a pyramid. Carbon dating of organic material gives a minimum secular age of around 30,000 BP for this structure (Moon, 2014, p. 97), much older than scholars can (or wish to) comprehend. I have been in correspondence with a Bosnian Pyramid volunteer who has tried repeatedly and fruitlessly to get changes made on this *Wikipedia* page. All of his changes have been deleted immediately by the *Wikipedia* editors.

The huge structure (covering 15 hectares) of Gunung Padang in Java has received much the same treatment from archaeologists and from *Wikipedia* (Gunung Padang, 2022). Although this structure is very clearly manmade, a volcanologist claims it's an extinct volcano with some building on top. It may be as old as 28,000 years (secular). (For more information on this megalithic site, see Bachelard and Rompies, 2013; Dockrill, 2018; Dipa, 2024.)

From the viewpoint of simple logic, the Biblical story of the Tower of Babel as the original pattern of all these ziggurats/pyramids makes far more sense than the explanations and denials of unbelievers. The mathematics of probability could also be invoked to show that it is extremely unlikely that these similar structures around the world all evolved separately (for information on probability see, e.g., Pishro-Nik, 2014). Probability is a discipline that has been often overlooked in traditional archaeology and history, but there are places where it can be useful to creationist arguments. For example, probability comes up in finding the Exodus in the Egyptian timeline. Egypt totally collapsed twice in the same way, and historians have accepted this very unlikely scenario without questioning how unlikely this could be. For a discussion of this with respect to the Egyptian dynasties, see Habermehl (2013b).

Importance of the Babel Story for Biblical Apologetics

Many modern scholars do not accept the meaning of the Tower of Babel as a sign of rebellion against God. One belief is articulated by the famed Andre Parrot, whose writings about ziggurats are well known (Parrot, 1949, 1955). On the meaning of the Tower, he says (based on a "growing conviction"), "Instead of a clenched fist raised in defiance towards Heaven, I saw it rather as a hand stretched out in supplication, a cry to Heaven for help" (Parrot, 1955, p. 9). If we should wonder how he could possibly get that interpretation out of the Biblical account, it soon becomes apparent that it is because he does not consider the Biblical story to be true history; he believes that the Genesis record of the Babel tower must have been written down in the ninth to eighth centuries BC, and was based on ruins of ziggurats found in South Mesopotamia (Parrot, 1955, pp. 15–17). His statement that the Babel story being a reference to these ruined ziggurats "is now accepted by almost all biblical scholars" unfortunately remains all too true in liberal circles. See, for example, Siff (2008), for another version of this belief.

There is an irony in this wholesale rejection of the historicity of the Biblical record, because in their own way all these "Biblical" scholars are following in the footsteps of those rebellious Babel builders of long ago.

In showing that the ziggurat complexes around the world offer strong support for the literal city and Tower of Babel of the Bible, we have in hand a powerful apologetic for answering these naysayers. It is the most important point of this entire paper.

Summary

We conclude that the many ziggurats and pyramids around the world, and their accompanying religious complexes, must have a common origin because of their design resemblances. That common origin must be the original Babel city and tower in Shinar. The early people would have dispersed in all directions from Babel, taking knowledge of the original tower/city design with them. This constitutes strong evidence that the Biblical story of Babel is literally true.

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Physics Evidence for God's Current Existence and Activity Using Einstein's General Theory of Relativity

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Abstract

Physics with its mathematical equations using Hooke's Law, Einstein's General Theory of Relativity, and Cauchy's Law of Mechanics show evidence of God's existence for the first time as a boundary value problem. Philosophical arguments for God's existence have been based upon cosmological and ontological reasons such as those from Socrates to Thomas Aquinas. However, the evidence herein does not invoke any aforementioned philosophical or logical arguments. Instead, a purely physics argument and the associated set of mathematical equations using the General Theory of Relativity and its use for the universe are shown as evidence that the Cauchy traction vector, *t*, operates on the outside of the universe, when the continuum body is assumed to be the universe. Bible verses are presented that correlate the traction force, *t*, with the hand(s) of God. Finally, since the mathematical equations provide a boundary value problem and not an initial value problem, the activity of the Cauchy traction force, *t*, is acting *now* and not just in the past, thus refuting atheism and deism.

Key Words: Cauchy Law, General Theory of Relativity, Hooke's Law

Introduction

Martin (1992) summarized the philosophical underpinnings of atheism and noted 210 million atheists and 805 million agnostics (those who claim not to know if God exists or does not exist), reaching about 21% of the world's population in 1982. Later, Dawkins (2006), Hitchens (2007), Hawking (2009), and Hitchens et al. (2019) popularized atheism around the world. In 2022, approximately 450 to 500 million atheists and agnostics self-identified worldwide (7% of the world's population) according to Keysar (2017, pp. 40–53), with China alone accounting for 200 million people of that demographic. The reason that China is predominately atheist is due to communism, which as a totalitarian political structure, declares that the "state" can take care of society, not God. Hence, no God is needed. However, it was Darwin's book (Darwin and Kepler, 1859) that was the watershed for widespread support for atheism since he hypothesized that evolution controls the origin of species, meaning that the minor species variations

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that we observe in nature give rise over time to all different species. This leads to a purely naturalistic premise that all life does not need a Creator God nor a current controlling—or influencing—God in the universe.

Counter to atheism, the Greeks were the first to argue for God's existence based on intellectual logic. Socrates (470–399 BC), Plato (427–347 BC), and Aristotle (384–322 BC) believed in God as the Prime Mover, as the First Cause, as the Unmoved Mover. Augustine (AD 354–430) (Hill, 1961) argued that historically documented testimonies provide a valid basis for knowledge of God. Anselm (AD 1033–1109) (Forshall, 1840) built upon Augustine's arguments that the first and greatest "being" must necessarily exist. Thomas Aquinas (AD 1225–1274) made five arguments about God's existence that built upon those of Socrates, Plato, Aristotle, and Anselm, which provided modern arguments (Spitzer, 2010) which Tipler (1994, pp. 1–17) presented as the Omega Point Theory:

(1) *Argument from Motion*: Since nothing can move itself because of inertia, an external agent or force is/was necessary to cause or instigate the motion that is in the universe.
(2) *Argument from Cause*: Based on the Law of Causality in which cause-effect relationships exist everywhere in the cosmos, there has to be first cause and that everything that begins to exist is an effect; thus there must be an ultimate First Cause.
(3) *Argument from Perfection* (ontological argument): The universe contains an ordered sequence of beings from the simplest basic organisms to the most advanced, complex organisms such as humans. This "ever-increasing degree of perfection" points toward a final being that must be perfect and ideal.
(4) *Argument from Design*: the Earth and its inhabitants contain an observable and a very complex order such that it could not have come about by random chance events over a long period of time but required a designer outside of the design.
(5) *Argument from Necessity* (cosmological argument): Everything that exists does so in relation to something else, so there must be a "necessary being" that is contingent on nothing else for its existence.

Hence, Aquinas said that God is perfect, self-existent, and designed everything that caused the motions in the universe. Hick (1964) summarized all of these philosophical arguments for God's existence, then presented the counterarguments from the skeptic's perspective (Russell 1992; Rand 1963, 1997; Dawkins and Ward, 2006; Hitchens, 2007), etc.) and then showed the weakness of their counterarguments.

In our current 21st century, we have had some rationalists discuss God's existence from logic's perspective. Kalanov (2007, 2009, 2010) argued a theoretical proof of existence of God by way of existence, uniqueness, and absoluteness strongly expressing the current need to conduct science in the context of absolute scientific truths using rational dialectics and commonly accepted axioms. Zacharias (2020) argued that human failures and/or evil is universally recognized, if not experienced, by everyone to their own admission. *As such, if there is evil, then logically there must be good that can only come from a good God.* Most recently, Fatić (2021, pp. 428–438) argued for an ontological proof of God's existence by use of ethics.

Mathematically, Kurt Gödel (AD 1906–1978) provided a proof that was dated around 1941 but not published until 1987. Gödel (1995a; 1995b, pp. 403–404; see also Sobel, 1987) presented an induction argument starting with observations and concluding with God's existence.

Given the context of the historical arguments for God's existence, the contribution of this paper is a new physics argument with its associated mathematics to prove God's existence. *It is not based upon philosophical arguments.* Albeit God, who exists outside of the space-time-matter universe, acted upon and still acts upon the outside boundary of the universe with His hands as a traction force to affect the internal stress state within the universe, as the universe acts as a continuum body.

Hooke's Law, Cauchy's Law, the Definition of Stress, and a Boundary Value Problem

We first discuss the basics of a boundary-value problem (BVP), Hooke's Law (Hooke, 1678), and Cauchy's Law (Cauchy, 1827). A BVP (Axelsson and Barker, 2001) essentially integrates the boundary conditions within a set of differential equations that provides the "existence" of a solution that is "unique." In continuum mechanics, we start with the conservation equations of mass, momentum, and energy and find out that we have too many equations for the number of constants, so the equations cannot be solved simultaneously. However, we can add in constitutive equations, which dictate the material identity and its behavior, we get the same number equations and unknowns, so the set of differential equations can simultaneously be solved. Hence, we can add in Cauchy's Law to bring in boundary conditions into the set of differential equations and we get a BVP.

Now to determine the constitutive relationships, we can start with Hooke's Law (Hooke, 1678), which in its original form stated that the externally applied force, F, needed to compress or extend a spring-like material by some distance, x, is linearly proportional to that distance with regard to the constant, k. Thus,

$$F = kx. \tag{1}$$

Hooke's Law was later and more conventionally associated with the stress, σ, not force, F, and strain, ε, not displacement, x, as both sides of the equation was divided by length squared

giving rise to the following equation called Generalized Hooke's Law,

$$\sigma = Y\,\varepsilon, \tag{2}$$

where Y is Young's (elastic) Modulus, ε is the strain, and σ is the stress.

In continuum mechanics, the stress, σ, measures the local force divided by the area within a deformable body on which the external forces, originally called tractions (Cauchy, 1827) act. Because the deformable body under external traction forces is assumed to be continuous, the internal stresses are distributed continuously within the volume of the material body, i.e., the stress distribution in the body is expressed as a piecewise continuous function of space coordinates and time. Actually, the definition of stress originates from Cauchy (1827) in which the stress, σ was defined from the traction force $\underline{t}$ operating on a body. Essentially, Cauchy (1827) stated that a stress tensor σ exists that maps the unit normal to a surface to the traction vector acting on that surface as the following equation,

$$t_j = \sigma_{ij} n_{i,} \tag{3}$$

where n_i is the unit direction vector, t_j is the traction vector, and σ_{ij} is the stress tensor in indicial notation.

The continuum stress is mathematically called a second rank tensor. The term tensor is a structure of numbers or functions that transforms according to a specific mathematical rule, when the independent components undergo a linear transformation. One can think of tensors as a mathematical mapping that transforms one tensor into another. The most general three-dimensional stress tensor includes nine components that are represented with a double subscript provided the range of each subscript is three. In four-dimensional space, like for the General Theory of Relativity, each subscript has four dimensions, not three. For instance, the stress tensor is designated by indicial notation as σ_{ij} and thus has nine components in three-dimensional space as *i* and *j* go from 1 to 3. Hence, the stress tensor, σ_{ij}, is internal within the body and arises from the traction forces, moments, or anything acting on the outside of the continuum body. The first subscript of the stress tensor, σ_{ij}, designates a normal to the plane under consideration, and the second subscript designates the direction of the local force. For example, let us consider the shear stress component, σ_{12}, which exists on the 1-plane but is oriented in

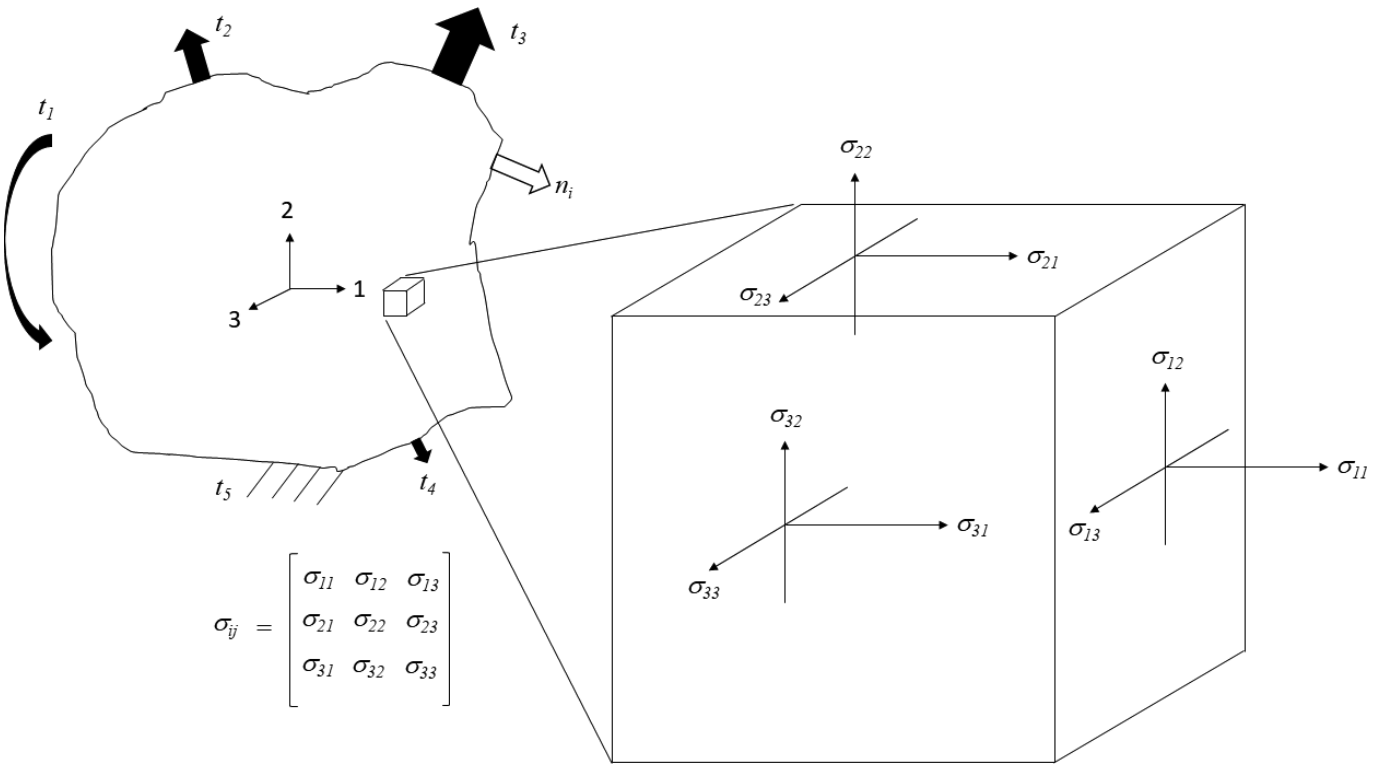


Figure 1. A generic continuum body showing the local stress tensor, σ_{ij}, and each of its components arising from the traction forces, t_1-t_5, with its associated unit vector, n_i.

the 2-direction. The positive directions of the components of shear stresses on any side of the cubic element are taken as the positive directions with respect to the coordinate axes. Figure 1 delineates each local stress component at a continuum point.

The discussion about stress (and strain) within a continuum body finds its practical relevance in solving boundary-value problems (BVPs) using finite element analysis (c.f., Axelsson and Barker, 2001). BVPs bring together the conservation of mass, momentum, and energy along with the constitutive relations (e.g., Hooke's Law) to resolve the stress (and strain) state of a continuum body, and the finite element method is a way to resolve all of the equations.

Finite Element Analysis (FEA) was first characterized by Turner et al. (1956) and Clough (1960), who first coined the term. When computers first were developed, Clough (1960, pp. 345–378) employed them to break each continuum body into smaller elements (discretization) and then tie together the elements solutions to resolve the stresses throughout the body. Since that time, finite element methods have grown to routinely be used for design, modeling, simulations, visualizations, and analysis and have been experimentally validated for very complex systems; NASA's space shuttles (Ko et al., 1986), trains crashing (Milho et al., 2003), car crashworthiness (Fang et al., 2005), planes crashing into the World Trade Center (Lynn and Isobe, 2007). Since the finite element method was invented, there probably has been over multiple millions of simulations that have been validated experimentally to illustrate its robustness, accuracy, and usefulness. Thousands of numerical methods, codes/software, and geometric meshes have been developed over time. One key in the finite element simulations is the constitutive equation or material model. The simplest constitutive equation is Equation (15), Hooke's Law. More complicated constitutive equations can be employed beyond elasticity (Hooke's Law), like viscoelasticity, plasticity, damage, etc. Hence, complicated BVPs have not only been solved by finite element methods, but they have been experimentally validated. FEA is worth ~$5 billion (research nestor, 2022) today with an estimated $12 billion impact by 2031. Even with this huge worldwide usage, nobody to date has solved the BVP of the whole universe.

One final comment related to a BVP that is important in the context of solid mechanics and the General Theory of Relativity is related to the continuum spins. The displacement, x, in Equation (1) and strain, ε, in Equation (2) relate to the geometry side of the constitutive relationship. Both of these can be derived from the deformation gradient, which is the most fundamental geometric quantity in solid mechanics. Once the deformation gradient is defined, then we can also derive the velocity gradient, which has both mathematically symmetric and antisymmetric parts. The antisymmetric part of the velocity gradient is the elastic continuum spin. Any material that has some sort of orientation, whether its crystallographic for metals, or fiber alignment for composites, presents a local anisotropy that will rotate upon deformation or a stress applied from the outside of the continuum body.

Crystal plasticity (Asaro, 1983) or texture (Kallend et al., 1991; Kocks et al., 2000) is a term for metals that has enjoyed a robust history of modeling that has illustrated the aforementioned point. Horstemeyer and McDowell (1998) numerically showed that although macroscale continuum rotations in tension or compression still admit lower-length scale rotations, they subtract each other out to make an isotropic continuum material. However, at the grain scale, it is very anisotropic. In simple shear or torsion, Horstemeyer and McDowell (1998) showed that a different rotational rate like the crystal plasticity or texture effect will occur within all of the crystals when compared to tension and compression and will also change the responding stress state. This "torsional softening" occurs when the traction, t, on the outside of the continuum point is a torsional load. If the traction, t, is a tensile load (or compression), the whole continuum will be homogeneous and isotropic, but locally at each length scale, it will be highly anisotropic and rotations will be observed throughout different length scales. If crystal-plasticity models were applied to the universe in a BVP, then we would expect predictions of galaxy cluster rotations, galaxy rotations, solar system rotations, planet rotations, etc.

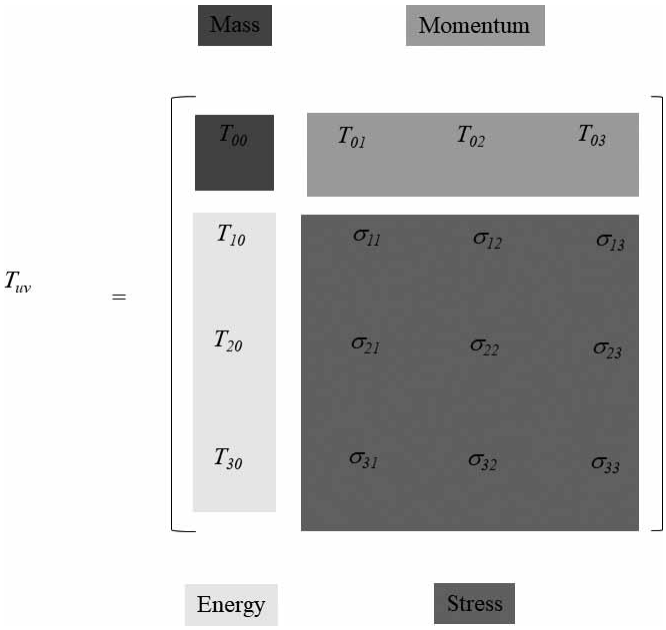
Einstein's General Theory of Relativity

If one could mathematically cast Einstein's (1916; 1922, pp. 54–75) General Theory of Relativity as a form of the governing equations from continuum theory including the constitutive equations, then one could solve the universe's BVP. As a true mathematical corollary, the continuum mechanics equations including Hooke's Law were mapped exactly to Einstein's General Theory of Relativity by Tenev and Horstemeyer (2018a, 2018b; 2019). The General Theory of Relativity (Einstein, 1916) is given by the following,

$$T_{uv} = [c^4/(8\pi G)](R_{uv} - \tfrac{1}{2}Rg_{uv}), \tag{4}$$

where T_{uv} is the stress-energy tensor, c is the speed of light, G is the gravitational constant, R_{uv} is the Ricci Tensor, R is the first invariant of the Ricci Tensor, and g_{uv} is the geometric metric tensor.

The u and v are indicial notation indicators that index from 1 to 4 for four-dimensional space, similar to the i and j for the three-dimensional director vectors used earlier to describe the stress tensor, σ_{ij}. The T_{uv} is called the stress-energy tensor given by the following matrix,



(5)

One can see that the General Theory of Relativity has the stress tensor, σ_{ij}, embedded on the left-hand side of Equation (4) similar to Generalized Hooke's Law in Equation (2) as delineated in Equation (5). Tenev and Horstemeyer (2018a, 2018b) mathematically showed that the right-hand side of Equation (4) is "strain-like" similar to Generalized Hooke's Law in Equation (2). Consequently, the gravitational constant is "modulus like" also illustrated in Generalized Hooke's Law of Equation (2). Note that Equation (5) appears to put together the continuum conservation equations of mass, momentum, and energy and also the constitutive relations. Hence, Tenev and Horstemeyer (2018a, 2018b; 2019) showed that the standard continuum equations can indeed be mapped to the General Theory of Relativity as summarized in Table I. From Tenev and Horstemeyer (2018a, 2018b) the key interpretation is that gravity is proportional to the Laplacian of the strain tensor,

$$\nabla^2\varepsilon \sim c^2 k\mathrm{r}, \tag{6}$$

where ∇^2 is the Laplacian operator, k is the Einstein constant ($= c^4/(8\pi G)$, and r is the density of the matter-energy. Essentially, the General Theory of Relativity in non-Euclidean space can be mapped to Generalized Hooke's Law and the continuum conservation equations. The analysis by Tenev and Horstemeyer (2018a, 2018b) is summarized in Table II.

Since the General Theory of Relativity (Einstein, 1916) shown in Equation (5) encompasses all of the conservation equations (mass, momentum, and energy) and constitutive relations, it only needs Cauchy's Law to be applied to it to represent a full BVP. Hence, FEA (Finite Element Analysis) could be used with the General Theory of Relativity to solve BVPs for the universe. To date, no FEA has been developed nor used in this manner. Regardless, the conclusion arises that *there are traction forces, t_i, on the outside of the cosmos.* Since some "thing" is on the outside of the cosmos, one can assume that the traction forces, t_i, as shown in Equation (3) are God's hands on the outside of the universe. Thus, just like any traction force, t_i, outside of a continuum body can immediately (in a quasi-static sense) influence the internal stress-state in a rigid body and its deformation manner, God's hands influence everything in the space-time-matter universe. The following *evidential* proof is substantiated by the aforementioned work:

1. The continuum mechanics' Hooke's Law and governing conservation equations (mass, momentum, and energy) were correlated directly to the General Theory of Relativity and were shown to be an exact mathematical equivalence by Tenev and Horstemeyer (2018a, 2018b). The stress tensor, σ, is a subset of the energy-stress tensor,

$$\mathrm{T} \in \sigma. \tag{7}$$

Table I. The equivalence of the General Theory of Relativity and standard continuum mechanics equations where $\hbar$ is Planck's constant, and ν is Poisson's ratio.

General Relativity View	Continuum Solid Mechanics View
Physical Space	Solid cosmic fabric
Spacetime	World volume of the cosmic fabric
Gravitational potential Φ	Volumetric strain $\varepsilon = -\Phi/c^2$
Gravitational waves	Shear waves in the fabric
Matter curves spacetime	Matter prescribes fabric strain
Action integral in free space $\mathcal{S} = \frac{1}{2\kappa}\int R\sqrt{\lvert g\rvert}\,\mathrm{d}^4x$	Action integral outside of inclusions $\mathcal{S} = \frac{L^2Y}{24}\int R\sqrt{\lvert g\rvert}\,\mathrm{d}^4x$
Constants of nature: $G, \hbar, c, \quad \kappa \equiv 8\pi G/c^4$	Elastic constants: $Y = 6c^7/2\pi\hbar G^2, \quad \nu = 1$

Table II. Differences that needed reconciliation to equivalence the General Theory of Relativity and standard continuum mechanics equations.

General Relativity	Continuum Solid Mechanics
Four dimensions	Three dimensions
Non-Euclidean Space	Euclidean Space
Curvilinear coordinates	Cartesian coordinates
Bending Boundary Conditions	Uniaxial Boundary Conditions
Curved Space	Straight Space

2. If Cauchy's Law is applied to The General Theory of Relativity (and there is no reason to think otherwise), then the set of equations can be cast into a boundary-value problem (BVP) just like Hooke's Law and the continuum conservation equations and be discretized into smaller continuum points to be used in FEA (this is mathematically a correlation).

Equation (3) + Equation (4) (8)

3. In solving the BVP, traction forces outside of the boundary are required by definition of Cauchy's Law to resolve the changing internal state of the universe.

Note: Equation (5) (9)

Figure 2. The traction force, *t*, in Cauchy's Law represents the hand of God outside of the universe.

4. Since something exists outside of the universe like the traction force, *t*, that something is God by definition. One could interpret the traction force, *t*, as the hand of God that is "existent" and "unique" (Axelsson and Barker, 2001), since it is determined within the context of the BVP. (This is based on Biblical references and is then an assertion.)

Discussion

There are several points that need further discussion related to the aforementioned physics and mathematical evidence for God's existence using the set of equations to formulate a boundary-value problem for the universe. One is the distinction between a boundary value problem and an initial-value problem. Another relates to the question of which part of the Godhead is actively involved as the traction force, *t*, meaning either the Father, Jesus, or the Holy Spirit. Also, the argument that the traction force, *t*, is the hand(s) of God representing the traction force, *t*, on the outside of the universe is an assertion made by the authors but has many Biblical references and inferences.

Since the set of equations, which relate to everything in the universe, are formulated within a boundary-value problem, the traction forces, *t*, are acting in the current state as defined by continuum mechanics and not just in the original reference state. In continuum mechanics, the reference state is the initial state and the current state is what is happening *now* but can include the history of the materials within the continuum body. One can think of the example of the Big Bang Theory as an initial-value problem, whereas one can think of the Designer/Creator God who not only made everything from the beginning but also controls and influences what happens within the continuum body of the universe at every time increment that is *now* as a boundary-value problem. One can also think of the initial-value problem as Deism, where God started things at the beginning and set up all of the laws of nature but does not interact with His cosmos afterward. Alternatively, one can think of the boundary-value problem as related to the Christian God, who not only started the universe but continues to interact within the cosmos.

The physics and mathematical evidence also indicate the local stresses arise from the external forces, whether they are applied in tension, compression, and/or torsion, where the local geometry/structure help determine the local stress like any boundary-value problem found in solid mechanics. Since rotations are observed in the universe at different length scales, we would expect no difference from crystal plasticity considerations from the kinematics (geometry) in the constitutive model [Equation (2)]. From this evidence, we will call the local effects arising from the traction, *t*, long-range transients. These long-range transients do not entail the very personal

aspect of the Holy Spirit interacting with or within a human, which we will call short-range transients. Hence, the long-range transients arise from the boundary conditions outside of the cosmos, whereas the short-range transients arise from the Holy Spirit's motion within the cosmos. Now, it is not clear what part of the Godhead or how the Godhead would be moving upon the outside of the universe: (1) Could it be by the Father's hands, (2) could it be by Jesus's hands, or (3) could it be the work of the Holy Spirit? Currently, the authors, given the obvious uncertainties, believe that it is by the hand(s) of the Father, as will be discussed next.

The authors assert that the Cauchy traction force, f, is the hand of God and most likely that of the Father. Although the "hand of God" might be a Jewish euphemism, it may actually have more direct meaning. Here are the following Bible verses that provide a basis for the long-range transients related to the evidence of God's existence being His hands. 1 Chronicles 29:12 provides the notion that the strength of a material and the power (the time-rate of change of energy) are realized as that coming from the hands of God the Father.

> 1 Chronicles 29:12 (KJV): Wealth and honor come from you (God); you are the ruler of all things. In your hands are strength and power to exalt and give strength to all.

The following Bible verses give the impression at first blush, that God's hands represent a shortrange transient; however, when one thinks about the boundary-value problem in that any force on the outside of the universe can affect immediately the local continuum body at any length scale, then it cannot be dismissed that it also could be viewed as a long-range transient.

> Psalm 8:3 (NKJV): When I consider Your heavens, the work of Your fingers, the moon and the stars, which You have ordained;
>
> Isaiah 48:13 (KJV): My own hand laid the foundations of the earth, and my right hand spread out the heavens; when I summon them, they all stand up together.
>
> Isaiah 40:12 (KJV): Who has measured the waters in the hollow of his hand, or with the breadth of his hand marked off the heavens? Who has held the dust of the earth in a basket, or weighed the mountains on the scales and the hills in a balance?
>
> Psalm 95:5 (KJV): The sea is his, for he made it, and his hands formed the dry land.
>
> Habakkuk 3:4 (KJV): His splendor was like the sunrise; rays flashed from his hand, where his power was hidden.
>
> Job 36:32 (KJV): He fills his hands with lightning and commands it to strike its mark.
>
> Job 12:10 (KJV): In his hand is the life of every creature and the breath of all mankind.
>
> Isaiah 64:8 (KJV): Yet you, Lord, are our Father. We are the clay, you are the potter; we are all the work of your hand.

Summary

This paper documents physics and mathematical evidence for the existence of a currently acting God using Hooke's Law, Cauchy's Law, and Einstein's General Theory of Relativity to develop a boundary-value problem for the cosmos that defines the Cauchy traction force, *t*, to be on the outside of the cosmos. The authors assert that the traction force, *t*, arose and continues to operate as the hands of God that provide external loads, which, in turn, affect everything within the space-time-matter continuum body of the universe. Since the set of equations, which relate to everything in the universe, are formulated within a boundary-value problem, the traction forces, *t*, are acting in the current state (as defined by continuum mechanics) and not just in the original reference state. In other words, the boundary-value problem relates to *now*, but an initial-value problem mathematically relates only to the initial state. The spiritual translation is that the boundary-value problem reflects God's current hand on the universe, but an initial-value problem would have had God's hands on the universe just at the beginning and then just let it go from there without more influence, like deism.

Further corroboration of this idea of connecting the General Theory of Relativity to the continuum mechanics equations of mass, momentum, energy, and constitutive equations (Hooke's Law) gives us different length-scales of rotational entities in the universe. The expectation is that the cosmos would have different length-scale rotational quantities based on continuum mechanics. In fact, it does: galaxy cluster rotations, galaxy rotations, solar system rotations, planet rotations, etc., which arise from the kinematics of crystal plasticity.

The authors also propose that the traction force, *t*, of the universe's boundary-value problem mathematically represents the hands of God holding the universe, so that any squeeze instantaneously brings an internal stress to any location within the universe. Different Bible verses are provided to give a basis for God's hands controlling the cosmos.

The presuppositions related to the evidence are the following:

- Continuum mechanics, which has been experimentally validated on Earth and our solar system, can extrapolate to the whole of the cosmos as it correlates with the Einstein's General Theory of Relativity.
- A boundary-value problem (BVP) with all of the necessary and sufficient mathematical equations applies to the cosmos.
- The Bible is inerrant, so Biblical references argue that the hands of God control the cosmos.

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Giantism and Delayed Maturation in Fossil Sharks: Evidence for Extreme Longevity?

Jake Hebert

Abstract

The Bible's assertion that the Genesis patriarchs routinely experienced lifespans of hundreds of years is one of the claims in Scripture most ridiculed by skeptics. Hence, Biblical creationists should be interested in possible scientific corroboration of this claim. Whatever factor or factors were allowing extreme human longevity in the pre- and immediate post-Flood worlds were likely also affecting the animal kingdom, as well. Hence, it is reasonable to suspect that animal lifespans were also once much greater than they are today. In this light, we examine fossil shark data for possible evidence of extreme longevity. Paleontologists have used allometric relationships and growth rings within shark vertebrae to construct ontogenetic length-versus-age growth curves for both extinct and extant sharks. Growth curves for fossil sharks are generally too short to provide direct evidence that fossil sharks experienced much greater longevity than extant sharks, but they are sufficiently long to show that fossil sharks took longer to mature than comparable extant sharks. Longevity studies of extant animals have repeatedly shown that greater ages at skeletal and/or sexual maturity are positively correlated with greater longevity, as are larger adult body sizes. Hence, the apparent delayed maturation and large adult body sizes of these giant fossil sharks is indirect evidence that they had much greater lifespans than extant sharks. By extension, it is partial scientific corroboration of the extreme human lifespans recorded in the earliest chapters of Genesis.

Key Words: antediluvian, fossils, giantism, growth rings, longevity, ontogeny, pre-Flood, sharks, von Bertalanffy growth curves

Introduction

The recent movies *The Meg* and *Meg 2: The Trench* have done for megalodon what the movie *Jaws* did for great white sharks: they have brought the giant extinct shark *Otodus megalodon* into the public consciousness. The megalodon is thought to have been the largest shark—or fish—to have ever lived (Rafferty, 2023). The idea of a giant shark swimming the oceans and devouring prey (including humans!) with its enormous jaws (Figure 1) is admittedly terrifying.

The name *megalodon*, meaning 'big tooth,' is certainly appropriate, as megalodon teeth are much larger than

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teeth of the extant great white shark *Carcharodon carcharias* (Figure 2).

Maximum length estimates (Shimada, 2019; Perez et al., 2021) for a (presumably) fully-grown megalodon, based upon tooth sizes, range between approximately 14.2 meters (46.6 feet) to greater than 20.3 meters (66.6 feet). Pimiento and Balk (2015) cite a shorter length of 10.54 meters, but this is a modal value, with the longest estimated lengths in their study between 17.0 and 17.9 meters. A recent length estimate based on the reconstruction of a vertebral column was about 15.9 meters (Cooper et al., 2022). However, Sternes, et al. (2024) have argued that the megalodon was longer but less stocky than depicted in the reconstruction of Cooper et al. Sternes et al. suggested that previous maximum length estimates of 15 to 20 meters were probably too short, and that the ontogenetic growth model of Shimada et al. (2021), discussed later in this article, was probably an underestimate.

Popular depictions often show the megalodon as an oversized version of the great white shark *Carcharodon carcharias* (Figure 1). However, controversy abounds among paleontologists as to the megalodon's relationship to the great white. It seems that few, if any, evolutionary paleontologists believe that the great white is a descendant of the megalodon. However, some have argued that the great white is the closest living relative to the megalodon (Gottfried, Compagno, and Bowman, 1996, pp. 55–66). Such paleontologists think (Ehret et al., 2012) all large "megatooth" sharks with serrated teeth should be placed into the genus *Carcharodon*. In this thinking, the great white evolved alongside the megalodon, rather than descended from it. Hence, *Otodus megalodon* should be reclassified as *C. megalodon*.

Others think *C. carcharias* evolved from a group of broad-toothed mako sharks, which included *Carcharodon* (*Cosmopolitodus*) *hastalis*, formerly known as *Isurus hastalis*, formerly known as *Oxyrhina hastalis*. In this view, the megalodon has a separate lineage and should retain its designation as *O. megalodon*. Currently, this view seems to have the most support among evolutionary paleontologists.

Figure 1. The megalodon has often been depicted as a giant great white shark, although there is debate among evolutionary scientists as to whether the two sharks were related. Image Credit: Karen Carr. CC BY 3.0. https://creativecommons.org/licenses/by/3.0/.

However, this conclusion may have been driven in part by evolutionary circular reasoning. The claim that the great white descended from extinct mako sharks was ostensibly due to subtle differences in tooth morphology, and the strong, more obvious tooth similarities that were the original basis for considering great whites and megalodons related (Figure 2) are now generally attributed (Rafferty, 2023) to convergent evolution (!).

Ehret et al. (2012) argued that a new species *Carcharodon* (*Cosmopolitodus*) *hubbelli* sp. constituted a transitional form between *Carcharodon* (*Cosmopolitodus*) *hastalis* and *Carcharodon carcharias*. As is often the case in paleontology, a radiometric "recalibration" played a major role in this conclusion (Ehret et al., 2012, p. 1139):

> We also provide a recalibration of critical fossil horizons within the Pisco Formation, Peru using zircon U-Pb dating and strontium-ratio isotopic analysis. The recalibration of the absolute dates suggests that

Figure 2. Size of a megalodon tooth compared to two great white shark teeth. Image credit: Brocken Inaglory. CC A-SA 3.0 Unported. https://creativecommons.org/licenses/by-sa/3.0/deed.en.

> *Carcharodon hubbelli* sp. nov. is Late Miocene (6–8 Ma) in age. This research revises and elucidates lamnid shark evolution based on the calibration of the Neogene Pisco Formation.

Within a creationist framework, it seems entirely reasonable that the megalodon really *was* a giant version of the great white shark. Evolutionary scientists (Gottfried, Compagno, and Bowman 1996, p. 57) who think the megalodon should be placed into the *Carcharodon* genus have enumerated similarities between great white and megalodon teeth (Figure 2):

> (1) As *C. carcharias* [great white] teeth grow larger, they become increasingly similar in morphology to *C. megalodon* teeth, with increasingly finer and more numerous serrations and more robust proportions, including deeper roots and a broader neck. We suggest that a *C. megalodon*-type tooth would be the result of extrapolating the ontogenetic changes seen in *C. carcharias* teeth to a megatooth-sized shark.
>
> (2) Presumed subadult teeth of *C. megalodon*, described by Uyeno and Sakamoto (1984), are morphologically very similar to teeth of *C. carcharias*, including the size and nature of the serrations.

They also noted (pp. 58–59) similarities in the vertebrae of the sharks:

> The similar morphology of the teeth and vertebral centra in fossil and living species of *Carcharodon* lends credibility to this assumption [that megalodon morphology may be inferred from great white morphology].

On the other hand, Sternes, Wood, and Shimada (2022) argued that fossil data are currently insufficient to draw firm conclusions about megalodon body shape, and they may be correct.

In any case, can we learn something from the megalodon's large size? And is there a connection between this large size and the astonishing longevities that the Bible reports for the Genesis pre-Flood and immediate post-Flood patriarchs?

The Bible matter-of-factly asserts that humans in the antediluvian world routinely attained ages of more than 900 years (Genesis 5:3–32). Even some time after the Flood, humans were still experiencing centuries-long lifespans (Genesis 11:12–32). Such extreme longevity is far beyond our present-day experience. Hence, creationists should be interested in possible corroboration of the Bible's claim in this regard, either from historical or paleontological data. Previous creationist authors have discussed extrabiblical historical and cultural confirmations of the first eleven chapters of Genesis (Patten, 1982; Oestreicher, 1989; Cooper, 1995; Cooper, 2011; and Liguori, 2021), including the claims of greater past longevity (López, 1998). Others have discussed possible evidence of greater longevity in Neanderthal fossils (Cuozzo, 1998, 1999), as well as a possible connection between greater longevity and past giantism (Patten, 1982; Beasley, 1990; Nelson, 2017).

This paper discusses examples of gigantism and delayed maturation in fossil sharks. Both fossil data and theoretical considerations suggest that these giant sharks took much longer to mature than comparable extant sharks. Because of the studies repeatedly correlating delayed maturation and larger adult body sizes with greater longevity, these observations constitute indirect evidence that fossil sharks were living much longer than comparable extant sharks.

Connections Between Longevity, Maturation, and Body Size

Studies (Sato, 1994; Miller et al., 2002; Genade et al., 2005; de Magalhães et al., 2007; Ricklefs, 2010a, 2010b; Ridgway et al., 2011; Lee et al., 2013; Moss et al., 2016) have shown that, in extant creatures, greater longevity is often positively correlated with greater ages at maturity. Generally speaking, the longer it takes an organism to attain to sexual or skeletal maturity, the longer its lifespan will be.

Here we are attempting to ascertain whether fossil representatives of the Genesis kinds were living longer than the modern-day representatives of those kinds. For this reason, longevity comparisons within a *baramin* or 'Biblical kind' are likely to be of greater interest to creationists than inter-baramin comparisons.

Creationists generally agree that creatures within a particular genus can usually safely be assumed to belong to a single baramin or 'Genesis kind,' even if the baramin itself actually corresponds to the family level or higher in the Linnaean taxonomic classification system (Woodmorappe, 1996). Most of the studies listed above were inter-genera comparisons, but a few (Sato, 1994; Genade et al., 2005; Lee et al., 2013), were intra-genus or intraspecies comparisons. The results by Sato (1994), however, did not include a test for statistical significance.

Likewise, studies (de Magalhães et al., 2007; Wasser and Sherman, 2010; Ricklefs, 2010a; Ridgway et al., 2011; Holm et al., 2016) have also shown a positive correlation between greater longevity and larger adult body sizes: larger creatures tend to live longer. Unfortunately, none of the above studies were confined to a single genus or species. Sato (1994) did find such a trend for a single species of bivalve, but as noted above, he did not perform a test for statistical significance.

Admittedly, there is evidence contrary to these conclusions (see Marchionni et al., 2020 for a summary). However, West et al. (2001) used the principle of energy conservation and a well-known allometric rule called Kleiber's Law (Brody et al., 1932; Kleiber, 1932, 1947, 1961; Brody, 1945) to show that adult body mass M should be proportional to the fourth power of the age at skeletal maturity t_{mature}:

$$M \propto t_{mature}^4 \qquad (1)$$

This result had been anticipated by others (Lindstedt, 1981; Calder, 1984; and Schmidt-Nielsen, 1986), who observed that biological timescales in general were proportional to body mass raised to the fourth power.

Likewise, fossil *Crassostrea* and *Magallana* oysters also provide evidence for both conclusions (Kirby, 2001; Kirby and Jackson, 2004; Harzhauser et al., 2016), provided that counts of annual growth rings within bivalve shells are reasonably accurate. A discussion is provided in Hebert, Overman, and Sherwin (2024).

In summary, greater longevity seems to be positively correlated with both larger adult body sizes and greater ages at maturity (Figure 3).

In this light, it is striking that the earliest age at which a Genesis 5 patriarch is listed as having a son is 65 (Genesis 5:15, 21). Given the strength of the human sex drive, it seems extremely unlikely that the Genesis patriarchs were becoming sexually mature at 15 or 16, but were all choosing to postpone marriage 50 years! Rather, it seems far more likely they were taking longer to reach adulthood than do extant humans. Thus, the greater ages at maturity recorded in Genesis 5 make sense in light of the results of these studies: one would expect very long-lived humans to take longer to mature than humans with much shorter lifespans. It also raises the question: were long-lived antediluvian humans larger than extant humans, as some creationists (Taylor, 1987) have suggested? A comparison of Genesis 6:4 and Numbers 13:33 shows that the Nephilim were giants, but were 'normal' humans before and just after the Flood *also* larger than extant humans? There is some circumstantial evidence that this may have been the case, at least in the post-Flood world (Hebert, 2023a), but a detailed discussion must await some other time.

In any case, whatever factor or factors were allowing humans to attain extreme longevity in the pre-Flood and immediate post-Flood worlds (more pristine genomes, better nutrition, higher atmospheric oxygen concentration, etc.) would almost certainly have also affected the animal kingdom. Hence, we should not be surprised if animal fossils also show evidence of much greater size and/or longevity. Hebert (2023b) included a preliminary discussion of possible examples of this, and this paper is one in a series that attempts to flesh out the argument (see also Hebert, 2024, and Hebert, Overman, and Sherwin, 2024).

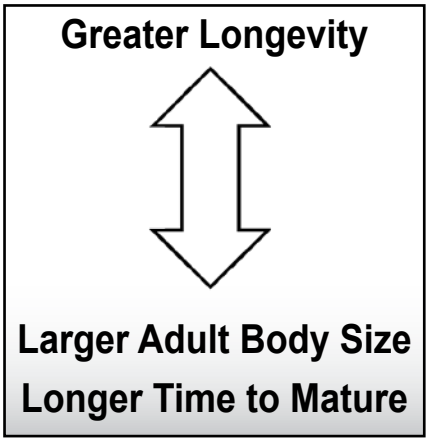

Figure 3. Studies of extant animals have shown that larger adult body sizes and longer maturation times are positively correlated with greater longevity.

Background: Growth and Growth Curves

Many animals exhibit asymptotic growth: as they mature, their total body length L either reaches or asymptotically approaches a maximum value that we designate as L_∞ (Figure 4). This asymptotic growth is described mathematically by the von Bertalanffy (1938) growth equation:

$$L(t) = L_\infty \left(1 - e^{-k(t-t_0)}\right) \qquad (2)$$

In Equation (2), t is the time since birth (measured in years) and k is a parameter (with units of years^{-1}) that governs the relative speed at which an organism approaches adulthood. The parameter k is not a growth rate *per se*, but it is a proxy for growth rate, with high k values representing faster growth and lower k values representing slower growth. Other similar growth equations do exist, but the von Bertalanffy equation is thought to provide the best fit to data for slow-growing, long-lived species (Amalfitano et al., 2022).

The value t_0 is the (theoretical) time at which the organism's length is zero. If the creature has a positive, non-zero size at birth, t_0 is a negative number, indicating that the creature had zero size at the beginning of its gestation, $-t_0$ years before birth. The parameter t_0 will be zero if the organism has a size of zero at birth.

Equation (2) is usually obtained from length-versus-age data for a popula-

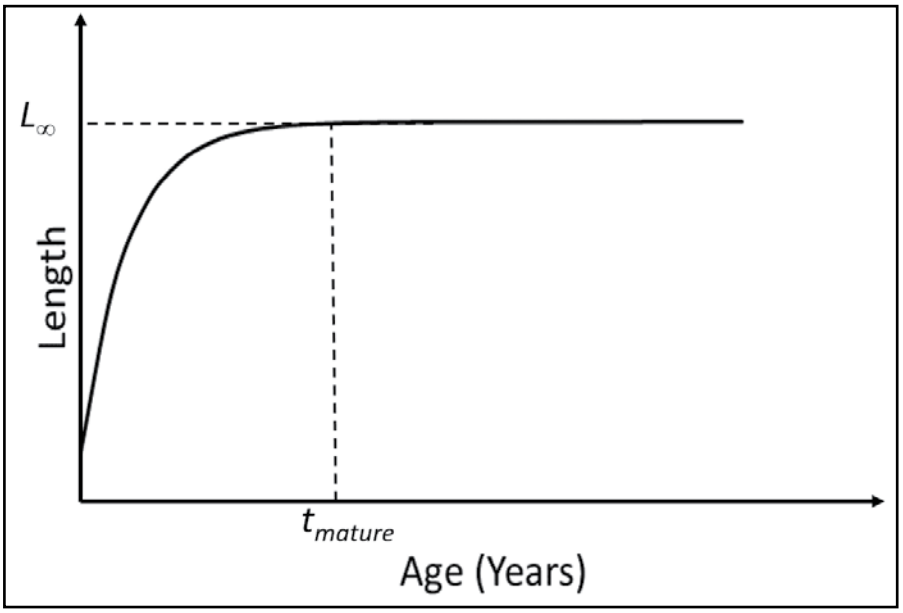

Figure 4. The von Bertalanffy growth curve, showing an organism's length or height as a function of time since birth or hatching. Note that growth effectively, if not completely, stops when the organism reaches skeletal maturity at time t_{mature}.

tion of organisms. L_∞ is thus the average adult body size for the population. Since this is a population average, individual specimens in the population will be characterized by L_∞ values that are both longer and shorter than this. Naturally, organisms with larger values of L_∞ will also have higher adult body masses M.

Given enough time, the growth rate of an organism with *determinate* growth will become vanishingly small when it reaches skeletal maturity at time $t \approx t_{mature}$. Some organisms undergo *indeterminate* growth, meaning that they continue to grow, albeit slowly, for as long as they live. If an organism's growth has not yet "levelled off" at some time t, the organism has not yet attained its full potential size. For an organism exhibiting determinate growth, once the slope of the curve in Figure 4 becomes vanishingly small at time t_{mature}, the organism has effectively reached skeletal maturity. Note that t_{mature} is not necessarily the same as the age at sexual maturity, t_{sex}. In many organisms, the age at sexual maturity does not necessarily coincide with the age at skeletal maturity; some organisms become sexually mature long before attaining skeletal maturity. Nevertheless, one might expect organisms that take longer to reach skeletal maturity to also take longer to reach sexual maturity.

Inferring Size and Growth Data from Shark Vertebrae

Since shark vertebrae are made of cartilage rather than bone, preserved fossil shark vertebrae are rare, and the vast majority of shark fossils consist of teeth. However, some calcified fossil vertebrae have been found, and paleontologists have used growth rings in the vertebrae to infer growth rates and size estimates of fossil sharks. In fact, vertebral growth bands are virtually the only means that paleontologists and marine biologists have to infer this information regarding extinct elasmobranchs (Shimada et al., 2021).

Alternating translucent and opaque concentric bands are evident in the cross-sections of shark vertebrae centra. These couplets are alternately referred to as rings, band pairs, or vertebral growth increments. Paleontologists have traditionally assumed that each band pair is formed annually, and studies seemed to vindicate this assumption for multiple shark species (Smith, 1984; Killam and Parsons, 1989; Ribot-Carballal et al., 2005; Joung et al., 2008; Barreto et al., 2011; Kotas et al., 2011; Hall et al., 2012; and Liu et al., 2018). However, some studies (Chen et al., 1990; Anislado-Tolentino et al., 2008) suggested biannual deposition in the scalloped hammerhead *Sphyrna lewini*. Also, Wells et al. (2013) showed that ring formation occurred twice per year in the case of the juvenile blue shark, *Prionace glauca*.

A difficulty in the ring-counting process noted by several researchers is that the outermost rings become thinner and harder to count in older sharks (Francis, Campana, and Jones, 2007; Harry, 2017), resulting in systematic underestimation of true age. For instance, Hamady et al. (2014) seemed to confirm that ring deposition was annual in white sharks but that thinning of bands in older great whites would complicate attempts to infer age from vertebrate data.

However, a study of seven shark species by Natanson et al. (2018) has called these simple assumptions into serious question. Their study showed that different vertebrae on the same shark can have different numbers of rings! Ring growth is apparently more closely related to the need for vertebrae to support body girth and length than to time *per se*. This conclusion was supported by the fact that the greatest intrashark differences in ring counts occurred for the five species whose girth varied the most along the length of their respective vertebral columns (Atlantic angel sharks, white sharks, porbeagle sharks,

shortfin makos, and common thresher sharks). For sharks whose girths were much more uniform along the vertebral column (blue and dusky sharks), counts were much more consistent.

Natanson et al. all suggested that shark species could be subdivided into three general categories: (1) those whose band pairs were validated as annual throughout their lives, (2) those whose band pairs were validated as annual for only a portion of their lives, and (3) those for whom band pairs simply could not be used for ageing studies. They noted that their results necessitated a re-evaluation of previous age estimates based on ring or band counts. However, they argued (p. 1450) that this did not necessarily invalidate all previous results:

> If band pairs are structural and related to growth, can they still be used for ageing? One cannot refute the few well-conducted direct studies indicating that band pair deposition occurs annually or biannually during some portion of the lifespan of the shortfin mako, porbeagle and leopard sharks (*Triakis semifasciata*), such as reported by Natanson *et al*. (2002), Smith *et al*. (2003), Wells *et al*. (2013), and Kinney *et al*. (2016), among others. However, this relationship to time must be considered loosely correlated over the span of these studies because we have shown that both the shortfin mako and the porbeagle have varying band pair counts along the vertebral column and ontogenetic changes in band pair deposition. For example, in the juvenile phase, vertebral centra are of similar size and band pair counts are similar along the column because these fish are generally growing faster than adults with a more uniform girth while increasing in length. Thus, band pair counts are similar along the vertebral column of juveniles, as shown herein. On average, the growth rate at this size relates to wider band pairs, which may be deposited annually, as has been validated in several species…. The results of the present study do not refute the validated ages previously published, but rather they explain the discrepancies observed in the literature (summarized in Harry 2018).

Although paleontologists are generally aware of the issues raised by Natanson et al. (2018), they will often assume as a first approximation that band pairs in fossil shark vertebrae are annual. Geochemical variations in the bandings within the centra of an Eocene lamnoid *Otodus obliquus* shark (MacFadden et al., 2004) were consistent with the assumption that the bands are seasonal or annual. However, this shark was apparently only 19 years old when it died, so this confirmation was only valid, at best, for juvenile *O. obliquus* sharks.

Allometric relationships are used to convert vertebrae centrum diameters into estimated total body lengths. Under the assumption that the bands are deposited at regular, periodic intervals, ontogenetic growth curves may be constructed.

Figure 5. Artist conception of *Ptychodus mortoni*, one particular species in the extinct genus *Ptychodus*. Image credit: Dmitry Bogdanov. CCA 3.0 Unported. https://creativecommons.org/licenses/by/3.0/deed.en.

An "Old" Adolescent *Ptychodus* Shark

Ptychodus (Figure 5) is an extinct genus of shark thought to have exhibited durophagous behavior (i.e., the eating of organisms with hard shells). Based upon its body type (and also upon an assumed evolutionary phylogenetic affinity), the *Ptychodus* genus is thought to have been similar to the extant genera *Heterodontus* and *Ginglymostoma* (Shimada et al., 2010). The genus *Heterodontus* consists of the bullhead sharks, of which there are nine extant species. These are relatively small bottom-feeders that are harmless to humans. Most adults are only about a meter in length, though some species can grow as large as 1.65 to 1.7 meters (Rafferty et al., 2023). The

genus *Ginglymostoma* consists of two extant species of nurse shark, the Atlantic *Ginglymostoma cirratum* (Smithsonian Tropical Research Institute, biogeodb.stri.si.edu, accessed September 21, 2023) and the Pacific *Ginglymostoma unami* (Murch, no date). Atlantic nurse sharks are typically between 2.10 and 2.40 meters long (French et al., 2018). The Pacific nurse shark has a maximum length of about 2.8 meters (Murch, no date).

Jambura and Kriwet (2020) describe two large ptychodontid shark vertebrae centra (Figure 6) obtained from Upper Cretaceous limestone rocks in northern Spain, from a coastal outcrop near the village of Soto de la Marina. These vertebrae centra are housed in the vertebrate collection of the University of Vienna's Department of Paleontology (collection number EMRG-Chond-SK-1), and are publicly accessible.

They used the larger vertebra centrum (EMRG-Chond-1b), labelled as "B" in Figure 6, to estimate vertebra radius as a function of age. This centrum is 70 mm in diameter, as measured along the dorsal-ventral line. Dorsal, ventral, and mediolateral radius estimates all yielded similar radial growth patterns. Because of the fragmentary nature of the centrum near its edges, they measured radius rather than the diameter. Centrum diameters were obtained by multiplying the radius measurements by two.

Jambura and Kriwet were not able to determine precisely where this particular centrum belonged in the overall shark vertebral column, so they assumed it to be the largest vertebrae, in order to yield the most conservative estimates of body size. The relative constancy of the spacing between bands indicated that the shark's growth had not yet started to slow down, implying that it was still a juvenile.

Jambura and Kriwet estimated this shark's total length by extrapolating from length and centrum data for the known

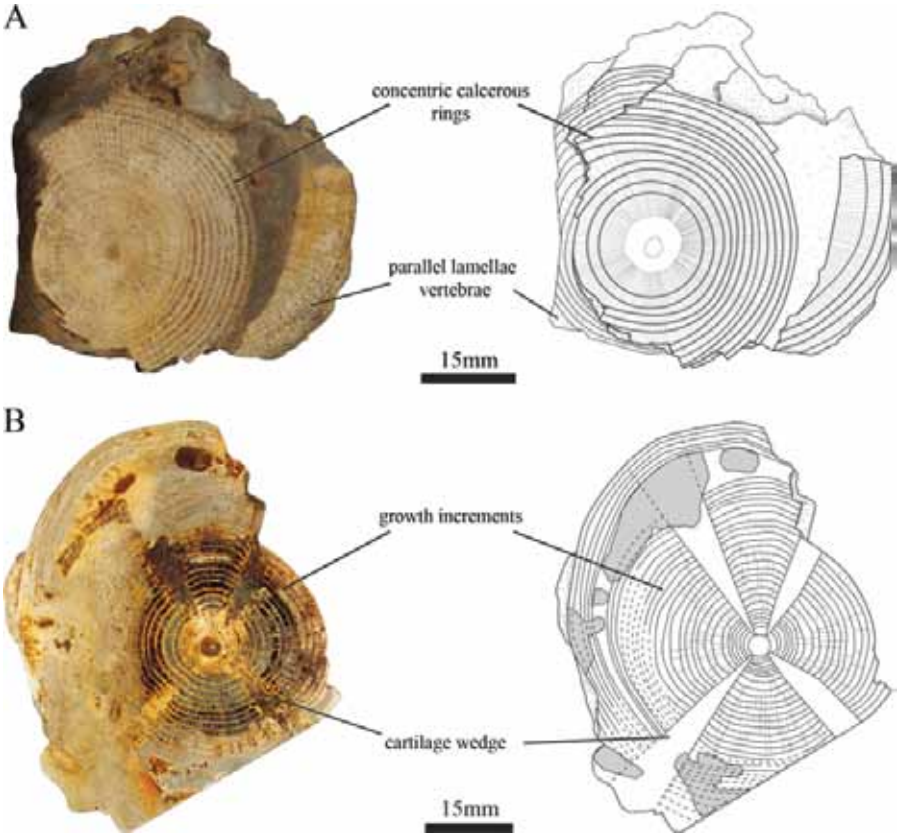

Figure 6. Figure 3 from Jambura and Kriwet (2020), showing vertebral growth bands within two calcified shark vertebrae. Image credit: P. L. Jambura and J. Kriwet. CCA 4.0 International. https://creativecommons.org/licenses/by/4.0/deed.en.

fossil species *Ptychodus occidentalis*. They also used allometric relationships between centrum diameter and total body length for great white, tiger, and whale sharks to obtain a range of estimates for total body length as a function of time.

The first method yielded an estimated length for this subadult specimen of 8.87 to 11.83 meters. The second method yielded a more conservative length estimate of 4.30 to 7.07 meters long. It should be noted that the upper limit of this conservative length range (7.07 meters) is longer than that of Deep Blue, the largest known extant great white shark (Biswas, 2018), whose estimated length is no more than 6.1 meters (20 feet)! Tooth, jaw, and vertebrae fossil material indicated that the *Ptychodus mortoni* (Figure 5) body length could be between 10 and 11 meters, yet *Ptychodus* fossil teeth exist that are even larger than those upon which the 10-meter-length estimate was based (Shimada et al., 2010)! Jambura and Kriwet (2020) also cited estimated lengths of 13 to 14.4 meters for *P. rugosus*, although they cautioned that these estimates were quite uncertain as they were based on very limited fossil data.

Jambura and Kriwet concluded that the shark was 30 years old when it died, under the assumption that band deposition was annual. Jambura (Anonymous a, 2020) expressed amazement at this fact:

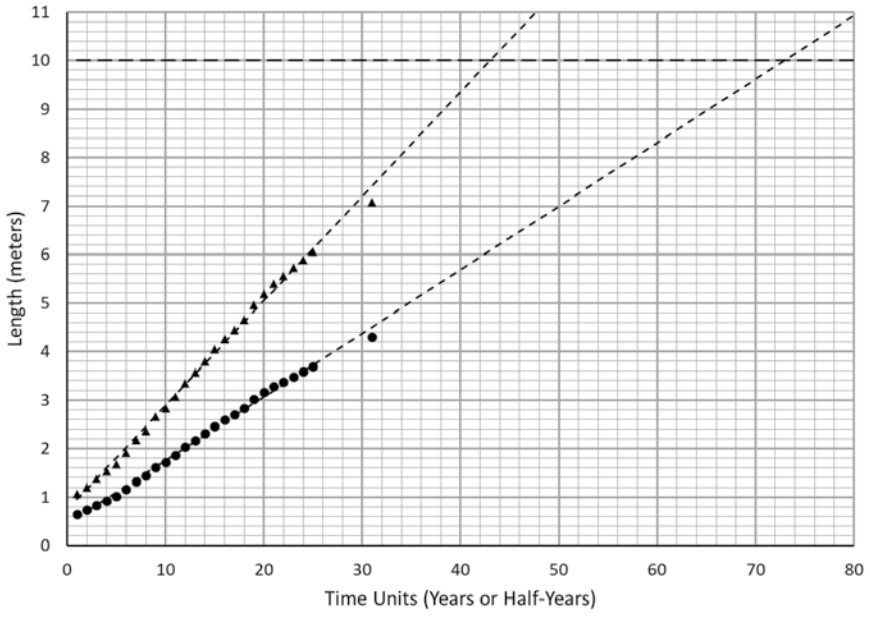

Figure 7. Estimated minimum time range for a *Ptychodus* shark to attain to a total body length of 10 meters, based upon linear extrapolation of Jambura and Kriwet's (2020) range of estimated growth trajectories. Triangles indicate length estimates based upon a body type similar to that of a whale shark, and circles indicate length estimates based upon a body type similar to that of a great white shark.

> We calculated a size of 4–7 meters and an age of 30 years for the examined shark. It's astonishing that this shark was not yet mature when it died despite its rather old age.… [T]his shark doesn't show any signs of flattenings or inflections in the growth profile, meaning that it was not mature—a teenager, if you want. This suggests that these sharks even grew much larger and older.

Jambura and Kriwet (2020, p. 9) stated: "Given that our specimen most likely has not yet reached maturity and therefore represents a subadult, previous size estimations of around 10 m [17] seem possible for this group. Although more accurate maximum size estimations need to wait until a complete specimen can be analyzed, our study agrees with previous work that †*Ptychodus* was one of the largest durophagous vertebrates ever to have lived [footnote, brackets, and dagger symbol, indicating an extinct genus, in original]."

Jambura and Kriwet (2020, p. 11) also stated: "Under the assumption of an annual growth band deposition, †*Ptychodus* matured very late (after more than 25 years) and showed great longevity, similar to the giant filter-feeding sharks that live today…. " Basking and whale sharks are thought to have lifespans, respectively, of up to 50 years (Johnston and Hendry, no date) and 80–130 years (Hsu et al., 2014; Perry et al., 2018).

However, it is possible to obtain tighter constraints on the age at maturity, under the assumption of an adult body length of 10 meters. Using Jambura and Kriwet's data, we can estimate the minimum time for a *Ptychodus* specimen to become fully-grown. Jambura and Kriwet's estimated maximum and minimum growth trajectories are shown in Figure 7. While the downward deflection of the rightmost data point in each trajectory *could* be indicative of a slow-down in growth, these downward deflections could also be due to random scatter in the data. Also, when they attempted to fit von Bertalanffy curves to their data, Jambura and Kriwet obtained a hard-to-believe adult body length of more than 20 meters. Hence, the most conservative approach is to fit straight lines to the two trajectories, rather than attempting to fit von Bertalanffy curves to them, even though we know the true growth trajectories *should* be similar to von Bertalanffy growth curves. From Figure 4, note that the slope of a von Bertalanffy growth curve can only decrease over time. But *any* decrease in slope that might occur after the age of 31 in Figure 7 will *increase* the amount of time for the shark to reach its adult body length. Thus, linear extrapolation of the data in Figure 7 yields the absolute *minimum* time range for this *Ptychodus* specimen to attain to a length of 10 meters. A*t least* 43 to 73 years would be needed to attain to a 10-meter body length, under the assumptions of one growth band per year. Even under the assumption of two growth bands per year, the time to maturity would still have been about 21 to 36 years. As noted earlier, in extant animals, large adult body sizes and greater maturation times are consistent with increased longevity.

To put this in perspective, the horn shark (*Heterodontus francisci*) is a species of bullhead shark and an extant durophagous shark. Its maximum length is 1.20 meters (Buch and Bowling, 2019). In captivity, it can live for 12 years (Herstein, 2000), although there is an unconfirmed report of one living to an age of 25 (Anonymous c, no date). Likewise, the Bonnethead Shark (*Sphyrna tiburo*) is an extant durophagous shark, with average length at maturity of less than a meter. Maximum observed ages are

between 12.1 and 17.9 years (Frazier et al., 2014; Frazier et al., 2023). Yet under the assumption of an adult body size of 10 meters, just the growth interval of this fossil durophagous *Ptychodus* shark was probably longer than the entire lifetimes of these extant durophagous sharks, even under the assumption of two growth bands per year!

Jambura and Kriwet stated (p. 1), "Our results indicate that ptychodontid sharks were large viviparous animals, with slow growth rates, matured very late and, therefore, show typical traits for K-selected species." The phrases "K-selection" and "K-selected species" occur frequently in evolutionary writings, reflecting an evolutionary, selectionist framework. As the quote above shows, "K-selected" species are characterized by slow growth, late maturity, and large body size. Hence, when reading the evolutionary literature, creation researchers should be especially alert to occurrences of "K-selection" terminology, as it is associated with characteristics (delayed maturation and larger body sizes) that have repeatedly been linked to greater longevity. Thus papers in the mainstream evolutionary paleontology literature discussing "K-selection" or "K-selected organisms" could inadvertently be highlighting indirect evidence for extreme pre-Flood longevity!

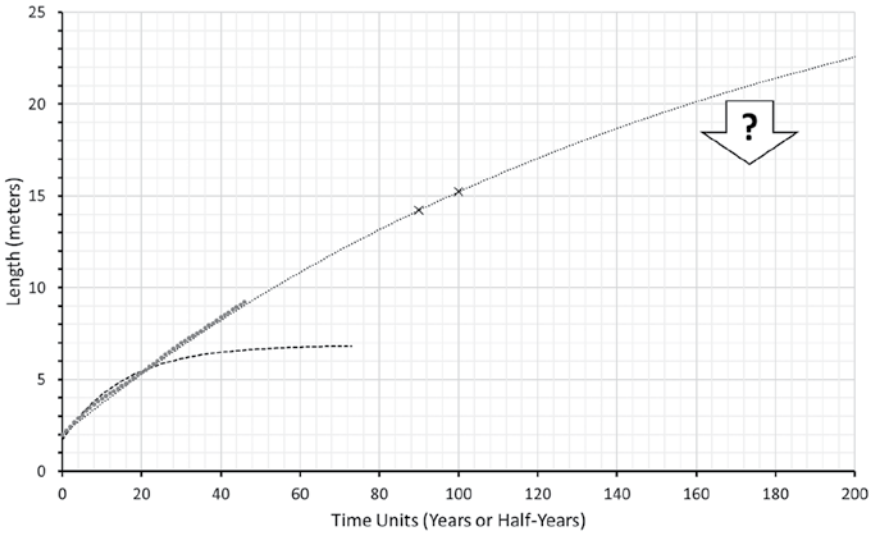

Figure 8. Length-versus-time data (gray dots) inferred from *Otodus megalodon* vertebrae, as well as an extrapolated von Bertalanffy growth curve (dashed line). The data points indicated by the two black crosses were not independent and were not used in the construction of the smoothed curve. After Figure 2a in Shimada (2021). Wintner and Cliff's (1999) inferred great white shark growth curve (short-dashed line) is included for comparison.

An "Old" Adolescent Megalodon

Shimada et al. (2021) counted 46 growth rings in three megalodon vertebrae centra, taken from the disarticulated Miocene megalodon specimen IRSNB P 9893 (formerly IRSNB 3121), housed at the Royal Belgian Institute of Natural Sciences. All three vertebrae showed 46 growth band pairs. They estimated the shark's total length to be 9.21 meters, and they used the assumption that, at any time, total body length was proportional to the (current) vertebrae radius in order to estimate how this total length varied in time. This allowed them to construct a tentative von Bertalanffy growth curve (Figure 8), even though such curves are usually constructed from data obtained from a population of organisms, rather than data from a single individual. The relatively constant spacing between the bands (gray dots in Figure 8) indicates that, at death, this specimen was still a juvenile whose growth had not yet started to slow down.

While recognizing the difficulties in vertebral ring-counting pointed out by Natanson et al. (2018), they assumed that each of the 46 band pairs represented a year (p. 3256):

> In the absence of compelling evidence to the contrary, and given that all three vertebrae we sampled had the same number of regularly spaced bands, we assumed that these bands represent annual growth markers in *Otodus megalodon*.

As acknowledged by Natanson et al. (2018), counting difficulties are likely to be less severe in younger, adolescent sharks, and the regular spacing of these 46 growth bands indicate that this was a young individual.

The great white shark growth curve of Wintner and Cliff (1999) is included in Figure 8 for comparison. The maximum number of growth bands in Wintner and Cliff's shark vertebrae samples was 13, but I have extrapolated their curve past 13 "time units" based on their inferred von Bertalanffy equation. It should be noted that both the implied great white pup length of 1.71 meters and asymptotic length of 6.86 meters are a little higher than expected. Great white sharks are typically 1.20 to 1.50 meters long at birth, and the asymptotic length is thought to be between 6.0 and 6.4 meters (Rigby et al., 2019).

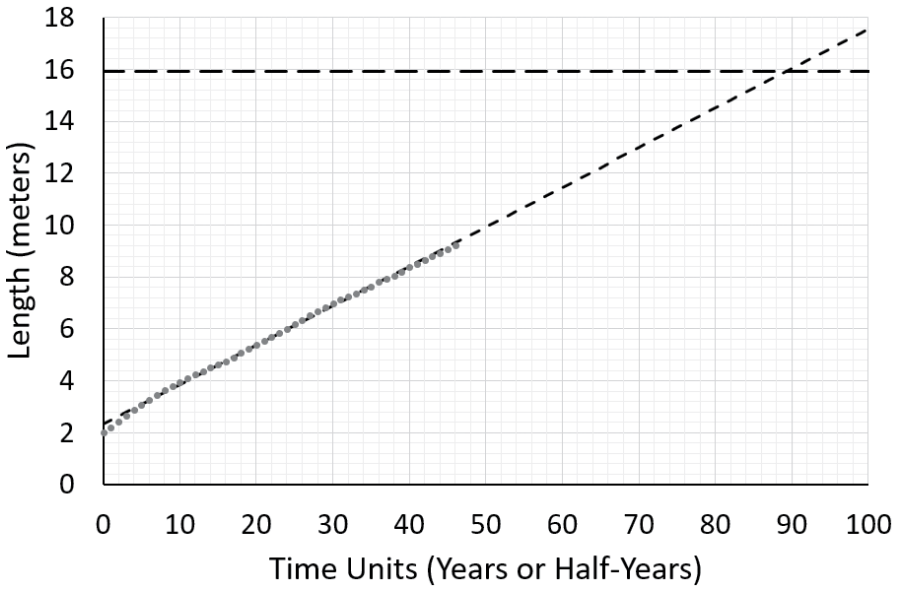

Figure 9. Estimated minimum time for a megalodon to attain the body length of 15.9 meters estimated by Cooper et al. (2022), based on linear extrapolation of Shimada's (2021) inferred megalodon length-versus-time values.

Their resulting growth curve in Figure 8 should be viewed as quite tentative, as it was obtained without any data at all in the 'plateau' part of the growth curve (compare Figures 3 and 8). Thus, their extrapolation beyond these 47 data points is highly uncertain (note the downward pointing arrow in Figure 8). Indeed, a face value interpretation of their growth curve implies an incredible body length of almost 32 meters, or 105 feet! Likewise, it would have taken 498 years to reach 95% of its total adult body length. Although this shark *was* large and long-lived, those numbers seem much too high.

Yet in hindsight, Sternes et al. (2024) suggested that this particular growth curve was an *underestimate*. It should be noted that K. Shimada and M. L. Griffiths were co-authors on this 2024 paper, as well as authors of Shimada et al. (2021), so presumably Shimada and Griffiths concur with this new assessment. Their phrasing is a little imprecise, so it is not exactly clear what they mean. It seems unlikely that they meant that the tentative adult length of 32 meters for megalodon was correct. More likely, they are implying that the allometric equations used to convert centrum diameter to body length underestimate body length.

Shimada et al. also obtained two body-length estimates from two large megalodon teeth. In Hebert (2023), I stated that Shimada et al. had used these teeth data, along with the vertebrae data, to obtain their growth curve. That was incorrect. Rather, they only used the 46 growth rings to obtain their growth curve. They then used allometric relationships and megalodon teeth data to infer estimated total body lengths of 14.17 and 15.33 meters. From their von Bertalanffy curve, Shimada et al. concluded that these body lengths would have occurred at ages of 88 and 100 years, as shown by the black crosses in Figure 8.

Again, these extrapolated numbers should be considered very tentative. What is of far greater interest is the *un*extrapolated portion of the growth curve. Fortunately for our purposes, this is the part of the growth curve subject to the least uncertainty. This megalodon, though still a juvenile, was likely already longer than even Deep Blue, the largest known great white shark, whose body length is thought not to exceed 6.1 meters (Biswas, 2018).

In Figure 9, I obtain a rough estimate of the minimum amount of time it would have taken a megalodon to become skeletally mature. As noted earlier, megalodon length estimates vary considerably, from 14.4 meters to more than 20.3 meters (Cooper et al., 2022). Here I take 15.9 meters to equal the adult body length, using the value provided by Cooper et al. (2022). This length was obtained via computer modeling and vertebral data from an "exceptionally well-preserved" megalodon fossil. However, we keep in mind that Sternes et al. (2024) have argued that this length is likely too short. I performed an informal linear regression (recognizing that the data points are not independent) to obtain the best-fit straight line equation to the data shown in Figure 8. Since the data implied L_0 = 2.0 meters, I forced the y-intercept to be 2. As shown in Figure 9, this extrapolated regression line intersects the line y = 15.9 meters after the passage of 89 time units. Again, the slope of a von Bertalanffy equation can *only decrease* over time. Any potential downward deviation of this regression trajectory will cause the regression line to intersect the line y = 15.9 meters at a time *greater than* 89 units. Hence, 89 years is the absolute *minimum* amount of time for a megalodon to become 15.9 meters long, under the assumption of one growth band per year. Under the assumption of *two* annual bands per year, this growth would still have taken more than 44 years. Both the megalo-

don's large size and prolonged period of maturation are indirect indications of great longevity.

Comparison with the Long-Lived Greenland Shark

The Greenland shark, *Somniosus microcephalus*, is very long-lived, with an estimated lifespan of between 250 and 500 years. In fact, it is the longest-lived of all extant vertebrate species. This shark's extreme longevity is generally attributed to a very slow metabolism resulting from the very cold waters in which it lives (Nielsen et al., 2016; O'Connor, 2017). The Greenland shark is also one of the largest extant sharks, with a length between 2.4 and 7 meters. It is believed to take about 150 years to reach maturity. Both its large size and stretched-out growth interval are consistent with the trends mentioned earlier linking greater longevity in extant animals to greater adult body sizes and longer growth periods.

However, cold temperatures can't be the explanation for the apparent longevity of the two fossil sharks discussed above. The *Ptychodus* fossil was found in Cretaceous strata, and evolutionary scientists think the Cretaceous climate was warm. Some creationists have long suggested that the pre-Flood world was warmer than today's world, with presumably warmer oceans (Whitcomb and Morris, 1991). Moreover, Cretaceous strata were deposited during the Flood, with likely much warmer oceans due to intense volcanism (Oard, 1990) and rapid production of new hot, seafloor (Baumgardner, 1990). So creationists and evolutionists both would agree that the ocean in which this *Ptychodus* shark swam was probably warm, but for different reasons. Moreover, evolutionists think megalodons lived in temperate-tropical waters (Shimada, 2021), and creationists (at least those holding to a "high" Flood/post-Flood boundary) would argue that Miocene strata were also deposited during the Flood. Hence Miocene oceans should have been fairly warm, as well. Yet despite living in temperate-to-warm waters, these fossil sharks demonstrate characteristics indicative of extreme

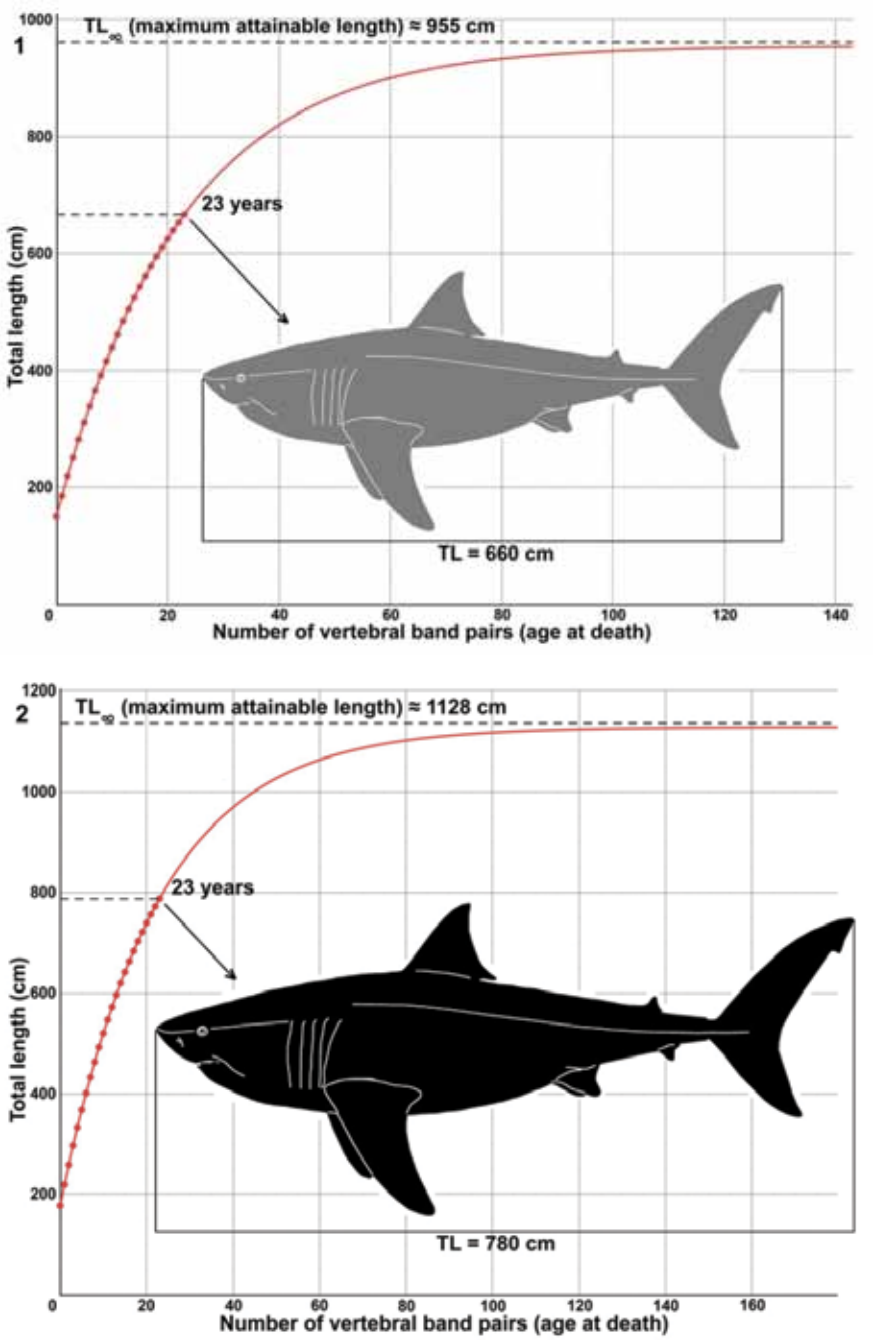

Figure 10. Figure 14 from Amalfitano et al. (2022), showing constructed von Bertalanffy growth curves for a *Cretodus crassidens* shark specimen (Late Cretaceous) from northern Italy. Amalfitano et al. reported that this shark specimen would have taken 64 years to reach 95% of its estimated body length. Image Credit: J. Amalfitano, F. M. D. Vecchia, G. Carnevale, E. Fornaciari, G. Roghi, and L. Giusberti. CC BY 4.0 International. https://creativecommons.org/licenses/by/4.0/.

longevity. Thus, their apparent longevity is truly exceptional.

Cretodus crassidens: A Giant Shark from Italy

Amalfitano et al. (2017) described a "virtually complete" (Amalfitano et al., 2022) large shark skeleton, catalogued as MPPSA IGVR 91032, found in Late Cretaceous rocks in northeastern Italy. They tentatively assigned it to the genus *Cretodus* but later narrowed the classification to the species *Cretodus crassidens* (Amalfitano et al., 2022). The shark's total body length at time of death was estimated to be between 6.60 meters and 9.55 meters. Although recognizing the difficulties in ring counting pointed out by Natanson et al. (2018), they used the assumption that each vertebral growth band represents a year to estimate its age at death to be 23 years. They also used this assumption to construct possible von Bertalanffy growth curves (Figure 10). These growth trajectories implied that the shark's total body length at age of maturity would have been between 9.55 meters and 11.28 meters. It should be acknowledged, given the lack of data in the "plateau" part of the growth curve, that there is considerable uncertainty in the estimated total lengths at maturity. However, since the data capture some of the curvature in the growth trajectory, the uncertainty is not as great as in the case of the megalodon growth trajectory inferred by Shimada et al. (2021). Under the assumption of one growth band per year, Amalfitano et al. estimated that this *C. crassidens* specimen had a longevity of about 64 years, with longevity defined (Taylor, 1958; Natanson et al., 2006) as the typical age for a species to attain to 95% of its adult length. Under the assumption of two growth bands per year, this age would have been 32 years. It seems more appropriate to call this the age at skeletal maturity, t_{mature}, rather than longevity *per se*. Again, a von Bertalanffy growth curve does not tell us *anything* about longevity, at least not directly. It only tells how long it takes for the organism to reach a certain size. Both large adult body sizes and prolonged maturation intervals are associated with greater longevity (Figure 3).

Giant Fossil Sharks Whose Diminutive Descendants May Still Be Extant

The shark examples discussed so far are presumably extinct, although perhaps the extant great white is a dwarfed version of the megalodon. Are there other possible examples of extant sharks whose fossilized relatives were much larger than the extant versions?

Yes. One possible example is the snaggletooth shark, *Hemipristis elongata*, a kind of weasel shark. It is the only extant representative of its genus and, according to the online *Encyclopedia of Life* (eol.org, Smithsonian National Museum of Natural History), it can grow to be 2.40 meters long, although a larger 3.81-meter-long specimen was reportedly caught in Mumbai in 2003 (Katkar and Josekutty, 2003). Yet the extinct snaggletooth *Hemipristis serra* was much larger, with an estimated total length of about six meters (Pimiento et al., 2019). *H. serra* fossil teeth are found in Miocene, Pliocene, and Indonesian Pleistocene deposits and are much larger than those of extant snaggletooth sharks: a large *H. elongata* might have teeth with slant heights of 2 to 2.5 cm, whereas, large fossil *H. serra* teeth from Florida are almost 7.5 cm long (Heim and Bourdon, 1997).

Another possible example are the thresher sharks, genus *Alopias*. There are three extant thresher sharks (Bourbon, 2006–2009), the largest of which is the common thresher, *Alopias vulpinas*, which can routinely be 2 to 5 meters long (Martin, no date), with a maximum length of 5.7 meters (Martinez, 2023). Teeth of the common thresher shark are relatively small, with two examples I saw advertised online (buriedtreasurefossils.com on September 14, 2023) having lengths of 1.4 and 1.59 centimeters. In an examination of eight modern *A. vulpinas* jaws, Shimada (2006) reported crown heights not exceeding 0.9 centimeters.

Fossil representatives of *Alopias* are known only from their teeth, which can be much larger than those from extant versions. Neogene fossil teeth from *A. palatasi* can be more than 4 centimeters long (Kent and Ward, 2018, pp. 157–160). It is a reasonable assumption that if the teeth of fossil *Alopias* sharks were much larger than those of extant *Alopias* sharks, then their total body lengths were probably much larger, as well. In fact, the extinct Neogene thresher sharks *A. grandis*, *A. palatasi*, and "*Alopias*" *Trigonotodus grandis* are commonly known as giant threshers. The teeth of "*Alopias*" *Trigonotodus grandis* have been described (Bourdon, 2006–2009) as "highly enlarged versions of thresher teeth."

Ward and Bonavia (2001, p. 133) note that larger versions of *Hexanchus griseus*, the bluntnose sixgill shark, existed in the past:

> For Neogene species of *Hexanchus*, the species *H. gigas* (Sismonda 1857) is usually employed. However, we have been unable to identify any convincing characters, *other than size* to separate Recent and Miocene specimens. [emphasis mine]

Of course, the name *gigas* is derived from the ancient Greek word for *giant*. Thus, the Neogene species of *Hexanchus* appears to have been a giant version of the extant bluntnose sixgill.

Summary, Conclusions, and Suggestions for Future Research

The large body sizes and apparent delayed maturation of fossil sharks are consistent with longevities greater than

those of comparable extant sharks. This fits the Bible's account of early Earth history: whatever factors were enabling extreme human longevity would almost certainly have affected the animal kingdom, as well. Thus, these observations provide extra-Biblical confirmation of the extreme longevity of the antediluvian Genesis patriarchs.

Creation researchers should be alert to future additional growth curves for extinct sharks that might be published in the mainstream paleontological literature, especially if shark experts are able to reduce the current uncertainties in annual ring counts. In that case, such growth curves could provide additional evidence of delayed maturation and giantism, which in turn, are indirect arguments for greater longevity.

Creation researchers should also be alert to future findings of giant shark teeth that are otherwise identical to those of extant sharks, as this would constitute additional evidence that modern sharks are dwarfed versions of fossil sharks. Even evolutionary scientists have noticed that Recent and fossil teeth are often very similar. Ward and Bonavia (2001, p. 135) wrote: "[i]n the teeth of Miocene sharks, there is often little or no morphological difference between the fossil and Recent counterparts. In many cases a fossil name was used because the dentition of the Recent representative of the lineage was poorly known." For this reason, it is very likely that taxonomical names for extinct and extant sharks need to be "cleaned up" considerably. Very likely the true number of basic shark kinds is much less than that assumed by evolutionary paleontologists.

For example, a team led by David Cicimurri (South Carolina State Museum, Columbia, South Carolina) recently-discovered (Cicimurri, Ebersole, and Martin, 2020) the two shark species *Mennerotodus parmleyi* and *Mennerotodus mackayi*, which they acknowledge as being very similar to the modern-day sand tiger shark *Carcharias taurus*. As described in a 2020 press release (Anonymous b, 2020):

> Before naming these two species, the team of scientists spent months reconstructing the dentitions of these ancient sharks from hundreds of isolated teeth and comparing them to modern species. According to Cicimurri, "by piecing together and examining the dentitions of these new shark species, we were able to determine that they are closely related to modern Sandtiger Sharks, so close in fact, that we were able to use modern Sandtiger jaws to reconstruct them."
>
> "Like in modern Sandtiger Sharks, the front teeth in the mouths of the fossil species are very tall and fang-like" said [Jun] Ebersole [McWane Science Center, Birmingham, Alabama]. "These teeth often project out of the mouth, giving the shark a snaggle-toothed appearance, and were perfect for feeding on fishes, crabs, squids, and even other sharks"….

Given the great similarity in teeth shape, it is not hard to imagine that *Mennerotodus* and *Carcharias taurus* are actually the same Genesis kind. These *Mennerotodus* teeth were not exceptionally large, but they may have belonged to a juvenile sand tiger shark, rather than a full-grown adult.

Thus creationists should be "on the lookout" for published descriptions of any giant versions of such teeth, as well as *Mennerotodus* growth curves constructed from vertebrae fossil data. Should *Mennerotodus* be shown to be a giant, slow-growing version of the extant sand tiger shark, this would constitute still more evidence of giantism and greater longevity in sharks.

Also, creationists should be alert to "K-selected" or "K-selection" terminology in the mainstream paleontological literature, as these are used to describe organisms that are large and slow-growing. Hence, the appearance of such terminology in a paper may be a clue that the paper contains information which creationists might consider to be evidence of great longevity.

Nor is the giantism of these sharks a rare exception. Giantism is ubiquitous in the fossil record (Woetzel, 2013; Coppedge, 2023), which suggests that such longevity was widespread, if not universal.

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What Is the Meaning of the Floods on Mars?

Part III: Mars Floods Explained Within Biblical Earth History

Michael J. Oard

Abstract

Uniformitarian theories of Martian history present many problems. A Biblical alternative is proposed that includes the Day-4 cratering hypothesis and Mars' crustal magnetism. Greatly reduced magnetism in the centers of the four largest impact craters suggests that most large Mars impacts occurred during the Genesis Flood. These impacts, and subsequent volcanism generated by them, produced a climate with sufficient liquid water for the Martian floods. A young age for Mars is supported by several geological observations. Rapid flooding can explain the valley networks and the outflow channels and provide a tighter volume estimate of around a 100 m Global Equivalent Layer (GEL). The flood water was absorbed into the subsurface and into hydrated minerals. That temporary atmosphere disappeared as water vapor precipitated out and the atmosphere cooled. Precipitation also absorbed CO_2 and SO_2 which helps account for their atmospheric disappearance.

Key Words: catastrophic floods, crater dating, Day 4 cratering hypothesis, glaciation, Global Equivalent Layer (GEL), hydrated minerals, impacts, magnetism, outflow channels, Valles Marineris, valley networks, volcanism, young ages

Introduction

Mars presents many mysteries for uniformitarian science. One is the origin of the valley networks (VNs) and outflow channels. Their existence raised six major questions (Carr and Malin, 2000). The first four were answered in Oard (2024); VNs and outflow channels were carved by catastrophic floods, through a combination of overland flow and groundwater sapping, both of which required precipitation. However, outflow channel flooding originated from groundwater eruptions in grabens or faults and from chaos regions. Uniformitarian scientists provide widely variable estimates of the quantity of water needed, from 3 to 5000 m GEL, but cannot account for the water's origin. GEL stands for Global Equivalent Layer, or the average water depth equalized over the entire globe. Some suggest that impacts and/or volcanism supplied water by melting subsurface ice, but they are stymied by their timescale, which would separate these events by

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long periods of time, leaving the source of water still a mystery.

This part will answer the fifth and sixth questions: (5) Where did the water go? and (6) What do the channels and valleys imply for the planet's climate history? Question 6 will be answered within Biblical Martian history throughout Part III. Several unanswered aspects of the first four questions will be revisited including the source of water, the quantity of water, and how VNs and outflow channels formed. Since the Biblical time scale does not need billions of years to maintain a thick atmosphere, Biblical explanations will provide a more coherent explanation.

Crater Dating Highly Inaccurate Within Uniformitarian Deep Time

Crater dating is how planetary scientists date the surface of Mars to determine its history. Planetary scientists choose a sufficiently large area, count the craters, and determine their size. The more the craters, the older the surface. The method is calibrated with crater counts on the Moon in which absolute ages of Moon rocks have been sampled. There are many problems with this form of dating.

Do Not Know Total Cratering History

Crater dating is inaccurate since evidence of some craters can be removed or obscured by impact debris, lava flows, dust storms, and flooding (Malin and Edgett, 2003; Palumbo and Head, 2018). Additionally, a surface can have so many impacts that it is saturated (Ehlmann and Edwards, 2014). Each large primary impact produces thousands of secondary craters, making it difficult to distinguish small primary craters from secondary craters (Burr et al., 2009). Saturated impact surfaces and confusion between primary and secondary craters make it difficult—if not impossible—to determine a relative timescale for the surface of Mars using the superposition of cratering.

Table I. The four periods of secular Mars history.

Period	Date (billion years-Ga)
Pre-Noachian	Before 4.1Ga
Noachian	4.1 to 3.7 Ga
Hesperian	3.7 to 3.0 Ga
Amazonian	3.0 Ga to present

Numerous Anomalous Results

The process has yielded anomalous results. The early Noachian climate (Table I) is thought to have been warm and wet, causing heavy weathering on the highlands that eroded and degraded craters (Carr, 2006, p. 35; Steakley et al., 2019). These earlier craters exhibit missing ejecta, low or missing crater rims, and relatively flat, shallow floors that are usually filled with sediments (Forsberg-Taylor et al., 2004). In contrast, Hesperian and Amazonian craters are pristine and unweathered, indicating a cold and dry climate. However, weathering sequences are also found on Arabia Terra, which is a part of the highlands that is dated in the Amazonian Period instead of early Noachian. Crater dating (Carter et al., 2015) gives anomalous results.

VNs are generally dated Late Noachian and outflow channels as Hesperian, but both are found *throughout* Mars history according to crater dating. Volcanic surfaces that have few craters (Carr, 2012) should be young, but the volcanoes also have VNs that are thought old. The early warm, wet climate that caused highland weathering would best explain the flooding features. However, to accommodate Hesperian and Amazonian outflow channels and VNs, Soto et al. (2015) postulated many brief episodes of a warm, wet climate, yet they are not manifested in crater weathering and erosion. Some surfaces have weathered minerals, such as jarosite, that are considered to be 3 to 4 billion years old, demonstrating that water has never affected the mineral (Squyres and Knoll, 2005). This contradicts the existence of brief warm, wet periods in the Hesperian and Amazonian.

There are few craters directly associated with VNs making them difficult to date (Hoke and Hynek, 2009). They have been assigned a wide range of dates. Ice sheets show few craters and are thus thought to be young (Byrne, 2009), but would not snow and ice build- up at the same time as the flooding?

Martian crater-dating has led to other contradictions, such as the timing of the Tharsis volcanism. Many scientists think the volcanism was early (Phillips et al., 2001), but others conclude it was late (Turbet et al., 2020). Because Tharsis volcanism caused the edge of the Hellas crater to be uplifted, it is likely that volcanism postdated major impacts (Phillips et al., 2001).

The Noachian period also lacks alluvial fans. Most fan systems are dated as having developed during the dry Hesperian and Amazonian periods (Wilson et al., 2021). One would expect alluvial fans to form during the warm, wet Noachian. The reason most fans are dated to younger periods is their lack of craters. But it is possible to explain this with rapid impacting, followed by flooding with residual impacts.

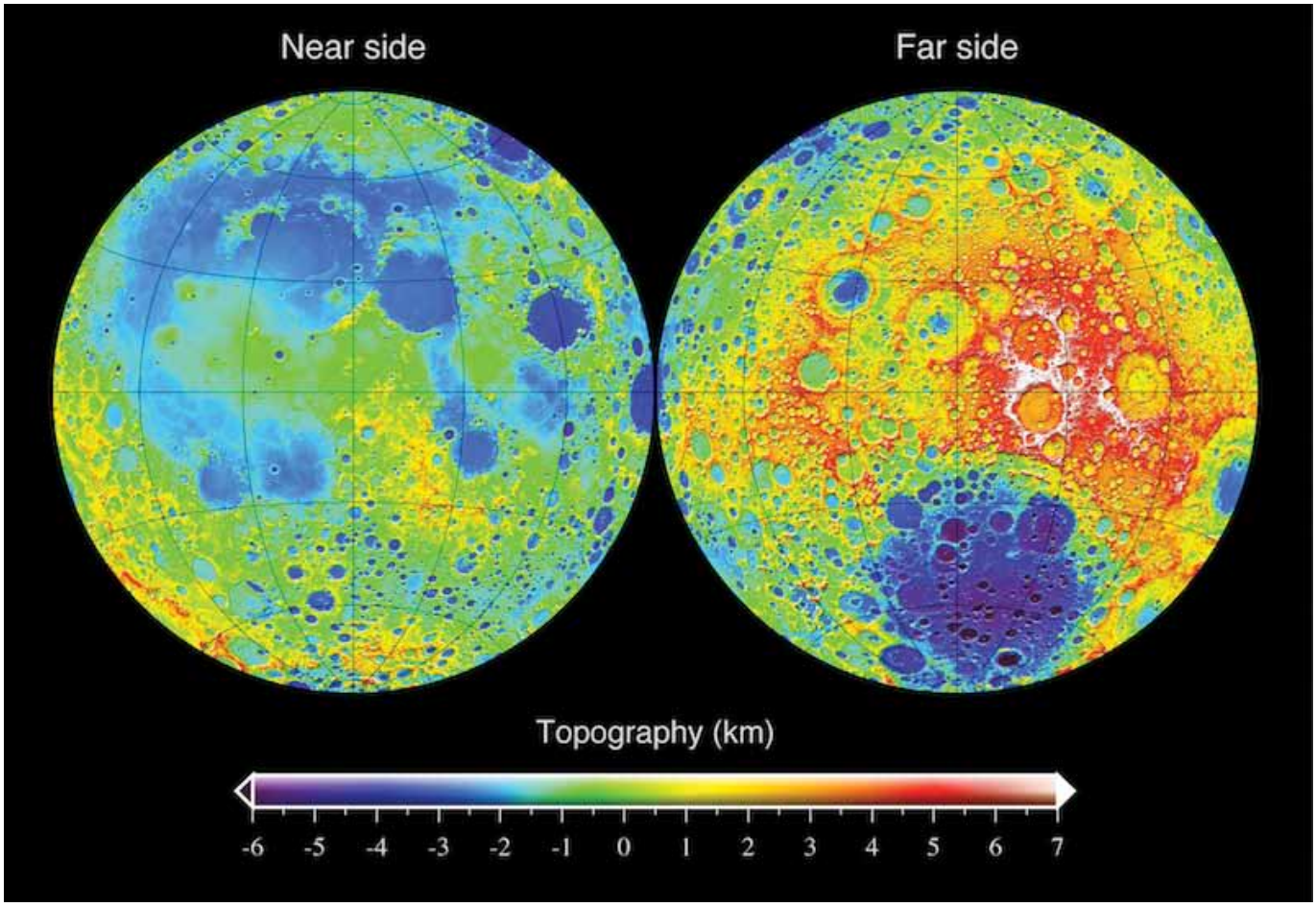

Figure 1. The color-coded topography of the Moon obtained from the Lunar Orbiter Laser Altimeter in two Lambert equal area images projected on the near and far side hemispheres (Mark A. Wieczorek, Wikipedia Commons CC-BY-3.0). Except for South Pole/Aitken, the large impact basins are on the near side.

Some Astronomers Admit Crater Dating Inaccurate

Some astronomers acknowledge crater counting only provides a rough estimate of timing. Recently, Voosen (2021) expressed the opinion that crater counting is highly uncertain, but is all they have to work with in terms of relative dating. The crater-dating method is difficult to apply:

> "Older surfaces have more superimposed impact craters. While this is a simple relationship, the method is in practice often difficult to apply, particularly for younger surfaces where smaller craters must be counted, which are more vulnerable to erosion and for which there might be confusion distinguishing primary craters from secondary craters.… there are, however, considerable uncertainties associated with converting crater frequencies to absolute ages…" (Carr, 2006, p. 15).

Burr et al. (2009, p. 53) support using caution with crater dating:

> "In general, age-dating of Martian surfaces based on crater statistics is subject to question based on the evidence for both wide-spread mantling and exhumation…, as well as evidence of efficient secondary production…"

The Day-4 Cratering Hypothesis

These issues suggest a need for an alternative explanation of Martian history with a better relative dating system. Faulkner's (1999, 2000, 2014) Day-4 cratering hypothesis provides clarity. He proposes that the Solar System bodies were *made* from preexisting material created on Day 1, and that during and/or

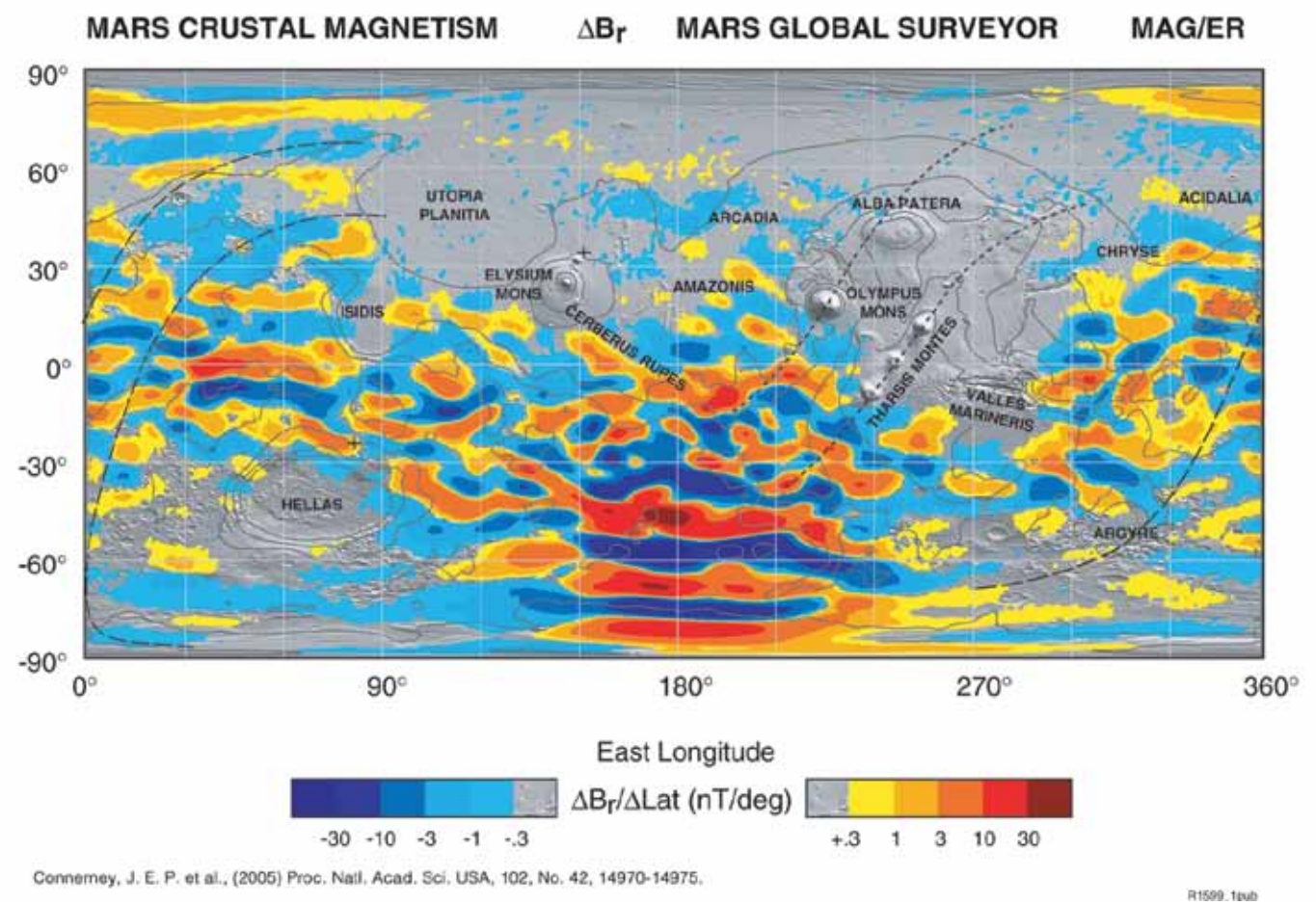

Figure 2. Map of Mars crustal magnetism (NASA). Notice the alternating positive and negative anomalies and that some areas have little or no magnetism.

soon after assembly on Day 4, small objects remained orbiting the Solar System bodies and later impacted them. Earth was not affected since it was created *before* Day 4. Thus, the craters in the highlands of the Moon and other Solar System bodies are the result of Day-4 cratering. However, the large basins on the near side of the Moon, with diameters around 1,000 km, came later during Noah's Flood and were superimposed on the highland craters. Faulkner suggests that the Flood impacts resulted from a narrow, intense, swarm of asteroids, some very large, travelling on parallel paths. These asteroids impacted only the Earth and Moon in a matter of days indicated by the asymmetric distribution of the large craters on the near side of the Moon as shown in Figure 1 (Samec, 2008). Otherwise, large basins would be more random as the Moon spun on its axis. The Day-4 cratering hypothesis and Flood cratering would render the uniformitarian crater-dating scheme invalid.

Day-4 Cratering Hypothesis Extended to Mars

This hypothesis can be extended to Mars' cratering pattern and its unusual remnant crustal magnetism. The mostly east-west magnetic anomalies are found mainly in the southern highlands as shown in Figure 2. This remnant magnetism implies a strong magnetic field once existed on Mars.

Large Impacts Destroy Magnetism

When an impact occurs, it destroys the preserved magnetic signatures by excavation, shock, and heating (Hood et al., 2003). Normally, a signature would be restored afterward, especially in the melt towards the center of the crater. Most small- to medium-sized Martian craters

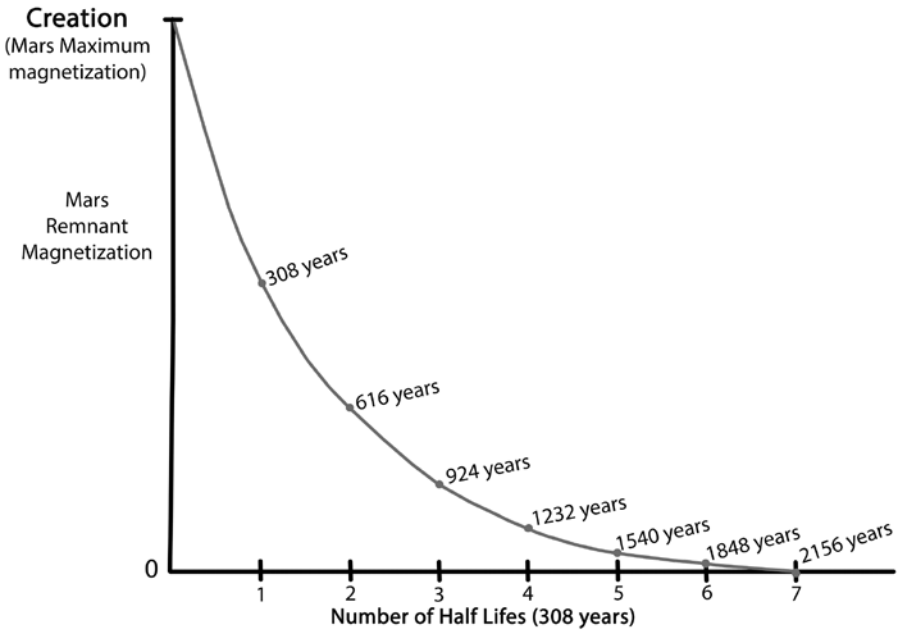

Figure 3. Decrease in Mars magnetism with a half-life of 308 years over 7 half-lives after Humphreys' communication (drawn by Melanie Richard).

exhibit a magnetic signature. However, some areas show weak to no magnetic signature, including large impact basins; large volcanic areas, such as the Tharsis rise; Valles Marineris; and much of the northern lowlands. Mars' magnetic field had decayed prior to the formation of these features: "Magnetic disruption near large impact craters such as Hellas and Argyre establishes that magnetization came before the impacts…" (Jurdy, and Stefanick, 2008, p. 38).

Volcanism would thermally demagnetize the area, and Mars had no magnetic field to reset the rocks (Lillis et al., 2008). If there was even a slight magnetic field, cooling of ferromagnetic minerals would have produced a thermoremanent magnetic field (Lillis et al., 2013b).

Impact Timing of the Decay of Mars' Magnetic Field

In Biblical Earth history, planetary magnetic fields began at Creation and were caused by circulating electrical currents in the liquid core (Humphreys and De Spain, 2016). However, secular scientists know such a magnetic field would decay by friction and last only thousands of years. Because they believe in billions of years, they invented the "dynamo" theory. A dynamo supposedly overcomes the Second Law of Thermodynamics and somehow keeps generating the electrical current.

Planetary scientists have expanded this theory to solar-system bodies, despite being hypothetical, like a perpetual motion machine. Scientifically, it is not proven to work (Humphreys and De Spain, 2016), and is simply another ad hoc hypothesis covering and obfuscating the flaws in the evolutionary/uniformitarian paradigm.

Humphreys (personal communication, 2021) calculated the half-life of Mars' magnetic field as 308 years. Using this, we can place many of the numerous small- to medium-sized impacts on Day 4 of Creation, when the magnetic field was very strong. Mars' crust is ~40 km thick (Vervelidou et al., 2017), and so impact craters with diameters greater than 300 km would erase any magnetic signature. Those happening early reset to the existing magnetic field; later impacts and resulting melts did not regain remanent magnetism or magnetically reorient.

Is it possible to time these latter impacts? Figure 3 shows the decay of Mars' magnetic field as related by Humphreys. After four half-lives, 1232 years after Creation, the magnetic field would be 1/16 as strong; after five half-lives, or 1540 years, it would be 1/32 as strong; after six half-lives, or 1848 years, it would be 1/64 as strong; and after seven half-lives, or 2156 years, it would be 1/128 as strong and nearly zero.

Although the lack of magnetism over volcanic regions indicates that the volcanism came later than Day 4 when the magnetic field had substantially declined, the magnetism is too complicated and cannot be used to time the volcanism (Lillis et al., 2013a). The reason for this is that the heat of the magma would variably erase the original magnetic signature of the crust. If there had been a magnetic field, the cooling lava would have captured it.

Later Impacts Can Be Timed to About the Time of the Genesis Flood

Magnetism of impact craters greater than 300 km in diameter provides a clock with respect to the decay of the magnetic field, assuming a crater's magnetization was not altered later (Lillis et al., 2013a; Vervelidou et al., 2017). As it turns out, the craters *do* have very weak magnetism (Vervelidou et al., 2017), indicating that the impacts occurred just before the magnetic field died around 1500 to 2100 years after the initial creation of the magnetic field. The maximum magnetic signatures in the inner

half of the four largest impact craters are shown in Table II and are similar, indicating a similar time of impact. The numeric average of their magnetization is 0.145 A/m.

The magnetic field could have been a little higher in these large craters since post-impact processes, such as chemical alteration, crustal thinning, and hydrothermal activity, can also reduce magnetism (Vervelidou et al., 2017). This would imply that these large impacts occurred at about the time of the Genesis Flood. Faulkner (1999, 2014) thought Flood impacts affected only the Earth and Moon. However, this analysis indicates they also may have occurred on Mars. Perhaps other solar-system bodies were also hit at the time of the Flood.

Table II. Maximum magnetization of four large impact basins, from the inner crater (Vervelidou et al., 2017).

Crater	Maximum Magnetization (A/m)
Hellas	0.18
Utopia	0.16
Isidis	0.13
Argyre	0.11

Why Not Large Impacts on Earth?

Large impact basins seen on the Moon and Mars are not found on Earth. The largest accepted terrestrial impacts are the Vredefort and Sudbury structures, both about 250 km in diameter.

I believe God protected the Earth from most of the large impactors while letting a small number of the small-to-medium ones strike. Wayne Spencer, an impact specialist, once believed this, and probably still does, that God superintended the paths of the asteroid bodies:

> "But whether we place impacts in Creation Week or at some other time, it seems inescapable that some unknown factor reduced the effects of impacts on the earth. Some sort of intelligently directed bombardment that limited objects' trajectories could also be a possibility, but this is very close to Faulkner's hypothesis also. It is very difficult to imagine some natural physical effect that would so dramatically reduce the number of impacts on earth. Thus, some degree of supernatural protection of earth from impacts seems to be a necessity, regardless of when they took place. If supernatural protection of earth is a possibility, this in turn opens up the possibility of impacts in the solar system at some time prior to the Flood." (Spencer, 2014, p. 324)

Based on about 200 "confirmed" impacts on Earth (Schmieder and Kring, 2020; Lim et al., 2021) and possible impacts, including continental basins, I think Earth absorbed at least 500 small- to medium-sized impacts during the Flood (Oard, 2023).

Climatic Deductions from the Day-4 Cratering Hypothesis

Biblical history eliminates the faint young Sun hypothesis, which is why many climate models fail (Ramirez and Craddock, 2018). Instead of 1/3 the Earth's solar radiation, as in the uniformitarian climate models, Mars would have received 43% based on its distance from the Sun (Cang and Luo, 2019), and atmospheric greenhouse gasses would more efficiently support a warm, wet climate.

The planet Mars is only a few thousand years old, with little change in its orbital parameters. The present obliquity of 25° was probably so during Mars flooding. High obliquity is not needed to allow glaciation on Mars.

Impacts and Volcanism Can Provide Needed Water Quickly

Given a Biblical history, water likely existed on Mars in the subsurface. There is significant water in the Solar System, and it is likely the Universe was formed from water (Humphreys, 1997). Using the relative dating of remanent magnetism, Mars' large impacts and major volcanism happened at about the same time, releasing large volumes of subsurface water. Because events were not spaced many millions of years apart (Hynek et al., 2010; Hoke et al., 2011), their cumulative effect was to trigger precipitation and flooding. Loizeau et al. (2018) think one impact can cause enough precipitation, but Segura et al. (2008) suggested that all large impacts together would result in 560 to 3000 m GEL, easily enough water to erode VNs and outflow channels. Palumbo and Head (2018) estimated all Noachian impacts would produce 3 km GEL, while as little as 3 to 100 m GEL may have done the job. Scheller et al. (2021) say impacts could deliver 600 m to 2700 m GEL. Clearly, large impacts could produce Martian flooding. Volcanic activity would also contribute water, as well as CO_2 and SO_2, that would help melt surface ice.

The impacts apparently ended quickly, explaining why flood features (Baker, 2001), some minerals (Squyres

and Knoll, 2005), subsurface ice, and ice sheets exhibit few craters.

Evidence for Young Ages

Evidence supports a Biblical young age for Mars. One example is the distribution of the current polar ice caps. Mars' obliquity is about 25°. Computer models predict it would vary from 10° to 35° during the past 5 million years. Between 5 and 20 million years ago, it would have averaged 35° in a range of 25° to 45° (Lasker et al., 2004). Further back, the orbit is too chaotic to model with confidence. Climate models predict ice deposited in equatorial latitudes (30°S to 30°N) when the obliquity changed from today's 25° to the 35° of 5 Ma (Schon and Head, 2012; Hepburn et al., 2020). Planetary scientists believe water vapor creating tropical ice comes from sublimation of mid-latitude ice and polar ice. But there is *no* evidence of tropical glaciation except at high altitudes like Tharsis (Schon and Head, 2012). This indicates that the planet is less than 5 million years old.

If mid-latitude ice developed over millions of years, as claimed, it should have significant internal layers of dust, since Mars has numerous dust storms (Vandaele et al., 2019). Ice at 30–50° is unstable and should have sublimated over millions of years, but it remains stable thanks to a shield of surface dust. Planetary scientists believe the thick mid-latitude ice accumulated over many obliquity cycles. If so, applying uniformitarianism, *each* cycle's ice should have a protective dust layer. However, there is very little dust *within* the ice (Bramson et al., 2017). So, snow and ice built up quickly, without multiple obliquity cycles over millions of years. Other physical features provide evidence for a young age.

Fans and deltas, one of which is shown in Figure 4, can form within decades at peak (uniformitarian) flow (Fassett and Head, 2005). But modern flume studies show deltas can form in days (Kraal et al., 2008). They would be expected to form even faster given Biblical catastrophism.

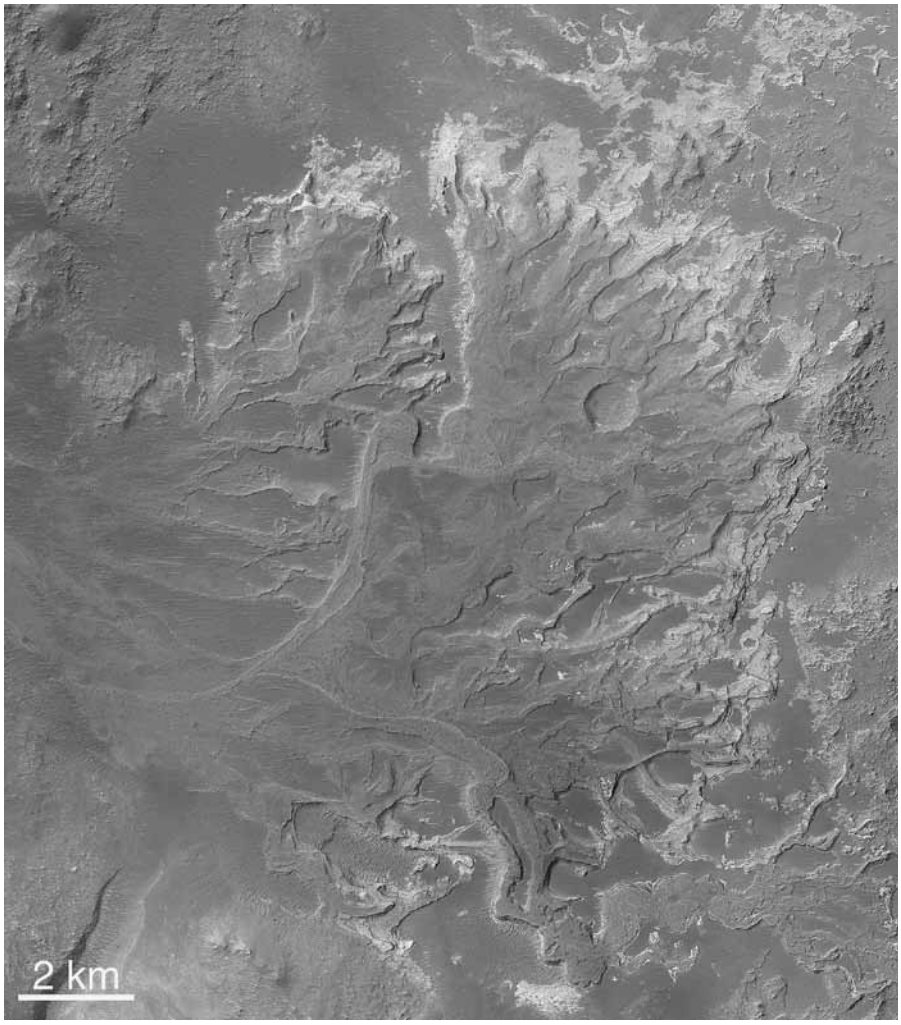

Figure 4. The Eberswalde delta on Mars (NASA). Note the meanders with cutoffs, now seen in inverted relief from wind erosion.

Water from long-term flooding should have been collected in the Hellas impact crater (Irwin et al., 2011), but it has not because flooding was quick and limited. If VNs had formed, as thought, in the late Noachian (3.7–3.8 Ma), they should have been filled by dust and/or volcanic debris but have not.

It is believed that Martian volcanism occurred throughout its history. But this is a problem (Hargitai and Gulick, 2018), just like the proposed long-term volcanism on the Moon (see Part I). This conundrum is best explained by a young age.

Many unweathered minerals, such as olivine, pyroxene, and feldspars, are found on Mars' surface (Jakosky and Mellon, 2004). Olivine enrichment is common on bedrock plains (Coward et al., 2019). Even given favorable conditions of cold temperatures, low pH, and large grain sizes, olivine can only last 20 to 30 Ma. On Mars, there must either be an ongoing olivine enrichment mecha-

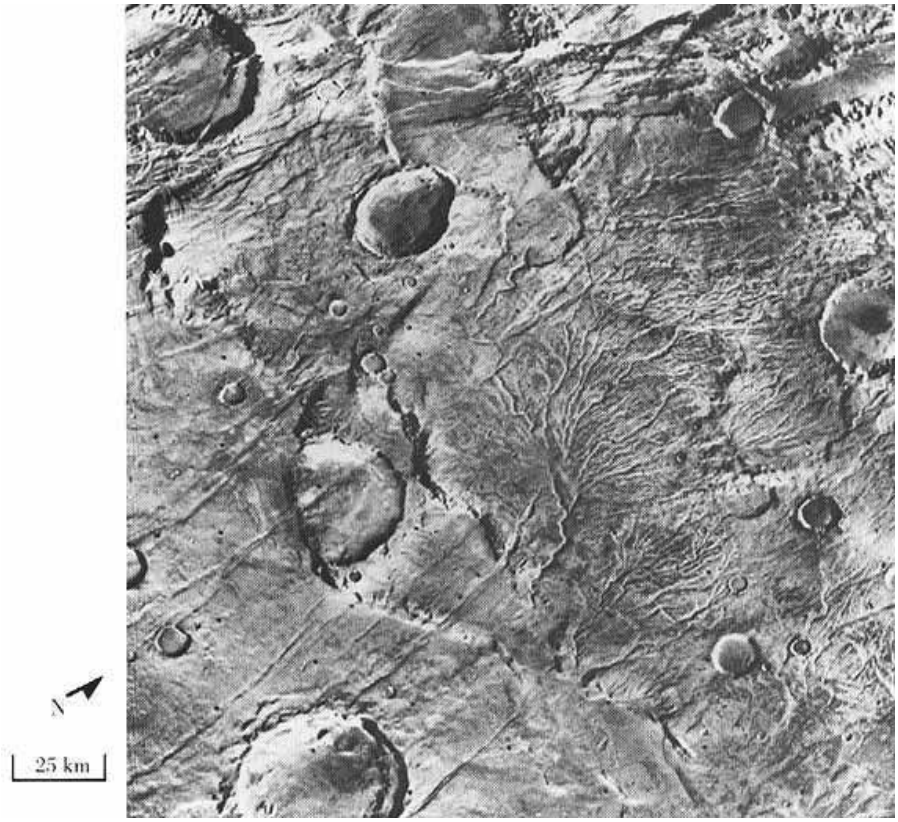

Figure 5. Branched valley network as seen by Viking Orbiter (Jim Secosky, Wikipedia Commons PD NASA). Field of view is roughly 200 km across.

nism or Mars must be young. Such observations also suggest one or more quick precipitation event(s):

> "One possible explanation for the discrepancy is that liquid water may have been present on Mars only during discrete episodes or isolated events in its history. In one extreme view, the water would have been mobilized by the ancient large impacts. The released water would have produced a hot torrential rain that could have carved the valley networks and eroded the surface but that didn't last long enough to chemically alter surface minerals." (Jakosky and Mellon, 2004, p. 75)

Amorphous silica is observed on the surface of Mars and according to Tosca and Knoll (2009), it should not last more than 400 million years.

Weathered minerals observed on Mars can be formed rapidly from acid rain during impacts and volcanism (Zolotov and Mironenko, 2016). The acid rain is expected to especially form Fe/Mg smectite, a few meters to tens of meters thick. The reason there are few sediments and weathered minerals in outflow channels (Leverington, 2021) is likely because acid rain ended quickly. Bishop et al. (2018) believe there is increasing evidence that weathered clays formed during a short-lived aqueous event(s) on a cold, arid planet. This is especially the case if the clays formed in a warm environment created by large impacts and volcanism.

How Did the Valley Networks Form?

The origin of VNs (Figure 5) is controversial because of their many strange features (see Part I). How can they be explained in the Biblical timescale?

Numerous planetary geologists have concluded that VNs must have formed from an episode of precipitation and flooding so brief that it failed to produce VNs in some areas, produced an immature drainage pattern, and simply flowed down the topographic slopes (Segura et al., 2002; Craddock and Lorenz, 2017; Hargitai et al., 2017; Ramirez and Craddock, 2018). Snowmelt from glaciers is an unlikely explanation (Shi et al., 2022). Low drainage density could also result from thick regolith in the southern highlands that can absorb a lot of water (Irwin et al., 2011), especially during a brief event. Discharge rates were likely high (Hargitai et al., 2017). VNs likely were eroded rapidly, since the sediments in the highlands are expected to be unconsolidated (Hoke et al., 2011), and thus should have been eroded and transported more readily.

A short, intense event is also supported by the paucity of chemical weathering products of a multimillion-year warm, wet climate (Irwin et al., 2005). The problem with abundant, easily weathered minerals, such as olivine, is solved by one quick event; there simply has not been enough time for extensive weathering in the short Biblical timescale. Reinforcing a rapid-event interpretation is that chemical sediments formed by acid rain are little altered; water has not affected them since deposition (Tosca and Knoll, 2009).

The Evidence for Groundwater Explained by Precipitation

The strongest evidence for groundwater is the existence of amphitheater-headed tributaries. However, amphitheater-headed valleys can be caused by overland flow (Hoke and Hynek, 2009),

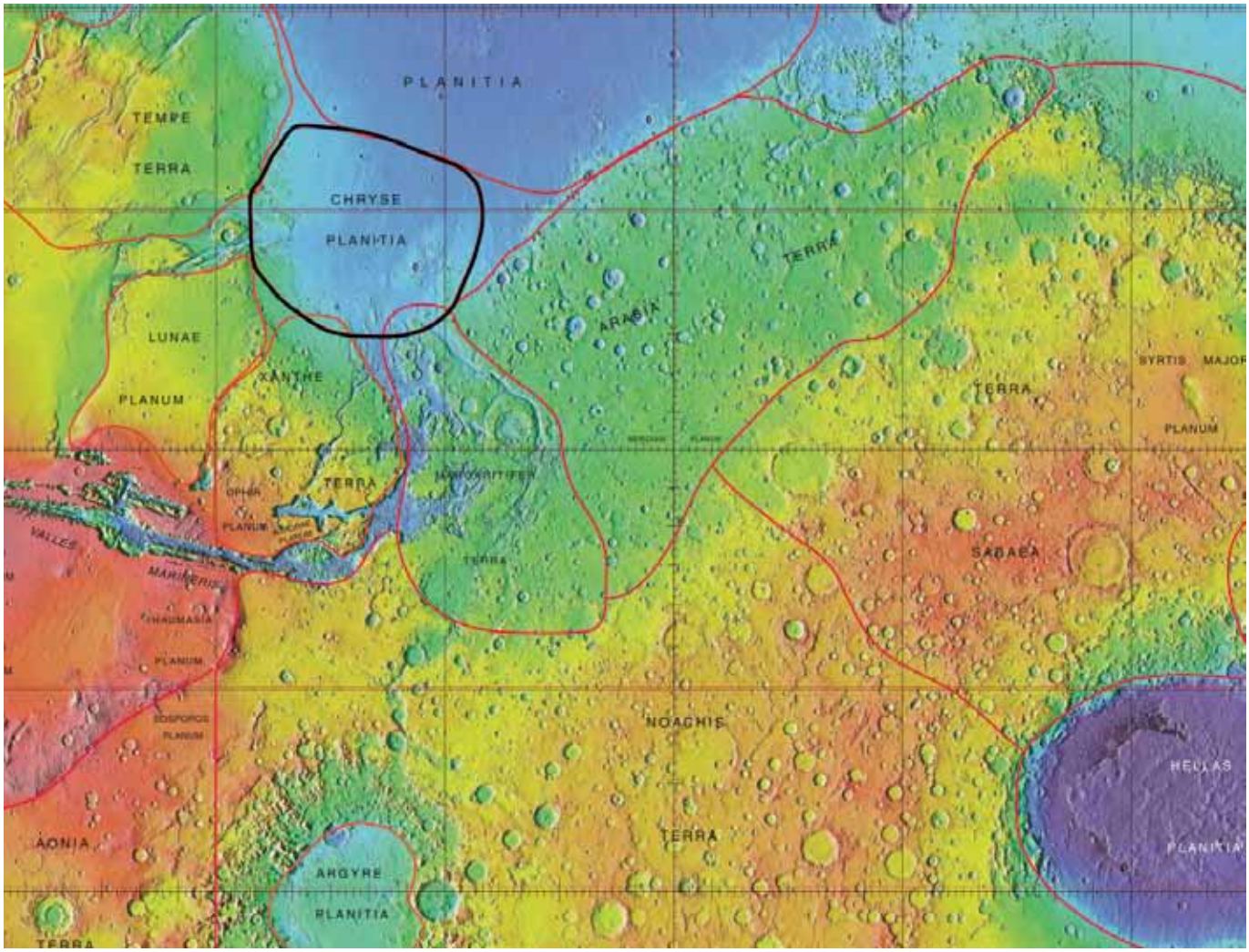

Figure 6. Chryse Planitia, in the black outline, in relation to surrounding areas color coded with blues and purples of low altitude and red and brown for high elevations (NASA).

and ongoing precipitation is needed to recharge groundwater (Shi et al., 2022).

Some Valleys Formed by Breached Lakes

Some VNs were apparently eroded by overspill and drainage from lakes (Segura et al., 2002; Hoke and Hynek, 2009; Palumbo et al., 2020), which could account for some valleys not changing width downstream. Goudge et al. (2018, 2021) estimated that more than 200 lakes breached when only *one* flood over topped the rims, since the greatest potential energy would be at the moment of breaching. Perhaps the largest valley, Ma'adam Vallis, was formed by the single breach of a large paleolake. Maximum flow was estimated at 1 to 5 x 10^6 m^3/s, eroding a valley 8 to 25 km wide that debouched into Gusev crater, the landing spot for the Spirit rover (Irwin et al., 2004).

Impacts and/or Volcanism Can Account for VNs

Such evidence for short-term precipitation correlates with the timescale of episodic climate change from large impacts as described by Turbet et al. (2020) in Part II. A long-lived-warm, wet climate is not needed on Mars—a brief episode would work (Wordsworth et al., 2015).

VNs Not Necessarily Formed at 30°S

Turbet et al. (2020) claimed that most VNs formed at 30°S, but that location would mark the sinking branch of the Hadley general circulation cell of a warm, wet atmosphere. As on Earth, the Hadley cell is formed by rising air near the equator that cools and descends at 30° latitude. However, Martian VNs are found today from about 50°N to 65°S (Cassanelli and Head, 2019).

Irwin et al. (2011) thought the patchy distribution of VNs was due to convection, with spotty heavy rain, and aided by upslope flow from the northern lowlands to the southern highlands. Support for their scenario comes from short VNs enclosed in basins of the highland plateau with many breached basins along the north slope of the dichotomy (Irwin et al., 2011). Such orographic effects could account for the fact that the VNs are mainly in the southern highlands, where convection is expected to be the most intense.

How Did the Outflow Channels Form in Biblical Earth History?

Outflow channels were probably formed by large, abrupt floods (Gallagher and Bahai, 2021). The main outflow channels are found around and flow into Chryse Planitia, a large low area about 30°N (Figure 6). Circum-Chryse outflow channels are dated late Hesperian to middle Amazonian, by crater density (Rodriguez et al., 2015). This exacerbates the problem of flooding in the cold, dry climate of that time. The combination of outflow channels and sparse craters suggests rapid bombardment led to climate change and the flooding.

Lakes in Valles Marineris

Since Valles Marineris is just south of many outflow channels (Figure 6), it may well be connected to flooding, especially since deep lakes are thought to have once existed there, based on layered sediments found at many locations (Carr, 2006; Liu et al., 2018; Loizeau et al.,

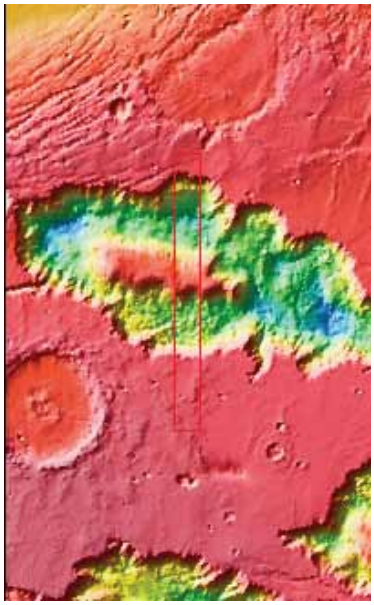

Figure 7. Hebes Chasma, a northern isolated chasma north of Valles Marineris. Blues and purples are low altitude and red shows high elevations (NASA). It is 319 km long, 130 km wide, and up to 8 km deep. The middle elevation is Hebes Mensa, a large remnant of layered materials, left after the catastrophic drainage of the lake.

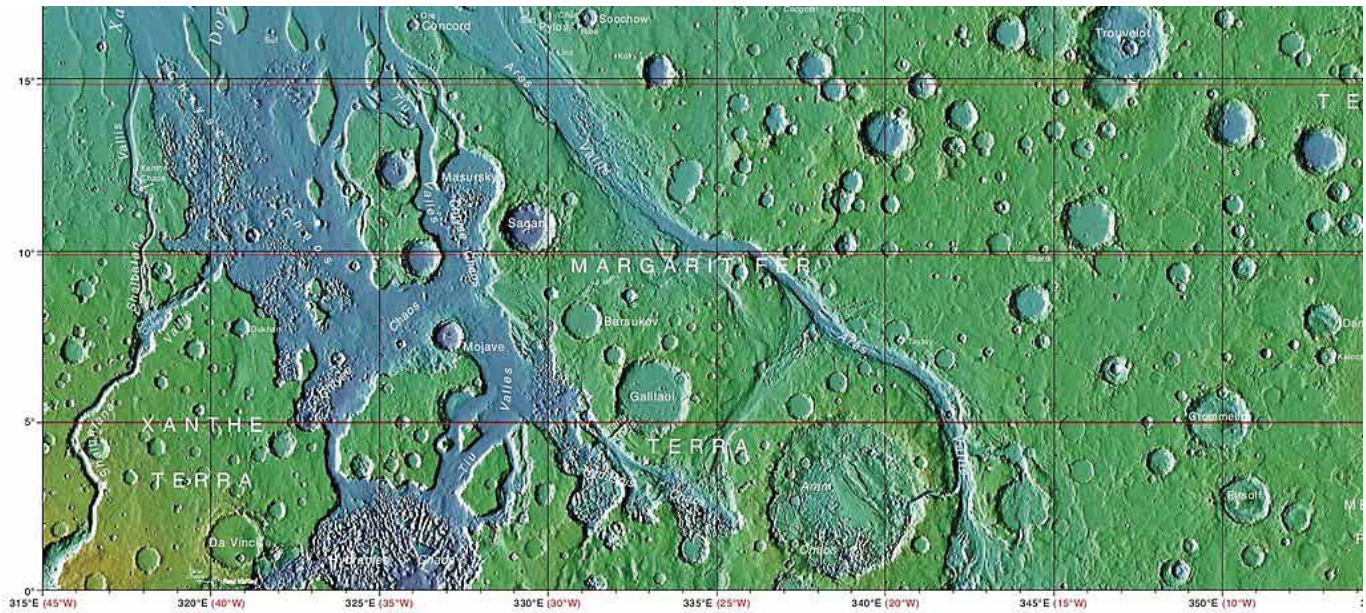

Figure 8. Topographic map of Oxia Palus region of Mars. Blues are low elevations and greens high elevations. Note the chaos regions and valleys, including Ares Vallis and Aram Chaos in the middle of the picture (Jim Secosky, Wikipedia Commons PD USGS).

2018). Sulfate-rich, layered deposits are over 6000 m thick in western Candor Chasma. The lakes were likely created by large impacts and associated volcanism which released groundwater that was recharged by heavy precipitation, and runoff from the surrounding plateau (Davis et al., 2018). Lake depths imply that the eastern end of Valles Marineris was blocked (Warner et al., 2013).

The persistence of Martian lakes for tens of millions of years flies in the face of climate models. The most obvious solution is a much shorter timescale, such as the Bible's.

Floods from Valles Marineris

It appears that these large lakes were the source of the floods that eroded the outflow channels (Carr, 2006; Williams and Weitz, 2014). Evidence suggests catastrophic breaching since the flow was maximized at the onset of flooding (Andrews-Hanna and Phillips, 2007). It is unlikely that the floods were sourced by groundwater, given the relative impermeability of even unconsolidated rock, especially if, as some researchers believe, the ground was frozen kilometers deep (Harrison and Grimm, 2008). Carr (2006, p. 114) concluded from estimated discharge rates that erosion of outflow channels required large volumes of stored surface water suddenly released.

For example, Kasei Valles is the largest outflow channel. "It starts within Echus Chasma, a large north-south canyon that narrows to the south and almost merges with the completely enclosed Hebes Chasma..." (Carr, 2006, pp. 115–116). Hebes Chasma is a northern east-west canyon of the Valles Marineris system with thick sediments but is isolated from the main canyons (Figure 7). This coincidence suggests that a deep lake burst from Hebes Chasma at first underground until it exited to the north in a chaos region in Echus Chasma. The flood had very high potential energy, resulting in initially heavy erosion. This supports Robinson and Tanaka (1990), who believed that Kasei Valles was carved by one flood with a discharge of 0.9 to 2.3 x 10^9 m^3/s and velocities of 32 to 75 m/s.

Several other outflow channels start north and east of the eastern Valles Marineris (Rodriguez et al., 2015) that originated from deep lakes in Valles Marineris. Carr (2006) shows that Shalbatana Vallis started from Orson Welles chaos, but to the south are linear collapse regions that lead to Ganges Chasma of the Valles Marineris system. Carr suggests that the outflow channel originated from subsurface drainage of the lake formerly in Ganges Chasma. The water first flowed underground and then erupted in chaos regions, eroding the region. Evidence for underground flow is from ground collapse in places. Carr (2006, p. 120) concluded:

> "Such a high-standing lake, and accompanying water table, would have provided the high hydrostatic pressures needed to account for the high discharges estimated for the channels that start in the chaos-filled depressions to the east and north of the canyons, which are 3–5 km below the postulated lake level."

As the water drained from Valles Marineris, it left fluvial landforms in the chasms. Later wind erosion inverted some channels (Davis et al., 2018). Since there is no body of water and/or ice at the end of the outflow channels, the water must have spread and infiltrated the subsurface. Ice covering Chyrse Planitia was from snowfall after the flooding.

Ares Vallis, shown in the center of Figure 8, is another spectacular outflow channel believed to have formed by a catastrophic flood (Pacifici et al., 2009). The upper Ares Vallis is 25 km wide and 1500 m deep. Multiple strath terraces were formed in Ares Vallis, suggesting multiple floods. However, a single flood can produce inner channel terraces (Pacifici et al., 2009; Cassanelli and Head, 2018). The origin of Ares Vallis was probably water issuing from Aram Chaos in Aram impact crater (Roda et al., 2014). The water likely accumulated in the crater before breaching the rim. It was likely from one event that took place in days. Komatsu and Baker (1997) estimated that a discharge of 10^8 to 10^9 m^3/sec eroded Ares Vallis.

So, it appears that the outflow channels breached from lakes from large craters or from the very deep canyons of Valles Marineris, as some planetary scientists believe. The potential energy would have been the highest before the breach, which sometimes started underground. The underground water eventually rose to the surface and issued forth at chaos regions.

How Much Water?

The volume of water needed to erode the VNs in a single flooding event is likely on the lower end of the estimates, possibly around 10 to 20 m GEL. Since it is likely the outflow channels were carved by one flood, the total amount of water would also be modest. A good estimate would be 40 m GEL (Carr, 2006, p. 121). Surface and subsurface ice are within that range too, so the total volume of water necessary was probably around 100 m GEL.

Where Did the Water Go?

If the Day-4 cratering hypothesis is correct, where did the floodwater go? There are several options. The water could have: (1) evaporated and/or sublimated into the atmosphere and ultimately into space, (2) been locked into hydrated minerals, (3) infiltrated the subsurface and/or (4) accumulated in an ocean in the northern lowlands that is now frozen.

Very Little Water Lost to Space

Recent estimates suggest that the water could not have escaped into space, even

given billions of years (Kurokawa, 2021; Scheller et al., 2021). The thermal loss in 4 billion years is only 3 to 25 m GEL (Jakosky, 2021). Within the Biblical timescale, almost no water could be lost to space.

Water Incorporated into Hydrated Minerals

Another option would be for water aiding in the formation of hydrated minerals at the surface or subsurface (Kurokawa, 2021; Temming, 2021), and there are extensive hydrated minerals on Mars (Loizeau et al., 2018). Some of these hydrated minerals are Fe/Mg smectites, Al smectites, chlorite, serpentine, prehnite, analcime, kieserite, gypsum, alunite, and jarosite (Ehlmann and Edwards, 2014). The *Perseverance* rover discovered signs of such minerals, along with water eroded features and a 40-m delta cliff (Witze, 2021). Most of the hydrated silicates are associated with impacts (Hopkins et al., 2017). Fe/Mg smectite is the most common clay on Mars, and it can store significant water (DePasquale and Jenkins, 2022), estimates range from 70 to 860 m GEL (Wernicke and Jakosky, 2021). Some of the hydrated minerals may have originated with the Day-4 cratering. Regardless, hydrated minerals potentially account for all the floodwater.

Water Absorbed into the Subsurface

Some planetary scientists do not think much water could be absorbed into the regolith because of the thick cryosphere (Carr and Head, 2019). But a third possibility is that free water infiltrated the subsurface without bonding to minerals. Water from the catastrophic floods eroding outflow channels would have flowed out onto the northern lowlands. There is no surface water there now, except for a mantling of ice. But there are thick buried sediments (Edgar and Frey, 2008); up to a few km of volcanic and detrital sediments (Carter et al., 2010). Palumbo and Head (2018) believe there is about 580 to 1150 m GEL in the regolith of Mars. Most of the outflow channels flowed out into the southern Chryse Planitia, which has thick sediments (Brož et al., 2019). The water from these floods could migrate into them, as long as the subsurface was not frozen.

Most of the water eroding the VNs would have flowed into low spots at generally low latitudes and could have infiltrated the subsurface. It seems likely that all the Martian floodwaters percolated downwards, and today form the subsurface ice (Carr, 2006, p. 17). Jakosky (2021) believes that much water percolated into the crust, but given present conditions it would be blocked by subsurface ice. The problem vanishes if uniformitarianism is not assumed at the outset.

Did Water End Up in a Northern Ocean and Frozen?

Another possibility is that the water from outflow channels ended up in the low Northern Hemisphere forming an ocean that subsequently froze. The belief of a northern ocean is controversial, and it seems that the evidence is not favorable for it (Sholes and Rivera-Hernández, 2022). Outflow channel water would have drained into the lowland and could have formed a temporary "ocean," which could have been absorbed either into hydrated minerals or the subsurface.

Where Did the Thick Atmosphere Go?

What happened to Mars' thicker atmosphere, if the Day-4 theory is true? Over time, it cooled and dried, leaving it high in CO_2. However, it is possible that it was not always high in CO_2 since there are few carbonates on the surface and in the regolith (Edwards and Ehlmann, 2015).

Discussion and Conclusion

A goal of Flood geology is a sophisticated Flood model that can anchor many apparently contradictory geological, geophysical, and paleontological observations. Many of these are initially offered as "proofs" against Biblical history, like the millions of dinosaur tracks and eggs on bedding planes of sedimentary rocks, "stromatolites," "reefs," or crustal rifts. Such a model would affirm the truth of Genesis.

Such models require careful thought. There is much misinformation, bias, poor assumptions, and unknowns in Earth and planetary science. One safeguard is to use the principle of multiple working hypotheses, as advocated by T.C. Chamberlin (1890) in reference to the fledging science of geology. It is good to have several ideas, and as we gather data, we have options. With time, the best model should manifest itself.

The Flood was a unique tectonic, volcanic, erosive, depositional, and diagenetic event that reshaped the surface of the Earth. Only two physical mechanisms are mentioned in the Bible, the fountains of the great deep and the windows of heaven, and they are not clearly defined. Catastrophic Plate Tectonics (CPT) is currently the most popular Flood mechanism. It posits lateral crustal motions of about a dozen large plates and numerous microplates during the Flood (Austin et al., 1994). An alternative theory is a Flood caused by asteroid and/or comet impacts, followed by differential vertical tectonics of the crust and mantle that restored the Earth to equilibrium at the present geography and topography (Bardwell, 2011). This can be called the Impact/Vertical Tectonics (IVT) model. It is also possible that impacts were a secondary mechanism to CPT.

Our detailed knowledge of Mars' surface is very recent, yet it appears that the planet experienced impacts, volcanism, and catastrophic floods. These can be related to Biblical history

in that numerous impacts occurred on Day 4 followed by Flood impacts, some of which were very large. These Mars impacts accompanied by volcanism, possibly caused by impacts, can be the cause of the surprisingly large floods on Mars. Impacts should be considered in any Flood model for Earth.

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Lithification of Sediments

Part II: Field Study in the Great Falls Coal Field, Montana

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Abstract

Recent research has produced data useful in inferring burial depths for sandstones from compaction microtextures. Burial depths can also be inferred from erosional remnants and coal rank, among other means. These methods are especially useful over generally horizontal plains when other methods are unavailable to provide minimum overburden depths. That immense amounts of erosion occurred in the study area has long been recognized, but no effective lithification model has been available whereby to estimate burial depths or diagenetic environments. In this paper, we present research from the northern Great Plains focused on sandstones in an effort to develop a semi-quantitative lithification model for estimating initial overburden thickness (burial depth) and conditions of lithification. While development of such a model eludes us, approximations are possible and can be very helpful in studying Earth history.

Key Words: burial depth, coal rank, intergranular volume, Great Falls Coal Field, lithification, porosity, sandstone

Introduction

There are many wide plains across the Earth to which continental erosion studies do not apply, which are devoid of coal, adequate erosional remnants or folds, etc., by which to estimate depths of sediments eroded from the landscape. The Great Plains of North America form such a location, with much of the Great Plains devoid of coal for inferring burial depth. In these locations, an estimate of the erosion can be attempted using the character of sandstones at or near the surface. For this method to provide us with confidence, it needs to be checked against other methods. We have previously analyzed the variables involved in sandstone cementation (Klevberg and Oard, 2023). The objective of this project was to attempt to find a correlation between burial depth of sandstones and coals and their lithologic properties. The location of the study area is shown in Figure 1. Non-geologists may benefit

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from the primer on lithification in Appendix A.

Geologic Setting

The study area is suited to the objectives of the project due to its structural simplicity, well-developed stratigraphy, the lithologies present, and nearby erosional remnants. It is located on the western edge of the Northern Plains within sight of the Rocky Mountains. The mountain front is abrupt, with significant deformation of sedimentary strata to the west and little deformation to the east of the Disturbed Belt in northwestern Montana. While nearly level sedimentary strata characterize the landscape east of the Disturbed Belt, there is some apparent deformation. The Sweetgrass Arch (Figure 1) is the dominant structure in the area. It is an antiform trending north-northwest to south-southeast from just southeast of Great Falls to near the Canadian border. The limbs dip only a few degrees below the horizontal to the west and east.

Figure 1. Outline of Montana showing study area (rectangle). Anticline symbol marks the trend of Sweetgrass Arch, the primary structural feature impacting the study area.

Planation surfaces, erosion surfaces capped with coarse gravel, typify the area. Relict valleys containing the Missouri River and its tributaries cut into these surfaces, and erosional remnants (buttes) project from them (Figures 2 and 5). Lower benches are smaller and more dissected; the Greenfields Bench (a.k.a. Fairfield Bench) is the largest intact remnant of a planation surface in the study area. The gravel cap is composed of lithologies found in the Rocky Mountains to the southwest. Based on the clast size and slope, and the lateral extent and architecture of the deposits, the gravel was catastrophically deposited. These gravel-capped erosion surfaces are characteristic of north-central Montana. The geologic map (Vuke et al., 2002) describes them simply as "terrace gravels" since they mantle terraces, which in this case are portions of a planation surface. Had these terraces formed over long periods of time by fluvial erosion, a weathering gradient would be expected in the gravel that caps them, but this is not observed. In interpreting these features, it therefore appears more likely that First, Second, and Third Benches (Figure 2) are fractal features that could be expected to result from waning sheet flow or nascent channelized flow during the transition from the Abative Phase to Dispersive Phase of the Deluge (Walker, 1994; Klevberg and Oard, 1998; Oard and Klevberg, 1998; Barrick, 2018, pp. 95–102; Barrick et al., 2020).

Both the plains and the nearby mountains are dominated by sedimentary rocks. The Front Range is largely steeply dipping limestone and dolostone strata with interbedded clastics, while the rocks of the plains are largely clastics with a slight westward dip (west limb of Sweetgrass Arch). The Greenfields Bench is an eastward-dipping planation surface carved into westward-dipping strata (Figure 8), carved indiscriminately into hard and soft rocks and mantled with gravel. This is typical of planation surfaces, which are not being created by modern processes but rather destroyed by them (Oard, 2008, 2013). Evidence of glaciation, in the form of diamict (drift, till), is found north of the Greenfield Bench, and a relict (outwash) channel forms the north boundary of the bench and possibly marks the southern extent of continental glaciation. The apparent extent of glaciation is irregular but approximately covered the northernmost fifth of the study area.

Sedimentary strata are commonly interpreted as transgressive-regressive cycles that resulted in deposition of primarily marine strata with some interbedded continental (non-marine) materials (Carstarphen et al., 2011). Carbonates are much more common at greater depth, and nearer the surface, bentonite and other volcaniclastic materials predominate. The most common rocks are fine-grained clastics. Igneous rocks in the study area are most notably shonkonite flows of the Adel Mountains Volcanics that cap Square Butte and other nearby buttes south of the Sun River and west of the Missouri River (Figure 2). Laccoliths, dikes, and sills are common in the Highwood Mountains and

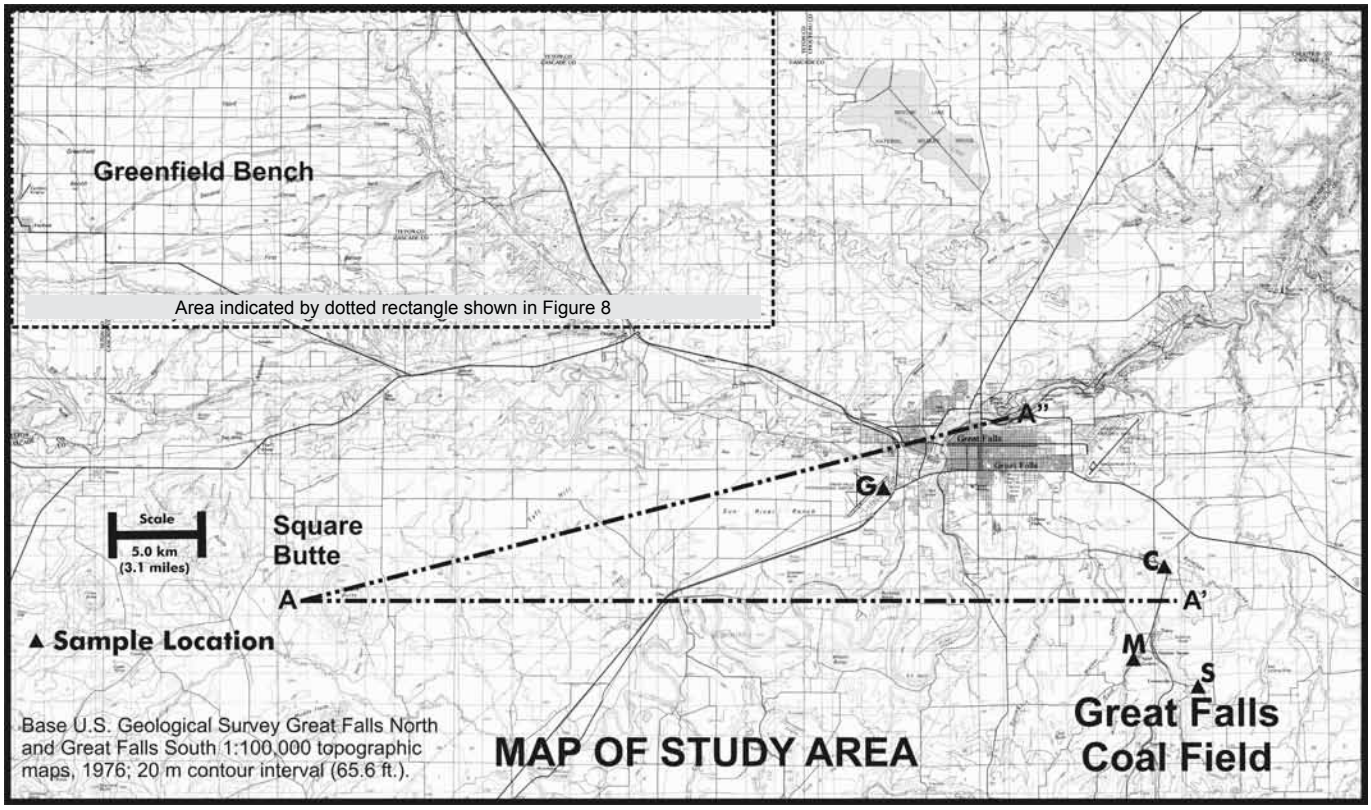

Figure 2. Location of study area is shown on Figure 1. Line A-A' is the cross-section shown on Figure 6, and Figure 7 is the section indicated by the line A-A"

Little Belt Mountains east and southeast, respectively, of the study area. Pediments from these mountains ramp down into the benches on the plains. As much as 2,500 m (8,000 ft.) of sedimentary rocks overlie metamorphic basement in the study area (Carstarphen et al., 2011).

Stratigraphy and Structure

Bedrock is exposed as outcrops along the valley sides (Figure 2) but is mantled by soil cover or diamict where not capped by gravel on benches. Most of the formations and distinctions between their members must be determined from subcrop (borehole data). The dominant lithologies are shale and claystone. Lesser amounts of sandstone, siltstone, and bentonite are encountered. Limestone is minor, and conglomerate is uncommon. The principal sandstones are found in the Flood Member of the Blackleaf Formation (Montana Group), the Sunburst Sandstone, and Cut Bank Sandstone members of the Kootenai Formation, and the uppermost Morrison Formation (Colorado Group). The stratigraphy is presented on the idealized section in Figure 9 and in greater detail in Appendix C. Figures 6 and 7 show both stratigraphy and structure.

Coal

Coal is present in the Blackleaf, Kootenai, and Morrison Formations (Vuke, 2000). The coal of commercial value has been variously classified as basal Kootenai or upper Morrison; the original distinctions in these formations was made based on assumed evolutionary age and not on lithologic grounds (Fisher, 1909). Later, the Kootenai came to be recognized by area drillers as the first red bed, and the first major coal became the marker for the upper Morrison. The Morrison coal extends east approximately 100 miles (170 km) from the Great Falls mining district to Lewistown (Figure 1) and to the west 25 miles (40 km) and was mined at various locations along this length where topography afforded access. The main coal seams in the study area are overlain by approximately 55 m (150 to 200 ft.) of overburden and were accessed from the valley walls near the mining communities of Tracy, Sand Coulee, Centerville, and Stockett (labeled "Great Falls Coal Field" on Figure 2). Mining was by room-and-pillar methods with horse-drawn cars. Mining ceased shortly after

World War II (Vuke, 2000). While the coal is of good quality for heat production, its high sulfur content (up to 4%) and competition from nearby petroleum production has prevented redevelopment of the resource (Silverman and Harris, 1967; Rossillon et al., 2009).

Methodology

This section describes sample collection and analysis and the means of estimating overburden thickness and compaction. The geologic setting is described in the following section.

Sampling

Four samples were collected by the lead author in or near the Great Falls Coal Field: one from the basal member (Flood) of the Blackleaf Formation (G), and three from the subjacent Kootenai Formation: Sunburst Member (S) near the top of the formation, Cut Bank Member from near the base (C), and a sample from the sandstone at the contact between the Kootenai and Morrison Formations (M). The locations of these samples are shown on the map of Figure 2. Sample G was collected from a run of core (Figure 3), sample C from a fresh road cut, and samples M and S from outcrops. Hand samples were fresh, sound rock.

Analysis

The samples were submitted to American Engineering Testing's petrology laboratory in Saint Paul, Minnesota. The laboratory prepared thin sections and reported on the properties of the samples (Appendix B). The samples were classified per Folk (1974) as shown in Table I and Figure 4.

Estimating Overburden

Five methods for estimating burial depth were outlined in Part I (Klevberg and Oard, 2023). These are: 1) from the height of erosional remnants, 2) projected from an eroded anticline or dome, 3) from coal rank, 4) from the amount of continental margin sediments, and 5) from stratigraphy. The first, third, and fifth methods are applicable here.

Height of erosional remnants is a useful measure in the study area. Particularly prominent is Square Butte (Figure 5), west of Great Falls (Figure 2). If the shonkonite capping Square Butte was emplaced as a flow, then about 365 m (1,200 ft.) of sediments were removed from above the samples collected for this project. As shown in Figures 6 and 7, the sedimentary strata that appear level and uniform to the eye are actually dipping to the southwest and vary in thickness. If the strata were deposited before uplift (i.e., original horizontality), then some of these contacts may make a better datum to compare the thickness of overlying strata than simply using elevation above modern sea level. We compared both, interpolating and rounding.

Coal in the Great Falls Coal Field is sub-bituminous B and high volatile bituminous C (Anderson, n.d.; Fisher, 1909; Silverman and Harris, 1967; Rossillon et al., 2009). Charts or curves for estimating burial depth (e.g., Thomas, 2013) assume the present average geothermal gradient to correlate the temperature for pyrolysis of kerogen to coal with depth of burial.

Stratigraphic estimates are more problematic. Outcrop information is primarily from the coal field and major valleys. Subcrop information is primarily from water wells and a couple of wildcat oil wells; this information was obtained from the Ground Water Information Center of the Montana Bureau of Mines and Geology. Published information was consulted for the study area (Figure 8). Figure 9 was created from well logs and Carstarphen et al., (2011). The four samples collected for this project were from the south end or west limb of the Sweetgrass Arch (described in a following section), while Figure 9 is from the west limb approximately 30 miles (50 km) northwest of the sampling locations. The nearly horizontal attitude of the beds and their general uniformity does not appear to introduce any large errors into the correlation. The vertical locations of the samples are indicated on the composite log. A complete composite log for Cascade and Teton Counties is provided in Carstarphen et al. (2011); this was used to create the separate rock column and stratigraphic column shown on Figure 10. As is evident from the large amount of white space in the right column, much of the alleged time has no rock identified with it. Some of these unconformities are likely true unconformities (erosional surfaces), such as the unconformity on top of the Belt Supergroup, while others are paraconformities representing imaginary (inferred) time. The true unconformities represent material that was eroded before additional material was deposited. Thus, the rock column represents *minimum* overburden. However, if some of the stratigraphic column was never deposited above the four sample locations due to nondeposition, lateral thinning of formations, etc., then it is possible that the stratigraphic method will overestimate the original burial depth.

Estimating Compaction

The method of estimating compaction of sandstones is described in Bjørlykke (2014). Sandstone properties used for these estimates are shown in Table II.

1. Intergranular volume is based only on size of framework grains and is 49% for fine-grained sandstone (Chuhan et al., 2002). We give them all an initial porosity (η_0) of 49%.
2. All are poorly cemented, so assume no significant void loss due to quartz cement.
3. Grain shape: high grain angularity produces higher porosity (Fawad et al., 2011). Reduce 4% for angular-

Figure 3. Lead author logging core from boring in basal (Flood Member) Blackleaf Formation sandstone. Sample G was obtained from slightly more than 9 m (30 ft.) into the sandstone bedrock.

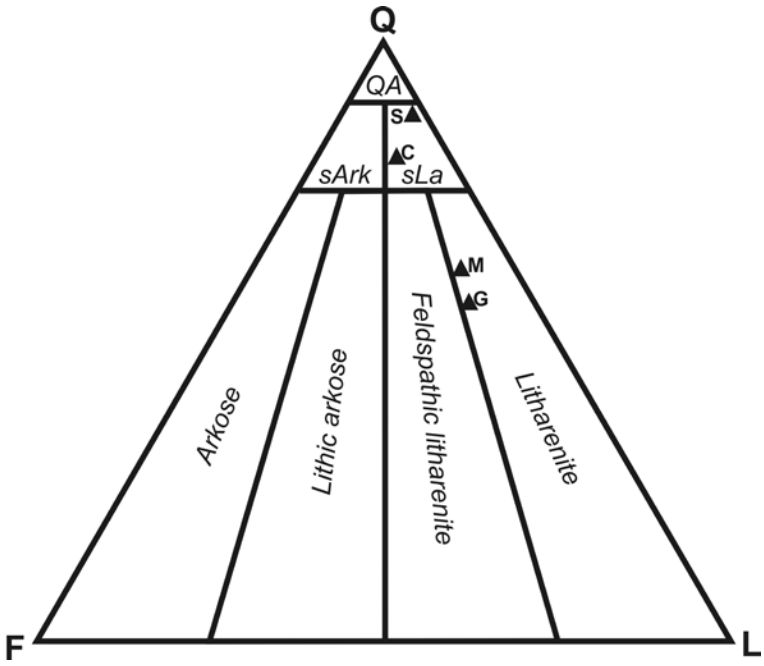

Figure 4. The four sandstone samples plotted on the Folk (1974) ternary diagram.

Table I. Sandstone Classification

Properties	G008C	G008G	G008M	G008S
Quartz	75–85%	55–60%	60–65%	85–90%
Feldspars	3–5%	5–10%	5–10%	1–2%
Lithic Fragments	10–15%	30–35%	25–30%	10–15%
Matrix	cryptocrystalline	cryptocrystalline	cryptocrystalline	cryptocrystalline
Cement (in addition to matrix)	poorly cemented, minor calcite	poorly cemented, minor calcite	poorly cemented, iron oxide, minor quartz	poorly cemented, minor iron oxide
Classification	submature to mature fine-grained sublitharenite	immature to sub-mature fine-grained litharenite	immature to submature fine-grained litharenite	immature fine-grained sublitharenite
Sampling Locations				
Latitude	47°29'05.85"	47°23'08.16"	47°26'46.12"	47°23'57.44"
Longitude	111°21'08.16"	111°07'27.49"	111°08'57.14"	111°10'09.59"

Figure 5. Square Butte, an erosional remnant rising 330 m (1,100 ft.) above the plains west of Great Falls, Montana. It is capped by the hard igneous rock shonkonite, which protects the softer sedimentary rocks beneath it. The similar Crown Butte is several miles in the background.

grain-dominated sandstone and zero for well-rounded.

4. Sorting: the greater the degree of sorting, the greater the porosity, but fracturing with depth decreases sorting (i.e., increases heterogeneity or grading) as fragments are generated. Estimated range of porosity change from poorly sorted to well-sorted to be 6%.
5. Matrix content: the greater the amount of clay and other grains, the lower the remaining porosity. We assumed half of filled pores are cement, so the rest would be initial matrix. Matrix+cement value provided by laboratory.
6. Water compaction: estimate the compaction factor due to water would be one-half the difference of dry sand and wet sand (measured on dry basis). Based on lead author's experience with engineered fills, well-sorted sands would be an approximately 5% decrease, and poorly sorted sands, 9%.

Table III shows the authors' estimates of η_0 using the above factors (#2 = no change).

Comparing With Coal Rank

The sandstone estimates shown above are considerably higher than the eroded

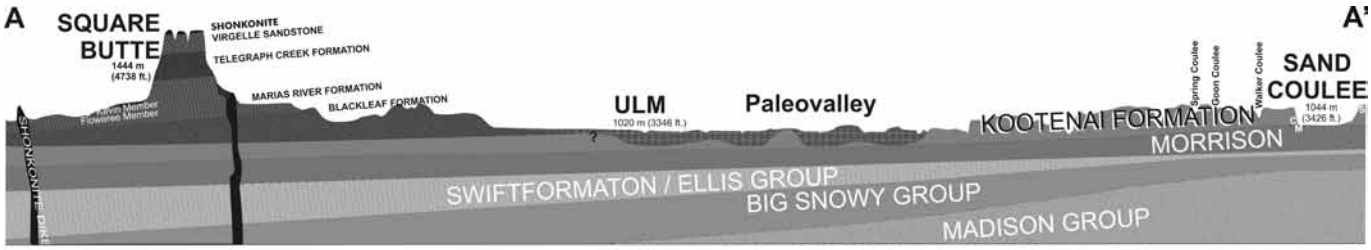

Figure 6. Geologic cross section derived primarily from Vuke (2000) following line A-A' on Figure 2.

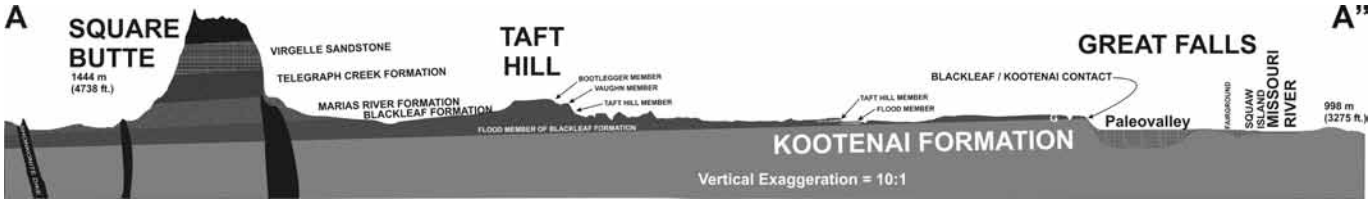

Figure 7. Geologic cross section derived from Vuke (2000) and Vuke et al. (2002) following line A-A" on Figure 2.

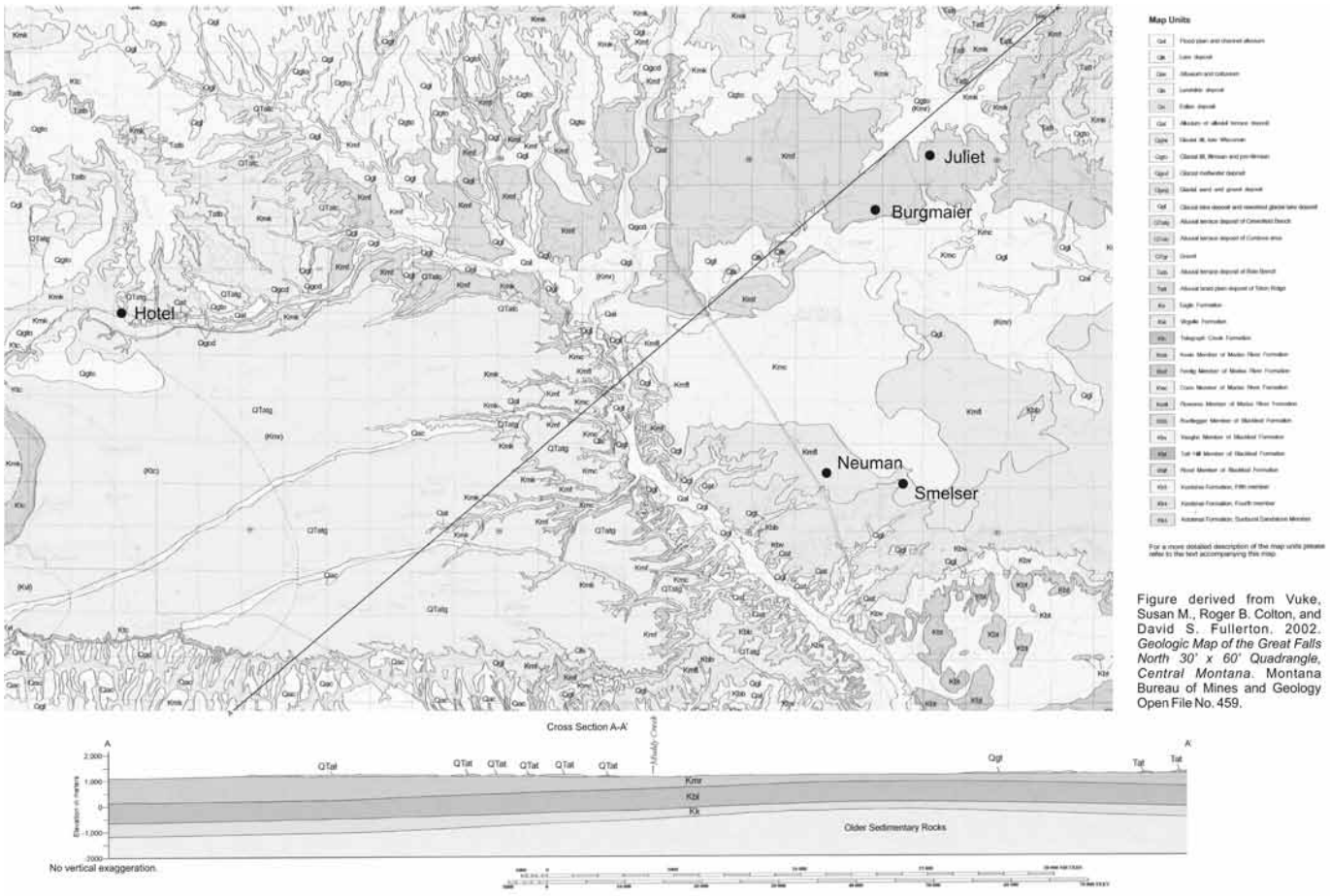

Figure 8. Geologic map with cross section showing Greenfields Bench, from Vuke et al. (2002), showing locations of well logs used in Figure 9.

overburden estimates based on coal rank. We do not know why there is such a large difference, but it could be due to further assumptions in the results of Bjørlykke (2014). Typical petroleum basin modeling incorporates uniformitarian, deep-time assumptions (Klevberg, 2022). Bjørlykke (2014), however, points out that time is not an important factor in sandstone compaction. Based on the rank of the coal and assuming a geothermal gradient of 26–27°C/1,000 m (i.e., increase of 15°F per 1,000 ft. of depth), this coal was buried about 2,800–4,000 m (9,180–13,120 ft.) (Thomas, 2013).

Groundwater Modeling

We had originally proposed to use Aqtesolv® software to model groundwater flow through unconsolidated sediment and gradually consolidating sediment under the assumption that groundwater transport of silica either upward or laterally into the sand strata would have been a particularly important means of lithifying sandstones. As described in Part I of this paper (Klevberg and Oard, 2023), this now seems unlikely, and recent research has not supported this hypothesis (Bjørlykke and Jahren, 2018; Prajapati et al., 2020). Therefore, the transport modeling idea was dropped.

Findings

Two sandstone samples were classified as litharenites, and two as sublitharenites (Table I). Properties observed in thin section are summarized in Table II. The detailed laboratory report is contained in Braaten and Moulzolf, 2018 (Appendix B). Figures 11 through 14 show hand samples, cut and lapped samples, and thin-section magnified images.

Samples of coal were not collected as part of this project; coal sampling and analysis was done by the U.S. Bureau of Mines in previous decades. The coal ranges from sub-bituminous B to high-volatile bituminous C with a

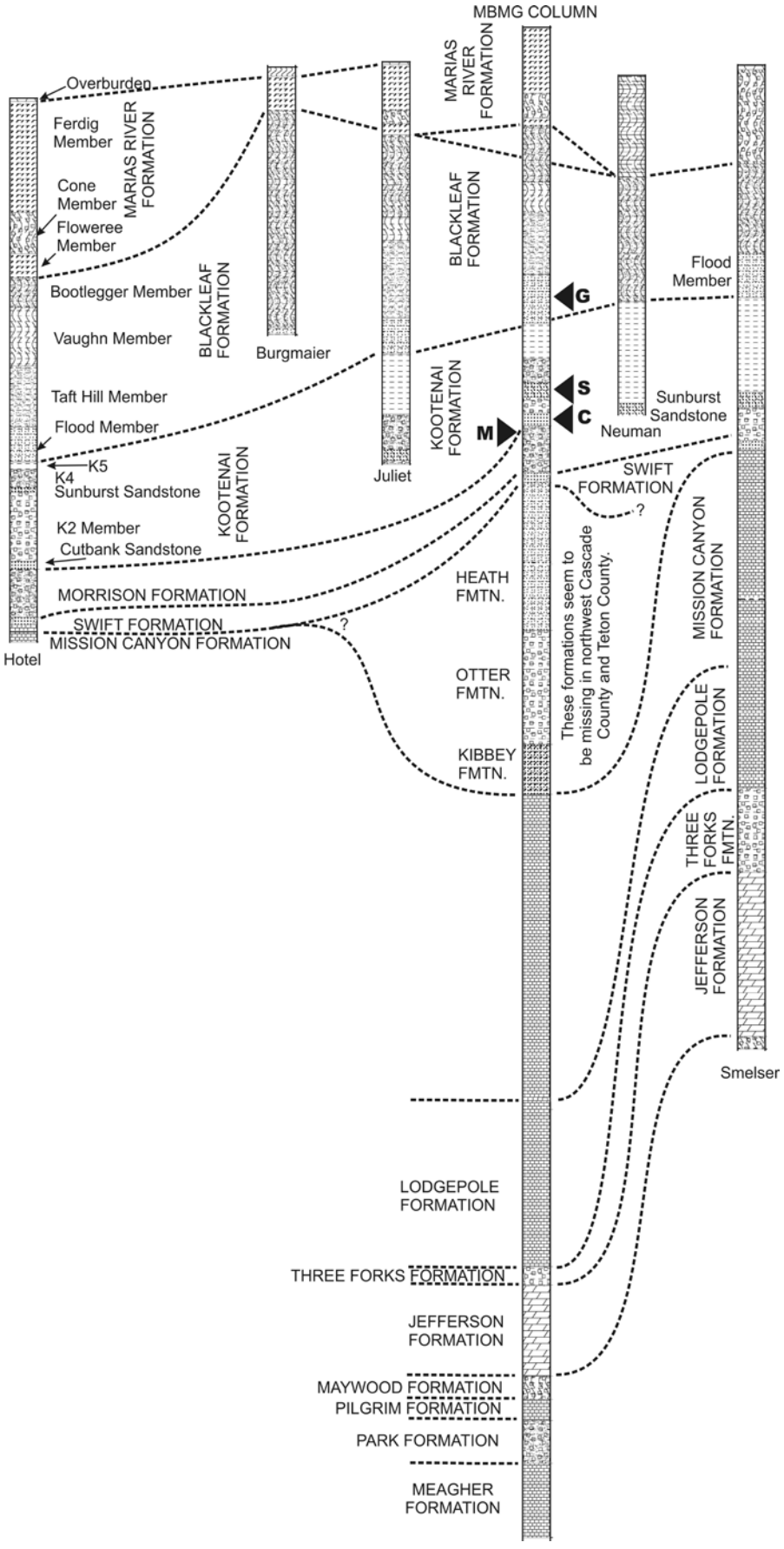

Figure 9 (*left*). Stratigraphic section showing formations encountered per five available well logs and the composite (MBMG) column from Carstarphen et al. (2011), as shown in Figure 8. Stratigraphic position of the four sandstone samples collected for this project shown by <.

heating value of 9,000 to 13,000 Btu/lb.[1] (Silverman and Harris, 1967). Enough samples from enough locations were collected to provide considerable precision in representing an enormous mass of coal. Silverman and Harris (1967, p. iv) state: "The Great Falls–Lewistown coal field contains an estimated 750 million short tons of bituminous and subbituminous coal reserves in seams more than 14 inches thick." Coal seams in the Kootenai and Blackleaf Formations tend to be few, thin, and less-pure than the Morrison and were therefore not commercially mined.

Estimated Burial Depths

Overburden estimates based on sandstone properties followed the methods described in Klevberg and Oard (2023) and began with estimation of change in intergranular volume (IGV) or initial (matrix-free) porosity as summarized in Table III. The change in IGV was used to estimate compaction pressure from overburden using Bjørlykke's relation for reservoir sandstones (Bjørlykke, 2014). Results are included in Table IV along with estimated overburden using the methods outlined in Klevberg and Oard (2023).

1 U.S. coal is typically evaluated for heating value in terms of British thermal units per dry pound of coal (Btu/lb.).

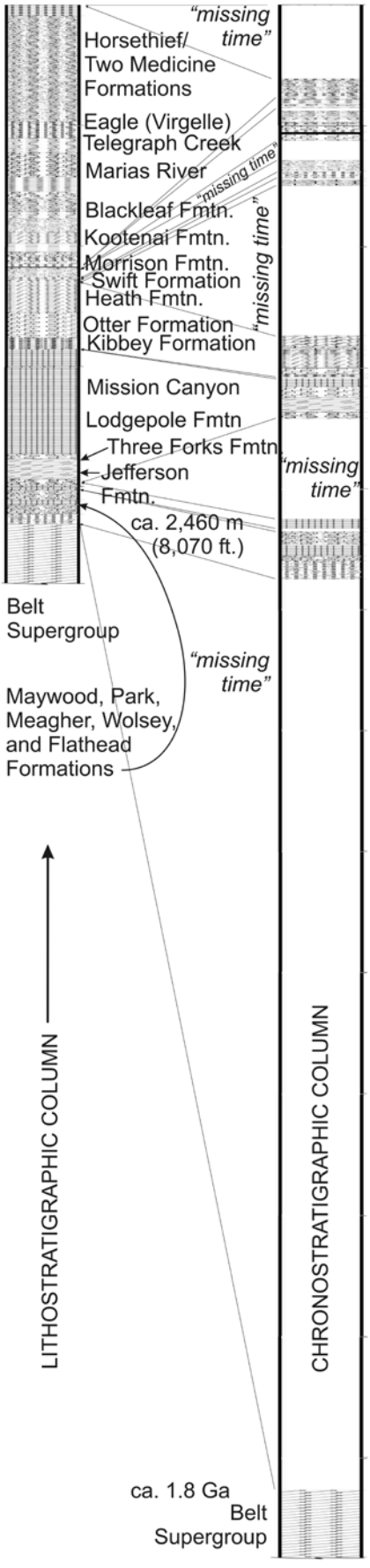

Figure 10 *(right)*. The left column is a lithostratigraphic column ("rock column") based on subcrop, and the right column is the geologic column ("time column") for the study area per Carstarphen et al. (2011). Notice how much of the alleged time has left no record in the rocks. Although some of these hiatuses show at least minor evidence of being unconformities, others show no such evidence.

Table II. Sample Properties

Sample	G008G	G008S	G008C	G008M
Geologic Unit	Flood Member, Blackleaf Formation	Sunburst Member, Kootenai Formation	Cut Bank Member, Kootenai Formation	Morrison Formation (uppermost unit)*
Classification	litharenite	sublitharenite	sublitharenite	litharenite
Sand Size	fine	fine	Fine	fine
Sorting	poor to moderate	poor	moderate to well	moderate to well
Grain Shape	angular–subangular	subangular	subangular	subangular–subrounded
Grain Size	0.2–1.9 mm	<5 µm–0.7 mm	0.1–0.3 mm	0.02–0.6 mm
Maturity	immature–submature	immature	submature–mature	immature–submature
Quartz	55–60%	80–85%	75–85%	55–60%
Feldspars	5–10%	1–2%	3–5%	5–10%
Lithic Fragments	30–35%	10–15%	10–15%	25–30%
Matrix, Cements	ca. 2% muscovite, glauconite, calcite	13–20% iron oxide with microquartz and phyllosilicates	<10% microquartz, phyllosilicates, calcite	25–35%, half iron oxide, balance microquartz, phyllosilicates
Opaque Minerals	3–5%		2–3%	
Pore Space	15–20%	5–15%	10–20%	5–15%
Comments	cross laminated; strained quartz, deformation twinning in mica	iron oxide is zoned; strained quartz	planar laminated; strained quartz	planar laminated; strained quartz

* Now more commonly classified as basal unit of Cut Bank Member, Kootenai Formation; superjacent to Morrison carbonaceous shale.

Table III. Estimates of Initial Porosity

Sample	Grain Size	Sorting	Shape	Matrix	Wet Sand	Porosity
G008C	49%	48%	45%	40%	35%	35%
G008G	49%	48%	45%	43%	38%	38%
G008M	49%	48%	46%	40%	35%	38%
G008S	49%	43%	40%	34%	25%	38%

Estimated Overburden

Overburden is proportional to burial depth, with the assumption that the average density of the overburden resembled typical density values of Kootenai and Blackleaf Formation strata. Table IV summarizes results from the three applicable methods for estimating overburden along with the method of Bjørlykke: estimates based on a graphical approach, local stratigraphic-section comparison (rock column based only

Figure 11. Sample G was collected from drill core obtained at the location shown in Figure 2 (47°29'05.85" North, 111°21'08.16" West). A is HQ core in tray. B is the section of core from which the sample was obtained, cut and lapped. C is thin section in plane polarized light. Arrows: 1 = detrital quartz, 2 = polycrystalline lithic fragments, 3 = feldspar, 4 = pore space. D is thin section in cross polarized light. The sample is a litharenite.

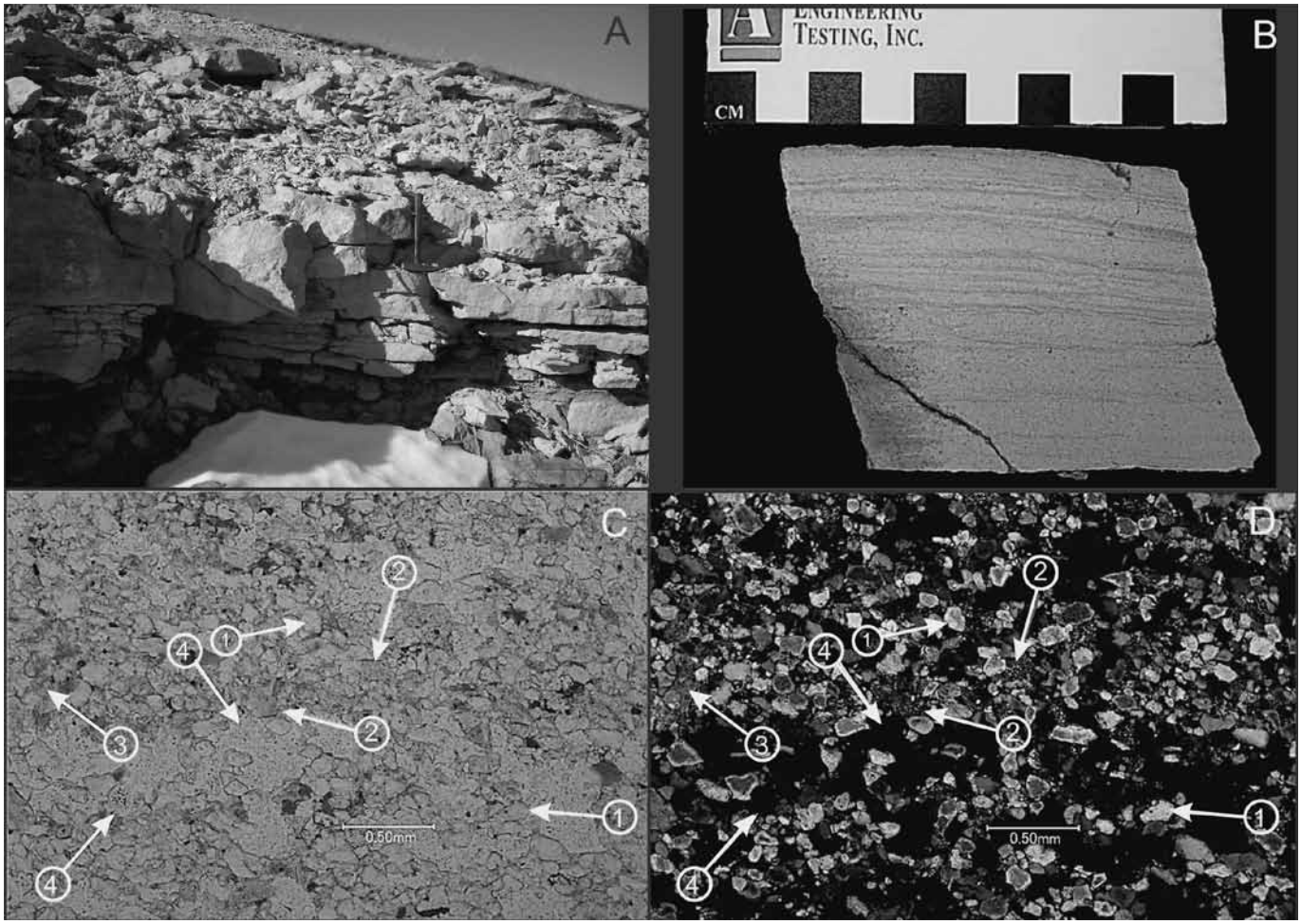

Figure 12. Sample C was collected at the location shown on Figure 2. A is fresh road cut north of Tracy (by Gerber, 47°26'46.12" North, 111°08'57.14" West) with rock pick at sample location of Cut Bank Sandstone. B is the sample as cut and lapped. C is thin section in plane polarized light. Arrows: 1 = detrital quartz, 2 = polycrystalline lithic fragments, 3 = calcite, 4 = pore space. D is thin section in cross polarized light. The sample is a sublitharenite.

on local outcrops), chronostratigraphic column (rock column plus presumed missing section from entire study area), and coal rank. The graphical approach provides a *minimum* overburden pressure based on Figures 6 and 7 compared with erosional remnants. The local stratigraphic section was derived from topographic maps and observed outcrops. It is also a *minimum* value as it does not account for earth materials eroded above the present land surface. The full stratigraphic section is based on both outcrop and subcrop in the study area as interpreted by Vuke et al. (2002) and Carstarphen et al. (2011). It is therefore more speculative than the local rock column, but probably still represents a minimum overburden thickness. Coal rank estimates are from Thomas (2013, p. 111).

Comparison of Results

The first three methods of estimated compaction pressure from overburden to infer burial depths are intended to provide minimum values, while the last two (Bjørlykke and coal rank) are intended to directly estimate depths using sandstone and coal properties, respectively. The minimum values are all less than the direct estimates as expected. However, the sandstone and coal rank methods differ markedly. The burial depth difference (based on the graphical method) between samples (115 m) is less than 2% of the average Bjørlykke depth estimate, so it may be neglected. Assuming a normal Gaussian distribution, the 95% confidence interval (±σ) is 2,800–9,800 m. The lower confidence limit

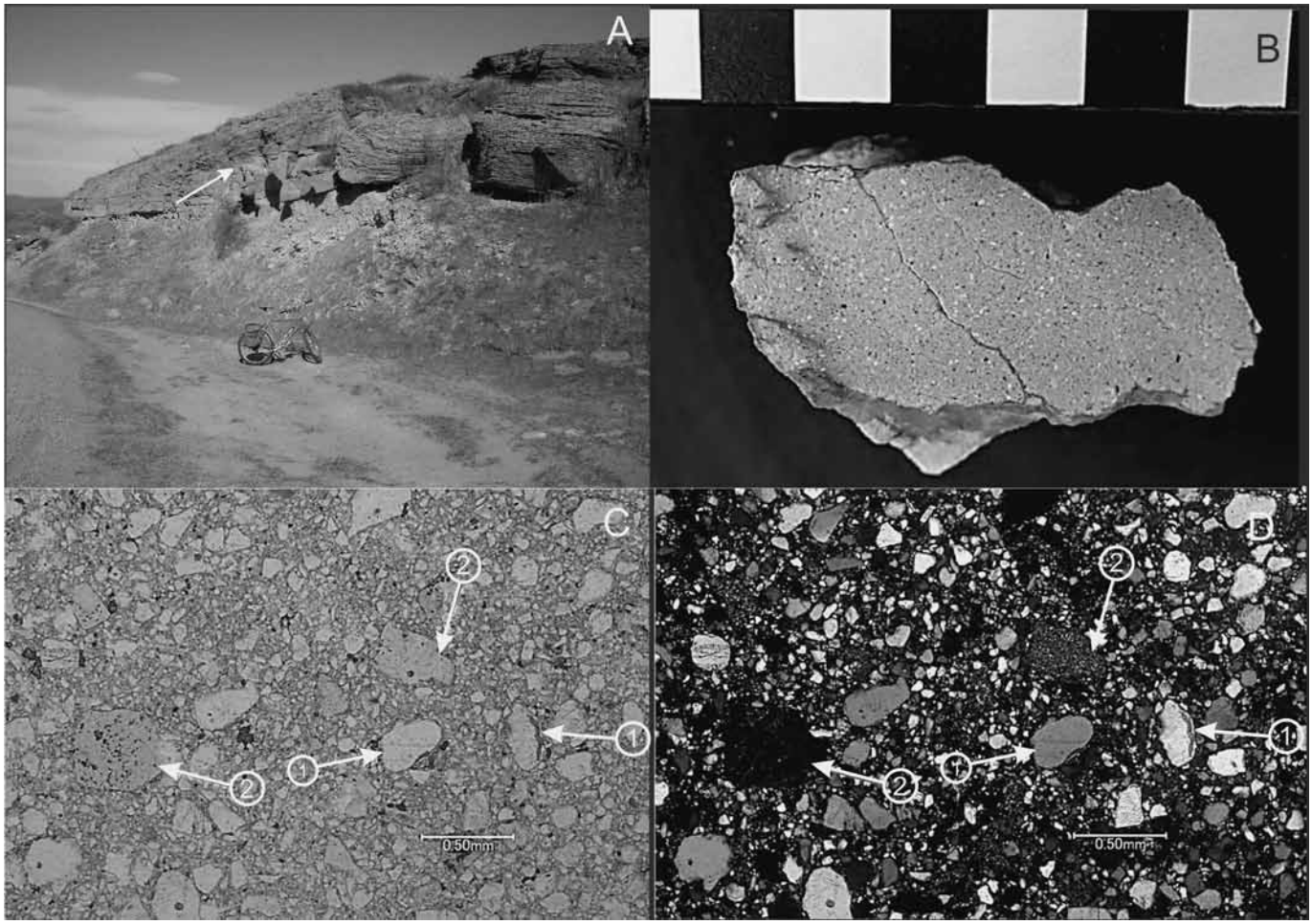

Figure 13. Sample S was collected at the location shown on Figure 2. A is Sunburst Sandstone Member outcrop east of Centerville (47°23'08.16" North, 111°07'27.49" West), view toward the west-northwest. Sample location indicated by arrow. B is the sample as cut and lapped. C is thin section in plane-polarized light. Arrows: 1 = detrital quartz, 2 = polycrystalline lithic fragments. D is thin section in cross-polarized light. The sample is a sublitharenite.

coincides with the lower limit of the coal rank estimated value; however, the mean using the Bjørlykke sandstone method is over twice the mean value using the coal rank method. There is a great deal of difference between the sandstone values, and they appear random relative to stratigraphic position. While some posit a minor unconformity between the Kootenai and Morrison Formations (Silverman and Harris, 1967), it would hardly accommodate 2,800 m of erosion between samples G008C and G008M per the Bjørlykke sandstone method. If the iron cement in sample G008M was deposited during mechanical compaction and thus interfered with it, then the estimated burial depth should be unrealistically low, not high.

Summary and Conclusions

Results may be summarized thusly:

1. Both Bjørlykke sandstone and coal rank methods indicate burial depths greater than the minima required by graphical and stratigraphic methods.
2. Variation in results using the sandstone methods is considerable, and the methods should be considered no better than order-of-magnitude estimates.
3. The coal rank coincided with the lower confidence limit of the sandstone method for the four samples in this study. It would be more conservative to use these results than the Bjørlykke sandstone results.
4. The sandstone results varied from each other at least an order of magnitude more than the actual vertical differences between samples (i.e.,

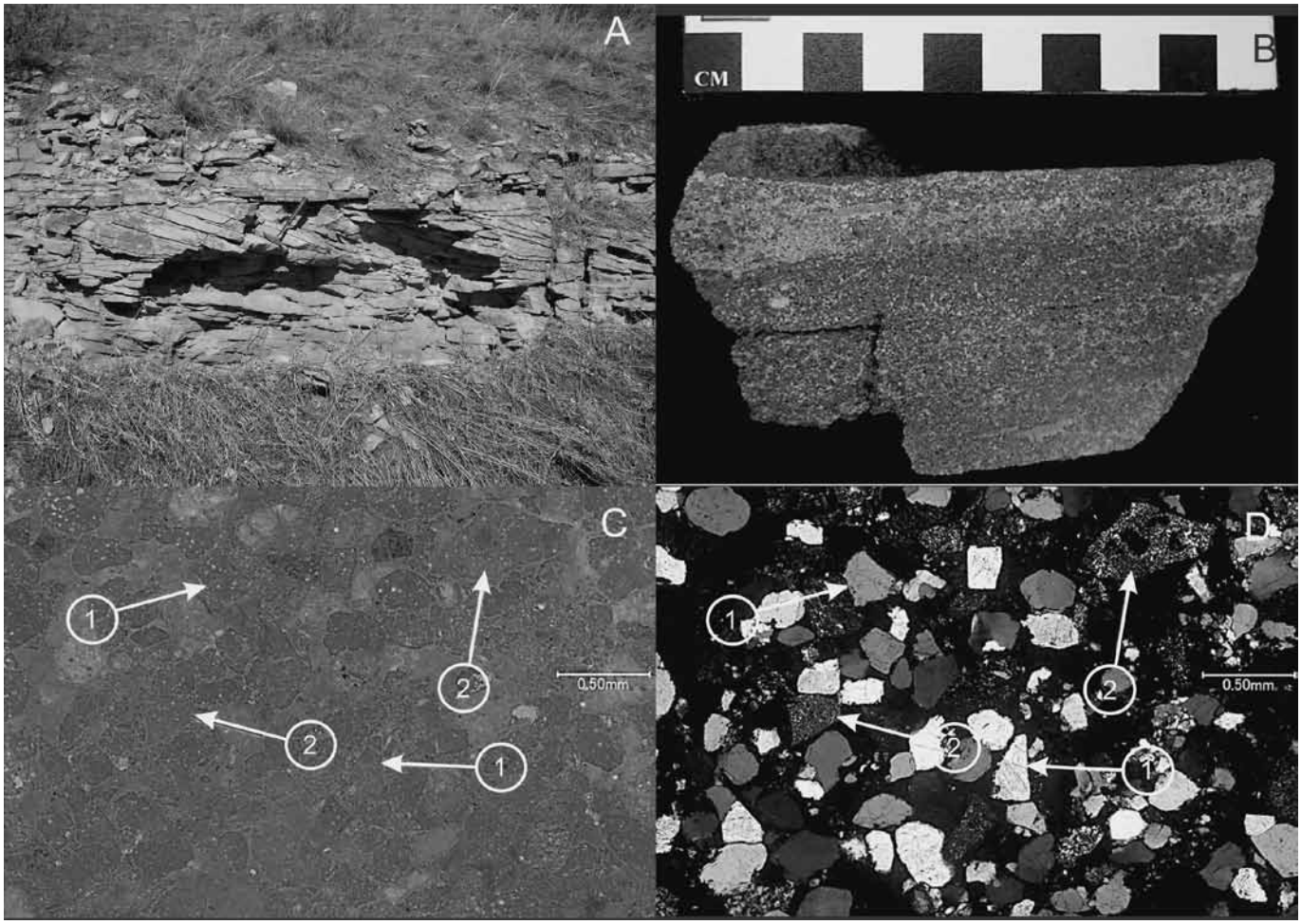

Figure 14. Sample M was collected at the location shown on Figure 2. A is sample location M west of Sand Coulee post office (47°23'57.44" North, 111°10'09.59" West), outcrop of medium-hard, medium-grained, thin-bedded and cross-bedded sandstone. Rock pick is at approximate location of sample. B is the sample as cut and lapped. C is thin section in plane polarized light. Arrows: 1 = detrital quartz, 2 = polycrystalline lithic fragments. D is a thin section in cross-polarized light. The sample is a litharenite.

Table IV. Estimated Overburden Thicknesses

	Sample			
Method	**G008G**	**G008S**	**G008C**	**G008M**
Graphical	375 m	425 m	480 m	490 m
Local Section	300 m	400 m	425 m	440 m
Full Section	1,050 m	1,150 m	1,175 m	1,190 m
Bjørlykke	5,600 m	4,800 m	6,000 m	8,800 m
Coal Rank	2,800-3,200 m	2,800-3,200 m	2,800-3,200 m	2,800-3,200 m

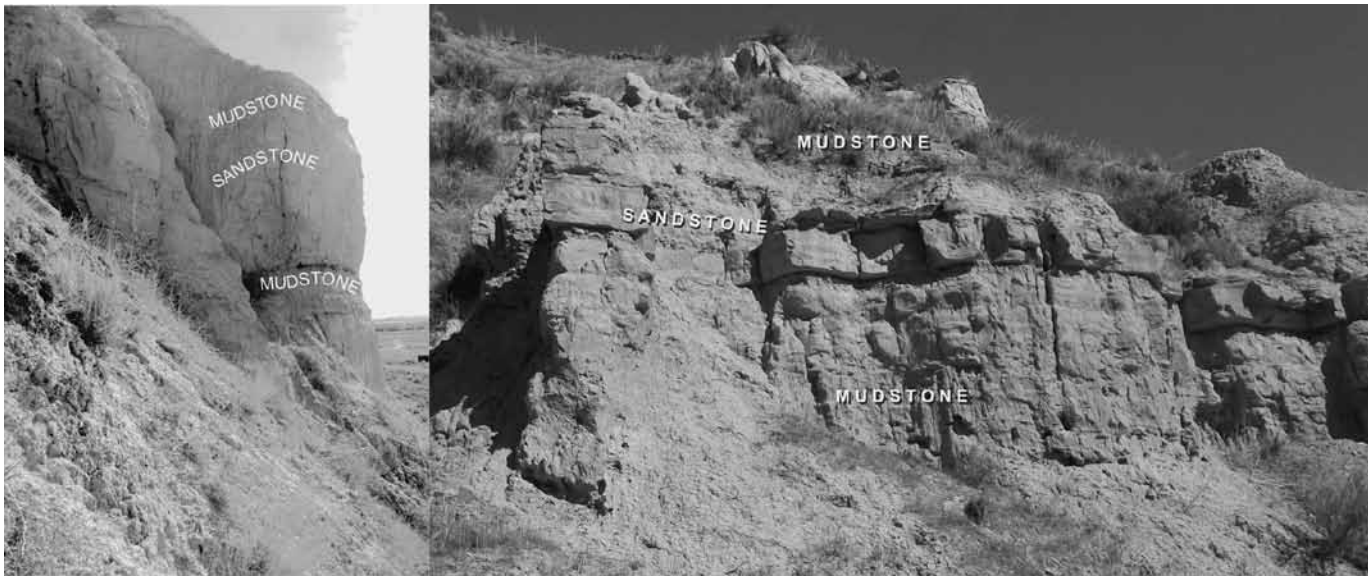

Figure 15. Fort Union strata near Broadus, Montana, containing lithified and unlithified intervals.

burial depth) would explain.

5. No vertical difference was indicated by coal rank since no difference in coal rank occurs over the limited vertical interval in the study area.
6. Lithologic differences between the samples are not reflected in any obvious pattern of compaction with depth.

In addition to the above, we draw the reader's attention to Figures 11 through 14. The presence of considerable angularity and lithic fragments in sandstones from four different units matches well with diluvial expectations of rapid physical weathering without much time for chemical weathering prior to deposition and diagenesis. It does not seem to match uniformitarian expectations of weathering horizons over vast ages of deposition and gradual lithification.

Inference of burial depth based on degree of lithification of sandstones is crude at best. Part of the explanation for this lies with the complexities of the sediments: grain size, sorting, angularity, mineralogy, grain coatings, matrix, etc. Another complicating factor is cementation, as explained more fully in Part I (Klevberg and Oard, 2023) and in Appendix A below. The importance of this can be illustrated in sedimentary sequences (Figure 15). While lithology can explain competent sandstone between poorly lithified mudstones, hard sandstones between poorly lithified sandstones are also common (Figure 13A). This clearly cannot result from compaction pressure. We may thus conclude that inference of burial depth can never be more than a crude approximation.

With or without precise means of burial-depth estimation, the need for a lithification model remains, and research will continue, especially for reservoir rocks. At this stage, we have only crude methods of obtaining initial estimates of maximum burial depth. We have at our disposal relatively accurate methods of estimating *minimum* overburden thickness (graphical from erosional remnants and local rock column), but these are of limited, local applicability. Equations of state and their time derivatives—i.e., rates of lithification-have yet to be developed. These will be far more complicated than mere overburden pressure.

As reported by the laboratory, compaction was evident in the samples (Table II and Braaten and Moulzolf, 2018, Appendix B). Evidence of compaction is often visible at the macroscopic scale, too, as in the contact between Kootenai and Morrison: "In most places the undulatory configuration of the base of the sandstone is due to compaction of the underlying shale and coal" (Silverman and Harris, 1967, p. 7). Bjørlykke's method, which is based on experimentation, is a step in the right direction, but it is still very crude based on the results of this study. Researchers should investigate whether reliance on popular modeling software with their uniformitarian assumptions for petroleum maturation may play a role in

the application of Bjørlykke's method. Because coal rank may have more to do with thermal history than pressure, it may make a better "thermometer" than burial-depth indicator.

More comprehensive lithification models are needed that include cementation (chemical compaction and chemical non-compaction) and that are independent of the kind of uniformitarian assumptions that hamstring basin models. These models can have import for reservoir analysis, geomechanical modeling, and analysis of diagenesis. However, they remain models and are beset by the inherent limitations of the modeling process. In the case of the sandstones proximate to the Great Falls Coal Field, we infer that the initial overburden contributing to the lithification of the four sampled units was probably more than 300 m (1,000 ft.) but likely less than 3,000 m (10,000 ft.). Until further research and refining of models is accomplished, these crude estimates are all that is possible, and confidence in more precise estimates is not warranted. Burial histories based on such inferences are subject to even greater potential error.

Acknowledgements

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Appendix A

Sedimentary rocks present questions for diluvialists as well as uniformitarian scientists. Once sediments accumulate, they need to be cemented to become sedimentary rocks. Compaction is only one mechanism contributing to lithification. We commonly see sedimentary rocks on the surface, and sequences of various types of sedimentary rocks in cliffs that are almost always cemented. How did they lithify? Was it during the Deluge? Were near-surface sediments cemented after the Genesis Flood? Or can it be both?

Cementation, related to the porosity and permeability, is a complicated process that depends upon numerous variables that have not been completely worked out: "As a result, porosity reducing processes need to be understood in order to evaluate and model [oil] reservoir quality in sandstones" (Monsees et al., 2020, p. 1). Xia et al. (2020, p. 2) state: "In fact, the process of porosity evolution caused by post-accumulation compaction in sandstone reservoirs remains poorly understood." Porosity is the percentage of the bulk volume of a rock, sediment, or soil that is occupied by air or fluid, whether isolated or connected (Neuendorf et al., 2005, p. 508). Permeability is different and is defined as the property or capacity of a porous rock, sediment, or soil for transmitting a fluid (Neuendorf et al., 2005, p. 483). Permeability can vary a lot with any particular porosity, but in general permeability of sandstones is an exponential function of porosity (Li et al., 2017).

Cementation depends upon the type of sediment deposited, such as sand, mud, carbonate, or combinations of these three. It also depends upon the character of the detrital or framework grains, such as the size, sorting, angularity, mineralogy, the amount and composition of matrix within the sediment, etc. (Bjørlykke, 2014). Sorting refers to the uniformity of the sizes of the grains (Neuendorf et al., 2005, p. 613). The framework or detrital grains are the main grains that make up the sediment, for instance quartz sand in a sandstone. Some sandstones like quartz arenite have greater than 90–95% quartz grains. But other sandstones may also be high in feldspar and rock particles that significantly affect cementation.

Besides the framework grains, the sandstone not only has voids, it also has smaller matrix particles between grains that make cementation even more complicated. The sum of voids, matrix particles, and cement is called the *intergranular volume* (IGV) (Cui et al., 2017).

During and after a sediment accumulates, diagenetic and authigenetic processes change the sediment, one of these processes being cementation. Diagenesis is the sum of all physical and chemical changes in minerals during and after their initial accumulation (Neuendorf et al., 2005, p. 176). Authigenesis is a little different. It refers to the processes by which *new* minerals form within a sediment or sedimentary rock during or after deposition, such as recrystallization or cementation (Neuendorf et al., 2005, p. 44).

Appendix B

See A.E.T. report, pp. 316–319.

Appendix C

See Table of Stratigraphy of Study Area, p. 320.

Appendix B: AET report, p. 1

24-LAB-004
PETROGRAPHIC EXAMINATION OF ROCK, ASTM C295

AET JOB NO: 24-20180 **DATE:** 9-18-2018
SAMPLE ID: G008 C **PETROGRAPHER:** C. Braaten

DESCRIPTION:
The rock was classified as a sublitharenite, fine grained sandstone. The rock was poorly cemented and generally consisted of sand sized quartz and lithic particles. The rock used for analysis was a cross section, which was laboratory sawcut from the original sample. The original dimensions of the rock were approximately 102 mm (4") x 76 mm (3") x 51 mm (2") thick. The selected sawcut section of rock was approximately 83 mm (3-1/4") x 68 mm (2-11/16") x 34 mm (1-5/16") thick. A thin section was also produced from the other cross section of the rock. The rock was contained alternating laminations which were similar to yellowish gray and medium gray (Munsell® 5Y 8/1 and N5) in color. Thin section and hand sample of the rock were used for the rock description. The sample used for thin section was impregnated with an optically clear epoxy to aid in sample stabilization.

In hand sample, the rock was relatively soft and friable. The rock also appeared to be "fresh" and unweathered. A Mohs hardness pick of 3 produced a scratch and liberated grains from the rock. The hand sample appeared relatively absorptive as a water bead dispersed into the stone within several seconds. The rock contained numerous, relatively parallel, laminations. These laminations generally alternated between yellowish gray and medium gray. The yellowish gray layers ranged in thickness from approximately 1 mm up to 8 mm and the medium gray layers ranged from approximately 0.5 mm up to 2 mm in thickness. The yellowish gray layers were dominant within the rock. A few fractures were also observed within the rock.

In thin section, sand-sized quartz and lithic particles were the major constituents observed within the rock. The grains were chiefly sub-angular and moderately to well sorted. Combining these two textures classifies the rock as submature to mature sandstone. Grains ranged in size from approximately 0.01 mm up to 0.3 mm. Quartz was observed as monocrystalline grains and polycrystalline within lithic particles. Several quartz grains exhibit undulose extinction (straining). Lithic particles comprised approximately 10-15% of the rock. Quartz and feldspar minerals comprised the rest of the detrital grains, where feldspar was approximately 3-5% and quartz was approximately 75-85%. Pore space was difficult to estimate due to difficulty in thin section preparation; however, it appeared to be approximately 10-20%. The lithic particles consisted of chert and polycrystalline quartz. Cryptocrystalline mineral material was observed as cement/matrix within zones of the rock. The cryptocrystalline mineral material appeared "dusty" and was most likely comprised of micas, quartz, and/or clay minerals. Small amounts of carbonate cement were observed in a patchy nature throughout the rock. A few opaque materials were observed within the rock. These opaques did not exhibit a metallic luster and may be organic material or oxides.

MINERALOGY:		OPTICAL PROPERTIES:			
MINERALS	VOL(%)*	COLOR	BIREFRINGENCE	RELIEF	OTHER
quartz	80 – 85	colorless	low 1st order	low	detrital grains and within lithic particles
feldspar	3 – 5	colorless	low 1st order	low	detrital grains
muscovite	trace	colorless	2nd order	moderate	detrital grains
biotite	trace	pleo. green/brown	3rd to 4th order, masked	moderate	detrital grains
calcite	1 – 2	colorless	high 3rd to 4th order	variable	patchy zones of cement
opaques	2 – 3	opaque	--	--	brown to black in reflected light
cryptocrystalline material	< 10	colorless to "dusty" brown	--	--	cement/matrix material, possibly micas, quartz, and/or clay minerals
iron-oxide	2 – 3	opaque	--	--	reddish brown in reflected light

* Based on visual estimation of thin section

Appendix B: AET report, p. 2

24-LAB-004
PETROGRAPHIC EXAMINATION OF ROCK, ASTM C295

AET JOB NO: 24-20180 **DATE:** 9-18-2018
SAMPLE ID: G008 G **PETROGRAPHER:** C. Braaten

DESCRIPTION:
The rock was classified as a litharenite, fine grained sandstone. The rock was poorly cemented and generally consisted of sand sized quartz and lithic particles. The rock used for analysis was a cross section, which was laboratory sawcut from the original sample. The original dimensions of the rock core were approximately 76 mm (3") diameter x 44 mm (1-3/4") long. The selected sawcut section of rock was approximately 73 mm (2-7/8") x 42 mm (1-5/8") x 30 mm (1-3/16") thick. A thin section was also produced from the other cross section of the rock. The rock contained alternating zones which were similar to very light gray to light gray and medium dark gray (Munsell® N8 to N7 and N4) in color. Thin section and hand sample of the rock were used for the rock description. The sample used for thin section was impregnated with an optically clear epoxy to aid in sample stabilization.

In hand sample, the rock was relatively soft and friable. The rock also appeared to be "fresh" and unweathered. A Mohs hardness pick of 3 produced a scratch and liberated grains from the rock. The hand sample appeared relatively absorptive as a water bead dispersed into the stone within several seconds. The rock contained numerous, irregularly oriented seams (cross laminations?) of different color.

In thin section, sand-sized quartz and lithic particles were the major constituents observed within the rock. The grains were chiefly angular to sub-angular and poorly to moderately sorted. Combining these two textures classifies the rock as immature to submature sandstone. Grains ranged in size from approximately 0.02 mm up to 1.9 mm. Quartz was observed as monocrystalline grains and polycrystalline within lithic particles. Several quartz grains exhibit undulose extinction (straining). Lithic particles comprised approximately 30-35% of the rock. Quartz and feldspar minerals comprised the rest of the detrital grains, where feldspar was approximately 5-10% and quartz was approximately 55-60%. Pore space was approximately 15-20%. The lithic particles consisted of chert, siltstone, and polycrystalline quartz. Small amounts of carbonate cement were observed in a patchy nature throughout the rock. Deformation twinning was observed within a few mica particles. A few opaque materials were observed within the rock. These opaques did not exhibit a metallic luster and may be organic material or oxides.

MINERALOGY:		OPTICAL PROPERTIES:			
MINERALS	VOL(%)*	COLOR	BIREFRINGENCE	RELIEF	OTHER
quartz	85 – 90	colorless	low 1st order	low	detrital grains and within lithic particles
feldspar	5 – 10	colorless	low 1st order	low	detrital grains
muscovite	trace	colorless	2nd order	moderate	detrital grains
glauconite	trace	pale green	anomalous	low	detrital grain
calcite	1 – 2	colorless	high 3rd to 4th order	variable	patchy zones of cement
opaques	3 – 5	opaque	--	--	brown to black in reflected light

* Based on visual estimation of thin section

Appendix B: AET report, p. 3

24-LAB-004
PETROGRAPHIC EXAMINATION OF ROCK, ASTM C295

AET JOB NO: 24-20180 **DATE:** 9-18-2018
SAMPLE ID: G008 M **PETROGRAPHER:** C. Braaten

DESCRIPTION:
The rock was classified as a litharenite, fine grained sandstone. The rock was poorly cemented and generally consisted of sand sized quartz and lithic particles. The rock used for analysis was a cross section, which was laboratory sawcut from the original sample. The original dimensions of the rock were approximately 95 mm (3-3/4") x 76 mm (3") x 44 mm (1-3/4") thick. The selected sawcut section of rock was approximately 92 mm (3-5/8") x 45 mm (1-3/4") x 33 mm (1-5/16") thick. A thin section was also produced from the other cross section of the rock. The rock contained alternating laminations which were similar to pale yellowish brown and grayish orange to light brown (Munsell® 10YR 6/2 and 10YR 6/6 to 5YR 5/6) in color. Thin section and hand sample of the rock were used for the rock description. The sample used for thin section was impregnated with an optically clear epoxy to aid in sample stabilization.

In hand sample, the rock was relatively soft and friable. The rock also appeared to be "fresh" and unweathered. A Mohs hardness pick of 3 produced a scratch and liberated grains from the rock. The hand sample appeared relatively absorptive as a water bead dispersed into the stone within several seconds. The rock contained generally sub-parallel to parallel laminations. The laminations alternated in color between pale yellowish brown and grayish orange to light brown. The grayish orange to light brown laminations contained iron oxide cement.

In thin section, sand-sized quartz and lithic particles were the major constituents observed within the rock. The grains were chiefly sub-rounded to sub-angular and moderately to well sorted. Combining these two textures classifies the rock as immature to submature sandstone. Grains ranged in size from approximately 0.02 mm up to 0.6 mm. Quartz was observed as monocrystalline grains and polycrystalline within lithic particles. Several quartz grains exhibit undulose extinction (straining). Lithic particles comprised approximately 25-30% of the rock. Quartz and feldspar minerals comprised the rest of the detrital grains, where feldspar was approximately 5-10% and quartz was approximately 60-65%. Pore space was approximately 5-15%. The lithic particles consisted of chert, siltstone, shale, and polycrystalline quartz. Several detrital quartz grains appeared to have syntaxial rims of quartz. Iron oxide was observed as a cement within a few of the laminations and cryptocrystalline mineral material was observed as the cement/matrix within the other laminations. The cryptocrystalline mineral material appeared "dusty" and was most likely comprised of micas, quartz, and/or clay minerals.

MINERALOGY:		OPTICAL PROPERTIES:			
MINERALS	VOL(%)*	COLOR	BIREFRINGENCE	RELIEF	OTHER
quartz	55 – 60	colorless	low 1st order	low	detrital grains and within lithic particles
feldspar	5 – 10	colorless	low 1st order	low	detrital grains
amphibole	trace	pleo. green	2nd order, masked	moderate to high	detrital grains
biotite	trace	pleo. green/brown	3rd to 4th order, masked	moderate	detrital grains
cryptocrystalline material	10 – 15	colorless to "dusty" brown	--	--	cement/matrix material, possibly micas, quartz, and/or clay minerals
iron-oxide	15 – 20	opaque	--	--	reddish brown in reflected light

* Based on visual estimation of thin section

Appendix B: AET report, p. 4

24-LAB-004
PETROGRAPHIC EXAMINATION OF ROCK, ASTM C295

AET JOB NO: 24-20180 **DATE:** 9-18-2018
SAMPLE ID: G008 S **PETROGRAPHER:** C. Braaten

DESCRIPTION:
The rock was classified as a sublitharenite, fine grained sandstone. The rock was poorly cemented and generally consisted of sand sized quartz and lithic particles. The rock used for analysis was a cross section, which was laboratory sawcut from the original sample. The original dimensions of the rock were approximately 76 mm (3") x 64 mm (2-1/2") x 44 mm (1-3/4") thick. The selected sawcut section of rock was approximately 60 mm (2-3/8") x 45 mm (1-3/4") x 28 mm (1-1/8") thick. A thin section was also produced from the other cross section of the rock. The rock was similar to yellowish gray (Munsell® 5Y 8/1) in color with a few dark yellowish orange (Munsell® 10YR 6/6) zones. Thin section and hand sample of the rock were used for the rock description. The sample used for thin section was impregnated with an optically clear epoxy to aid in sample stabilization.

In hand sample, the rock was relatively soft and friable. The rock also appeared to be "fresh" and unweathered. A Mohs hardness pick of 3 produced a scratch and liberated grains from the rock. The hand sample appeared relatively absorptive as a water bead dispersed into the stone within several seconds. Several micro-fractures were observed within the rock. A few zones within iron oxide cement were also observed.

In thin section, sand-sized quartz and lithic particles were the major constituents observed within the rock. The grains were chiefly sub-angular to angular and poorly sorted. Combining these two textures classifies the rock as immature sandstone. Grains ranged in size from approximately < 5 µm up to 0.7 mm. Quartz was observed as monocrystalline grains and polycrystalline within lithic particles. Several quartz grains exhibit undulose extinction (straining). Lithic particles comprised approximately 10-15% of the rock. Quartz and feldspar minerals comprised the rest of the detrital grains, where feldspar was approximately 1-2% and quartz was approximately 85-90%. Pore space was approximately 5-15%. The lithic particles consisted of chert and polycrystalline quartz. Cryptocrystalline mineral material was observed as the cement/matrix within rock. The cryptocrystalline mineral material appeared "dusty" and was most likely comprised of micas, quartz, and/or clay minerals. Iron oxide was observed as a cement within a few zones within the rock.

MINERALOGY:		OPTICAL PROPERTIES:			
MINERALS	VOL(%)*	COLOR	BIREFRINGENCE	RELIEF	OTHER
quartz	80 – 85	colorless	low 1st order	low	detrital grains and within lithic particles
feldspar	1 – 2	colorless	low 1st order	low	detrital grains
amphibole	trace	pleo. green	2nd order, masked	moderate to high	detrital grains
zircon	trace	colorless	high 3rd to 4th order	very high	detrital grains
cryptocrystalline material	10 – 15	colorless to "dusty" brown	--	--	cement/matrix material, possibly micas, quartz, and/or clay minerals
iron-oxide	3 – 5	opaque	--	--	reddish brown in reflected light

* Based on visual estimation of thin section

Appendix C—Stratigraphy of Study Area

Group	Formation	Member	Lithologies (Vuke, 2000; Vuke et al., 2002)
Montana	Telegraph Creek		Very fine to fine grained calcareous sandstone interbedded with silty mudstone, fissile shale: 150–330 ft.
Colorado	Marias River	Kevin	Intimately interbedded, concretionary limestone, shaly very fine grained sandstone; middle unit has numerous beds ironstone concretions, concretionary limestone and dolostone, discontinuous conglomerate; thin bentonite beds, calcareous concretions in basal unit: 0–700 ft.
		Ferdig	Hard shale, few thin beds limestone concretions, hackly limestone; in middle unit, very fine grained, wavy/lenticular bedded sandstone/siltstone w/trace fossils, numerous flakes iron stained siltstone; few fine grained sandstone stringers, ferruginous dolostone and limestone concretions in basal unit: 100–200 ft.
		Cone	Calcareous/silty shale w/white specks, fish scales, petroliferous, interbedded w/thin, silty, irregulaly bedded crystalline limestone, over argillaceous, shaly, platy limestone, over calcareous/noncalcareous shale w/bentonite bed, zone septarian limestone concretions; basal limonitic siltstone, fish teeth and bones: 50–65 ft.
		Floweree	Noncalcareous shale, silty shale w/thin beds fine grained sandstone and siltstone, concretions: 10–35 ft.
	Blackleaf	Bootlegger	Relatively well cemented thin beds of sandstone and siltstone interbedded with silty shale and several bentonite beds; fish scales on some bedding planes; many places coarse grained, well cemented sandstone or pebble conglomerate at top w/fish scales, bones; two basal fine-medium grained sandstone units: 150–330 ft.
		Vaughn	Colorful, very bentonitic claystone interbedded with thinner lenticular bentonitic siltstone, sandstone, tuffaceous, porcellanitic; clinoptilolite, carbonaceous shale beds, some coal, basal medium grained arkosic sandstone: 52–86 ft.
		Taft Hill	Bentonitic siltstone, bentonitic shale, bentonite beds, over fine to medium grained, glauconitic sandstone; lower dominantly poorly to moderately fissile shale w/siltstone, fine grained sandstone, thin bentonite beds: 242–249 ft.
		Flood	Fine to medium grained, relatively resistant sandstone, siltstone, some granule conglomerate, coarse sandstone, carbonaceous shale, zone of calcareous sandstone concretions, over shale, siltstone, sandstone w/trace fossils. Sandstone west, shale east: ca. 140 ft.
	Kootenai	Kk5	Red weathering mudstone w/lenses, beds cross bedded, micaceous sandstone, nodular limestone concretions. Lower unit shale, lignite: ca. 230 ft.
		Kk4	Limestone, interbedded shale, fossiliferous, over fine to medium grained, platy, thin to medium bedded sandstone, mudstone interbeds; channels with fill ranging from mudstone to sandstone, interbedded, overlying or cutting through the Sunburst Sandstone, locally resting on the Cutbank Sandstone (Hopkins, 1985; Schwartz, personal communication, 2002). Channel fill fine to coarse grained, biotitic, lithic sandstone with steep forsets and sparse associated coal stringers: up to 200 ft.
		Sunburst	Well sorted, well cemented, resistant quartz sandstone, limonite specks, cross bedding, ripple lamination, trace fossils near top: 50 ft.
		Kk2	Dark gray mudstone grading downward into red mudstone: 0–100 ft.
		Cut Bank	Moderately well sorted, coarse to fine grained, festoon cross bedded, quartzose sandstone, fining upward, chert, discontinuous basal chert conglomerate: 0.1–100 ft.
	Morrison		Weathered mudstone w/interbedded micrite lenses, fine to medium grained, calcareous, thin bedded, sandstone like underlying Swift Formation, subbituminous coal / carbonaceous shale bed ≤12 ft. thick near top; gradational contacts w/Swift, Kootenai, but significant intraformational unconformity: 86–166 ft.

Bolded names indicate units sampled in this study.

Notes from the Panorama of Science

Which Came First?

Evolutionists have always been quick to proclaim that evolution is science, and since evolution is supposed to be the only scientific option for studying origins, one would expect that evolution should be able to tell us what was here first on this Earth. Since origins is the study of first life and if evolution is a working process, then evolution should have no problem telling us "Which came first." We are all familiar with the amusing question, "Which came first: the chicken or the egg?" The chicken grows from an egg, and the egg is laid from a chicken, leaving open the humorous question of which came first. However, putting humor aside, this question of "Which came first" brings out an important point about the origin of life. It should be obvious that the chickens we see today are not the result of one chicken or one egg, and either one, whichever was first and assuming no unnatural deaths, would have just grown old and died without the possibility of reproducing new offspring. Regardless of your answer to this question, we have learned nothing about the origin of life, but maybe that is the point of the chicken and egg question! Maybe the "chicken and egg" question is designed to make us choose between two wrong choices, diverting our attention away from the real answer.

Within the realm of physics, biology, and chemistry, there are many scientific laws that have been discovered and found to be always working. A scientific law is simply an observation of nature that has proven itself to be always true, always in effect in all places without exception, like the Law of Gravity. There are other laws of science that are always in effect with no exceptions such as the First and Second Laws of Thermodynamics, and others.[1] The First and Second Laws of Thermodynamics are recognized as the most universal and fundamental of all scientific laws and are even accepted as truth by most evolutionists. By asking which came first, we can learn more about evolution and these laws of science.

Evolution and the First Law of Thermodynamics

The First Law of Thermodynamics is a universal law saying that *matter and energy cannot be created nor destroyed* (under natural circumstances). Although the First Law of Thermodynamics is a law of science, it is also a problem for evolutionists. The First Law states that new matter is not being created, but evolution requires there to be more genetic information in the DNA to allow for one species to change into another. More genetic information means more matter, but the First Law says that the total amount of matter and energy cannot be increased, which is why it is also called the Law of Conservation of Matter and Energy. Since evolution and the First Law seem to contradict each other, maybe we should be asking… which came first: evolution or the First Law of Thermodynamics? If someone responds saying the First Law came first, ask them how a "Law" of Conservation would ever allow a "process" requiring an increase in the amount of information to ever happen. If they respond saying evolution came first, ask them how a "process" of constant increase of matter can create a "law" where nothing new can be created or destroyed. I hope you see the glaring problem. Any attempt to answer this question of which came first, regardless of their answer, implies either that a process can create or change a scientific law, which does not occur in science or that a scientific law would allow a process to work that that law says cannot happen; something scientific laws don't do.

Despite the wishful thinking of many evolutionists, no process taking place in nature (including evolution if working) can control or change how all of nature works; processes can only work as nature and the scientific laws would allow. This means that there is nothing in nature that can change a law that already exists; nothing in nature can make the Law of Gravity or any other law not work! This fact alone means that evolution could not have created those scientific laws. So, where did man get the idea that *nothing new was being created?* Read Genesis 2:1. In this verse, God declares that His creative work is "*finished*." It should be very clear that the First Law of Thermodynamics is just man's interpretation of Genesis 2:1 expressed in scientific terms.

Evolution and the Second Law of Thermodynamics

The Second Law of Thermodynamics states that the entropy (or disorder) of a system is always increasing. *Entropy* is a scientific term for disorderliness, and the presence of the Second Law working in our universe tells us that when matter or energy is changing, that change *always* works toward a state of more disorder. This means that matter will only change from a state of order to one of chaos, never to a more-ordered system. The concept that the amount of disorder in a system is *always* increasing creates a

problem for evolutionists, and the problem can be easily seen when you ask the question… Which came first, evolution or the Second Law?" If evolution came first, how does a "process" of constant improvement create a "law" saying that constant improvement cannot happen? If the Second Law came first, how can a "law" of increasing disorder allow for the upward genetic improvement necessary for evolution to occur? Where did man get the idea that energy and matter will only deteriorate over time, if not from Genesis 3:15–19? In these verses, God placed a curse on man, the animals, the plants, and the ground. This means that the Second Law of Thermodynamics is only man's interpretation of the curses given in Genesis 3:15–19, expressed in scientific terms.

Evolution and Newton's Laws of Motion

Newton's laws of motion are three laws that describe the relationship between a body and the forces acting upon it, and the body's response to those forces. Newton's First Law is also known as the law of uniform motion. An object continues to do whatever it is doing unless another force is exerted upon it. If it is at rest, it continues in a state of rest. If an object is moving, it continues to move without changing its speed or direction (i.e., its velocity is constant). This is evident in space probes that continuously move in orbit in outer space. In the absence of opposing forces, a moving object tends to move along a straight-line path at the same speed indefinitely.

Although Newton's Laws of Motion are well established and accepted by all scientists, Newton's laws have a problem with some of the evolutionary claims, especially when we ask the question… Which came first?" For example, how can free-flying fragments of the Big Bang explosion become orbiting moons of another free-flying object when Newton's laws say it cannot happen. According to Newton's laws, if the fragments from the Big Bang are flying through space and if they will eventually become moons of another planet, there would have to be a force in space causing the fragments to change direction to create an orbit and another force to change the speed to allow them to stay in orbit. The Third Law of Motion says that a single force cannot exist by itself, and Newton's First Law says there would have to be a second force present to change the speed or direction of an object in space, but there is no other force present. By asking the "Which came first?" question, the Laws of Thermodynamics and Newton's Laws of Motion have revealed a major problem: evolution is more likely a problem for science than the best way to study science! But there is more.

Evolution and the Human Body

Sometimes asking which came first can reveal a new and totally different problem, especially when the whole system is not a collection of individual parts. In such an irreducibly complex system, the system can only function correctly when all the components of that system are present and working at the same time. Because of this irreducible complexity, asking which came first reveals the biggest problem of all; no individual piece of that system could have come "first" because every piece had to be present at the same time for that system to work properly. The best example of irreducible complexity is the human body. The human body is not like a bag of red, white, and blue marbles that could be prepared by any random addition of colored marbles to a bag. For evolutionists to say that the human body came from chemicals is very misleading because the human body, although made of chemicals, is much more than just a collection of individual chemical components.

The living body cannot survive without all the organs working properly at the same time; organs cannot survive without the cells within them working properly. Cells cannot function without the DNA; the DNA cannot function without its replication mechanism, and the replication mechanism cannot function without certain enzymes. These enzymes, although made of amino acids, are not made from their constituent amino acids; they are made from the cell's DNA, which cannot exist without its repair mechanism and totally different enzymes! Consequently, life requires fully functioning organs and cells, each with the necessary DNA and enzymes already present because living organisms are more than just a bag of body parts!

DNA and Its Repair Mechanism

As part of the normal replication process in humans, there is a repair mechanism for DNA. An enzyme reads the sequence of nucleotides along the DNA strand. If an incorrect nucleotide is detected in the strand, there is a mechanism that uses other enzymes to cut out the bad nucleotide and insert the correct one, thus repairing the DNA. Let's look at DNA and this repair mechanism and ask, "Which came first, assuming evolution is at work?" If DNA came first, how would the DNA even know it would be better off with a repair mechanism because molecules cannot think! If the repair mechanism came first, what use is a repair mechanism if DNA is not present? DNA and its repair mechanism are not stable chemical molecules; they would deteriorate by chemical oxidation. There is no mechanism to explain how either the DNA or its repair mechanism could exist for millions of years while the other evolved into existence; either one would just decompose back into pond scum long before the other would arrive. Although DNA and its repair mechanism are essential in the human body, neither one could have come first; both must be present at the same time, and neither the DNA nor its repair mechanism could exist without the rest of the cell.

Enzymes and Amino Acids

From the previous paragraph, we learned that there are enzymes that assist in the repair and replication of the DNA molecules when needed. From biology, we know that enzymes are very important molecules necessary for life to be maintained in living organisms, and we know from chemistry that enzymes are polymeric chains of amino acids, leading one to think that all enzymes in the body could have been made from those amino acids meaning the amino acids came first, but that would be wrong. While it is true that enzymes are made of amino acids, the amino acids in our body are made from other enzymes. This makes for a very interesting problem. Let's assume enzyme A is made of 100 different amino acids. In the human body, each individual amino acid, if needed, would have been made from 100 different enzymes, which are all different than enzyme A, but that is not the problem. In the human body, all enzymes are made from the DNA molecule in the cell when it is needed, not from the enzyme's component amino acids. Asking "Which came first?" here is pointless because neither one could have come first because enzymes are not made from their individual component amino acids. Just as enzymes are made "of" amino acids, and not "from" amino acids, our DNA and all living organisms are made "of" chemicals, but not "from" them.

Evolution and the Sexes

Since new life is the result of sexual reproduction between the male and the female of a species, let's ask "Which came first, the male or the female?" We know that the male and female of any species have different bodies, different reproductive organs, different DNAs, and with few exceptions (fish, snakes, frogs, and some reptiles, but not mammals), we know that one gender does not change into the other gender. So, how did the first parents of any mammalian species get here? Evolutionists always say that life evolved from one species into another over millions of years, but where did the first male (or female) of that first species come from? Evolution would require two independent but separate processes, one for the male and one for the female both requiring millions of years for completion, both finishing at the same time and relatively in the same place for reproduction to occur and life to continue. Common sense tells us that reproduction comes from "two parents," meaning both the male and female were present at the same time, just as the Bible says, "*… from the beginning of the creation God made them male and female*" (Genesis 1:27; Mark 10:6).

Which Came First? God or Evolution?

By asking the "Which came first?" question, we quickly realize that the chicken and egg question only diverts people's attention away from the important issue of how did life originate? By now, it should be obvious that it was not the chicken or the egg that came first and it was not evolution either. Equally impossible is the notion that scientific laws could have come first because that leads to the question, "Where did those scientific laws come from?" As previously mentioned, scientific laws are just observations of nature made by man; scientific laws are present to explain nature, not control or change it. The maker of the scientific laws requires knowledge of how nature works, and that requires a law-maker outside of nature because nothing can create itself for the first time (Law of Cause and Effect from physics). This Law of Cause and Effect also tells us that since "life" is already here (the "effect"), there had to be a "cause" outside of nature that made that life to exist; that law-maker and life-maker can only be God!

The only logical explanation for the origin of any living organism is by the hands of an intelligent Creator who made that organism all at once, not piece by piece, and made it to be exactly the way that it exists. What we learn from asking "Which came first?" is that the irreducible complexity of the human body confirms beyond any doubt that living organisms could not have originated by a stepwise or random process! Since the Second Law of Thermodynamics implies that the universe had a beginning, and the First Law of Thermodynamics states that nothing new is being created or destroyed, and since nothing can create itself, the energy required to overcome the Second Law and not violate the First Law must have come from outside our universe. The most scientific and logical conclusion would be that "*In the beginning, God created the heaven and the earth*," which includes the scientific laws. The next time someone asks you the "Which came first?" question, tell them it was God who came first since He is the "*Alpha and Omega, the beginning and the ending*" (Revelation 1:8).

Dr. Charles McCombs, President
Southwest Florida Bible Institute

References

McCombs, C. "Evolution Hopes You Don't Know Chemistry," and "Which Came First?" See genesisministries.store.

Letters to the Editor

The policy of the editorial staff of CRSQ *is to allow letters to the editor to express a variety of views. As such, the content of all letters is solely the opinion of the author, and does not necessarily reflect the opinion of the* CRSQ *editorial staff or the Creation Research Society.*

Some Thoughts on Clay Consolidation

[Publication of the recent article by Dunn (2024) does not change our commitment to a young-earth worldview. We still hold to the Biblical timescale. Our purpose in publishing the paper was to inform biblically-minded geologists of the challenge that clay consolidation seems to present in order to stimulate them to further research into the matter. —Editor]

Editor:

I think that there is an error in Dr. Scott Dunn's reasoning. The error in his reasoning is due to his underlying assumption of uniformitarianism. He may not realize it, but he is assuming that processes in the present are exactly the same as those in the past. Generally, this is a valid assumption, but not in this case.

There are at least two exceptions to the rule that the present is the key to the past. One is the Creation event which was mostly complete before God established the rules of physics. The other is the global Flood, which was a largely supernatural and not a natural event. I could go on for about ten pages about the Creation (as you may know), but I am trying to keep this brief.

When God started the Flood, He broke up the fountains of the great deep and opened the windows of heaven (Genesis 7:11, KJV). This was a supernatural event that completely destroyed the Earth that then was.

There is no reason to think that God did not use his supernatural powers to partially restore the Earth so that Noah and his family and the animals could again live upon it.

I do not believe that it took 2.7 million years for 1,000 meters of clay to be consolidated. That is not possible as the Earth is less than 7,000 years old. Instead, I believe that God could have commanded the clay and other soils to consolidate quickly, so that as the new mountains arose and valleys sank, it became again possible for the planet to support life.

Brad Spooner

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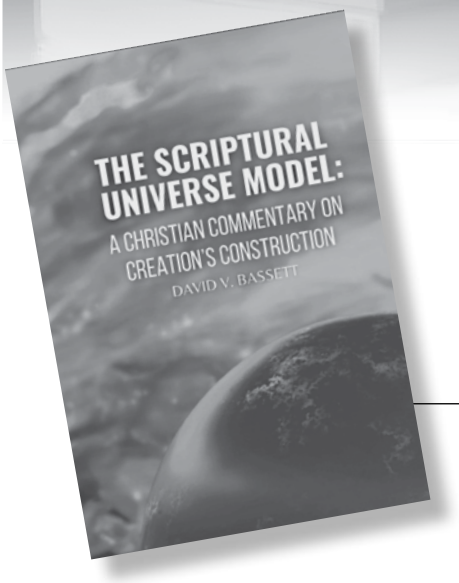
Dunn, S.L. 2024. The clay consolidation problem and its implications for Flood geology models. *Creation Research Society Quarterly* 60(3): 144–156.

Media Reviews



The Scriptural Universe Model: A Christian Commentary on Creation's Construction

by David V. Bassett

Beacon Street Press, Oklahoma City, OK, 2023, 223 pages, $25.00. (Scriptural and subject indexes are included.)

The first step I take when writing a book is to determine if a similar book has been published. If I locate one, I move on to other projects. One reason I take this approach is because publishers usually, when writing the prospectus, request a list of similar books and how, in detail, my book is different. For the book reviewed here, I am not aware of any book that covers the same topic in the same way, although various books do exist that cover the canopy theory (Baugh et al., 2019), and the electric universe (Scott, 2006; Thornhill and Talbott, 2007).

Bassett covers the first three days of creation, attempting to interpret it literally but explaining it rationally and scientifically. He relies not only on Genesis but also refers to other Scriptures to add support and insight to the account in Genesis. Specifically, he refers to Job 26:7–10, Psalms 104:2–5, and Proverbs 8:27–29, as well as other Scriptures, showing that, in contrast to critics, much of the Bible teaches details about the creation account, not just Genesis. Furthermore, different translations of the Bible are used to hone in on the meaning. Besides the King James Version, he references the 1560 Geneva Bible, the modern Living Bible, and the Common English Bible (to name a few) to gain insight from various scholars. In addition, the Hebrew is employed to better explore the Scriptures' original meaning. The four pages required to cite Chapter Three alone illustrate the extensive nature of the documentation.

His Creation Model

Bassett's model proposes *five* firmaments and an antediluvian-Earth supercontinent that overlays *four* internal Earth foundations. He also proposes *three* heavens originally separated by *two* crystalline boundary-constructs located over the *one* Earth. Note the symmetry of his model produces a 5–4–3–2–1 relationship. The book then defines in detail and documents each part of his model.

One strength of the book is to define words that are central to the book, such as the word *firmament*. Firmament is from the Latin *firmamentum*, which refers to supporting and strengthening. Note the word *firm* in the word *firmamentum*. The Hebrew for *firmamentum* is *raqia*, meaning simply a thinned-out expanse which is spread or stretched over something (p. 43). The three heavens of Scripture (2 Corinthians 12:2) separated from each other by two crystalline dividers (crystalline constructs) by the end of Day Three of Creation Week constitute the five different firmaments of the S.U.M. (the Scriptural Universe Model).

The Electric Plasma

One topic I found very interesting was Bassett's incorporation of the electric plasma theory proposed by Donald E Scott. This theory involves a very different picture of the origin of the universe in contrast to the current orthodox theory called the Big Bang. The electric plasma theory proposes that cosmic electric plasma (free electrons and positive ions) makes up over 99% of the known universe. These charged particles are responsive to both electric and magnetic fields. Scott's background includes bachelor's and master's degrees in electrical engineering from the University of Connecticut in Storrs, Connecticut. Following graduation he worked as a research scientist for General Electric in Schenectady, New York, and then earned a doctorate in electrical engineering at the Worcester Polytechnic Institute in Worcester, Maine. He was a faculty member in the Department of Electrical and Computer Engineering at

the University of Massachusetts/Amherst from 1959 until his retirement in 1998.

Plasma is superheated matter that is so hot that all its electrons are ripped away from the atoms, forming an ionized gas. The result is approximately equal numbers of positively and negatively charged particles. Evidence of this plasma is the glow in the form of stars, nebulae, and even the auroras that ripple above the north and south poles. Electric plasma theory has its critics, but also its supporters. Its founders include Kristian Birkeland (known as the Father of Plasma Cosmology), who was nominated for the Nobel Prize seven times, Irving Langmuir (known as the Father of Surface Chemistry), who was awarded the Nobel Prize in Chemistry in 1932, and Hannes Alfvén (known as the Father of Magnetohydrodynamics), who was awarded the Nobel Prize for Physics in 1970 for his essential contributions in founding plasma physics. This concept has challenged the Big-Bang model of the origin of the universe, Einstein's special and general theories of relativity, and the imaginative speculations of quantum mechanics. Bassett supports this view because it has observational evidence, laboratory experiments, and confirmed predictions, as well as its being in keeping with Occam's Razor. This theory states if two competing ideas exist to explain the same phenomenon, preference should be given to the simpler one.

Bassett proposes that the heaven mentioned in Genesis 1:1 is in the form of electric plasma that still, to this day, comprises nearly 100% of known space. The current orthodox model of the universe postulates that in the beginning was nothing: no space, no matter, no energy, and no time. Ultimately the Big Bang somehow created everything in the universe, including space, matter, energy, gravity, and electromagnetic radiation. Furthermore, the conventional mainstream cosmology taught today remains essentially a theory based solely on gravity and nuclear fusion. Supporters of the plasma theory, with its electric and magnetic fields, claim it has done more to organize matter in the universe into star systems and other large observed structures than has the force of gravity. Bassett documents in detail the discussion of Biblical support for plasma manifestations in Appendix C on pages 185–188.

Bassett also does an excellent work covering theology which is relevant to this top-down (Third Heaven-to-Earth interior) creation model. For example, though he cites the Scripture that some use to teach that the heavens and earth will be annihilated into nonexistence, and a new heavens and new Earth will be created allegedly *ex nihilo* as mentioned in Isaiah 65:17; 66:22, and 2 Peter 3:13, he rather effectively documents that the Scriptures which state the Earth will be destroyed by fire are *not* a total annihilation into nonexistence, but a literal event of purifying, cleansing, refining, and purging to destroy the dross of sin that now permeates the creation (p. 34). Once brought back to its original created plasma state and cleansed of sin, it will then be a renewed heavens and Earth (Revelation 21:1). In addition, Psalm 148:5b-6 adds, "for at his command the heavens were created, and he established them for ever and ever—he issued a decree that will never pass away." And Ecclesiastes 1:4 (NIV) says, "Generations come and generations go, but the earth remains forever." Thus, these verses he cites also testify to God's intention that this present heavens-and-Earth cosmos is to be everlasting—and eventually without the presence of sin.

Summary

This book is a carefully documented, scholarly tome designed to present a Biblically based, scripturally comprehensive, scientifically supportable creation model which this brief review cannot fully do justice to. I only mention some of the ideas that I noted, realizing that other readers will find other sections more beneficial. Although it covers science and Scriptures in detail, it is a very readable tome, and in some places even conversational. Bassett covers new ground and provides insight into the Scriptures which is backed up by science. In my judgment, it will become the standard that covers a pioneering attempt to understand the Scriptures and Creation. I focused on the plasma theory for two reasons: first is my interest in the topic and, second, because the book covers so many insightful ideas that to adequately discuss each would require a book-long book review.

Jerry Bergman, Ph.D.

References

Baugh, C., et al. 2019. *The Crystalline Canopy—The Book*. Creation Evidence Museum (CEM) of Texas, Glen Rose, TX. [*The Scriptural Universe Model* can only be purchased at the CEM or online at Southwest Radio Church's website: https://www.swrc.com/the-scriptural-universe-model.html.]

Scott, D. 2006. *The Electric Sky*. Mikamar Publishing, Portland, OR.

Thornhill, W., and D. Talbott. 2007. *The Electric Universe*. Mikamar Publishing, Portland, OR.

Instructions to Authors

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All submitted manuscripts will be reviewed by two or more technical referees. However, each section editor of the *Quarterly* has final authority regarding the acceptance of a manuscript for publication. While some manuscripts may be accepted with little or no modification, typically editors will seek specific revisions of the manuscript before acceptance. Authors will then be asked to submit revisions based upon comments made by the referees. In these instances, authors are encouraged to submit a detailed letter explaining changes made in the revision, and, if necessary, give reasons for not incorporating specific changes suggested by the editor or reviewer. If an author believes the rejection of a manuscript was not justified, an appeal may be made to the *Quarterly* editor (details of appeal process at the Society's web site, www.creationresearch.org).

Authors who are unsure of proper English usage should have their manuscripts checked by someone proficient in the English language. Also, authors should endeavor to make certain the manuscript (particularly the references) conforms to the style and format of the *Quarterly*. Manuscripts may be rejected on the basis of poor English or lack of conformity to the proper format.

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Lipman, E.A., B. Schuler, O. Bakajin, and W.A. Eaton. 2003. Single-molecule measurement of protein folding kinetics. *Science* 301:1233–1235.

Margulis, L. 1971a. The origin of plant and animal cells. *American Scientific* 59:230–235.

Margulis, L. 1971b. *Origin of Eukaryotic Cells*. Yale University Press, New Haven, CT.

Hitchcock, A.S. 1971. *Manual of Grasses of the United States*. Dover Publications, New York, NY.

Walker, T.B. 1994. A biblical geologic model. In Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism* (technical symposium sessions), pp. 581–592. Creation Science Fellowship, Pittsburgh, PA.

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Activities—The Society is a research and publication society, and also engages in various meetings and promotional activities. There is no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund and research center are maintained to assist in such projects. Contributions to the research fund for these purposes are tax deductible. As part of its vigorous research and field study programs, the Society operates the Van Andel Creation Research Center in Glendale, Arizona.

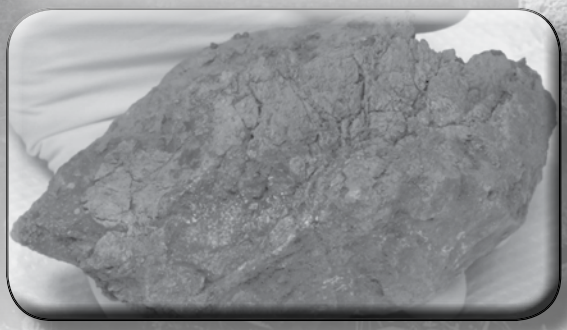
Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the Statement of Belief.

Statement of Belief—Members of the Creation Research Society, which include research scientists representing various fields of scientific inquiry, are committed to full belief in the biblical record of creation and early history, and thus to a concept of dynamic special creation (as opposed to evolution) both of the universe and the earth with its complexity of living forms. We propose to re-evaluate science from this viewpoint, and since 1964 have published a quarterly of research articles in this field. *All members of the Society subscribe to the following statement of belief:*

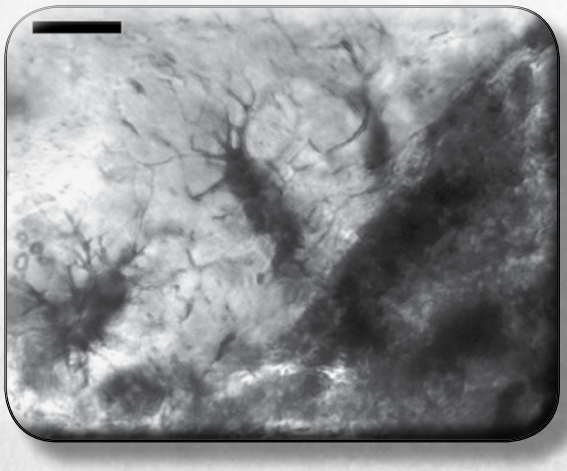
1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.
2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.
3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.
4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.

iDINO II

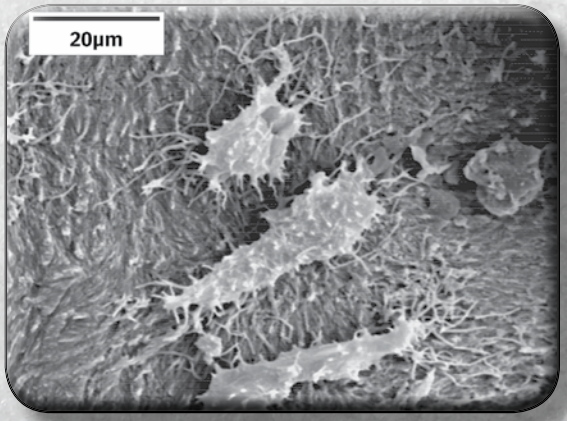
Investigation of Dinosaur Intact Natural Osteo-tissue



A fragment of the *Triceratops* brow horn. Fragments, such as this one, still contain tissue and cells.



Microscopic examination of tissue extracted from a *Triceratops* horn reveals bone cells still present.



Electron microscope picture of intact bone cells still in tissue extracted from a *Triceratops* horn.

How can pliable, stretchable tissue survive inside dinosaur fossils for over 65 million years?

How can this tissue still contain intact cells and even dinosaur proteins?

How can this fragile biological material survive for so long?

The answer to these questions directly challenges the current, evolutionary-biased, geologic timescale.

The Creation Research Society began its iDINO research initiative for the purpose of studying soft tissue in dinosaur fossils. The first phase of the project detected pliable, unfossilized tissue in a brow horn of a *Triceratops*. Within this tissue were intact osteocytes (bone cells). Some results from the iDINO project have been published in a technical microscopy journal and presented at an international microscopy conference. The Spring 2015 issue of the *Creation Research Society Quarterly* also features a special report of the iDINO project. Plus, to further spread the important information about soft tissue, the Society is developing a video (Echoes of the Jurassic).

The **second phase** of the project (iDINO II) will look more extensively at the process of tissue preservation. Evolutionists have offered various theories of how this tissue could survive for millions of years. iDINO II will methodically investigate these preservation claims, assessing their plausibility.

The iDINO results have already provided a strong challenge to the evolutionary worldview. More extensive and detailed examination may provide even stronger evidence that the age of dinosaur fossils is far less than 65 million years. To this end, the Society continues to seek those willing to fund this project with either one-time gifts or monthly donations.

For more information contact us at (928) 636-1153 or crsvarc@crsvarc.com.

Also visit http://tinyurl.com/nphm2c4 for project updates and details.