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Cover Photo Notes:

Curiosity Finds a Martian ‘Flower’: Smaller than a penny, the flower-like rock artifact on the left was imaged by NASA’s Curiosity Mars rover using its Mars Hand Lens Imager (MAHLI) camera on the end of its robotic arm. The image was taken on Feb. 24, 2022, the 3,396th Martian day, or sol, of the mission.

Curiosity’s View of ‘Benches’ on Mars: This panorama, made up of 122 individual images stitched together, was taken by NASA’s Curiosity Mars rover on November 18, 2020, the 2,946th Martian day, or sol, of the mission.

Curiosity’s View From the Top of the ‘Greenheugh Pediment’: Stitched together from 28 images, this view from NASA’s Curiosity Mars rover was captured on April 9, 2020, the 2,729th Martian day, or sol, of the mission after the rover ascended a steep slope, part of a geologic feature called “Greenheugh Pediment.” In the foreground is the crusty sandstone cap that stretches the length of the pediment, forming an overhanging ledge in some parts. At center is the “clay-bearing unit,” a region with a unique story to tell about the history of water on Mount Sharp, the 3-mile-tall (5-kilometer-tall) mountain Curiosity has been ascending since 2014. In the distance at the top of the image is the floor of Gale Crater, which is 96 miles (154 kilometers) wide.

Daybreak at Gale Crater: This computer-generated view depicts part of Mars at the boundary between darkness and daylight, with an area including Gale Crater beginning to catch morning light. Gale Crater looms in the distance, distinguished from adjacent craters by its central mountain of strata. Gale Crater straddles the dichotomy boundary of Mars, which separates the broad, flat, and young northern plains from the much older and rougher southern highlands.

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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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The Miracle of Jesus Walking on Water Through the Lens of Gravitational Time Dilation

Jonathan K. Corrado*

Abstract

Whether they are theologians, lay people, or non-believers, most have at least anecdotally heard of the miracle of Jesus walking on water. Many important lessons and insights can be gleaned from this important passage, including testimony to the identity of Jesus that bolsters belief in Him and His deity and a non-trivial display of Jesus' power over His creation. However, was God trying to convey more than just His ability to elude physics, and displaying His authority over the dimension of time and its creation? The dimension of time is an elusive and much debated dimension that is difficult to understand, and in the context of God and heaven, it is in many respects beyond human comprehension. However, as expressed by Albert Einstein, "the distinction between the past, present and future is only a stubbornly persistent illusion." This illusion can only be unlocked by God, and thus it was created by God. In this article, the miracle of Jesus walking on water is explored in relation to the phenomenon of gravitational time dilation; it is considered as an instance that reveals God's relation to time, as well as the complexity and awesomeness of creation in general. We show that the equations for time dilation around a massive body may serve as a model to show the independence of God from His creation of spacetime.

Key Words: Spacetime, time, gravitational time dilation, gravity

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Introduction

Whether Christian or non-Christian, most people have heard of the miracle of Jesus walking on water. This miracle, recorded in three of the four Gospels (Mt. 14:22–36; Mk. 6:45–56; Jn. 6:16–21, KJV), was the miracle that, above any other, convinced Jesus' disciples that He was undeniably the Son of God (Mt. 14:32–33, KJV).

Many important lessons and insights can be gleaned from this important passage, including testimony to the identity of Jesus that bolsters belief in Him and His deity. Other lessons include Jesus' sending us into the storms of life to build our faith; to not be driven by need or opportunity, but only by the will of God; the notion that sometimes Jesus shows up in our lives, but we do not recognize Him; and the implication that we are to "see" with our heart and not just our eyes. However, was God trying to convey more than a miracle and its associated lessons, and displaying His authority over the dimension of time and its creation?

Several places in the Bible hint at God's relationship to time. For instance, and most transparent, 2 Peter 3:8 (KJV) says, "But, beloved, be not ignorant of this one thing, that one day is with the Lord as a thousand years, and a thousand years as one day." This verse appears to indicate that time does not restrict God. Likewise, Psalm 90:4 (KJV) states: "For a thousand years in thy sight are but as yesterday when it is past, and as a watch in the night," indicating that—contrary to man's feebleness and finitude, as posed in Psalm 90:3 (KJV)—God is not subject to the constraints of time. Lastly, Isaiah 57:15 (KJV) says, "For thus saith the high and lofty One that inhabiteth eternity, whose name is Holy…" More succinctly, God dwells in eternity.

The dimension of time, however, is an elusive and much debated dimension that is difficult to understand. In the context of God and heaven, it is in many respects beyond human comprehension. While the words of the well-known hymn "Amazing Grace" express life in heaven in terms of a great expanse of time, the miracle of Jesus walking on water may shed light on the error of this understanding and the limitations on God it presupposes. Specifically, by walking on water, Jesus may have demonstrated His ability to overcome the force of gravity and, via the phenomenon of gravitational time dilation, exhibited His supremacy over the dimension of time, supporting the concept of His atemporal, "outside-time" existence.

God and Time

Every theistic worldview holds some view of how God is associated with the structure of our universe: that is, with space and time. If God is the creator of the universe, one might naturally question whether God created space and time as well, or whether space and time are merely aspects of the universe or something more fundamental. It turns out that a minority of philosophers and theologians believe that space is more fundamental than the universe. Many, conversely, believe that God brought space into existence (Wierenga, 1989). This view suggests that God is, to an extent, spaceless or "outside" space (Helm, 1988). Views of God's association with time, however, are riddled with disagreement. From Augustine through Aquinas, the major thinkers of early Christianity contended that, like space, God is "outside" time. They thought of God as eternal, in the sense that He is timeless or atemporal (Ganssle, 2001). On the other hand, a popular opinion among contemporary philosophers is that God is everlasting but temporal, experiencing some events before He experiences other events (Ganssle, 2001). If this is the case and God is temporal, His existence and His thoughts and actions have a specific location in time. He exists in the present moment, He has existed in every past moment, and He will exist in every future moment.

The miracle of Jesus walking on water may be able to shed light on this debate and the fuller extent of the complexity of creation by interpreting the relationship between gravity and time.

The Physics of Time and Gravity

Gravitational time dilation refers to the difference in the elapsed time as measured by two clocks. It was first described by Albert Einstein in 1907 as a consequence of special relativity in accelerated frames of reference (Schwartz, 1977). Gravitational time dilation is a phenomenon whereby time runs slower when in a higher gravitational potential. Put simply, the closer you are to a massive object like the Earth, the slower time runs; thus, time runs more slowly for someone on the surface of the Earth than for someone in orbit around the Earth (Humphreys, 2017). This phenomenon, as described by Einstein, is inevitable if the two axioms of Einstein's relativity theory are accepted: (1) the speed of light is constant for all observers; and (2) the weight induced by acceleration is fundamentally the same as that induced by gravity: the so-called equivalence principle (Einstein and Lawson, 2005).

Logical consistency and experimental results (Marletto and Vedral, 2020) support the idea that gravity causes clocks to run more slowly. The existence of gravitational time dilation was first confirmed directly by the Pound–Rebka experiment in 1959 (Pound and Rebka, 1959) and later refined by Gravity Probe A in 1976, among other experiments (Vessot et al., 1980; Malykin, 2015). Intriguingly, according to this theory, gravity does not warp the flow of time. In fact, it is the other way around: the warping of time causes gravity (Allday, 2019).

How does time cause gravity? Imagine a body in space. Absent a gravitational field or any forces, if the body starts motionless, it stays that way. At least, it stays motionless with respect to the three dimensions of space. Everything moves through the dimension of time.

Per Figure 1, space is displayed in two dimensions for simplicity, and time is displayed as a third dimension. Figure 1 shows the progression through time as the body moves up. It can be rationalized to have a positive velocity through time and zero velocity through space. When a second body is added, such as planet Earth—a massive object—it is understood that the presence of mass and energy warp spacetime. The most intense impact of that warping is to time, which produces gravitational time dilation (see Figure 2); again, bodies closer to Earth move through time more slowly (Rovelli, 2016).

A common equation used to explain gravitational time dilation is derived from the Schwarzschild metric, which describes spacetime in the vicinity of a non-rotating massive spherically symmetric object. In Einstein's theory of general relativity, the Schwarzschild metric is a solution to the Einstein field equations which relate the geometry of spacetime to the distribution of matter within it. The Schwarzschild metric

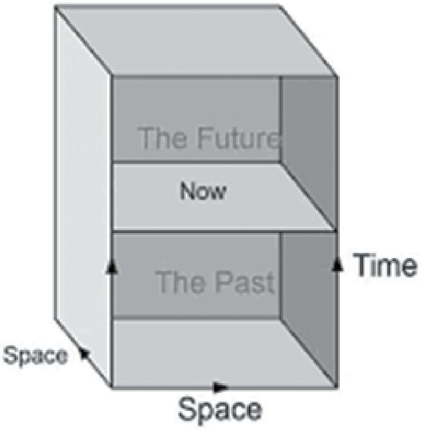

Figure 1. Einstein's block universe.

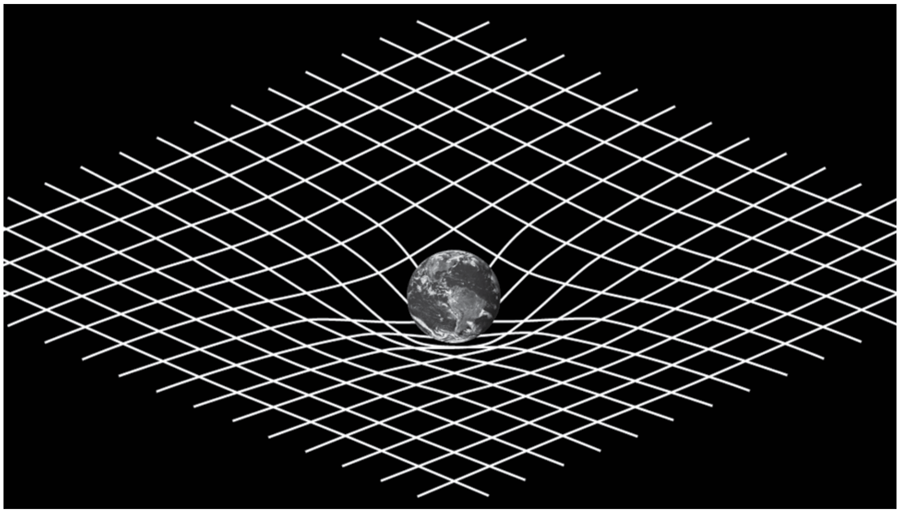

Figure 2. The warping of spacetime.

describes the gravitational field outside a spherical mass (such as Earth) on the assumption that the electric charge of the mass, the angular momentum of the mass, and the universal cosmological constant (the constant coefficient of a term that Einstein temporarily added to his field equations of general relativity, later reinterpreted as the energy density of space, or vacuum energy, that arises in quantum mechanics) are all zero. The solution is a useful approximation for explaining slowly rotating astronomical objects, such as Earth and the Earth's sun (Fromholz, Poisson, and Will, 2014). The equation is

$$t_0 = t_f\sqrt{1 - \frac{2GM}{rc^2}} \tag{1}$$

where

t_0 = time perceived between events for a body near a massive object (i.e., time inside the gravitational field);

t_f = time perceived by a body far away from the massive object not under the gravitational influence of any massive object, including the one under consideration (i.e., time outside the gravitational field);

c = speed of light;

G = gravitational constant;

M = mass of the object creating the gravitational field; and

r = radial distance from a person to the center of the massive object.

The Schwarzschild radius (r_0), the radius below which the gravitational attraction between the particles of a body must cause it to undergo irreversible gravitational collapse (Fromholz, Poisson, and Will, 2014), is defined as

$$r_0 = \sqrt{\frac{2GM}{c^2}} \tag{2}$$

Substituting Eqn. 2 into Eqn. 1 results in Eqn. 3, where t_0 can be expressed as

$$t_0 = t_f\sqrt{1 - \frac{r_0}{r}} \tag{3}$$

Note: If a mass collapses so that its surface lies at less than the radial coordinate r_0, then the object exists within a black hole.

From Eqn. 3, as a body moves farther from a massive object (*r* increases; r_0 is constant), the difference between the time perceived by a body far away from the massive object (not under its gravitational influence), t_f, and the time perceived between events for a body near the massive object, t_0, decreases (i.e., time moves faster as the body moves away from the massive object). That is, for a fixed time passage for a body close to the massive object, the corresponding time elapsed as perceived by a body far away is small. Furthermore, from the body that is close to the massive object's point of view, time will pass very quickly for the body far away from the massive object. So, from the warping of spacetime, clocks closer to a massive object take longer to tick than distant clocks do.

Note: As the body approaches a distance of r_0 from the massive object (the event horizon), time will have appeared to have come to a standstill to a body observing from far away; hence, the body will never reach a distance of r_0 from the massive object from the viewpoint of the body far away.

Also, the formula to find escape velocity—i.e., the minimum velocity required for a free, non-propelled body to escape from the gravitational influence of a massive object, thus reaching an infinite distance from it—is a simple rearrangement of terms solving for velocity in an equation in which the kinetic energy of an object is equal to its gravitational potential energy (Blanco and Mungan, 2021). This yields

$$v_e = \sqrt{\frac{2GM}{r_i}} \tag{4}$$

where

r_i = radius from the center of gravity of the massive object, and

v_e = escape velocity.

Assuming r_i is the radius of Earth and a body is on Earth ($r = r_i$), substituting Eqn. 4 into Eqn. 1 results in a derivation of the Lorentz transformation (Einstein and Lawson, 2005, p. 42)

$$t_0 = t_f\sqrt{1 - \frac{{v_e}^2}{c^2}} \tag{5}$$

So, from Eqn. 4, the velocity needed to escape a massive object's gravitational field decreases as a body moves farther from the massive object because the force of gravity weakens as the body moves farther away from the center of Earth's mass. From Eqn. 5, if the escape velocity decreases (as a body moves farther from Earth), the difference between the time perceived by a body far away from the massive object (not under its gravitational influence), t_f, and the time perceived between events for a body near the massive object, t_0, also decreases (i.e., time moves faster as the body moves away from the massive object). Because the force of gravity weakens as a body moves farther away from the center of Earth's mass, the velocity through time can be perceived as increasing the farther a body travels from Earth. If particles move through time according to those velocities, there is a sense of time flowing in a gradient: faster streams distant from the Earth, slower streams near to it. This is a similar concept to laminar flow of water in the center of a stream flowing more quickly than at the edge, where the shallower stream introduces friction on that flow (see Figure 3). It is as if Earth's mass creates a drag on the flow of time around it.

So, what happens to a body sitting in this stream of time? All bodies can be thought of as being made of many tiny clocks. Every atom, every subatomic particle is trying to tick at its own rate.

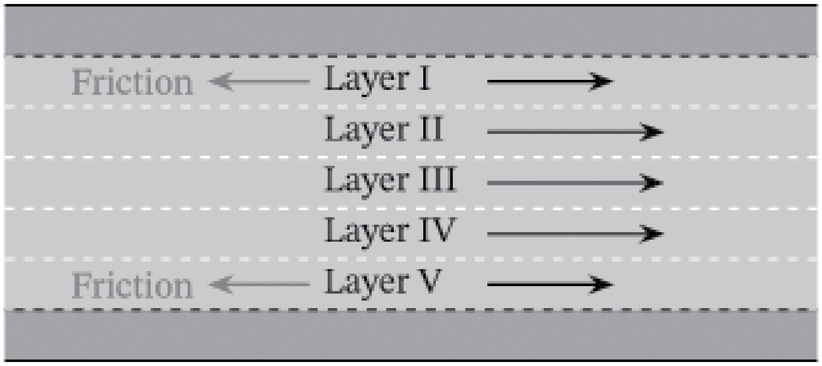

Figure 3. Laminar flow in a stream.

And each of those clocks has a velocity vector in time. So, what is the temporal velocity of the entire body? In Einstein's relativity, it must be remembered that time and space are not independent of each other. Objects do not just have a velocity through space or through time—they have a velocity through spacetime. This is referred to as their four-velocity (Einstein et al., 1952). All individual four-velocities begin purely in time, but the sum is rotated partially into space, and it is always rotated in the direction of decreasing flow, which, in a gravitational field, is downwards. The motion of any body in a gravitational field, then, is as follows: it gradually picks up velocity in the down direction via acceleration, and it pays for that acceleration by losing velocity (decelerating) in the time direction (Einstein et al., 1952).

There is a way of interpreting the math of relativity that states that everything travels at the speed of light. Light travels at the speed of light through space, and it is known that nothing with mass can reach that speed traveling through space. But if time is interpreted as a dimension like space, then a stationary mass really is moving at the fastest possible speed in the temporal direction. The four-velocity of a massive object is pointed almost entirely in the time direction. On the other hand, light itself travels at the speed of light through space only, not through time. A photon's clock is frozen (Rovelli, 2016, p. 52). It can be envisioned that its four-velocity is entirely rotated out of the time direction into space; although, technically, photons and other massless particles do not have a four-velocity, which is defined according to the ticking of one's own clock (i.e., one's experienced time), which, for the timeless photon, is zero.

In this picture, a falling body trades some of its enormous velocity through time to pay for a small velocity through space. This exchange looks favorable for space; a body in space gains a rapid plummet to its doom for an imperceptible slowing of its clock. The same favorable exchange can be seen when converting mass into energy via Einstein's general theory of relativity equation, $E = mc^2$. The speed of light is the exchange rate, and the speed of light is very large (Einstein and Lawson, 2005).

Implication for God's Relation to Time

Building on the above discussion, from Eqn. 3, if $r = r_0$, then a body is at the event horizon, a boundary beyond which events cannot affect an observer, resulting in $t_0 = 0$; no time is perceived between events for a body near a massive object. In this case, the four-velocity of a body would not rotate within the gradient of velocities resulting from warped time around a massive object. Thus, this body would not be subject to Einstein's relativity but would, in fact, be outside time. Barring the effect of black holes, if an object is not subject to time, then the object, in most circumstances, is not affected by the velocities and accelerations of an object constrained by time and thus would not experience four-velocity rotation. It would, therefore, not experience gravity. In the context of Jesus walking on water and the understanding of gravity and time in the above physics context, among other lessons and corollaries, Jesus may have expressed His ability to transcend the force of gravity, thus exhibiting His timelessness and His supremacy over the dimension of time. This supports the concept of His atemporal, outside-time existence, further bolstering the extent of the creation and His omnipotence in its manifestation.

Additionally, per Einstein's relativity, time and space are not independent of each other. An object outside time, therefore, must also be outside space. This supports the claim that God is outside both space and time and must have brought both into existence, supporting an *ex nihilo* creation concept (Whitcome, 2018).

This inference that God is outside time is a rejection of the claim that God is temporal. The claim of God's timelessness, as inferred by the miracle of Jesus walking on water, is that He exists not at any given time but beyond or outside time. In other words, rather than exist at particular points within time (i.e., temporal positions), God exists in eternity, where eternity is a non-temporal position (Craig, 2001). This also implies that God is not subject to temporal succession. God's relationship to each event in a temporal sequence is the same as His relationship to any other event. For example, God does not experience 300 BC before he experiences AD 2022. Both years are experienced by God in eternity as one "timeless present." So, as discussed in Daniel 10, while it is true that, in the 6th century BC, Daniel prayed and received a response from God, God's response to his prayers did not occur only at that time. Daniel's prayers were heard and answered by God in His eternal, timeless state of being. He did not listen to them first and then respond. He heard and responded in the same timeless instant: indeed, in the same timeless instant that He hears and responds to prayers in the present day.

Jesus's act of walking on water may not have involved a local reduction of gravity. However, given the various other possibilities (an increase in the viscosity of water, an additional supernatural force on the soles of His feet to exactly balance His weight, etc.), overcoming gravity is a strong possibility, as the act is a powerful demonstration of Jesus' direct control over natural law. His defiance of the law of gravity did not cancel, suspend, or alter this universal law. Instead, it was a manifestation of His stronger, divine power. Via analogy, Herbert Lockyer illuminates this principle:

> The law of gravity is not set aside when the magnet collects iron filings; it is only that the superior force of magnetism has overcome gravitation. So what happened that stormy night was the exercise of Christ's omnipotence, as He, the Creator of seas and winds revealed His authority over them, and they being His, He could use them as He desired. It was His will which bore Him triumphantly above those waters. (Lockyer, 1988)

Via this miracle, Jesus exercised His divine authority over the universal laws He created. In so doing, He conveyed much about Himself and His nature, for "it is the glory of God to conceal a thing: but the honor of kings is to search out a matter" (Prov. 25:2, KJV).

Jesus Exercises His Eternality

Christ walking on the water is discussed briefly in John 6:16–20. The details of the account are further elaborated upon in Mark, Chapter 6, and Matthew, Chapter 14; unlike Mark and Matthew, though, John ends this miraculous event with an interesting twist: "Then they willingly received him into the ship: and *immediately* the ship was at the land whither they went" (Jn. 6:21, KJV). Having exhibited His supremacy over the dimension of time by walking on water, Jesus ensures there is no ambiguity with this authority by lapsing time and "immediately" arriving at their intended destination some two or three-and-a-half miles away.

The Greek word used for "immediately" is *eutheōs* (*εὐθέως*), meaning *immediately*, *instantly*, *or at once*; it has 87 occurrences in the New Testament (Strong, 2007). While it does not always imply an instantaneous event—e.g., in Matthew 4:20, when the disciples "immediately" left their nets and followed Jesus—it clearly implies instantaneity in other cases. For instance, in Matthew 8:3: "Jesus stretched out his hand and touched him, saying, 'I am willing; be made clean,' and immediately (*eutheōs*) his leprosy was cleansed." Further, in Revelation 4:2: "Immediately (*eutheōs*) I [John] was in the spirit, and behold, a throne was standing in heaven and one sitting on the throne!"

Additionally, in John 6:1–15 (Mt. 4:13–21, Mk. 6:30–44, and Lk. 9:10–17), Jesus miraculously multiplied five small loaves and two fishes into enough food to feed 5,000 men (the multitude that Jesus fed probably numbered more than 15,000 if women and children are included in the count), thus displaying His superiority over the law of conservation of mass. This law states that in any system closed to all transfers of matter and energy, the mass of the system must remain constant over time. Mass may be rearranged in space, or the entities associated it may change form, but it can be neither created nor destroyed *by natural processes*. In this miracle, however, Jesus clearly added quantity, i.e., added mass from nothing; thus, he displayed His superiority over matter and thereby over the material world. It makes sense for the subsequent miracle discussed in the book of John to display His superiority over time, as He is the ultimate origin of both matter and time.

Implication for God's Creation of the Universe

The inference of God's timeless nature propagated by the miracle of Jesus walking on water derives from the perception that time itself is dependent. If time is dependent and God is not, the existence of time is predicated on God, but it is still possible for God to exist outside time. Either God created time, or He holds it in existence perpetually. If time was brought into being by God as a part of the creation of the universe, then it is important to understand whether the universe also had a beginning.

Jesus' act of walking on water and overcoming the force of gravity displayed, in part, His authority over time. This authority suggests that, like the rest of creation, God brought time into existence. Thus, it can be inferred that the universe and time both had a beginning, as opposed to the past being infinite. If time came into existence with the universe—i.e., if the universe has a finite past—then time must have been created by God. God, then, would have to be timeless and remain timeless.

Conclusion

Just as most philosophers and theologians believed that God brought space into existence (Wierenga, 1989)—suggesting that God is spaceless or "outside" space (Helm, 1988)—so the major thinkers of early Christianity, such as Augustine, may have contended that God is "outside" time. To this end, Augustine wrote, "You [O Lord] made that very time, and no time could pass by before you made those times. But if there was no time before heaven and earth, why do they ask what you did 'then?' There was no 'then,' where there was no time" (Augustine, 1960, p. 252). They thought of God as eternal in the sense of timeless or atemporal. This contention may be justified by Einstein's gravitational time dilation evaluated against Jesus' miracle of walking on the water. By walking on water, Jesus may have presented more than merely a miracle and sign of His Godhead; He may have displayed to the world His authority over the dimension of time, demonstrating atemporality, an "outside of time" essence. This implied atemporal timelessness of God gives us a clearer understanding of God's omnipotence and omniscience, and ultimately the power He possesses compared to the feeble, constrained existence of man.

In the book of Genesis, God created the world in six days because, as suggested in Psalm 90:4 and as supported by this paper, the 24-hour day that humans experience does not restrict Him and all that He does, including His exclusive work of bringing the universe into existence. God's eternality and timelessness is a facet of this absolute essence and perfect being. Further, Jeremiah 29:11 says, "For I know the thoughts that I think toward you, saith the Lord, thoughts of peace, and not of evil, to give you an expected end." This indicates that God has a plan for all His children predicated on His absolute knowledge of the entire timeline of human existence: past, present, and future. This understanding conveys more supremacy to His kingdom, power, and glory. God has neither our need for time nor our time-associated limitations. This is abundant justification to trust Him with our short, temporal lives.

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Lithification of Clastic Sediments— Part I: Significance, Processes, and Modeling

Peter Klevberg and Michael J. Oard

Abstract

Lithification is important to diluvial geology and the mineral industry, especially petroleum. Lithification can be used to determine the amount of eroded overburden, which we apply to North Central Montana. There are also five other ways to determine erosion and, using these, secular scientists have estimated immense continental erosion. We delve into the variables affecting lithification, emphasizing diagenesis and, in particular, mechanical and chemical compaction of sandstone. Despite many difficulties, the study of lithification has produced some data useful in inferring burial depths for sandstones from compaction microtextures.

Key Words: lithification, sandstone, burial depth, erosion, compaction, cementation

Introduction to Lithification

Sedimentary rocks are a powerful witness for the Genesis Flood (Oard and Reed, 2017). They come in layers that sometimes stretch thousands of kilometers in one direction, and in vertical sequences that show very little if any erosion between and within layers. The big picture defies the uniformitarian principle upon which all secular geology is based. Erosional features on the Earth's surface show numerous features difficult to explain by uniformitarianism, such as planation surfaces, long transported resistant rocks, tall erosional remnants, pediments, water gaps, and submarine canyons (Oard, 2008, 2013).

Sedimentary rocks cover about 70% of the continents and can range from zero to over 20,000 m (66,000 ft.) thick in some deep basins. For instance, the 350 by 550 km (220 by 345 mi.) South Caspian Basin has 26–28 km (85,000–92,000 ft.) of sediment, 12–14 km (39,000–46,000 ft.) of which is dated as Cenozoic (Knapp et al., 2004)! The top 3 km (10,000 ft.) of this sediment is dated Quaternary (Richardson et al., 2011). However, sedimentary rocks still present questions for creation scientists, as well as uniformitarian scientists.

Once sediments accumulate, they need to be lithified, i.e., cemented to form sedimentary rocks. We commonly see sedimentary rocks on the surface below a thin soil layer and sequences of various types of sedimentary rocks in cliffs that are almost always cemented. How did they get cemented? Was it during the Flood? Were near-surface sediments cemented after the Deluge? Or can it be both? Some creation scientists suggest that the topmost of the diluvial sedimentary rocks were commonly unlithified right after the Flood (Whitmore, 2013). Whitcomb and Morris (1961, p. 153) stated that the sediments in the Grand Canyon area "were still comparatively soft and unconsolidated." Unlithified sediments play into the idea that the Cenozoic strata were laid down

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by postdiluvial catastrophes with great erosion and redeposition of unlithified or poorly lithified diluvial sediments, amounting to 1,000 m or more (Whitmore, 2013).

Unlithified sediments likely occurred on top of the sediment pile at the peak of the Biblical Flood since cementation requires mechanical and chemical compaction, as we will describe in this paper. Then why are surficial sedimentary rocks mostly lithified, as shown by large structures resting on solid foundations (Figures 1 and 2)? Such lithification requires hundreds of meters of overburden to provide pressure overburden that is now missing. This erosion was not from post-Flood catastrophes (Oard, 2019), but occurred at the Recessional Stage of the Deluge when about 1,900 m of sediments were eroded off the continents forming the continental shelf and slope (Oard et al., 2023).

Figure 1. The foundation for the 6,000-ton catalytic cracker in the center of this picture is founded 13.7 m (45 ft.) into upper Kootenai Formation sedimentary bedrock to prevent even a few millimeters of differential settlement. The bedrock consists predominantly of claystone with sandstone interbeds (fine-grained, argillaceous sandstones).

Economic and Scientific Importance of Lithification

The degree and nature of lithification is of great economic and scientific importance. Geotechnical engineering focuses on geology as the interface with manmade structures, and the differences in response between soils and rock in bearing capacity, deformation, and seismic performance can be dramatic. Failure to recognize the importance of geotechnical factors can lead to failure of buildings, bridges, and other structures. Mining, both surface and underground, must take into account the geotechnical properties of the earth materials in order to be both safe and economical. Both degree and manner of lithification have important ramifications for petroleum reservoir rocks. Degree of lithification is also of great importance to the construction industry, which is dependent on earth materials.

Lithification impacts classification (e.g., sand, sandstone, and quartzite) and understanding of possible depositional and diagenetic processes. The resulting hardness, strength, and abrasion resistance are relevant to resistance to erosion, which is not only important to civil and geotechnical engineering, but also to explanation of topographic development and geomorphology, including development of the landscape surfaces on which we live. The rheological properties dramatically impact geomechanics and the potential for deformation of the strata.

Lithification Can Imply Eroded Overburden

When sediment is laid down, it has a relatively high porosity. As more sediment is laid down, the pressure of the sediment above, the lithostatic pressure, squeezes out the air or other fluid between the framework grains. The increased pressure causes changes in the framework grains and matrix as porosity decreases. Then cementing chemicals, or cement, are added to the grains to cement them together, and this reduces both the porosity and permeability. If all the variables can be estimated,

Figure 2. This 30-year-old reinforced stone foundation was built with upper Kootenai sandstone quarried 135 years ago, refaced, and reused. While the reinforced concrete piers and grade beams it sits on have an unconfined compressive strength of 5,000 psi (34 MPa), the sandstone averages 11,000 psi (75 MPa). The primary stone is a medium-bedded arkosic sandstone (immature, fine-grained to medium-grained subarkose) with minor iron cement; some of the stone is argillaceous (sublitharenite) but it still exhibits a strength of at least 7,000 psi (48 MPa).

then a rough estimate of the amount of overburden can be calculated, a major goal of this research project. If the sedimentary rocks are located at the surface, then this procedure will also give us a measure of the amount of erosion. Since many areas, such as the plains, do not have other means to estimate the eroded overburden, the lithification characteristics of surficial sandstones would be a useful tool to infer the amount of erosion.

North Central Montana Erosion

Our study area is in North Central Montana, an area important to historical geology. The amount of erosion over the plains of Central Montana with its isolated mountain ranges was first estimated to be "immense" by William Morris Davis of Harvard University, who proposed his famous "cycle of erosion" or "geographical cycle" in the late 1800s based on this area (Oard, 2013). He first threw out the Genesis Flood for an explanation of geology and geomorphology and assumed uniformitarianism. He surmised extensive erosion in the area that planed the land down into several erosion surfaces or peneplains. He recognized as much as 1,500 m (4,900 ft.) of erosion in the area based on erosional remnants of dikes and sills and on the igneous rocks in the Highwood and Crazy Mountains of Central Montana (Chorley et al., 1973).

Estimating the Amount of Erosion

In a subsequent paper, we will be estimating the amount of erosion in North Central Montana by several methods, including the features of sandstones at or near the surface. We will briefly examine some of the many methods for estimating the amount of erosion (and thus burial depth of a particular stratum) in a region. Some of them are indirect, such as chemical methods that rely on radiometric dating, which in turn are based on many uniformitarian assumptions. We will not use these. But there are five more direct methods.

One of these methods is based on the height of erosional remnants. This gives a minimum estimate because we do not know how thick the sediments originally were above the top of the erosional remnants. Since erosional remnants are often sedimentary rocks, and the rock is often cemented, we can safely assume hundreds of meters more of eroded sediments above the top of the erosional remnants in many cases (see below), since overburden is required to provide the pressure to compact and, for some important processes (Table I), to cement the sediments to rock. This method is illustrated in Figure 3.

A second method is to measure the erosion from an eroded anticline or dome which rose by the bowing up of sedimentary rocks. When anticlines uplift, the top is stretched and cracked. Thus, the center of the anticline would have been much more vulnerable to erosion, especially with Floodwater moving at high velocity above it. So, the top of the anticline would have been eroded, leaving the sides or limbs more intact. Measuring the amount of erosion at the center of the anticline is relatively easy using trigonometry. One projects the dip of the sedimentary rocks found along the sides of the eroded anticline up toward the top of the anticline and then estimates the thickness of the missing rock. This calculation assumes

Table I. Sources of Silica

Source	Process	Significance
pressure solution	localized stresses induce silica to enter solution and precipitate nearby	minor to major source of silica; proximate, so no transport problem
feldspar dissolution	dissolution of feldspar produces silicic acid and cations	minor to major source of silica depending on parent material
physil (clay mineral and mica) transformation	silica released during transformation from kaolinite to smectite and illite, and from smectite to chlorite	produces additional free silica from altered feldspars and volcanic ash
mudstone fluid expulsion	silica-rich fluids expelled from consolidating sediments	minor source, limited transport distance
fluid transport	silica dissolved elsewhere transported in ground water or hydrothermal fluids	fluid transport limits effectiveness, deposition is negative feedback
volcanic ash	dissolution of feldspar, glasses	amount of silica depends on ash mineralogy and environment
biogenic silica	dissolution or opalization of sponge spicules, radiolaria, diatoms	minor source of silica but sometimes observed

the thicknesses of the sedimentary layers were the same over the top of the anticline (i.e., a *concentric* fold), but sometimes the layers were thinner (a *similar* fold). So, the amount of erosion may be overestimated, especially if exposures are too few to ascertain whether concentric or similar folds are present. And since rock units commonly thin and thicken with distance, caution must be used when estimating any volume eroded over great distances. This geometric method is shown in Figure 4 and was the one we used for estimating 4,200–5,100 m (13,800–16,000 ft.) of erosion over the San Rafael Swell of the northwest Colorado Plateau (Oard and Klevberg, 2008). This erosion is close to the estimated average of 2,500 to 5,000 m (8,200–16,700 ft.) that has occurred over the *entire* Colorado Plateau, an area of 337,000 km^2 (130,000 mi.^{2})!

Note also that the top formation is the Green River Formation (GRF). Some creation scientists believe the GRF was deposited in a postdiluvial lake (i.e., Whitmore, 2006). However, Oard and Klevberg (2008) pointed out that the area of the GRF is 40,000 km^2 (15,600 mi.^{2}) and averages 2.5 km (1.56 mi.) deep. The amount of oil in the shale is enough to supply all the oil needs of the United States for 100 years! Tropical and subtropical fossils, such as palms and crocodiles, are found in the GRF at a continental interior site straddling the continental divide at about 2,100–2,400 m (7,000–8,000 ft.) above sea level (asl). How can the GRF be from a postdiluvial

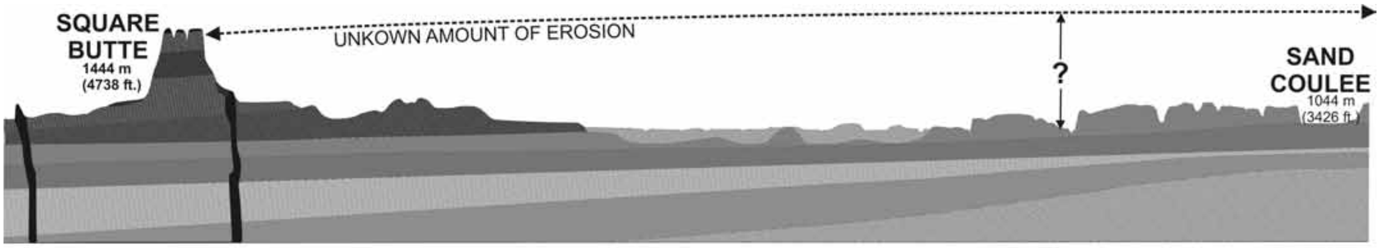

Figure 3. Cross section of formations south of Great Falls, Montana, showing interpolated line for estimating the amount of overburden eroded from an arbitrary sample location. Section is 50 km long, and vertical exaggeration is 10:1. Data are plentiful and deformation minor, but the uncertainties in the estimate are still significant.

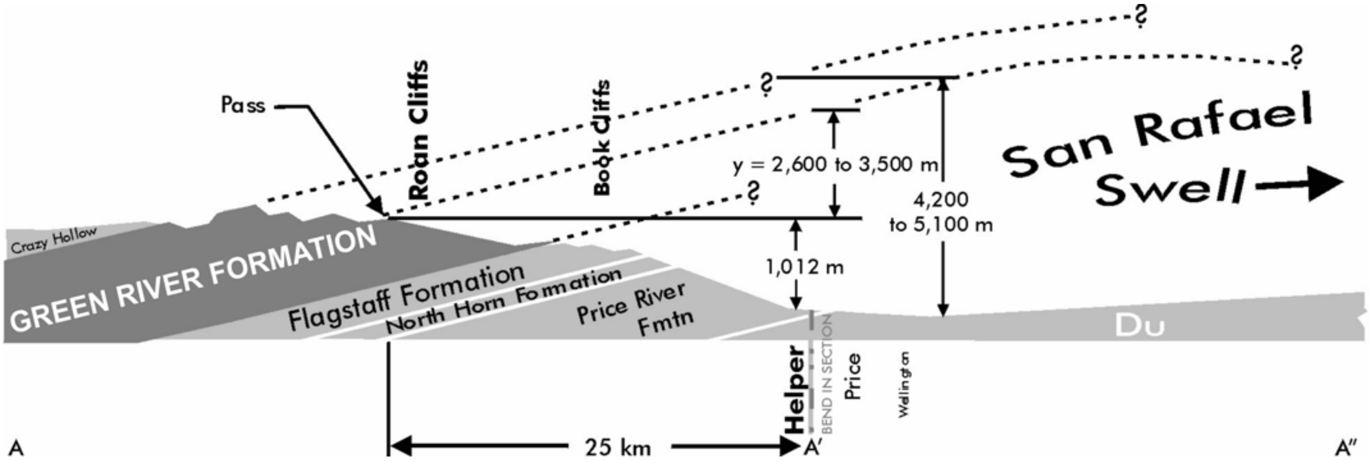

Figure 4. Estimating eroded cover from geometry of a fold. Modified from Figure 2 in Oard and Klevberg (2008).

lake? Just considering the erosion of the San Rafael Swell, those who believe the GRF is postdiluvial must believe that the GRF was laid down over the area, a huge anticline uplifted with 4,200–5,100 m (13,800–16,700 ft.) of erosion of the center, and the erosional debris not found at the edge of the anticline but apparently swept totally off the continent.

A third method of estimating the amount of erosion is by the rank of coal found at or near the surface. The formation of coal from plant material is generally related to the temperature (Thomas, 2013). Coal is made up of four ranks: lignite, sub-bituminous, bituminous, and anthracite, going from lowest to highest rank, with subdivisions within each of these. The hotter the temperature, the higher the rank. Thus, the rank of coal is typically related to the depth of burial and heating from the resultant thermal gradient. On this basis, coal near the surface indicates hundreds to thousands of meters of erosion of sedimentary rocks in the area. The amount of erosion depends upon assumptions, such as possible heating from a nearby heat source, the change in temperature with depth (i.e., thermal gradient), the existence of catalysts that can speed up the change, etc. So, like inferences about natural history typically are, coal rank estimates of erosion are educated guesses. The rank of bituminous and anthracite coal gave an estimate of about 4.0– 6.4 km (2.5–4 mi.) of sedimentary rock eroded from the Valley and Ridge Province just west of the Blue Ridge Mountains (Oard, 2011, 2013).

A fourth method of estimating the amount of erosion is to deduce the amount of continental margin sediments and assume that they originated from the adjacent continent. This estimate can be in error due to possible lateral input of sediments and a poor estimate of the offshore sediments. Based on this method, Oard (2013) estimated about 6,000 m (20,000 ft.) of erosion for the central Appalachians, about the same as the coal rank method. He also estimated about 2,400 m (8,000 ft.) of erosion from southwest Africa (Oard, 2017). A recent estimate of the amount of sediment in the oceans, especially the thick continental margin, has recently been made (Straume et al., 2019). If all the continental margin sediments resulted from diluvial runoff and 50% of sediments in the deep ocean, diluvial erosion during the Recessional Stage averaged about 1,900 m (6,230 ft.), as indicated on Figure 9 (Oard et al, 2023).

A fifth method of estimating burial depth is stratigraphically. The position of a given stratum relative to formations up-section can be used to estimate the amount of material previously overlying the subject stratum. This method is dependent on available outcrop and subcrop, along with additional geophysical data. It is also dependent on the veracity of correlation. Problems in stratigraphy have been pointed out by various authors (Klevberg, 1999, 2000a, 2000b; Berthault, 2002b, 2010; Oard and Reed, 2006), and this method is best suited to local or small regional application; application at a large regional extent may require many local studies integrated over the entire region.

Continental Erosion Was Immense

Evolutionary scientists have also made estimates in this range in local areas or regions. A total of more than 2,000 m (6,500 ft.) of strata has apparently disappeared from the Rocky Mountains and foothills of southern Canada (Schmidt, 1989; Osborn et al., 2006). Similar erosion has likely occurred on other continents, especially mountainous areas (King, 1983; Pazzaglia and Gardner, 2000). For example, 6,000 m (20,000 ft.) of rock probably was removed from the Flinders Range in South Australia (Chorley et al., 1984; Twidale and Campbell, 2005)! An estimated 3,000 m (10,000 ft.) of rock has been eroded from the Welch Mountains of the United Kingdom (Small, 1978). Partridge believes that more 1,000–3,000 m of rock has been removed from southern Africa since the Cretaceous Period in the uniformitarian timescale (Partridge, 1998). A total of 8,000–11,000 m (26,000–36,000 ft.) of sedimentary rocks are believed to have been removed from above the Vredefort impact crater, South Africa, while 5,000 m (16,500 ft.) was erased from above the Sudbury impact crater in southern Ontario (Senft and Steward, 2009).

These values of erosion reinforce the deduction by Oard et al. (2023) that an average of 1,900 m (6,320 ft.) of continental erosion occurred during the Recessive Stage of the Genesis Flood. The Recessive Stage was a powerful erosive mechanism that scoured the continents leaving behind unique landforms that are very difficult to impossible to explain by uniformitarianism. It also tells us that the sediments at or near the surface would most likely be lithified and unable to mass waste (Whitmore, 2013) during hypothetical postdiluvial catastrophes (Oard, 2019). Moreover, this 1,900 m (6,320 ft.) must be added back onto the continent to obtain a true picture of the amount of sediments collected on the continent at the peak of the Deluge. Adding 1,900 m (6,320 ft.) to the sedimentary rocks left on the continents will give us further insights into the powerful mechanisms of erosion, transport, and deposition during the Inundatory Stage.

Table II. Sediment Classification

Sediment Type	Description	Size	Resulting Lithologies
clastic	boulder	>256 mm	conglomerate
	cobble	64 – 256 mm	
	pebble	4.75 – 64 mm	
	sand	75μm – 4.75 mm	sandstone
	silt	5 – 75 μm	siltstone
	clay	<5 μm	mudrocks (various)
chemical	ions	dissolved	carbonates, precipitates

The Nature of Lithification

Deposition, diagenesis, and erosion in the past have produced what we observe in the present. Deposition explains the extent and magnitude of sedimentary rock bodies. Depositional structures and fabrics have led increasingly to semi-quantitative and quantitative inferences of depositional environment (fluid mechanics and energy), especially since the salient work of Berthault (2002a). Deposition, particularly lateral extent, and stratigraphy have been important emphases in the diluvialist renaissance following publication of *The Genesis Flood* (Whitcomb and Morris, 1961).

Diagenesis has received less attention and is the focus of this paper. It describes the changes occurring within a sediment body after deposition and includes compaction and cementation. As diagenesis affects rheological properties, it also impacts the timing and mechanisms of folding versus faulting. The problem specifically addressed here is whether burial depth can be estimated from diagenetic changes in a sedimentary stratum.

Geomorphology has received increasing attention in recent years (Oard, 2008, 2013; Whitmore, 2013). Based on the historical account presented in Genesis, an extensive erosion surface can be anticipated to dominate the continents. Geomorphology is therefore a key area of research for diluvialists. It also provides one variable in the quest for a means of estimating burial depths.

Analyzing Lithification

Sediments are classified as clastic or chemical and further distinguished by particle size or the type of dissolved ions from which they precipitated (Table II). As shown in Table II, gravel lithifies to form conglomerate, a lithology very important as an indicator of a high-energy depositional environment, but not especially common in the rock record. Sandstone, siltstone, claystone, and shale are much more common. Limestone is an example of a chemical sedimentary rock. Clastic sedimentary rocks respond to pressure and temperature during diagenesis and thus may be useful as burial-depth indicators. We are unaware of any corresponding properties in chemical sedimentary rocks.

The ideal lithology for use as a burial depth indicator would be a clastic sedimentary rock that would respond readily and predictably to overburden pressure. A well-sorted (poorly graded) gravel or sand would transmit the overburden loading immediately via particle-to-particle contact. Mudrocks, with their fine-grained matrix, would tend to be affected by pore pressures and would therefore respond much more slowly to overburden pressure. Sandstones are much more common than breccias and conglomerates and, being finer grained, provide a smoother response statistically to loading (Bjørlykke, 2014). As important petroleum reservoir rocks, sandstones have received much attention from the petroleum industry as well; thus, our attention is primarily on the use of sandstones as depth indicators. Coal has also received some study, however, and we will therefore include information from the literature on coal rank versus depth.

Ideal Lithology

In regard to sandstones, the ideal lithology would respond measurably to overburden pressure and exhibit the fewest possible potentially confounding variables. Finding an ideal quartzose sandstone, such as quartz arenite (also spelled "quartzarenite"), would greatly help in determining the amount of eroded overburden, but many sandstones are more complicated than this ideal (Figure 5). As a result, a nonideal sandstone presents innumerable complications, and other variables enter the process of mechanical and chemical compaction (i.e., cementation) that result in a cemented sedimentary rock (Pettijohn, 1975; Pettijohn et al., 1987). In these cases, it is almost impossible to infer the applied stress from overburden that would have been required to lithify the sediment. To more realistically estimate burial depth requires a lithology approximating this simpler "ideal" sandstone.

Mudrocks

Mudrocks make up about 50% of sedimentary rocks (Boggs, 2012), although estimates have varied. Mud is a mixture of silt and clay. Mudrocks include mudstone, shale, siltstone, and claystone. Mudstone is cemented mud without fine laminations, while shale is a mudrock with fine laminations (Neuendorf et al., 2005). Siltstone is a cemented silt, which is composed of over 50% silt-sized particles without laminations (Neuendorf et al., 2005). Claystone is consolidated clay that has more than 67% clay-sized particles (Neuendorf et al., 2005). Examples are shown in Figure 6.

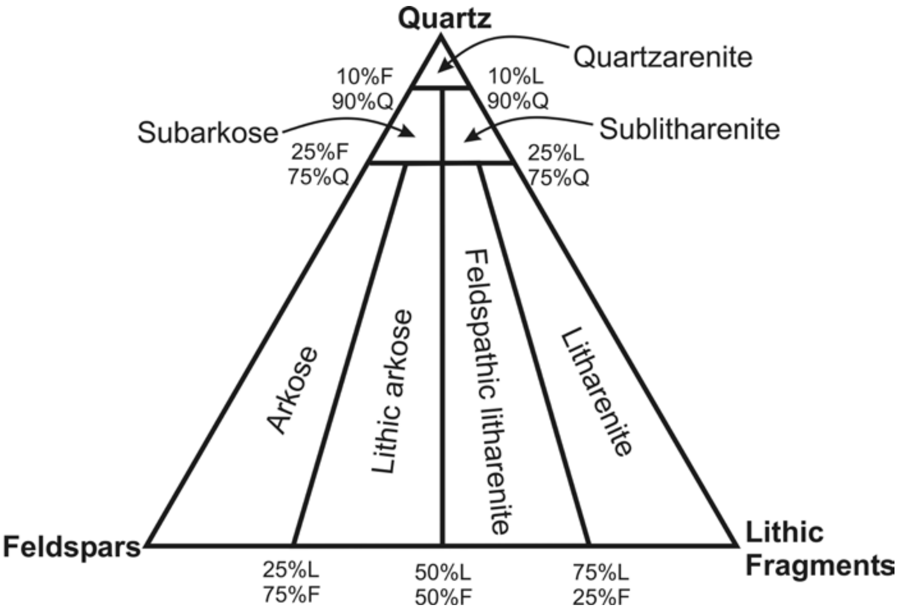

Figure 5. The commonly used Folk (1974) sandstone classification system was used in this study. *Mature* sandstones have well sorted (relatively uniform size), well rounded grains. Because of the resistance to physical and chemical weathering exhibited by quartz, mature sandstones tend to move toward the apex of the triangle (i.e., become more quartzose).

Processes of Diagenesis

Mechanical compaction is an important step in the lithification process. It may include mineral transformations. In general, mechanical compaction appears to dominate the early (shallower, cooler) stage, while cementation dominates the later (deeper, hotter) stage. As conditions change, equilibrium may favor different minerals, and mineral transformations will occur whenever activation energies are not too high. To estimate burial depths in the past from lithologic properties in the present, it is important to be able to distinguish compaction effects from cementation effects. The latter can interfere with the former.

Mechanical Compaction

Several important variables affect mechanical compaction of sands (Table III). Cementation ("chemical compaction") creates bonds between particles and hinders compaction. Mechanical compaction and cementation reduce porosity and thus the space to accommodate transmission and storage of water or hydrocarbons. Another diagenetic process, dissolution, can counter these processes and increase porosity (Cox, 1985; Taylor et al., 2010), but since our concern in this paper is lithification, we will concentrate on compaction and cementation. This is a very large and complex field of study, but Table

Figure 6. Examples of the sedimentary rocks referred to in Table III. A) Conglomerate, Cypress Hills Formation. B) Sandstone and shale, probably Greyson Formation, Belt Supergroup. C) Siltstone and claystone, probably Spokane Formation, Belt Supergroup. D) Clay and claystone, Tullock Member, Fort Union Formation. E) Limestone, Helena Formation, Belt Supergroup.

Table III. Factors in Sandstone Mechanical Compaction

Factor	Effect on Sand Compaction		References
	Low Pressure*	High Pressure*	
grain size	more for large grains	reduced effect (crushed grains)	6,7
mineralogy, breakage	$CaCO_3 > SiO_2$	reduced effect for $CaCO_3$	3,7
mineralogy, deformation	more for lithic grains	greatly reduced effect	5
mineralogy, dissolution	more if feldspars dissolved	reduced, feldspars → SiO_2	1
grain shape	more for angular grains	reduced effect (crushed grains)	7
sorting	more for well sorted	reduced effect (crushed grains)	2
matrix	enhanced by matrix	reduced by matrix	7
temperature	reduced if >80°C - silica available, creates overgrowths		4
pressure solution	may increase for $CaCO_3$	increased for $CaCO_3$, SiO_2 also	4
grain coatings	hinder cementation, so greater compaction		4
cements	reduce compaction	little effect (already compact)	1
anhedral, large quartz	fast quartz overgrowth until crystals become euhedral		3,6
polycrystalline quartz	hinder cementation, so greater compaction		3,6

*Approximately 0–25 MPa for low and 25–50 MPa for high, but inflection point varies greatly between deposits.

1 Bjørlykke, 2014
2 Sun et al., 2020
3 Prajapati et al., 2020
4 Oye et al., 2020
5 Xia et al., 2020
6 Lander et al., 2008
7 Chuhan et al., 2003

III provides an overview of these factors. For example, shallower burial (lower pressure) results in more compaction for large sand grains than small ones. As the grains crush, the smaller particles fit between the bigger ones and reduce the stress on individual grains. By the time the stratum is deeply buried (high pressure), it is much more resistant to further compaction. As shown in the second row of the table, mineralogy also influences this. If there is more calcite than silica ($CaCO_3$>SiO_2), then the weaker calcite grains will break more quickly and result in faster compaction, but by the time deep burial (high pressure) is reached, they will have already filled in voids and begun to resist additional compaction.

An idealized (simplified) pattern of sandstone cementation begins with continuous deep burial. At first the sand is compacted with a beginning porosity of 40 to 45%, depending upon a number of variables (Paxton et al., 2002). Simple mechanical compaction with increasing pressure causes the grains to change arrangement by slipping and sliding past one another, fracturing, undergoing minor pressure solution, and deformation of compressible grains, resulting in a more compact arrangement with less porosity (Brzesowsky et al., 2014; Xia et al., 2020).

Porosity decreases by mechanical compression down to 26%, which is reached at about 2,000 to 2,500 m (6,650–8,200 ft.) (Stricker et al., 2016b; Therkelsen, 2016) as long as no other cements are added before these depths. This corresponds to a lithostatic pressure of 20 to 25 megapascals (MPa). There is generally no further porosity loss due to mechanical compaction below this depth, where the temperature is usually around 70°C (158°F) assuming an average geothermal gradient as observed today of 20 to 30°C/1,000 m. However, mechanical compaction can continue down to 5,000 m (16,000 ft.) in basins with a low geothermal gradient (Fawad et al., 2011), such as in the Gulf of Mexico (Taylor et al., 2010). It is the *temperature* that determines the depth of effective mechanical compaction.

After mechanical compaction, so-called chemical compaction takes over (the term "chemical compaction" is entrenched but unfortunate wording, for while porosity generally decreases, it is often not the result of a reduction in volume but rather deposition of cement). Cementation can occur during mechanical compaction, such as the addition of calcite cement at shallow burial depths or other diagenetic effects, but for the idealized example, we are assuming a pure silica sand with no additions during mechanical compaction. More heterogenous or fine-grained sediments may deviate significantly from this example, particularly mudrocks.

Mudrocks are formed primarily by compaction rather than cementation, which is different from sandstone. It seems that mud is easier to cement internally than sand, although some mudstones and other mudrocks also have silica cement. Most mudrocks are largely cemented by the physils (i.e., clay minerals and micas—not all clay is composed of micas or *clay minerals*) that dominate the mineral composition (Table IV). Some researchers believe that quartz cement for mudstones is mostly from an open system, such as is argued for the oil-bearing Wilcox mudstone of the Gulf of Mexico and Texas coastal area (Day-Stirrat et al., 2010). First the mud is mechanically compacted: "…mechanical compaction dominates initially with grains becoming more closely packed together through slippage, rotation and breakage" (Goulty et al., 2016, p. 703). Mechanical compaction commonly goes down to about 2,000 m (6,650 ft.) before chemical compaction (i.e., recrystallization and/or cementation) starts (Peltonan et al., 2009). Provided enough potassium is available, commonly from feldspar dissolution and transformation of smectite to illite at 65–70°C (149–158°F), mud changes to mudstone. It appears that the potassium must come from an open system (Day-Stirrat et al., 2011). The pore water

Table IV. Common Cements

Cement Type	Process	Strength	Dominant Bonding
clay	grain coatings	low	Van der Waals
iron	grain coatings, pore filling	low – medium	ionic
carbonate	grain contacts, pore filling	medium	ionic
silica	grain overgrowths	high	covalent

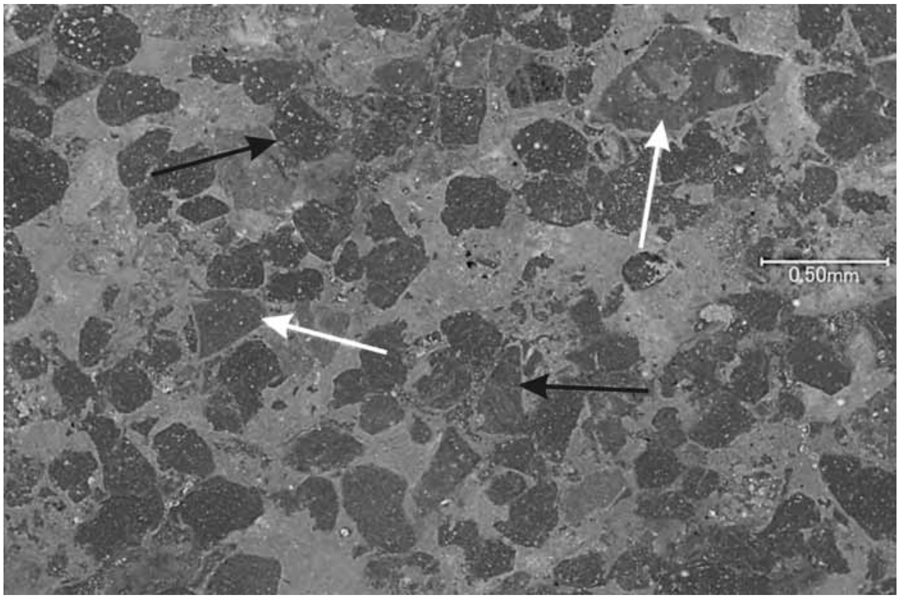

Figure 7. Cementation may occur during diagenesis, as shown by the iron cement in this sandstone sample from North-Central Montana. Black arrows point to detrital quartz grains, white arrows point to polycrystalline lithic fragments, and light gray between them is iron oxide cement (actual color is yellow ocher to orange).

must be released, or the mud becomes overpressurized and, with interbedded sand, the pore water is mostly expelled into the sandstones during compaction (Bjørlykke, 2011). The permeability of mudstones varies by 10 orders of magnitude, with the biggest differences in shallow environments, those less than approximately 500 m (1,600 ft.) depth (Mondol et al., 2008).

Chemical Cementation

There are various types of cement (Table IV). The strongest type is silica (silicon dioxide). Other types of cement are carbonates, iron oxides, and various types of clay minerals (Cui et al., 2017). Silica is the most common cementing agent for sandstones (McBride, 1989; Walderhaug and Bjørkum, 2003), and it is an especially strong cement. Carbonates are weaker cements and break down from chemical reactions, especially with acids. Cements can also change type during diagenesis, such as calcite being replaced by dolomite. Cements can be deposited during diagenesis (Figure 7), but they can also dissolve during diagenesis.

Above 70°C (158°F), silica cementation starts (Oye et al., 2020). In the simplest case, the cement consists of silica that is added to the study volume. Silica cementation depends upon the temperature and various kinetic effects (Molenaar et al., 2007; Xi et al., 2015; Niazi et al., 2019). The solubility of quartz increases exponentially above 70°C (158°F). Kinetic effects are overcome with increasing temperature and a high-silica supersaturation (Bjørlykke, 2014). One kinetic effect is the lack of surface area on the quartz grains because of a clay coating. Silica is added by several sometimes-controversial internal mechanisms (Table I) and one external mechanism, fluid flow (Oye et al., 2018; Wang et al., 2020).

A sand can be partially or totally cemented at depths shallower than 2,000 to 2,500 m (6,650–8,200 ft.) during mechanical compaction, especially by carbonate cement (Bjørlykke, 2014; Cui et al., 2017). The most common type of carbonate cement is calcite, but dolomite sometimes is the cement (Taylor and Machent, 2011). The carbonate cement can originate from a variety of mechanisms, such as dissolution of shallowly buried mud (Wang et al., 2016). Its solubility depends upon temperature, pressure, and pH. It is common to have interbeds of mudstone or carbonate within sandstone bodies, so it is not difficult for carbonate cement to originate nearby. The amount of carbonate cement can range up to about 30% of the intergranular volume, which is the sum of voids, matrix particles, and cement within the sediment.

If cement is added before the maximum mechanical compaction is reached in sandstones, then researchers know that cementation occurred *during* mechanical compaction. One can sometimes tell how deeply buried sandstones were by calculating the amount of the mechanical compaction above 26% porosity in these situations—or at least the *minimum* overburden to achieve the observed degree of compaction. The size and shape of quartz sand crystals also has a major impact on cementation rates and resulting porosity (Lander et al., 2008).

Grain coatings can greatly inhibit silica cementation because of a lack of bonding sites to the quartz framework grains (Busch et al., 2017), resulting in continued high porosity. So, the inhibition effect depends upon how much of the surface area of framework grains is covered (Busch et. al., 2020). Thus, the grain coating is an important variable for oil and gas accumulation (Busch et al., 2017; Hansen et al., 2017). For instance, clay, microquartz, mica, and hematite on sandstone grains retard quartz cementation (Harwood et al., 2013; Stricker et al., 2016b; Wang et al., 2017). The quartz cement cannot nucleate from coated quartz framework grains, and so porosity remains higher than expected (Hansen et al., 2017). This is one of the reasons why some deep sandstones are uncemented, such as some North Sea sands 2,500 m (8,200 ft.) deep (Therkelsen, 2016). This is also the reason why some North Sea sands have high porosity, up to 35% at 3,500 m (11,480 ft.) (Stricker et al., 2016a, 2016b, 2017; Maast, 2017). Such sandstones make ideal reservoirs for hydrocarbon accumulation.

Clay minerals (physils) are very common as cements in mudrocks, but in sandstones they often interfere with precipitation of the much stronger silica cement that is the primary diagenetic cement. Three phyllosilicate minerals are especially effective in coating quartz sand grains: chlorite (Taylor et al., 2010; Dowey et al., 2012), illite (Hansen et al., 2017), and mixed smectite-illite (Busch et al., 2020); see also Table I. Chlorite commonly comes from low grade metamorphism and the diagenesis of volcanic fragments, while illite mostly originates from the dissolution of feldspar grains, first changing to smectite clay that transforms into illite clay at temperatures of 65 to 70°C (149 to 158°F) (Goulty et al., 2016). Clay coatings depend upon the available clay, the amount of fluid flow, and the subsequent diagenetic pathway (Busch et al., 2020). Microquartz, which likely originated by the smectite-to-illite diagenetic reaction (Thyberg et al., 2010), retards quartz cementation because it creates a kinetic barrier (Taylor et al., 2010). Generally, the more the surface area of the quartz framework grains, the easier it is to add quartz cement (Walderhaug and Bjørkum, 2003). The lack of quartz cement is not a function of the amount of quartz in the pore water, which can be substantial at high temperatures, but on kinetic factors, such as the available surface area of quartz (Hansen et al., 2017; Emmanuel et al., 2020). Early carbonate cementation and clay coatings result in a wide range in cementation, porosity, and permeability for a given lithostatic pressure (Wang et al., 2017).

[To simplify analysis of the lithification process, we will start off with the ideal (fewest variables) cementation of a pure quartz sand into a sandstone with no matrix. Cementation of other sandstones and other types of sedimentary rocks is far more complex. A wide literature exists on sandstones and the cementation process, mainly because hydrocarbons are especially found within their pores and these are areas of active research by the oil and gas industry. There are two main types of simultaneous processes during the time cementation occurs: mechanical compaction and cementation ("chemical compaction")—they are not mutually exclusive. Mineral transformations may also be important.]

Authigenic Minerals

Numerous other diagenetic effects can occur during the cementing process, some of which are mentioned in Table I, often simultaneously (Stroker et al., 2013; Yuan et al., 2015; Li et al., 2017; Sun et al., 2020). As a result of feldspar dissolution, several physils can form and even change from one to another, releasing silica (Paxton et al., 2002; Peltonen et al., 2009). Cements can form and be dissolved or partially dissolved (Monsees et al., 2020). A sandstone can be cemented by more than one cement. Even some of the framework grains can be dissolved and replaced by cement (Taylor and Machent, 2011). The timing of each step in the cementation process can sometimes be discerned by cross-cutting relationships as seen in thin sections. Fluid inclusions in the rock can sometimes tell us the chemistry and temperature during diagenesis (Busch et al., 2017). Authigenic minerals which are produced by diagenesis are very common in sandstones, making up 13 to 59% of the rock, with the average about 26% (Therkelsen, 2016).

Figure 8. The laboratory at Norges Geotekniske Institutt (the Norwegian Geotechnical Institute) as it appeared from the mezzanine during Klevberg's visit in 2009. Cutting edge testing for the oil industry has occurred in this facility.

Modeling Lithification

There is a need to develop an effective model of sedimentary lithification to be used in a Flood model. To be useful, a lithification model must be more than speculation about natural history; it must be as quantitative and empirical as possible.

Need for a Lithification Model

Many of the concepts surrounding formation of sedimentary rocks are beliefs based on worldviews, sometimes with little or no scientific research behind them (Reed, 2001; Mortenson, 2004; Rudwick, 2005; Klevberg, 2014). Where economic interests rule, however, a more realistic approach is often developed to meet practical needs. We have previously proposed researching the equations of state for lithification directly through laboratory experimentation, but this represents a significant outlay of time and money (Figure 8). Thankfully, the oil industry has been willing to invest in some of this nascent lithification experimentation (Bjørlykke, 2014), and since sandstones are important reservoir rocks, much of the attention has centered on sandstones.

Tas Walker (1994) developed a natural history model based on the events recorded in Genesis. Walker's Biblical geological model has an Inundatory Stage, in which the water rises to a peak, followed by the Recessive Stage, in which the water runs off the uplifting continents and mountains and into the ocean basins and valleys

(Psalm 104:8) (Barrick, 2018; Barrick et al., 2020). These two stages are similar in all floods, especially flash floods, and Walker has divided the two stages into five phases. Thick sediments would have been deposited on the continents during the Inundatory Stage, which peaked at about Day 150 (Boyd and Snelling, 2014; Johnson and Clarey, 2021). Reed (personal communication, 2023) is in the process of estimating the amount of sedimentary rocks left on North America. Preliminary estimates are in the ballpark of 1,500–2,000 m (4,900–6,600 ft.). If we add 1,800 m (6,000 ft.) to the average amount of erosion during the Recessive Stage, we estimate that approximately 3,700 m (12,100 ft.) was deposited at the peak of the Deluge (Figure 9).

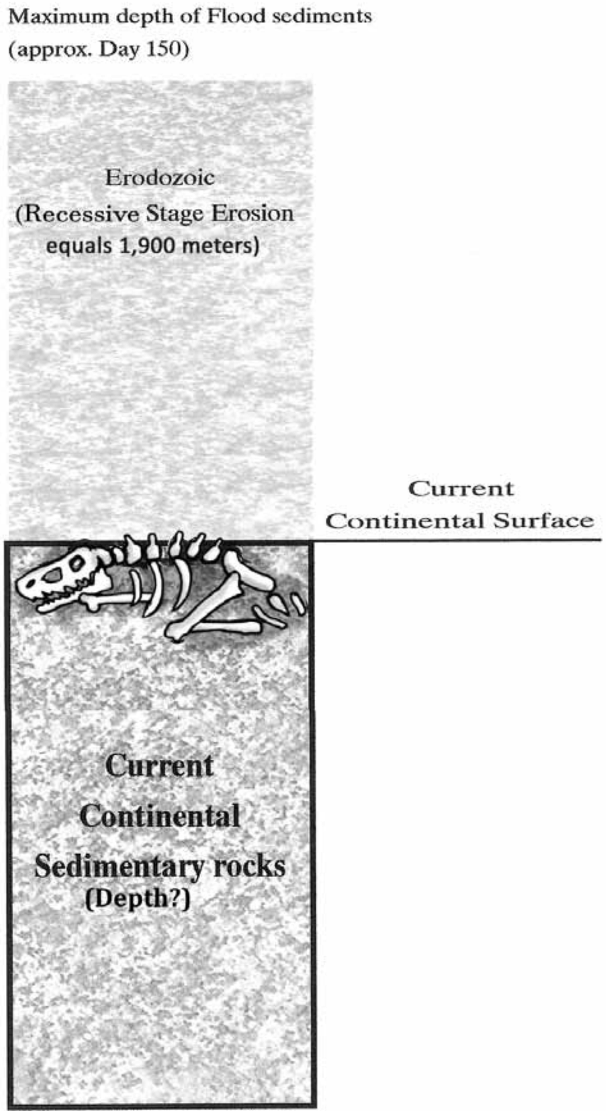

Figure 9. An estimated 1900 m (6,200 ft.) of sediments on average have been eroded off the continents to expose the present land surface. The term "-zoic" refers to life, and the late Roy Holt dubbed this period of erosion the "Erodozoic," probably because numerous buried organisms and fossils would be *eroded* and pulverized during the Recessive Stage.

Estimating Conditions

The diagenetic processes in sandstones listed in Table I require certain ranges of temperature and pressure or solution chemistry. Evidence for these processes may be inferred from thin sections or other data. How the sediments came to be exposed to these conditions and the duration of that exposure may hinge on Earth history assumptions. For example, it is common to assume the average present geothermal gradient and then employ computer programs such as PetroMod® or BasinMod® to infer a burial history, but these models depend on uniformitarian assumptions, a clear case of begging the question (circular reasoning). Experimental data to determine equations of state and rates of lithification (Figure 10) for various lithologies would be invaluable to break out of this circular reasoning problem.

Coal rank appears to be more closely linked to temperature than pressure (Thomas, 2013; Klevberg and Oard, 2022), and usually the average current geothermal gradient is used in the calculations. The current geothermal gradient, of course can be either lower or higher than what it was in the past. If lower, coal rank can provide an estimate of maximum burial depth. If higher, coal rank would be a minimum burial depth.

Discussion: The State of Lithification Modeling

A model is only as good as its inputs. Accurate scientific modeling requires determination of the equations of state that govern mineral and rock stability. As a first step in this direction, the authors designed experimental apparatus and conducted a lithification pilot study in 2014 (Klevberg, 2014). The pilot study was conducted on the clay–claystone transition due to the simplicity of lithification governed by mechanical compaction. This transition was reached in 29 weeks at an applied pressure equal to 300 m (1,000 ft.) of overburden (Figure 11). Still unknown are compaction curves for other applied pressures, limitations of pore pressure reductions based on stratum thickness and lateral extent of sandstone interbeds, and similar variables. This present paper has therefore leaned heavily on industry-financed progress made in sandstones using expensive apparatus and labor beyond our means (Figure 8). Pioneering work by Bjørlykke and colleagues have greatly advanced our knowledge of lithification.

Our goal has included correlating coal rank and inferred sandstone burial depths for North Central Montana. There may be some general patterns (Figure 12), but too many variables

State of the system:

$$S = f(M, T, P, pH, EH, SC \ldots)$$

Rate of lithification:

$$\partial S/\partial t = \partial f(M, T, P, pH, EH, SC \ldots)/\partial t$$

Figure 10. Equations of state include the variables needed to describe the state of a system. For a given parent material (M, including a defined grain size distribution and mineralogy), principal variables would be pressure (P), temperature (T), pH, EH, specific conductivity (SC), and possibly other chemical variables if the latter three commonly used ratios are not sufficient to define the state of the system. Taking the time (t) derivate of the equation obtains the rate at which equilibrium is reached, i.e., the rate of lithification.

are involved in coal rank—it is not just a function of overburden pressure. Sandstones, problematic as they may be, appear to be better burial depth indicators.

Methods of interpreting sandstone thin-section data are beyond the scope of an article such as this, but it is sometimes possible to determine whether stages in diagenesis overlapped. If there is evidence that matrix or cement interfered with mechanical compaction, then that particular unit may not be useful in estimating burial depth. However, it may be possible to determine a *minimum* burial depth and thus minimum amount of erosion, recognizing that actual burial depth may have been deeper due to these interferences.

In a subsequent article, we will present a field study of sandstones in the Kootenai and Blackleaf Formations of North Central Montana, some of which are associated with coal seams.

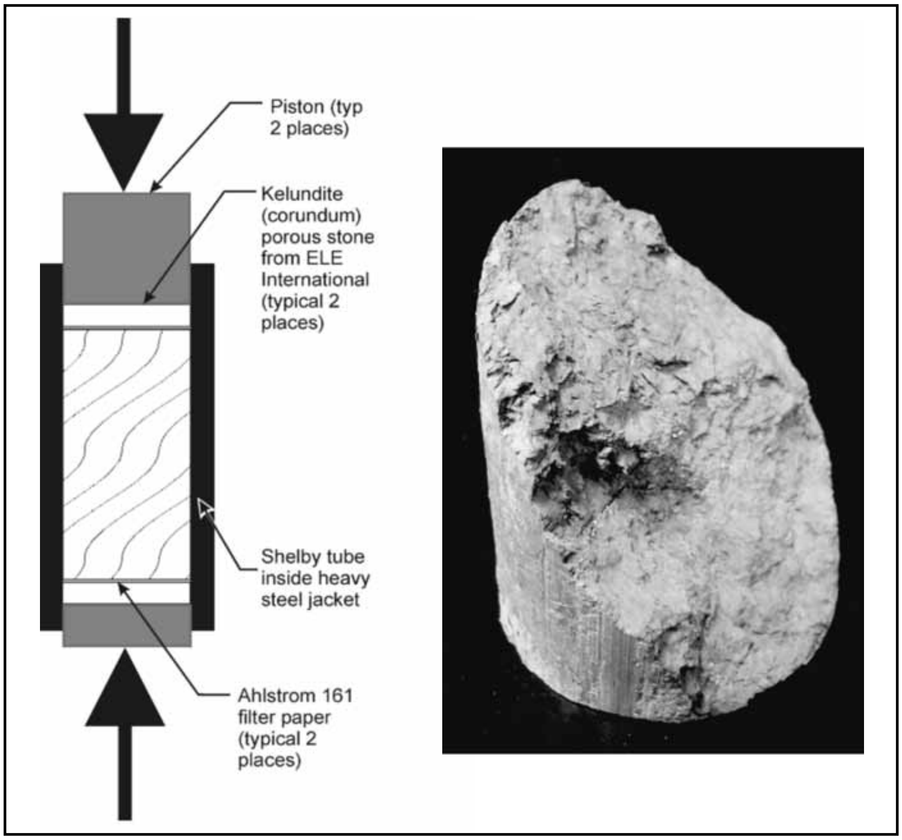

Figure 11. Schematic of test apparatus and photograph of resulting incipient claystone. A sample of fat clay was subjected to 900 psi (6 MPa) pressure, representing 300 m (1,000 ft.) of overburden, for 29 weeks. At the end of the period, it had consolidated to the borderline of unlithified sediment and rock.

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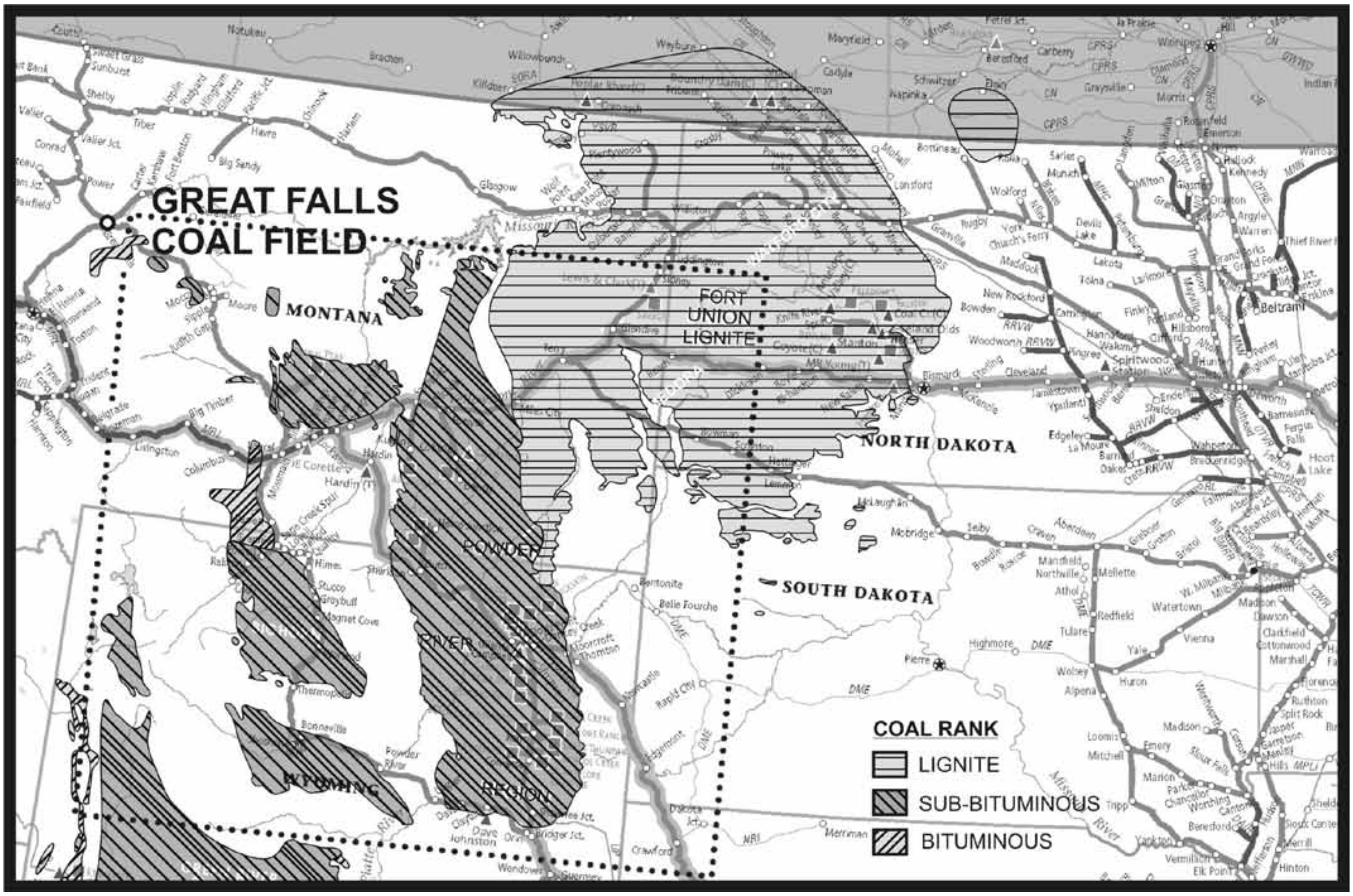

Figure 12. Map of extensive coal deposits of the north-central U.S.A. modified from Burlington Northern Santa Fe Railway figure. The generally higher rank of coal to the west and lower to the east corresponds to an inferred thinning of sedimentary cover (overburden) from west to east. Sandstone competence or hardness generally matches this gradient, but with many local exceptions. Square of dotted lines is area of primary commercial production (Powder River Basin).

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The Post-Flood Ark Dispersal and Early Pleistocene: Exegetical and Geological Notes on Genesis 8:13–22

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Abstract

This multidisciplinary research paper examines Genesis, Chapter 8:13–22 which is the immediate post-Flood phase of the global Genesis Deluge. In a companion paper, I previously performed an exegetical and geological analysis of Genesis, Chapter 8:1–12 which documented the receding phase of the global Flood which was responsible for depositing the Tejas Megasequence (Paleogene and Neogene of the geological column). The receding phase of the Flood described in Genesis 8:1–12 encompassed 135 days of highly significant Earth-shaping activity and is responsible for producing approximately a third of the total volume of the fossil-bearing portion of the geological column (Phanerozoic). The Tejas deposits are also responsible for the burying of numerous amounts of mammals, angiosperms, and many other plants and creatures living at higher pre-Flood elevations that are not found in lower (pre-Tejas) layers of the rock record. In this present analysis of Genesis 8:13–22, I exegete the Hebrew text showing that the earth surrounding the Ark landing site in the Middle East was completely dry by Genesis 8:14, and likely all the continents, which allowed for the disembarking of Noah, his family, and the animals off the Ark as noted in the following verses. Significantly, the Middle East is dominated by Tejas deposits of marine origin which were deposited in the receding phase of the Flood and according to the completed action of the verbal forms in the Hebrew text, was decidedly dry enough at the time of disembarkment and also for subsequent human development of the land of Shinar and the building of the tower of Babel.

Key Words: Genesis Flood, Pleistocene, Ice Age, post-Flood, N-Q Flood Boundary, Hebrew exegesis, Genesis, Chapter 8

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Introduction

The global Flood was forewarned of and preliminarily prepared for in Genesis, Chapter 6. In Genesis, Chapter 7, the Flood initiates with the bursting of the fountains of the great deep on day 1 with the Floodwaters progressively rising until they reached the Ark on day 40 (Johnson and Clarey, 2021). The first 40 days of the Flood were largely responsible for the sedimentary deposition of marine ecosystems and involved the initial megasequences of the Sauk (Cambrian, Lower Ordovician), Tippecanoe (Mid-Upper Ordovician, Silurian), and Kaskaskia (Devonian, Mississippian, and Pennsylvanian). At about day 40, we not only get the floating of the Ark, but the initial burial of tropical coastal land ecosystems which initiate the global sedimentation of progressively higher and more inland environments in the Absaroka and Zuni Megasequences (Clarey, 2020a). Continental separation of the pre-Flood Pangea megacontinent begins to accelerate about the middle of the Absaroka Megasequence (beginning of Triassic) and then continues through the Zuni (late-Jurassic and Cretaceous) (Clarey, 2020a). The Flood peaks at the end of Genesis 7 with the high-water mark being about day 150 where all the highest hills were covered with at least 15 cubits of water (about 22.5–30 feet) represented by the top of the Zuni Megasequence corresponding to just above the top of the Cretaceous System (Johnson and Clarey, 2021).

While the majority of the initiation and progression of the global Flood occurs within Genesis 7, it should be noted that one of the most critical parts of the global Flood occurs during Genesis 8:1–12 which I discussed in a previous paper (Tomkins, 2023). This would be called the receding phase in which huge amounts of Floodwater runoff occurred globally off the newly separated continents. This action was facilitated by the rapid uplift of mountain ranges such as those which occurred during the formation of the Rocky Mountains in North America and the Andes in South America. In fact, the receding phase of the global Flood is so important, that the most recent stratigraphic analysis of six continents indicates that 32.5% (personal communication, Timothy L. Clarey) of the total global volume of the fossil-bearing geological column (Phanerozoic) is composed of Flood runoff deposits known as the Tejas Megasequence (Clarey and Werner, 2023). It is noteworthy that the final receding phase of the Flood being represented in Tertiary rocks was acknowledged at the beginning of the Modern Creation-Science Movement in the epic book by Henry M. Morris and John C. Whitcomb (1961, p. 287), *The Genesis Flood*, in which they state: “In general, the record of the entire Tertiary [including Neogene] and early Quaternary…can be reasonably interpreted as preserving the record of the last phases of the Flood, including both the final deposits and geomorphic phenomena related to the [orogenic] rising of the lands and sinking of the [oceanic] basins that terminated the inundation.”

The receding final phase of the Flood not only has strong significance for explaining the vast amount of sediments in the Tejas, but it also affects the critical paradigm of where the end of the Flood exists in the rock record. The location of the Flood/post-Flood boundary has been hotly debated in creationist circles for the past several decades (Holt, 1996; Oard, 2004, 2010a, 2010b, 2011; Ross, 2012; Oard, 2013a, 2013b; Clarey, 2017, 2018; Clarey and Werner, 2019b; Clarey, 2020a, 2020b).

A proper determination of the post-Flood boundary is actually a critical issue to understand because it has direct connections to explaining the enormity of global Tejas strata along with massive amounts of Cenozoic animal and plant fossils, including extensive and thick Cenozoic coal seams (Clarey et al., 2021; Tomkins, 2021d; Tomkins and Clarey, 2021). In addition, a proper post-Flood model also has direct impact on key events such as human and animal dispersal from the Ark and the necessity of land bridges associated with the post-Flood Ice Age (Tomkins, 2021a).

Related to this whole debate are Biblical text issues regarding how quickly Noah and the animals left the Ark and dispersed post-Flood. The problem for early post-Flood boundary advocates who propose an end of Flood deposition at the top of the Cretaceous is the glaring fact that the entire Middle East, including regions immediately surrounding possible Ark landing sites around Mount Ararat, is covered in Tejas marine strata. In fact, many of these strata are of obvious marine deposition being composed of carbonate rocks (limestone) and salt deposits (Clarey and Werner, 2019a). While the most obvious explanation would be the acceptance of a late Flood boundary near the Neogene-Quaternary (known as the N-Q boundary), others are developing unlikely explanations to maintain their early post-Flood boundary models.

One such proposition is the unpublished claim by early Flood/post-Flood (K-Pg) boundary advocates that much of the post-Flood Middle East remained flooded and impassible to human dispersal (and presumably most animals too) for about 200 years after the Ark landed (personal communication, Timothy L. Clarey). The basic idea is that Noah, his family, and the Ark-borne animals remained in the mountains of Ararat for about 200 years while the waters continued to drain from Syria, Iraq, and Turkey. Then, presumably, once the region dried out enough to allow travel, Noah and his sons and their descendants traveled from the east to the Plain of Shinar and built Babel. While William Barrick has not committed to proposing any boundary for the post-Flood in the rock record to the knowledge of this author, he did propose the idea of a partially wet post-Flood world that seems to be the basis for this idea. In 2008 Barrick speculates (p. 275), "In essence, the Flood itself had ended when the surface of the ground was free of water on the 315th day. However, that does not mean that the waters had receded to pre-Flood levels. The water level may have remained significantly elevated for decades or even centuries."

But does the Hebrew text of the Genesis 8 narrative which covers this subject support the contention that after the Ark landed, the Middle East was still too wet to travel or does it indicate that it was dry enough to disperse according to God's commandment given directly to Noah in Genesis 8:15–17?: "Then God spoke to Noah, saying, 'Go out of the ark, you and your wife, and your sons and your sons' wives with you. Bring out with you every living thing of all flesh that is with you: birds and cattle and every creeping thing that creeps on the earth, so that they may abound on the earth, and be fruitful and multiply on the earth.'" While the clear directive given by God to Noah would seem evidence enough to answer this question, I have exegeted Genesis, Chapter 8:13–22, which not only counters this errant idea, but also better explains how it fits in with the immediate post-Flood Ice Age.

Exegetical Methods

Hebrew text analyses were facilitated by Accordance Bible Software (version 14) with the following packages: *Biblia Hebraica* with Westminster Morphology, Hebrew Masoretic Text with *Andersen-Forbes Morphology and Syntax Database*, and the *Hebrew and Aramaic Lexicon of the Old Testament* (HALOT). Owen's *Analytical Key to the Old Testament* (Volume 1, Genesis to Joshua) was also consulted (Owens, 1991) along with a variety of Hebrew reference grammars as cited in the text. The Hebrew transliterations in the following text are performed in SBL Academic format. English translation, unless otherwise noted, will be in the King James Version.

Genesis 8:13–22 Is Historical Narrative

Like Genesis 1 and many other parts of the Old Testament, Genesis 8:13–22 is Hebrew narrative giving historical truth, not poetry or mytho-history (Johnson, 2011; Drake, 2020; Tomkins, 2021b). This fact is distinctly defined by the Hebrew grammar where the majority of the verbal forms occur in what is known as a *waw-consecutive* in which the verb is prefixed by the letter *waw* and the verb itself is in the imperfect tense. This *waw* + imperfect tense grammatical construct effectively changes the normal imperfect tense (uncompleted action) into a perfect tense (completed action), hence the less-used term *waw-conversive*. While some Old Testament scholars question the regularity of this verbal rule, Pratico and Van Pelt (2019, p. 181) state, "Though the terminology 'past tense narrative sequence' is not commonly used, the term is descriptive of how the Imperfect with Waw Consecutive functions in narrative." Thus, these verbal forms consecutively and repeatedly describe completed historical events in the obvious historical narrative of Genesis 8. Since most of the verbal forms in Genesis 8:13–22 are *waw*-consecutives, I will try not to redundantly repeat this grammatical rule in the following exegesis. If a verbal construct is of a different form and conveys a significant and insightful meaning, I will take note of that. The style and format of Hebrew exegesis employed in this paper will be the same as that which I have used previously (Tomkins, 2022, 2023).

Genesis 8:13

"And it came to pass in the six hundredth and first year, in the first month, the first day of the month, the waters were dried up from off the earth: and Noah removed the covering of the ark, and looked, and, behold, the face of the ground was dry."

In the previous paper I discuss Noah's initial use of a raven (Gen. 8:7) and then several outings of a dove—each a week apart (Gen. 8:8–12) with the last bird mission involving the dove failing to return to the Ark (Gen. 8:12) (Tomkins, 2023). In this continuing scenario in verse 13, Noah had previously sent the dove out for the last time on the 285th day of the Flood. While this seemed to indicate that the land was sufficiently dry and vegetation had been established to support bird life, Noah waited another 29 days to remove the Ark's covering (possibly a part of the roof). At this point it had been 314 days since the Flood began and Noah actually then beheld the dry ground for himself.

This last part of the verse "and [Noah] looked" (*wayyarʾ*) followed by "and behold" (*wəhinnēh*) is interesting and has produced several helpful opinions by grammarians for this verse in particular. In an instance like this in which a *hinnēh* (behold) clause occurs after a verb (to look) is "without anticipation" of the object noun and "he saw and behold" = "he saw that" + "the surface of the earth had been dried up" which is a similar construction as occurs in Genesis 3:6 where Eve "saw that the tree was beautiful" (Joüon and Muraoka, 1991). Another Hebrew reference grammar expands on this idea in which this type of construction is said to be typically involved in a situation in which the observer is involved in a change of scene when they are "confronted with a new situation that is surprising to them" (van der Merwe et al., 2017). This linguistic construct known as *mirativity* is a means for indicating surprise on the part of the speaker (van der Merwe et al., 2017). Obviously, Noah was surprised and probably thoroughly elated to see this development after his long and traumatic 314-day ordeal in the Ark.

However, Noah must have also noted that while the ground was dry, the landscape was still not amenable to departure from the Ark. In fact, the last clause "*ḥārəḇû pənê hāʾăḏāmāh*" indicates that the "faces" (*pənê*) of the ground (*hāʾăḏāmāh*) were dry. Here we have Noah's subjective observation of what had been previously stated in the first part of the verse; "the waters were dried up from off the earth" (*ḥārəḇû hammayim mēʿal-hāʾāreṣ*), but it still leaves room for the whole earth to be fully dry for Ark disembarking which we eventually get to in the following verse. Nevertheless, the key grammatical point to make is that both forms of the verb *ḥāraḇ* (to dry) are in the qal perfect indicating a completed historical action. So at this point in the narrative, there was no longer a layer of water over the ground, but the soil was likely still too wet. Barrick in his helpful chronological summary of the Flood had noted that at this point it had been 90 days since the mountain tops had appeared and that the surface of the ground at this point was free of excess water (Barrick, 2008).

Cassuto notes regarding the timing given in verse 8:13 where it says, "in the first month, the first day of the month": "Precisely at the commencement of the year, on the anniversary of Creation, the world resumed again the form that God had given it when first it came into being" (Cassuto, 1964). While Cassuto, a Jewish Old Testament scholar and rabbi, was intriguing in claiming the significance of the date aligning with the annual anniversary of Creation, the world was hardly the same form as it was in the beginning at Creation. In fact, it was radically different as the apostle Peter notes: "Whereby the world that then was, being overflowed with water, perished" (2 Pet. 3:6). Cassuto actually clarifies what he was getting at in his exegesis of the following verse (v. 14) which I shall note shortly.

With the trauma of enduring the destruction of the world in a global Flood and Noah and his family being the sole survivors, Noah was obviously being extremely cautious not to do anything that might in the least conflict with God's purpose. However, he now felt that the present situation warranted the removal of the Ark's roof, here called "covering," *miksēh* from *kāsāh*, "to cover." After the covering was removed, Noah discerned with surprise and probably much delight that, as noted above, the surface of the ground was dry. In fact, the object noun construction "the surface (faces) of the ground" (*pənê hāʾăḏāmāh*) is clarified by the preceding verb in the qal perfect third plural (*ḥārəḇû*) to be dry.

Genesis 8:14

"And in the second month, on the seven and twentieth day of the month, was the earth dried."

At this point, Noah, his family, and the Ark's creatures have been inside the Ark for a little over a year at 371 days, and another 57 days have passed since Noah removed the covering from off the Ark and actually observed the dryness of the face of the ground. Noah is still being extremely cautious and awaiting the command of God to leave the Ark. And quite significantly, the earth is now fully dry enough for disembarking the Ark and its living contents disbursing throughout the Earth.

In all likelihood, these 57 additional days of waiting on the Ark had a definite practical purpose. It allowed vegetation time to germinate and grow on the previously dried-out surface. Rain after the Flood would have probably displaced the saltier Floodwater deeper into the subsurface and out of the top soil layers—allowing plants to grow and mature quickly after the Flood. This new growth provided food for the disembarked animals to feed on as they exited. If the land wasn't already dry for 57 days, it is unlikely there would have been any significant vegetation growth, and thus, the only food for the animals would have been on the Ark. So, getting off the Ark would have been futile if the land hadn't already been completely dry for nearly two months.

The dryness factor is emphasized by the clause *yāḇəšāh hāʾāreṣ* and the verb to dry (*yābēš*) is again used here as it was in the previous verse in the qal perfect denoting a completed historical event with "the earth" (*hāʾāreṣ*) as the object as opposed to "the ground" (*hāʾăḏāmāh*) in the previous verse—indicating a more global scope. Bandstra notes concerning this last clause in Genesis 8:14 that "So-called stative verbs, such as this one [*yābēš*], indicate the state of the subject [the earth]" (Bandstra, 2008). And in this verse, the proper level of dryness needed for the colonization of the newly reworked earth has been achieved. All speculation that somehow Noah, his family and the Ark's creatures somehow remained holed up in the mountains of Ararat for 200 years to wait for the earth to dry are utterly negated by a clear and normal reading of the Hebrew text.

Interestingly, Cassuto once again finds a parallel with the original Creation Week and helpfully notes that at this point in verse 14, "it was necessary to wait until the earth was *dried out* [*yāḇəšāh*] and returned to the state befitting the name it had received at the time of creation, when it was said (Gen. 1:9b): let the DRY LAND [*yabbāšāh*] *appear*" (Cassuto, 1964). Thus, just as the earth was properly dry in Genesis 1:9 for the continuation of the Creation Week in bringing forth vegetation on the Earth and living creatures, so also is the earth now fully and properly dry for the post-Flood restoration of plant life, animal life, and human life.

Genesis 8:15–17

"And God spake unto Noah, saying, Go forth of the ark, thou,

and thy wife, and thy sons, and thy sons' wives with thee. Bring forth with thee every living thing that is with thee, of all flesh, both of fowl, and of cattle, and of every creeping thing that creepeth upon the earth; that they may breed abundantly in the earth, and be fruitful, and multiply upon the earth."

Throughout the Genesis account of Noah, he was portrayed as a man who walked with God and obeyed Him and did not rely on his own reasoning. He built the Ark when he was told to, entered it when instructed, and now he receives the divine command to leave the Ark despite having already tested the earth's dryness (using the raven and doves) and observing the dry ground himself after removing the Ark covering. This speaking of God to Noah (*waydabbēr ʾĕlōhîm ʾel-nōaḥ lēʾmōr*) is ascribed to Elohim and not Yahweh as in Genesis 1 with the parallel of not only the departure of Noah and his family in view, but the repopulation of the Earth's land animals as well from the Ark's creatures. The verb *yāṣāʾ* for "Go forth" (*TWOT* 893; "go out, come out, go forth" (Harris et al., 1980)) is in the qal imperative as a direct command from Elohim which is further qualified by "from the ark" (*min-hattēḇāh*). Noah is not only commanded to come out of the Ark but his family with him and all of the Ark-borne creatures as well. Since the ground was now fully dry, God's command for Noah and every other living thing to get out of the Ark is clear.

And God not only commanded Noah to bring forth the Ark's creatures, but God makes another statement "that they may breed abundantly in the earth, and be fruitful, and multiply upon the earth." This statement by God is a reiteration of the original creation mandate of Genesis 1:26–28 and God instructs Noah to bring out the animals so that they might "breed abundantly" (*šāraṣ*), "be fruitful" (*pārāh*), and "increase" (*rāḇāh*) on the earth. This instruction is also reminiscent of God's blessing upon the initial animal kinds in creation (Gen. 1:22), where God blessed them in similar language to be "fruitful" (*pārāh*) and "increase" (*rāḇāh*).

This command concerning the Ark's creatures involves two key points worth noting. First, the innate capacity of creatures to dynamically adapt to a broad range of environmental conditions, is a marvelous testimony to the handiwork of an omnipotent Creator in engineering robust biological systems. Second, God's command given to creatures to reproduce and be fruitful also necessarily implies His superintending providence to bring the global biological colonization of the post-Flood world to pass. Elohim's purposes and decrees will not be thwarted.

But from a geological and geographic perspective, this Divine narrative further negates the errant idea that somehow the Middle East was too wet and Noah and the Ark contents had to stay put for another several hundred years for things to dry out. In fact, as I will discuss later, the geologic and climatic conditions in the immediate post-Flood era were providentially orchestrated to allow for the global dispersal of animals and humans through the development of intercontinental land bridges formed during the post-Flood Ice Age.

Genesis 8:18–19

"And Noah went forth, and his sons, and his wife, and his sons' wives with him: Every beast, every creeping thing, and every fowl, and whatsoever creepeth upon the earth, after their kinds, went forth out of the ark."

In response to God's command, Noah obediently went forth along with his sons, and his wife, and his sons' wives. The use of *yāṣāʾ* (to go) here stands in stylistic symmetry as the story of exiting the Ark began with God's command in verse 16 "go forth" and then the verb *yāṣāʾ* was used again by itself twice in verses 17 and 18; "bring forth" and "went forth," respectively (Cassuto, 1964). In other words, the obedient conclusion here in verse 18 corresponds to the opening words.

The creatures from the Ark were also brought forth; every beast (*kol-haḥayyāh*), every creeping thing (*kol-hāremeś*), and all flying creatures (*wəḵol-hāʿôp̱*), and all of the creeping things that creep upon the earth (*kōl rômēś ʿal-hāʾāreṣ*). It is reasonable to assume that this was done in a very orderly and progressive manner. Leupold states, "all creatures are not simply to be liberated to trot forth from the ark in wild confusion, which confusion might have resulted in the death of the weaker creatures" (Leupold, 1942).

Another interesting point is that the KJV says that the various types of animals went out by their "kinds" which would imply the Hebrew word (*mîyn*) as was used in Genesis 1 and was also used in Genesis 7:14 describing the animal contents of the Ark; "They, and every beast after his kind (*mîyn*), and all the cattle after their kind (*mîyn*), and every creeping thing that creepeth upon the earth after his kind (*mîyn*), and every fowl after his kind (*mîyn*)." However, the actual phrase in Genesis 8:18 is according to their "families" (*mišp̱āḥāh*). Mathews notes, "Although this reminds us of the creation refrain 'after its kind' (*mîn*), the different Hebrew word in v. 19 for 'kind' (*mišpāḥa*) points ahead rather than to the past" (Mathews, 1996). In other words, the use of the word "families" implies the reproductive fruitfulness of each kind of creature as it goes forth into the earth filling ecological niches for which it has the internal programming to diversify and adapt.

Genesis 8:20–21

"And Noah builded an altar unto the LORD; and took of every clean beast, and of every clean fowl, and offered burnt offerings on the altar. And the LORD smelled a sweet savour; and the LORD said in his heart, I will not again curse the ground any more for man's sake; for the imagination of man's heart is evil from his youth; neither will I again smite any more every thing living, as I have done."

Significantly, Noah's first recorded act after disembarking from the Ark is to build an altar to the LORD (Yahweh) in verse 20. On the altar (*mizḇēaḥ*) he built, he presents whole-burnt offerings, using some of the clean animals and birds. There are different views on the nature of this offering. One view is from the Jewish perspective of Cassuto who proposed that these offerings of Noah were not sacrifices of atonement because "there was no need for atonement, since suffering and death [of the Flood] purge away human iniquities" (Cassuto, 1964). Cassuto thus concludes that these sacrifices were solely an act of thanksgiving to Yahweh for delivering Noah and his family from the terrible year-long judgment of the global Flood.

The second and considerably more popular evangelical view is that while this offering does in fact express gratitude for God's deliverance, it is also an act of atonement (ESV Study Bible, 2008). The reasoning is that this is a normal aspect of burnt offerings and is accompanied by the mention of a pleasing aroma (citing Lev. 1:3–17) as an anthropomorphic description of the Lord's pleasure. Proponents of this view also note that the "Hebrew term for 'pleasing,' *nikhoakh*, conveys the idea of rest and tranquility" and "is related to the name 'Noah' (Heb. *Noakh*)" [*nōaḥ*] (*ESV Study Bible*, 2008). The main idea of this view being that the "burnt offering soothes God's anger at human sin" (*ESV Study Bible*, 2008). Roland McCune helpfully notes, "the idea of a sacrifice being a 'soothing aroma' appears to the thought of producing a calming or placating effect (Gen 8:21; the phrase is used 43 times in the Old Testament)" (McCune, 2009). Furthermore, we also have the early post-Flood example of the patriarch Job making burnt offerings for the sins of his children (Job 1:5). In this respect, Noah's offering was also a sacrifice on behalf of post-Flood humanity as well as an act of thanksgiving. Just as Job mediated for his family in the early post-Flood world, Noah was acting in a role of priest for the totality of the new post-Flood world. And because Noah had a strong and faithful devotion to God, for "he walked with God" (Gen. 6:9; 7:1; 8:1; Heb. 11:7), his sacrifice pleased the Lord.

We also see God's grace at work in accepting Noah's sacrifice and establishing a new basis for His relationship with the world in the following statement, "and the LORD said in his heart, I will not again curse the ground any more for man's sake." The verb used here for curse (*qālal*) is different from the verb *'ārar* (to curse) that was used in the original Adamic curse on creation in Genesis 3:17 ("*cursed* is the ground for thy sake"). Some have incorrectly argued here in Genesis 8:21 that God lifted or alleviated the original Adamic curse against the ground (*'ăḏāmāh*) after the global Flood. Because of the connection between Genesis 8:21c and Genesis 6:5b regarding an acknowledgement of the evil inclination of man's heart, we get the final clause of 8:21 ("neither will I again smite any more every thing living, as I have done"). This second statement substitutes the verb to smite (*nākāh*) for curse (*qālal*) and is preceded by the expression "I will not add again" (*wəlōʾ-ʾōsip̱ ʿôḏ*) translated "neither will I again." Here Michael Grisanti in *NIDOTTE* helpfully notes that this, "demonstrates that God promises not to judge humankind through a universal catastrophe as he had with Noah's Flood" and "God will never again curse the *אֲדָמָה* [*'ăḏāmāh*] because of an *אָדָם* [*'āḏam*]" (VanGemeren, 1997).

Genesis 8:22

"While the earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease."

The previous assurance that the Earth would no longer be destroyed by a global deluge is further elaborated upon here. The sentence starts with the idiomatic phrase "still while all the days of the earth" (*ʿōḏ kol-yəmê hāʾāreṣ*) translated as "while the earth remaineth" indicating that the remainder of the present post-Flood Earth will continue in a seasonal cycle until its final fiery destruction and the new heavens and the new Earth take its place (2 Pet. 3:10; Rev. 21:1). This emphasis on cyclic continuity is elaborated by "seed [seedtime] and harvest" (*zeraʿ wəqāṣîr*), "cold and heat" (*wəqōr wāḥōm*), "summer and winter" (*wəqayiṣ wāḥōrep̱*), and "day and night" (*wəyôm wālaylāh*). All of these seasonal cyclic descriptors are followed up by the negation of the verb *šāḇaṯ* (*lōʾ yišbōṯû*). This application of the negative particle *lōʾ* before the imperfect form of the verb is a special use that implies an absolute or permanent prohibition (Pratico and Van Pelt, 2019). An example of this is the "you shall not" for each of the ten commandments in Exodus 20:4–17.

While we are given the seasonally cyclic nature of the ensuing post-Flood world, it stands in contrast to the previous world before the global cataclysm. However, the climatology of the pre-Flood world is largely a mystery. Based on the longevity of humans as recorded in Genesis and the recent discoveries of apparent longevity of reptiles in the fossiliferous record of the Cretaceous (Sereno et al., 2001; Ricklefs, 2010), the environmental conditions appear to have been much more favorable to life. This may have been facilitated by higher levels of oxygen and perhaps even greater air pressure (Clarey, 2020a). Since God ordained the consumption of animals by humans after the Flood (Gen. 9:3), the greater pre-Flood longevity of animals and humans may have also been due in part to nutrition from plant kinds that were limited in extent or extinct after the Deluge.

Geological and Geographical Notes on the Post-Flood World

In a previous paper on Genesis 8:1–12, I explained how the final sedimentary rock layers were laid down in the receding phase of the global Flood as the newly separated continents and their mountain ranges were being uplifted and the sediment-laden waters poured off the continents (Tomkins, 2023). These last Flood layers formed what is known in the geologic column as the Paleogene and Neogene of the Cenozoic era and is also referred to as the Tejas Megasequence (Clarey, 2020a). The fossiliferous sediments of the Tejas are full of creatures that were apparently living at higher elevations in the pre-Flood world (Tomkins, 2021d).

Just above the Tejas are thin strata in various locations around the world that are called Pleistocene. While some of these deposits may actually be late-Flood rocks, the majority were likely formed after the Flood from the unique climatic conditions that occurred. In general, Pleistocene strata are typically composed of unsorted (random-size fragments) and unstratified (loose and not solidified) rocks and sediment as compared to the lower Flood layers of the geologic column that form distinct solid (lithified) strata (Tomkins, 2021c).

The Post-Flood Ice Age

One of the defining features of the Pleistocene is the global evidence of a post-Flood Ice Age (Tomkins, 2021c). Many of these geological deposits can still be observed in receding glaciers that are active around the world today. Continental glaciers, in particular, produce several distinctive geological features that we find in Pleistocene strata. One of these features is known as drumlins, which are low elongated hills containing the rock debris left behind by the glacier at its base. They are typically aligned with the direction of the flow of the ice. Another feature is known as end moraines, which contain what is called glacial till (loose rock) that forms at the end of the glacier where it is melting as fast as advancing and is often perpendicular to the glacial flow direction. Lateral moraines may even extend to the sides of the glacier or look like curved lobes, defining the path of the glacial advance. These, and other features like erratics (out-of-place rocks) from the Ice Age are found in lower latitudes than today's ice sheets and glaciers. These provide evidence that ice sheets in both the northern and southern hemispheres extended to lower latitudes than exist today and have since melted significantly.

While secular scientists have great difficulty explaining evidence of an Ice Age and have literally put forth dozens of speculative theories, a Biblical solution based on the global Flood fits the data closely. In this model, it is proposed that an outright Ice Age began shortly after the Flood (within 200 years) and may have only lasted for about 500 years (Hebert, 2021). The mechanism for the Ice Age event has been aptly applied as a four-point model using the acronym HEAT: 1) <u>**H**</u>ot oceans during the Genesis Flood were produced by the production of an entirely new seafloor of hot, molten material from the Earth's interior during the Flood and hot waters from "the fountains of the great deep" (Genesis 7:11). The hotter ocean water would have kept the coastal regions free of ice by creating a warmer micro-climate for animal and human dispersal along the edges of the continents and the exposed land bridges, 2) <u>**E**</u>vaporation into the atmosphere from the warm oceans would have increased levels of atmospheric moisture, allowing for high levels of snowfall over the cooler mid-to-high-latitude regions, 3) <u>**A**</u>erosols (airborne particulates) filling the atmosphere from the enormous amounts of subduction zone volcanic activity that occurred at the end of the Flood (Clarey, 2019) and post-Flood that would have resulted in blocking significant solar radiation—creating a cool climate for snow and ice to accumulate and, 4) <u>**T**</u>ime (500 years) would have been involved in this overall process of extended post-Flood volcanic activity that continued as the Earth was equilibrating from the massive amount of plate tectonics that had occurred during the Flood (Baumgardner, 2003).

Ice Age Land Bridges

Research in megasequence stratigraphy and Flood-based plate tectonics and subduction has shown how the pre-Flood Earth had originally been composed of essentially one large megacontinent called Pangaea that split apart into the global continental configuration of the seven continents we see today (Clarey and Werner, 2018; Clarey, 2020a). Not only is this massive level of tectonic activity and new seafloor production important in explaining the HEAT model of the Ice Age, but it also directly relates to the ability of humans and animals to repopulate the Earth after the Flood.

When the present geographical separation of continents by oceans is observed, it is difficult to explain how the various kinds of animals on the Ark could have dispersed around the Earth. However, when we take into account the post-Flood Ice Age, the problem readily disappears. The Ice Age would have created land bridges all around the world by exposing dry land as large proportions of the world's water would have been trapped as ice. In fact, the massive amount of water stored in ice sheets would have fortuitously lowered sea levels by 200 to 280 feet below today's level (Clarey, 2016; Tomkins, 2021c). The resulting land bridges would have made excellent pathways and migration routes for animals and humans to simply walk to the major continents.

One such interesting trail of evidence that serves as a good example of the land-bridge paradigm has to do with the presence of kangaroos in Australia. How is it that kangaroos only live in Australia, and how did they get there? In a recent discovery, kangaroo cave paintings have been documented in India, yet no kangaroos are known to currently live in India (Thomas and Clarey, 2021). However, India lies in the middle of the path across lower Asia leading from the landing site of Noah's Ark to Australia. Furthermore, there exists a submerged former land bridge connecting Asia to Australia that would have allowed the kangaroos to migrate. The reason that we typically only find certain types of animals on the various continents is because of this selective migration that occurred post-Flood for 500 years and was then brought to an end as the land bridges got covered with ocean as the vast amounts of frozen water bound up in the Ice Age melted.

The Mysterious Wooly Mammoth

Another defining feature of the post-Flood Pleistocene seems to be the evidence of large body-size (to conserve heat) and more hair as insulation, especially in creatures with the innate programming to live in the cold climates at higher latitudes. An excellent example of this is the wooly mammoth which was essentially a type of elephant that expressed the traits needed to live in cold climates, having a very large body-size compared to other types of elephants and a thick coat of hair. There is evidence that large herds of mammoths roamed the northern plains of Siberia and North America and that they were hunted by post-Flood humans for their meat and valuable hides.

Even today, we see large mammals living in the extreme cold of the north, such as walruses and polar bears. Like the mammoth among the created elephant kind, polar bears are the largest of the bear kind. This evidence of scaling is an innate adaptive mechanism built into creatures by their Creator. It is common to see larger variants of a created kind in cold climates while smaller variants of the same kind inhabit warmer environments at lower latitudes. And of course, one trait of creatures that have self-adjusted to warm environments is that they usually have less hair.

Summary and Conclusion

The Hebrew text of the Genesis narrative in 8:13–22 does not support the contention that the Middle East and parts of the Earth were too wet to allow dispersal from the Ark landing site. In fact, the repetitively utilized completed action of the Hebrew verb "to be dry" (*ḥārab̲*) along with the context indicates that the earth was dry enough to disperse according to God's commandment given directly to Noah in Genesis 8:15–17; "Then God spoke to Noah, saying, 'Go out of the ark, you and your wife, and your sons and your sons' wives with you. Bring out with you every living thing of all flesh that is with you: birds and cattle and every creeping thing that creeps on the earth, so that they may abound on the earth, and be fruitful and multiply on the earth.'"

The majority of the Pleistocene sedimentary layers are from post-Flood glacial and associated climatic activity during the roughly 500-year period of the Ice Age and are directly connected to the mechanisms surrounding the Flood. In fact, the Ice Age brought about by the tectonic activity of the Flood providentially lowered global sea-levels and provided the phenomena of temporary intercontinental land bridges so that the Earth could be repopulated by animals and humans after the Flood. Only the activity and conditions generated by the global Flood can explain the Ice Age, which was a key part of God's plan in the judgment and subsequent restoration associated with the global Flood.

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What Is the Meaning of the Floods on Mars? Part I: Their Surprising Discovery

Michael J. Oard

Key Words: Crater dating, glaciation, gullies, impacts, Mars, Mars floods, Mars magnetism, outflow channels, valley networks, Valles Marineris, volcanism

Abstract

Uniformitarian scientists were surprised to discover channels on Mars like the Channeled Scablands of eastern Washington. Climate models indicate that large-scale Martian floods are impossible. This paper will describe what appear to be flood features on Mars. Three types of channels on Mars are described in this paper: valley networks, outflow channels, and gullies. Like the Solar System's other solid bodies that have not been resurfaced by debris and volcanism, Mars possesses numerous impact craters, some very large, which provide a framework for the planet's history. Secular uniformitarian scientists divide the geologic history of Mars into four main periods which span 4.5 billion years.

Introduction

Numerous satellites and ground probes of Mars have produced unexpected discoveries, including features that imply catastrophic floods. These surprises are not unusual; nearly every satellite and probe into the Solar System brings unexpected results that challenge their expectations and should challenge the uniformitarian paradigm (Psarris, 2009). Even their cherished 'big bang' hypothesis seems at risk (Psarris, 2012, 2016). This initial paper, and two subsequent papers, will explore evidence of floods on Mars and several other features that might have been concurrent with Earth's global Flood.

The Great Surprise of Discovering Catastrophic Floods on Mars

Early satellites sent to Mars astonished scientists with abundant evidence of gigantic floods. Planetary scientist, Michael Carr (2012, p. 2194), exclaims:

> "Discovery of Mars' branching valley networks during the Mariner-9 mission in 1972 was a complete surprise because, by that time, we already knew that Mars had a very thin CO_2 atmosphere and that the surface was much too cold to permit streams of liquid water at the surface."

Catastrophic flood specialist, Victor Baker (2001), calls the floods on Mars another *outrageous hypothesis*, similar to that of J Harlen Bretz regarding the Lake Missoula flood (Bretz, 1923a, 1923b). So, uniformitarian scientists will concede large floods on Mars, with no surface liquid water, but reject the idea on a planet with over 70% surface-water coverage (Bates, 2005).

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Mars' outflow channels are similar to the Channeled Scablands of eastern Washington, USA (Oard, 2004, 2014). Another type—narrower channels similar to terrestrial river valleys—are called valley networks (VNs). VNs are generally about 1 to 5 km wide, about 50 to 350 m deep, and up to 4000 km long (Howard et al., 2005). The multiple diverging and converging channels in the Channeled Scablands can be a few tens of km wide and up to 200 km long, cut into soft silt of the Palouse Formation and the hard Columbia River Basalts as displayed by the red areas of Figure 1. In the Channeled Scablands of eastern Washington, numerous streamlined hills were left as erosional remnants, as shown in Figure 2. In the outflow channels of Mars, shown in Figure 3 for Kasei Valles, teardrop shaped islands, similar to those shown in Figure 2, longitudinal striae in rock, cataracts, plucked zones, and inner channels occur, similar to those of the Lake Missoula flood (Carr, 2006, p. 114). A few of the Mars outflow channels indicate much larger flows: "Results indicate that paleodischarges may have been 10 to 100 times greater than the known largest prehistoric floods on Earth" (Komatsu and Baker, 1997, p. 4151). These obviously challenge uniformitarianism.

Climate Models Indicate Flooding on Mars Impossible

Flooding on Mars is difficult to explain when considering uniformitarian climate models for Mars, which predict very cold, dry conditions:

> "However, recent 3-dimensional climate models predict a cold and icy early Mars…, in which water is preferentially deposited in the highlands as snow and ice and MAT [mean annual temperature] is ~225 K, well below the melting point of water…." (Rosenberg et al., 2019, p. 379)

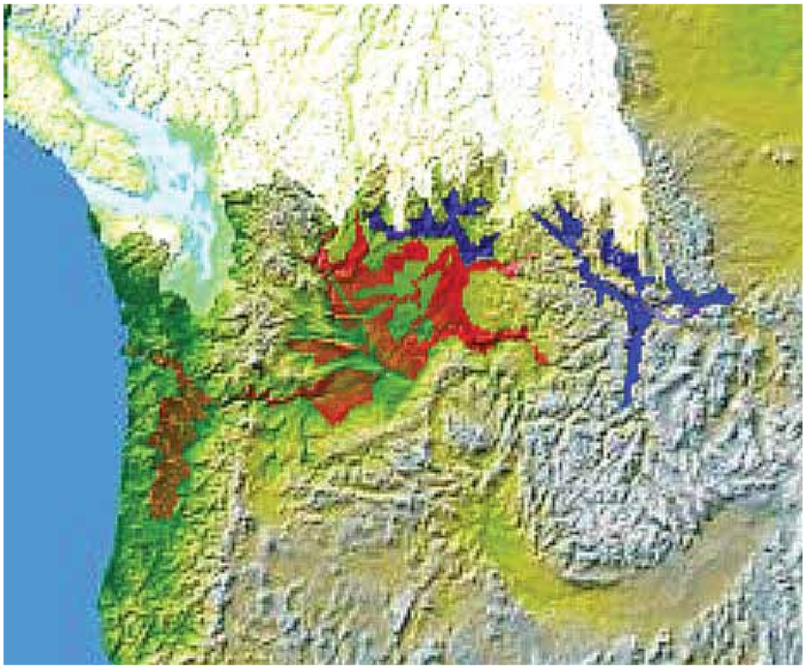

Figure 1. Path of the Lake Missoula flood (red) showing the extent of the southern Cordilleran Ice Sheet with glacial lakes Missoula and Columbia in blue (Matthew Trump, Wikipedia Commons CC-BY-SA-3.0 mitigated).

Floods on Mars imply a warm, wet climate. The conundrum is greater since the naturalistic origin model claims that solar luminosity was consistently reduced with time during most of Mars' history (Steakley et al., 2019), as shown by the graph in Figure 4. It would have been about 25% less than today at about

Figure 2. Streamlined silt hills from the Channeled Scablands just southwest of Palouse Falls.

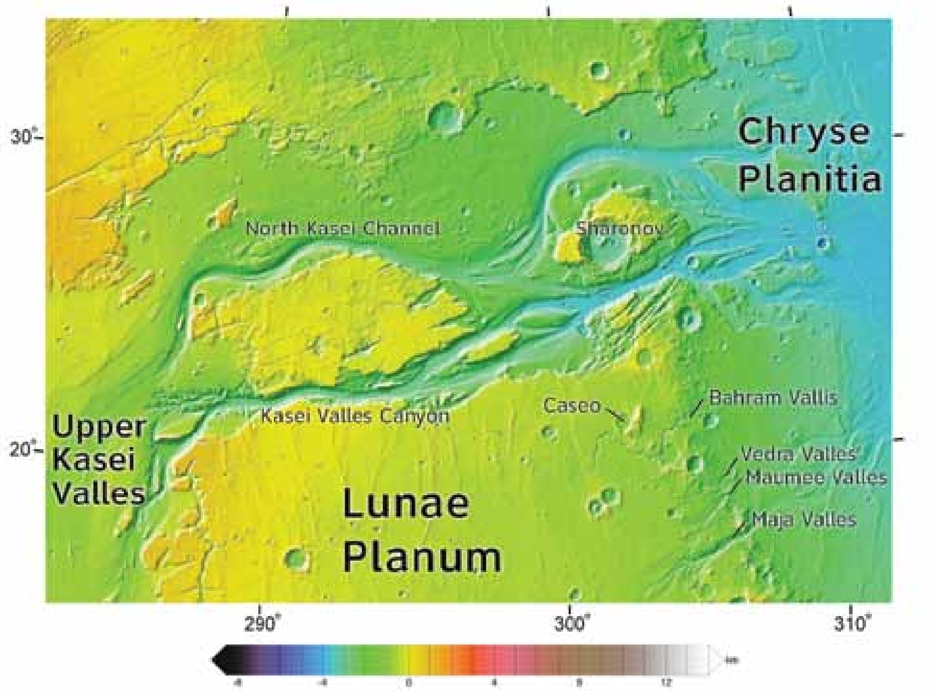

Figure 3. Kasei Valles on Mars (Aldaron, Wikipedia Commons CC-BY-SA-3.0). Note anastomosing path and teardrop-shaped erosional remnants.

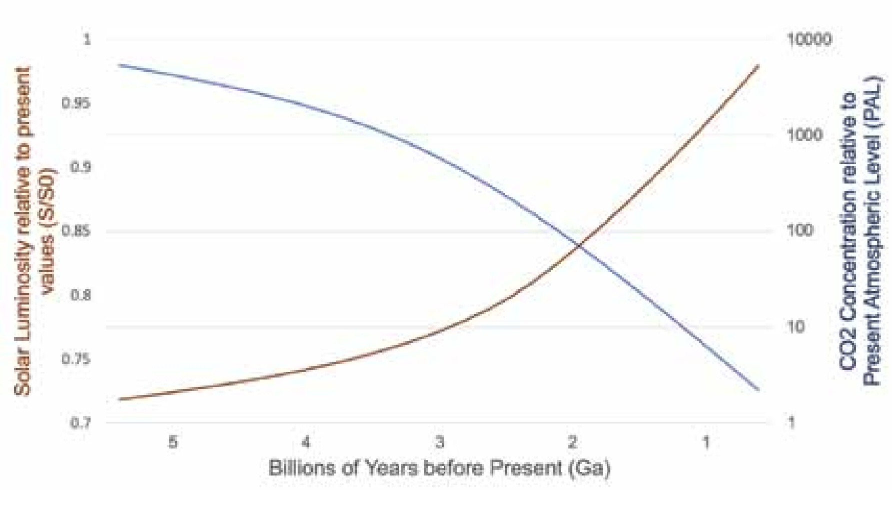

Figure 4. Historical decrease back in time in solar luminosity vs. CO_2 on Earth relative to the present due to the faint young Sun hypothesis (Gretashum, Wikipedia Commons CC-BY-SA-4.0). The values of solar luminosity on Earth also apply to Mars.

3.8 Ga (Wordsworth, 2016). It is already 43% less than Earth, due to distance. Early Mars would have had 1/3 the solar radiation Earth has today (Cang and Luo, 2019). So how did Mars have a warm, wet climate? Some think it never did (Carr and Head, 2003) while others continue looking for answers.

The faint young Sun hypothesis predicts Precambrian glaciation. Some periods of intermittent glaciation are inferred, but it is surprising that it was not one long period of global glaciation (Oard, 1997).

Researchers are struggling to come up with other potential mechanisms. One is high levels of greenhouse gases, but uniformitarians consider this unlikely, especially for "older" times:

> "Mars is presently so cold (average temperature of -60°C) that water freezes and ice subsequently sublimates. In fact, low solar luminosity would have kept Mars below freezing temperatures during its entire history regardless of how much green house [sic] gases such [sic] CO_2 were present. Despite the cold climate conditions, abundant geological, morphological, and sedimentological features indicate that liquid water flowed on Mars and in some cases accumulated in lakes." (Heydari et al., 2020, p. 12)

Numerous climate models have been developed. Researchers have learned that a CO_2 atmosphere is not warm enough (Wordsworth, 2016). Multiple bars of CO_2 cannot produce temperatures needed for liquid water (Wordsworth et al., 2013). Adding water vapor is not much help either. So, they claim higher hydrogen concentrations, an important greenhouse gas (Haberle et al., 2019), might cause warmer temperatures (Ramirez et al., 2014; Mangold, 2021), although its source has not been identified.

Perhaps the water came from volcanism (Navarro-Gonzáles et al., 2019). The Tharsis volcanism would have added up to 1.5 bars of CO_2 and 120 m Global Equivalent Layers (GEL) of water (Kamada et al., 2020). A GEL is a water layer covering Mars. However, it is unknown when Tharsis volcanism occurred—some say before flooding (Phillips et al., 2001) and some say after (Turbet et al., 2020).

The Planet Mars

Planetary scientists hope to solve the mystery flood features by accumulating more data on Mars. Figure 5 shows the general topographic features of Mars including the low altitude Northern Hemisphere with its higher ice cap, the Tharsis bulge showing the tall volcanoes, the higher and rougher Southern Hemisphere with its even higher polar ice sheet, and the deep Hellas (the blue area right) and Argyre impact craters (the green area left). All this information has been driven by the hype for Martian life (Carr, 2006). Despite a false alarm from what is believed to be a Martian meteorite in Antarctica, no life has been found (Sarfati, 1996, 2022). So, planetary scientists have been looking for the next best thing—water. Mars has plenty, but in a frozen state (Faulkner, 2009).

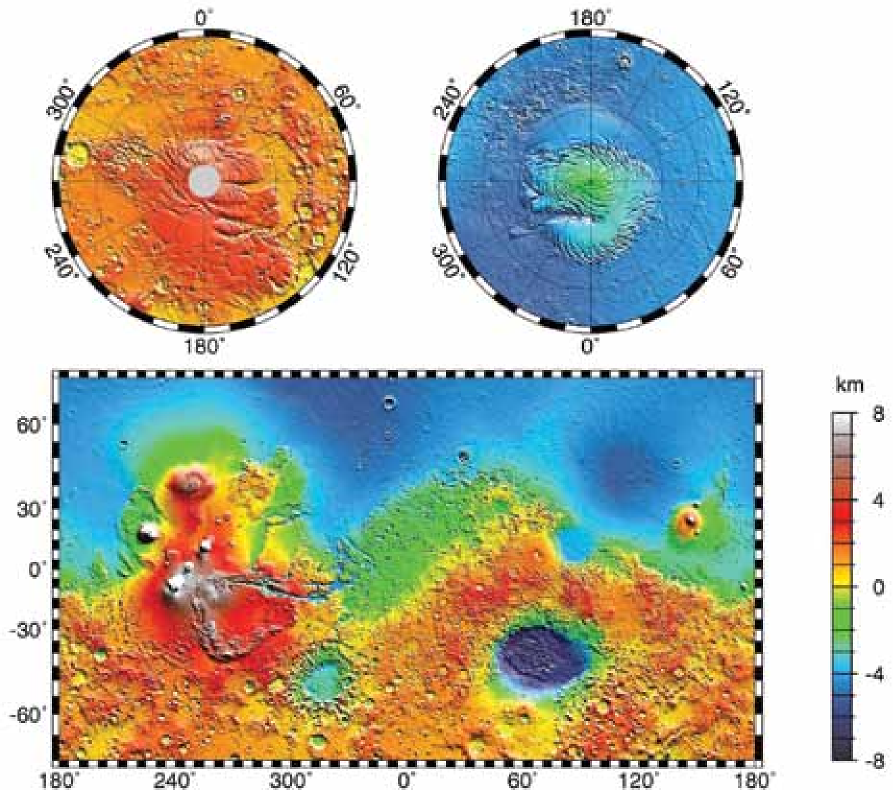

Figure 5. Map of Mars topography, including the north and south polar areas from the Mars Orbiter Laser Altimeter (MOLA) (NASA).

Mars Believed Formed from a Collapsing Dust and Gas Cloud

Uniformitarian cosmology assumes the Solar System formed from a collapsing nebula about 4.5 billion years ago. The Inner Solar System is rocky, while the outer planets are gas giants. There are numerous problems with that origin story (Chambers, 2004; Psarris, 2009; Sarfati, 2010). In it, dust and gas must first concentrate in the plane of the ecliptic (Chambers, 2004). Then dust must coagulate quickly into mountain-sized planetesimals, before particles are dispersed by solar radiation pressure, which formed first. Gravitational attraction and collisions developed planetesimals into planetary embryos, which collided to form the inner planets. Each step presents numerous problems.

It is believed that planetesimals impacted Mars early in its history—the Early Heavy Bombardment (EHB), of which there is little trace left (Oard, 2012). The EHB would have caused Mars' surface to be a "magma ocean," which is also believed to be the main reason why astronomers cannot detect much evidence for the EHB (Bottke and Norman, 2017).

As Mars cooled and the surface solidified, impact craters finally formed. Some astronomers place this at the end of the EHB; others call for a Late Heavy Bombardment (LHB). The LHB is controversial (Morbidelli et al., 2018; Brasser et al., 2020). Despite having no clear cause, proponents place it at about 4 Ga or even 3.9–3.5 Ga (Ćuk et al., 2010). Very few planetesimals should have existed then. After the LHB, impacts decreased dramatically.

Orbital Characteristics

Mars has a diameter of 3390 km, intermediate between Earth and the Moon. It possesses a core, mantle, and basaltic crust. It has an axial tilt of 25° at present but has supposedly ranged from 10° to 45° over the past 20 million years (Lasker et al., 2004). Mars, therefore, has seasons like Earth with warmer temperatures near the equator and cooler temperatures at higher latitudes and altitudes. Its orbit has a high eccentricity of 0.093, as compared to Earth's 0.017 (Carr, 2006). So, aphelion is 1.666 Astronomical Units (AUs), while perihelion is 1.495 AU. Mars has 28% of the Earth's surface area but has about twice the relief, ranging from 29.4 km at the top of Olympus Mons to the -8.2 km on the floor of the huge Hellas impact crater.

The Mysterious Crustal Dichotomy

Mars' crust ranges from 6 km to 102 km thick, averaging 45 km (Carr, 2006, p. 82). The Northern Hemisphere averages about 30 km, and the Southern Hemisphere, about 50 km. This is the "crustal dichotomy" that results in a topographic dichotomy as shown in Figure 5. The southern, well-cratered highlands are about 5 km higher than the northern lowlands. The slope of that boundary varies from a gentle, northward decline over 2500 km in northwest Arabia Terra to the same elevation drop within 250 km around the Isidis impact crater (Carr, 2006, p. 80).

The cause of the crustal dichotomy is much debated. Some believe the low Northern Hemisphere was formed by a giant impact (Andrews-Hanna et al., 2008; Citron, 2021) or several large ones (Manske et al., 2021). Others think it was caused by internal features, such as long-lived, single-plume mantle convection (Roberts, 2021). There are a variety of models. One evidence against the impact models is that the crust is not locally thinner beneath proposed Northern Hemisphere impacts, while it is locally thinner under Southern Hemisphere impacts, such as Hellas (Carr, 2006, pp. 82–83).

The Extremely Thin Atmosphere

The atmospheric pressure of Mars ranges from 6.9 to 9 mbar (Carr, 2006), compared to Earth's ~1000 mbar. It

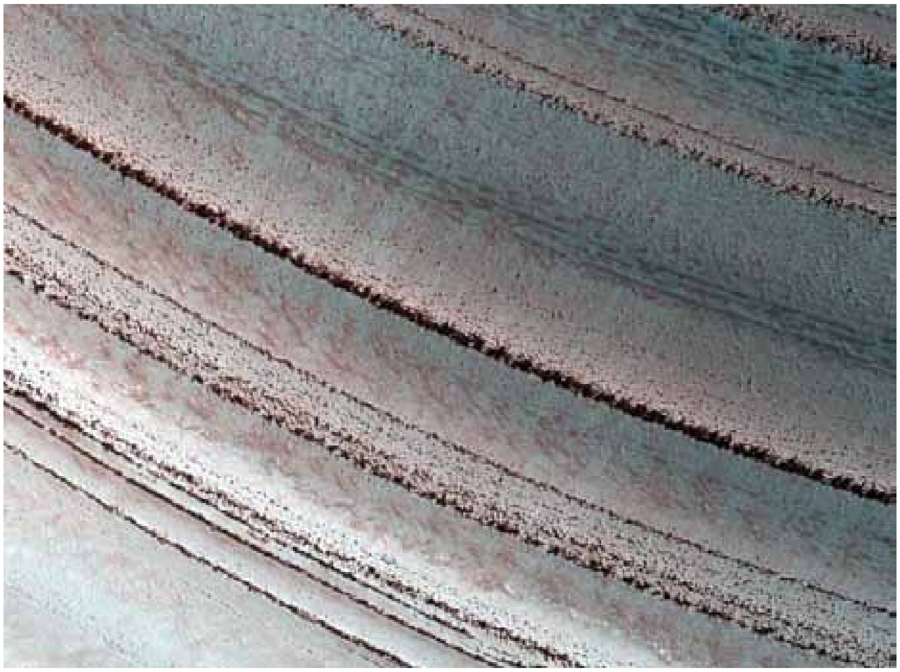

Figure 6. The Martian north polar layered deposits within the North Polar Ice Sheet from the Mars Reconnaissance Orbiter (NASA). The layers are assumed to record climate variations. The vertical scale of the light and dark bands is 10–80 m.

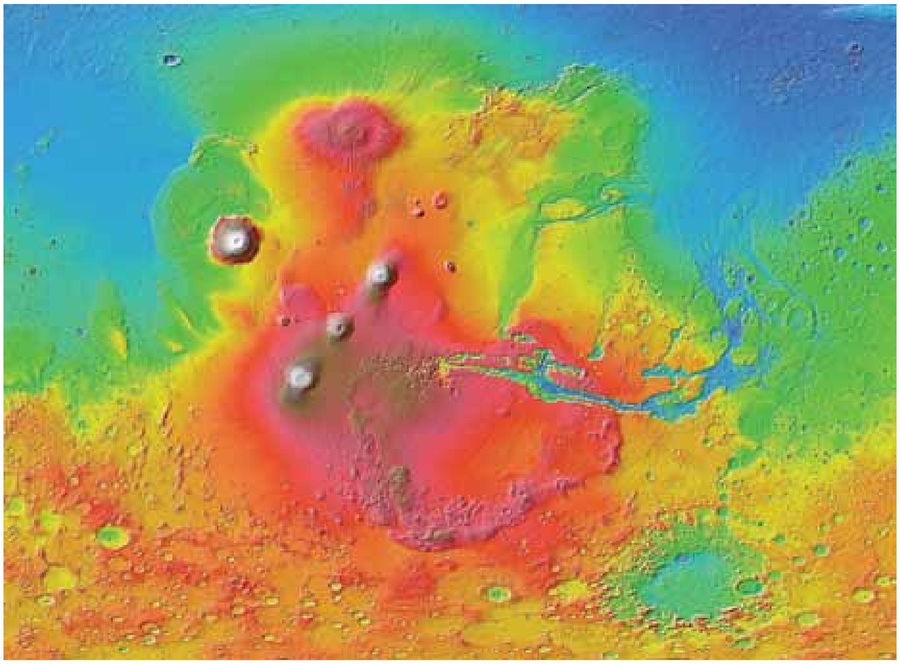

Figure 7. Mars Orbiter Laser Altimeter (MOLA) colorized topographic map of the western hemisphere of Mars, showing the Tharsis volcanic bulge, the Valles Marineris region, and the Kasei Valles. The Argyre impact basin is at lower right (NASA). Color code the same as on Figure 5.

is 96% carbon dioxide with a minor amount of water vapor. There are seasons with a low-to high-latitude temperature decrease and circulation, like Earth. The average surface temperature is 210°K (-113°F) but can range from 140°K (-240°F) at the poles to 300°K (81°F) during summer in the Southern Hemisphere (Carr, 2006). The diurnal range of temperature on Mars varies with latitude and season and is up to about 80°C (144°F) (Carr, 2006). The atmosphere can become very dusty and windy at times, and there are numerous sand or dust dunes on the surface. The atmospheric pressure must have been much higher during its floods.

Ice on Mars— Another Great Surprise

Uniformitarians were also surprised by abundant evidence of frozen water at the mid-and high-latitudes. The mid-latitudes have glaciers (Gallagher et al., 2021). This ice is only stable because of a thin coating of dust, while it is unstable at all depths below the surface in the lower latitudes (Carr, 2006). Melted glaciers have created glacial landforms. Moreover, there are abundant periglacial features having polygonal surfaces and possibly pingos (Soare et al., 2021). Carr (2006) believes the glaciers formed at high obliquity in the past. Obliquity is the tilt of Mars' axis with the plain of the ecliptic. Since the VNs and outflow channels are believed by many to have been caused by floods, sometimes of enormous size, the precipitation must have been heavy, causing rapid glaciation.

Equally mysterious are the polar ice sheets. The northern ice sheet is about 1000 km across and 2 km thick (Lalich et al., 2019) and the southern is about the same area and 3–4 km thick (Byrne, 2009). These ice sheets consist of alternating layers of water ice and dust on a vertical scale of 10–80 m (Levard et al., 2007), as shown in Figure 6. The total volume of polar ice is estimated at ~3.5 x 10^6 km^3 (Arnold et al., 2019), comparable to the Greenland Ice Sheet. It is believed that the South Polar Ice Sheet was once twice as large (Arnold et al., 2019). These ice sheets have a surface coating of frozen CO_2 that insulates the ice. They are estimated to contain about 20 to 40 m GEL (Scheller et al., 2021). Because they lack impact craters, geologists think they are very young.

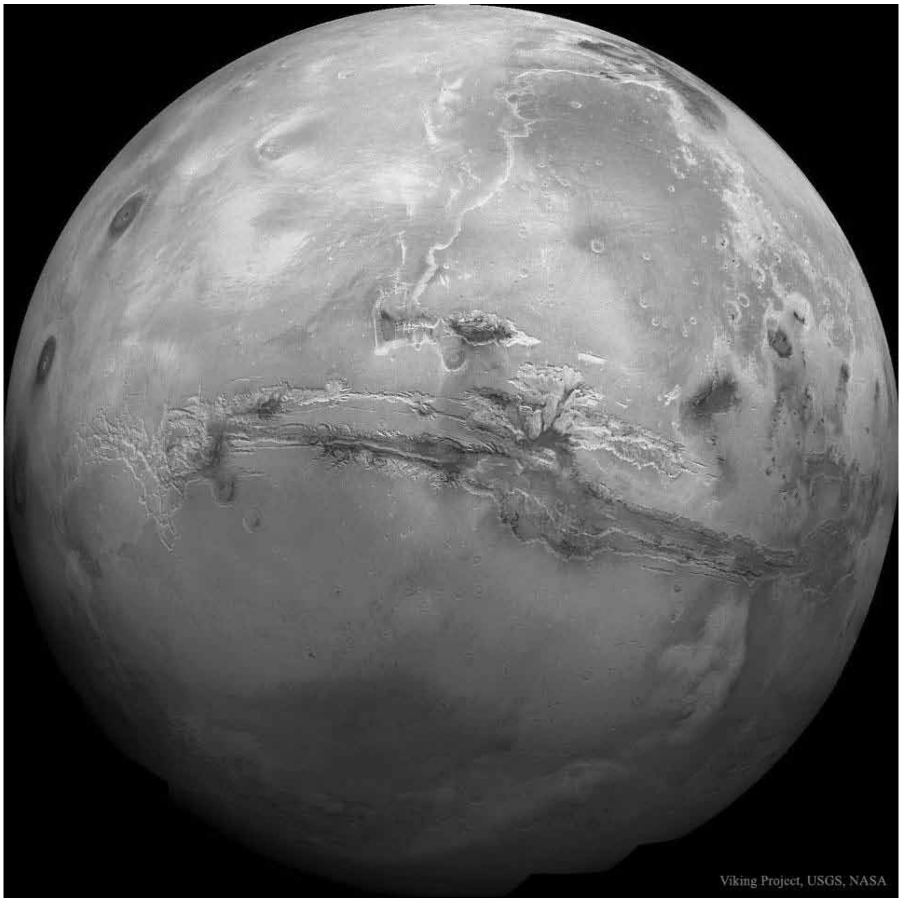
Viking Project, USGS, NASA

Figure 8. Valles Marineris: The Grand Canyon of Mars showing its massive length compared to the diameter of the planet (NASA). The elevation of the bottom of the canyon is about the same as the northern lowlands.

Enormous Volcanism

Mars shows evidence of massive volcanism. The amount of ejected volcanic material is estimated at 600 x 10^6 km^3; equivalent to a global layer of lava 4 km deep (Jakosky, 2021). Lava was concentrated in the Tharsis area, 5000 km across and 10 km high as shown on Figure 7 (Carr, 2006, p. 43) where several volcanic cones are found. Olympus Mons on the northwest part of the Tharsis bulge is 550 km (335 mi) across and 24 km (14.6 mi) above the surface, 2½ times the elevation of Mount Everest (Samec, 2013)! To the north, Alba Patera is 2000 km across but only a few km high. Another smaller area of volcanism occurs at Elysium Mons. Samec (2013) compares the total for volcanism in the Hawaiian-Emperor chain at 750,000 km^3 to that 4.5 times that volume for the five major volcanoes on Tharsis.

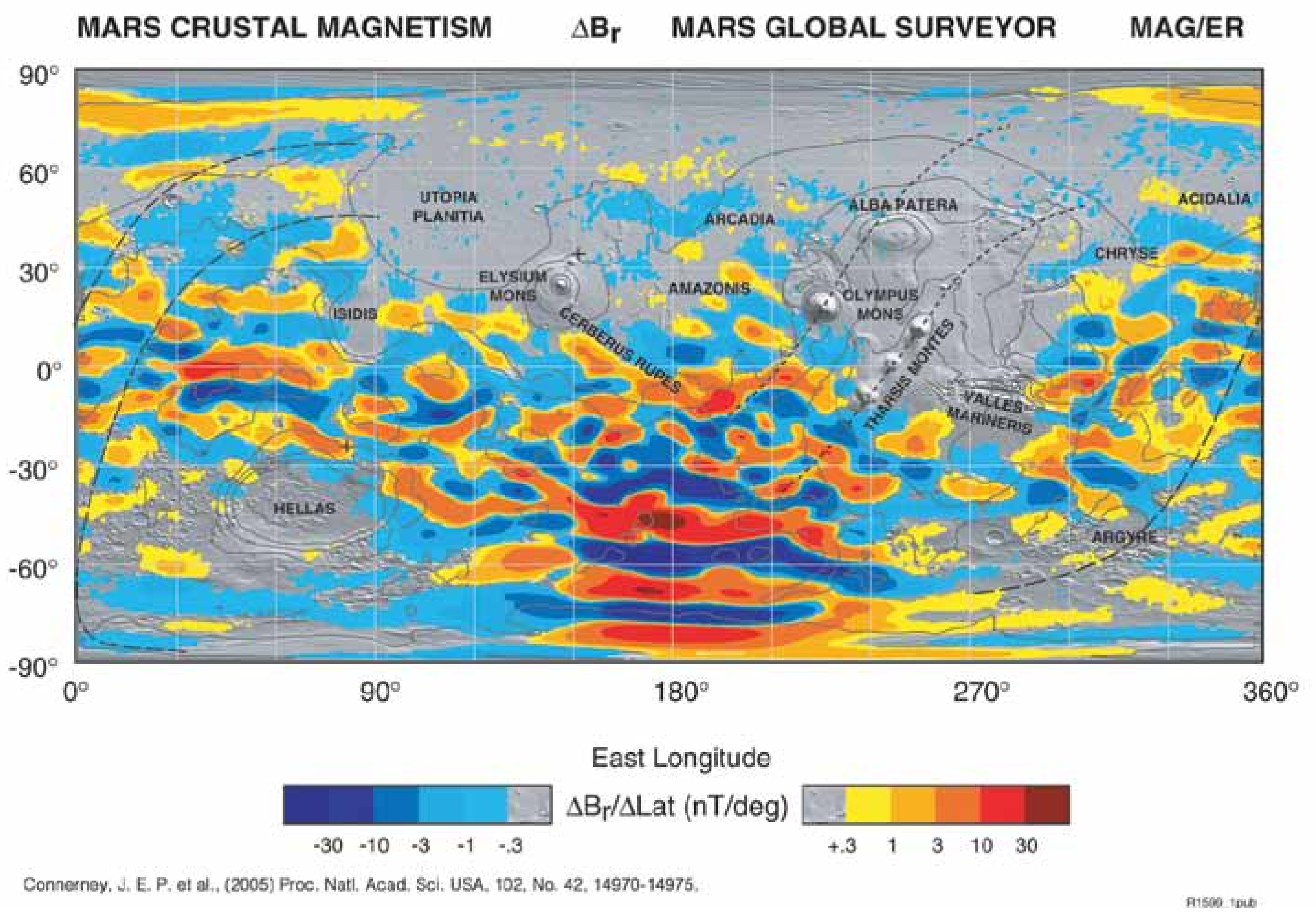

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Figure 9. Map of Mars crustal magnetism (NASA). Note alternating positive and negative anomalies and areas of little or no magnetism.

The Amazing Valles Marineris

In the eastern portion of the Tharsis bulge is the great canyon system of the Valles Marineris, a linear, east-west trending canyon which is composed of multiple short canyons as shown in Figures 7 and 8. Valles Marineris is much larger than Grand Canyon, which is only 446 km long, up to 30 km wide, and over 1800 m deep. The Mars canyon starts on the eastern Tharsis bulge, first as intersecting canyons, called the Noctis Labyrinthus, and continues 4000 km east to the Chryse basin. It was earlier thought that Valles Marineris was the result of radial grabens rifting around the Tharsis bulge of which the Valles Marineris is the largest rift by far, but more recently researchers admit they do not know its origin (Andres-Hanna, 2012). The drop in elevation is from about 7000 m at the western end to less than 1000 m at the eastern end (Carr, 2006, p. 95). The depths of the individual canyons are around 6000 m, but the depth is over 10,000 m in western Coprates Chasma. Most individual canyons are around 150 km in width, but Melas Chasma is almost 300 km wide.

The Past Magnetic Field

Mars has no magnetic field today, but scientists discovered large, regional magnetism in the crust of Mars (McKenzie, 1999), indicating a magnetic field early in Martian history (Solomon et al., 2005). The strong remnant magnetic positive and negative anomalies are about 10 to 20 times stronger and much wider than oceanic magnetic anomalies on Earth (Figure 9) (Jurdy and Stefanick, 2008; Lillis et al., 2008). Some researchers have rejected a plate tectonics explanation (Kerr, 1999; Coles et al., 2019, p. 15). Anomalies are located mainly in the southern highlands with weak anomalies over portions of the northern lowlands, large volcanic areas, and the large impact craters (Coles et al., 2019, p. 15). The magnetic field was dead by the time of the large Utopia, Hellas, Isidis, and Argyre impacts. This was at about the time of the postulated Late Heavy Bombardment (Jurdy and Stefanick, 2009). Secular scientists assume the magnetism was caused by a "dynamo" that lasted for several hundred million years in early Mars history. But dynamos are unlikely (Humphreys and De Spain, 2016). The remnant magnetism is thought to reside in igneous dikes or dike swarms magnetized in the presence of a strong magnetic field early in Martian history (Carr, 2006, p. 78). The pattern of magnetism on the surface of Mars can give us a relative Biblical timescale for Mars history which will be discussed in Part III of this series.

Figure 10. The near side of the Moon showing the large impact basins filled with black basalt on a background of smaller highland craters (NASA/JPL/USGS).

Mars Impacts

Mars' surface has thousands of impact craters as shown in Figure 5. The number of impact craters greater than or equal to 5 km is about 42,000 (Barlow, 2010). Established sizes range up to Utopia Planitia's 3400 km in diameter. There were once questions about Utopia Planitia's origin, but it is now accepted as an impact (Brasser et al., 2020). The Hellas crater is 2400 km in diameter and about 8 km deep (Coles et al., 2019, pp. 28–29). These craters are among the largest in the Solar System and compare with the Aitken crater near the South Pole of the Moon, which is 2500 km. Other craters of note on Mars are Isidis at about 1500 km and Argyre about 900 km across. Several large basins in the northern lowlands have been considered impact craters, such as Acidalia Planitia at about 2800 km and Chryse Planitia at about 1700 km in diameter. Chryse Planitia was once rejected as an impact crater, but a re-evaluation suggests it is because it has a near-circular area and a near-circular positive Bouguer gravity anomaly about as strong as Utopia Planita but not the other three large impact basins (Pan et al., 2019). A Chryse impact would be about 1100 km and probably relaxed and filled with debris quickly. Many other impact craters over 1000 km have been suggested, but not proven (Vervelidou et al., 2017). Frey (2008) believes there are 21 impacts greater than 1000 km (Roberts et al., 2009). Table I lists the four largest accepted impact craters on Mars, their diameters, and the suggested size of the projectile.

Toon et al. (2010) show a graph of impactor size and resulting crater sizes. This is based on assumptions that impact velocity decreases away from the Sun. Average velocities for impacts on Mars would be 9 km/s. A crater 1000 km in diameter would be produced by a body 180 km in diameter. But lower velocities would not apply if the Solar System passed through an asteroid cloud.

Mars is often compared to the Moon in its cratering size-frequency distribution (Carr, 2006, p. 23). Thus, it is expected that the Earth should have been similarly bombarded, but to date, evidence has only confirmed about 200 impacts (Schmieder and Kring, 2020). This is a crucial problem for uniformitarians.

Mars' Southern Hemisphere contains numerous impact craters. Very few

Table I. The four largest impact craters on Mars and the assumed impactor size based on Toon et al. (2010)

Impact crater	Diameter of crater	Diameter of impactor
Utopia Planitia	3400 km	>500 km
Hellas	2400 km	~500 km
Isidis	1500 km	300 km
Argyre	900 km	160 km

are found in the Northern Hemisphere, but there is evidence of many buried impact craters, up to 130–470 km in diameter, in over 14% of the northern lowlands (Watters et al., 2006). There are probably many more yet undetected in the northern lowlands, based on the southern part of the planet (Carr, 2006, pp. 162–164).

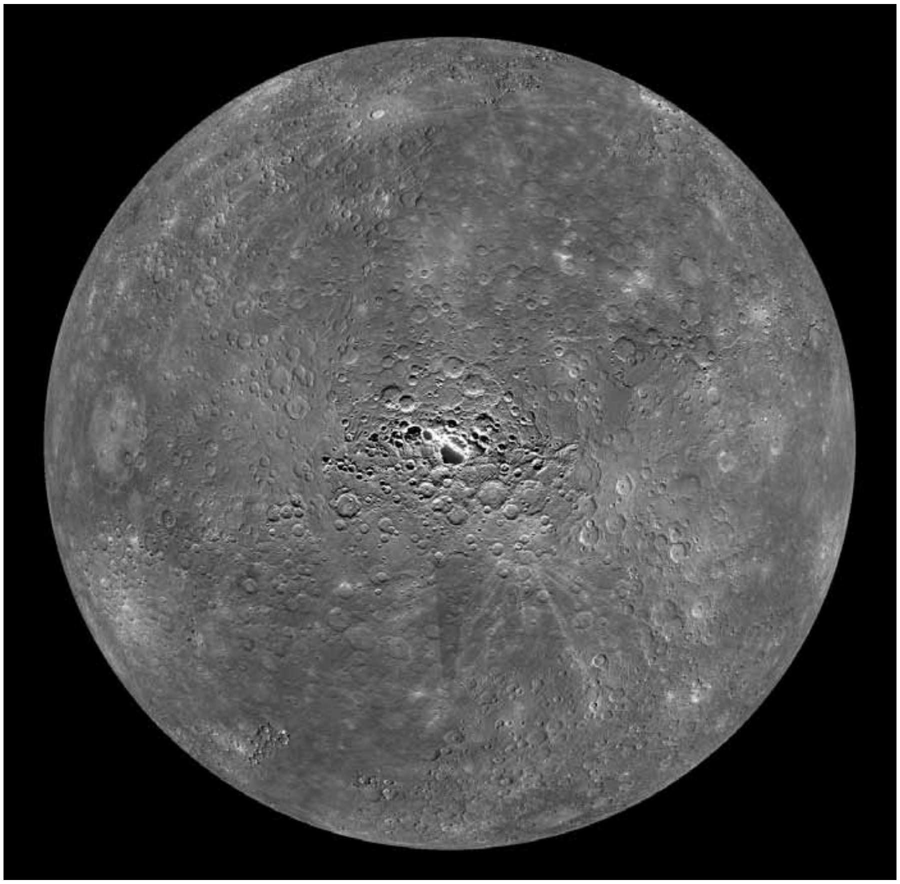

Figure 11. Mercury from the South Pole (NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington).

Whole Solar System Bombarded by Impactors

Cratering on Mars is similar to the surface of nearly all solid bodies of the Solar System as shown in Figures 10 through 14 which include images of four planetary moons and the planet Mercury:

> "Craters are ubiquitous across nearly every solid surface in the solar system, and they have long been used as a metric for assigning relative ages; If [sic] a surface has more craters of a given size per unit area, then it is older because crater accumulation is temporally cumulative." (Robbins, 2014, p. 188)

Thus, impact craters are the most significant landform in the whole Solar System:

> "Impact craters are the most distinctive landforms on solid planetary bodies other than the Earth. Almost every solid surface on every planet and satellite observed so far is cratered to some degree." (Carr, 2006, p. 23)

The only exceptions are locations where the older surface has been resurfaced or partially resurfaced by sediment, impact debris, and/or lava, such as Venus.

Impacts Violate the Uniformitarian Principle

It was argued up until the 1960s that Solar-System craters were volcanic caldera because of the strong belief in uniformitarianism, i.e., volcanic processes are observed today but large impacts are not. However, volcanoes, which also exist on many Solar-System bodies, including Mars, can be distinguished from impact craters:

> "Most calderas [on Mars] look very different from impact craters because they form by collapse rather than by excavation, and because they are commonly the result of multiple events rather than a single event." (Carr, 2006, p. 43)

Thus, secular scientists now believe that, over billions of years, large asteroid or comet impacts have swept the Solar System. The Earth, not being special, should also have been bombarded. This change is called neo-catastrophism, which recognizes a few, isolated major catastrophes on Earth, such as the Ice Age and the Lake Missoula flood, both of which once challenged uniformitarianism but were later incorporated into uniformitarianism and are now thought to be simply rare processes, rather than one-time events.

Figure 12. Rhea, a moon of Saturn, sports an immense impact scar on its leading hemisphere as seen above center on the day-night dividing line (NASA/JPL/Space Science Institute).

How Is the Surface of Mars Dated?

Scientists need a timescale for Mars to describe its history. How do secular scientists derive this for Mars and other planets? Since they cannot collect rocks for radiometric dating, they use a method called "crater dating." Superposition of craters provides a relative age: "Relative ages are determined from remote sensing mainly in two ways, from intersection relationships and from the number of superimposed impact craters" (Carr, 2006, pp. 14–15).

As stated by Carr, the second method is crater density. A well-cratered surface is considered old, and one with few craters is young. To tie this method to an absolute time scale, they use dates of Moon rocks compared to its cratering density and apply the derived dates to the Solar System (Robbins, 2014). Since Moon rocks were dated between 3 and 4 Ga, impacts are spread over billions of years. This assumes a constant flux from the asteroid belt after the Late Heavy Bombardment. They incorporate the distribution of asteroid orbits and size, and the gravity and target potential of Solar-System bodies (Michael and Neukum, 2010).

Moon rocks recovered from the Apollo and Luna missions gave dates of about 4 billion years for highland rocks and about 3.8 to 3.1 billion years for the mare basalts. Thus, researchers assume that the large impact basins on the near-side formed about 4 billion years ago, mainly during the LHB, but the basalt that filled the basins did not erupt until a billion years later! These dates make no sense, since we would expect that the basalt would fill the crater very soon after impact, since impacts fracture both the crust and mantle (Samec, 2008). Manske et al. (2021, p. 7) state that large impact craters should fill with basalt quickly:

> "It is expected that decompression melting contributes significantly to the total melt volume in large impacts, as more material from greater depths is stratigraphically uplifted with increasing impactor size."

The paradox grew when China recovered rocks from the northwest Procellarum mare (Chang'e-5 site) that were radiometrically dated at about 2 Ga (Che et al., 2021; Li et al., 2021). This was a maria area that was crater-dated at 3.2 to 1.2 Ga, suggesting problems with the method. An estimated 2000 km^3 of basalt lava erupted about that time. Some believe that the youngest mare basalt is about 1 Ga, indicating volcanism continued for 3 billion years (Qian et al., 2021)! Others have stretched the volcanism to 100 Ma (Braden et al., 2014). Why would these basalt eruptions last for over 3 billion years? What would cause a planet or moon to maintain its mantle heat that long? The Moon should have cooled early, ending volcanism after several hundred million years. Radioactive elements and water in the mantle do not solve the problem (Che et al., 2021; Hu et al., 2021).

Astronomers have divided Martian history into four major periods as shown in Table II (Bottke and Andrews-Hanna, 2017). The pre-Noachian is sometimes considered the early Noachian (Gulick, 2001), and the boundaries between the periods are a rough estimate. The EHB occurred during the pre-Noachian with the LHB during the Noachian. Some of the numerous impact craters on Mars are believed to have struck during the Noachian, including those in Table I. The Hesperian is the period that refers to the oldest surfaces after the end of heavy bombardment. The Hesperian did have 67 impacts that produced craters 5 to 400 km in diameter.

Valley Networks

Valley networks (VNs) are narrow valleys observed on Mars, especially on the southern highlands, but they stretch latitudinally from 50°N to 65°S (Cassanelli and Head, 2019). The valleys are 50–350 m deep, 0.5–5 km wide, and 100–200 km long (Irwin et al., 2011). Individual valleys are up to 4000 km long (Howard et al., 2005). There are a small number of valleys that are significantly larger and deeper: ~10 km wide and >500 m deep (Irwin et al., 2011) or even 20 km wide (Hynek et al., 2010). However, it is a uniformitarian mystery why smaller valleys a few 100 m wide and narrower are absent (Carr and Malin, 2000). The origin of VNs has been debated since the 1970s (Gullick, 2001), because there are several puzzling aspects.

Many VNs start on local highs such as crater rims or central peaks, where groundwater seepage is unlikely, strongly suggesting precipitation (Fassett and Head, 2008). They then proceed down a steep slope and end in an enclosed basin or crater. For instance, Samara Vallis descends about 3000 m over 1700 km (Carr, 2006, p. 140). Some valley profiles in the Isidis crater region descend about 5000 m in 800 km (Howard et al., 2005).

There are thousands of VNs similar to those shown in Figure 15. Steakley et al. (2019) claim there are over 80,000 individual valleys, but they must be counting numerous short valleys. VNs can be either U-shaped or V-shaped (Gullick, 2001). Their upper reaches commonly are stubby with theater-

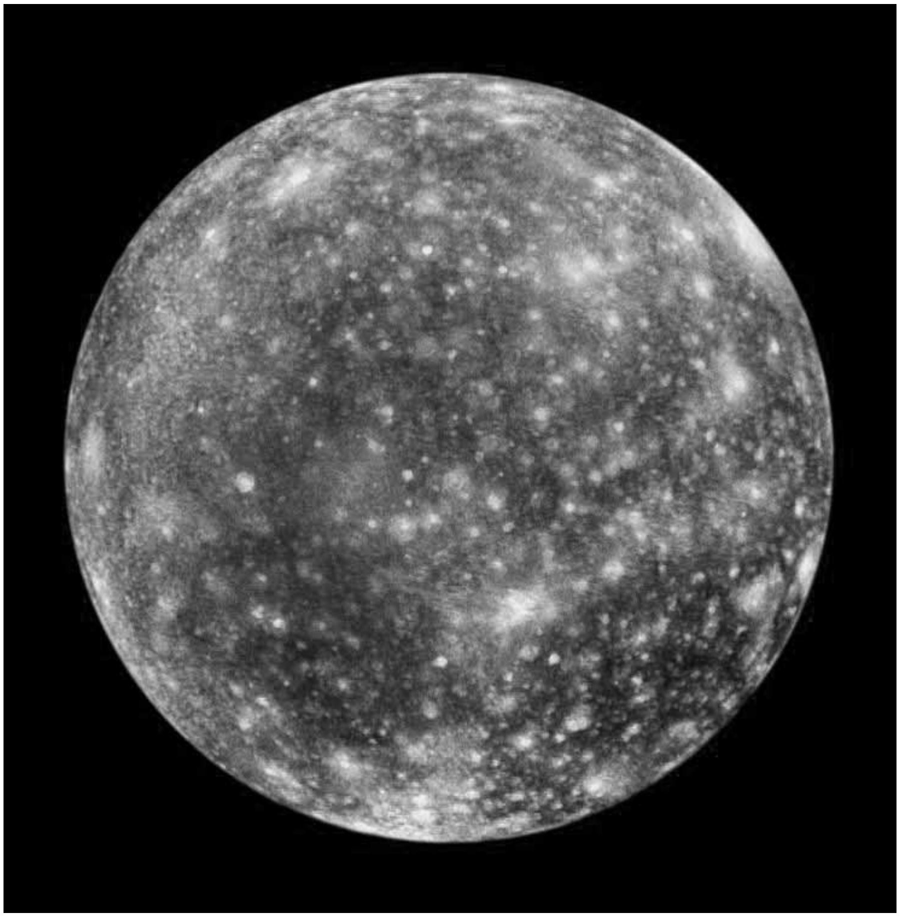

Figure 13. Callisto, a moon of Jupiter, showing numerous impacts (NASA/JPL/DLR).

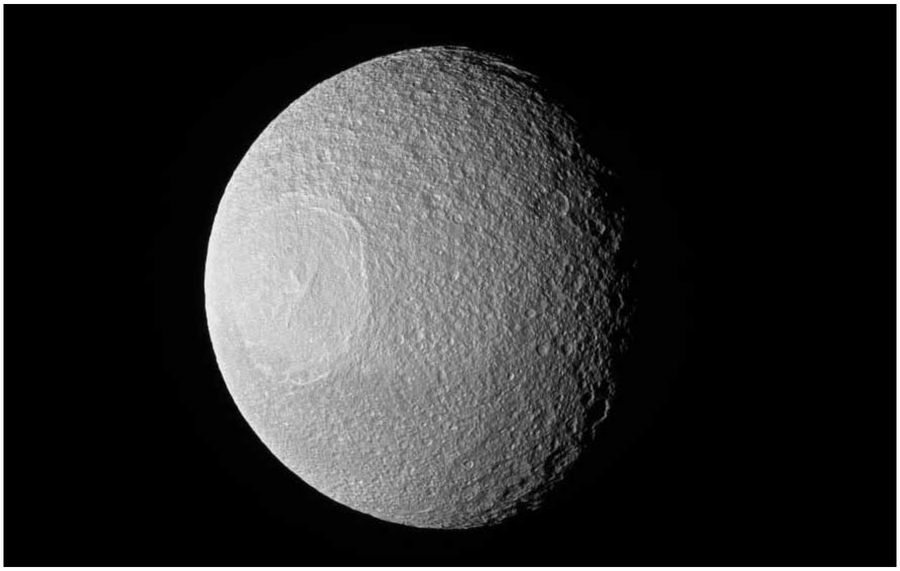

Figure 14. Tethys, an ice moon of Saturn, showing the large crater, Odysseus, on the left side (NASA/JPL-Caltech/Space Science Institute).

headed tributaries while the lower reaches are of low sinuosity, sometimes branching, and with broad flat floors, sometimes ending in an alluvial fan or delta. The ubiquitous wind on Mars has sometimes caused valley inversion on the downstream alluvial fans, in which the sides of a valley erode faster than the bottom, leaving the bottom of the channel as a ridge (Williams et al., 2009; Davis et al., 2019). VNs occur on most Martian volcanoes and are commonly denser and shallower, which implies precipitation (Hynek et al., 2010).

VNs are mostly dated late Noachian (Howard et al., 2005). Steakley et al. (2019) claim 90% formed in the Noachian, while Fassett and Head say only 70% are dated Noachian. Additionally, some VNs have been dated in the Hesperian and even as late as the Amazonian (Salvatore and Levy, 2021). This substantial variance is likely a contradiction to their crater dating scheme, since VNs should be carved close in time.

VN Occurrence, Sizes, Distribution, and Types

First, most VNs occur in the southern highlands along an east-west band at roughly 24°S latitude. When the Tharsis bulge formed, it shifted about 15–25° south by polar wandering to be near the equator, but on the opposite side of Mars the shift was about 15–25° north (Bouley et al., 2016), which is why the latitudinal range of VNs today is rather large. Why didn't VNs form at other locations, such as the northern lowlands?

Second, VNs often start full size with little to no width changes downstream (Irwin et al., 2011). They commonly flow northward down the crustal dichotomy into craters.

Third, VNs have a patchy distribution. They are found singly, or in clusters, but are absent over areas where they could be expected to exist (Gullick, 2001). For instance, there are few VNs found over the large Arabia Terra and between 30° to 60° S from the Argyre impact to the east of the Hellas impact (Bouley et al., 2016). Interestingly, drainage densities on Earth are 14 times those on Mars (Grand, 2000). VNs are believed to not conform to a warm, wet climate model with abundant precipitation (Gulick, 2001), as many researchers believe for early Mars.

Fourth, when compared to rivers on Earth, the drainage systems of Martian VNs are considered immature according to any measure (Carr, 2006, p. 143; Irwin et al., 2011; Craddock and Lorenz, 2017; Galofre et al., 2020). Geomorphically, VNs are mostly convex upward, the opposite of rivers on Earth (Irwin et al., 2011). They did not shape the topography, rather the current topography directed their paths (Irwin et al., 2011).

Were VNs Formed by Rain and Runoff?

Many researchers have suggested a groundwater origin for VNs in a cold, dry climate (Grand, 2000), but others believe they are due to precipitation and runoff (Hoke et al., 2010), especially since many VNs start at high elevations where groundwater is unlikely. In support of the origin by running water, fan-shaped deposits occur at the ends of some VNs. Some researchers have suggested a variety of mechanisms for the origins of the VNs:

> "Glaciation, mass wasting, faulting, and erosion by CO_2, wind, and lava have at times been invoked to

Figure 15. Channels near Warrego in Thaumasia. From the Mars 2001 Odyssey Thermal Emission Imaging System (THEMIS) (NASA/JPL/Arizona State University).

Table II. The four periods of 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

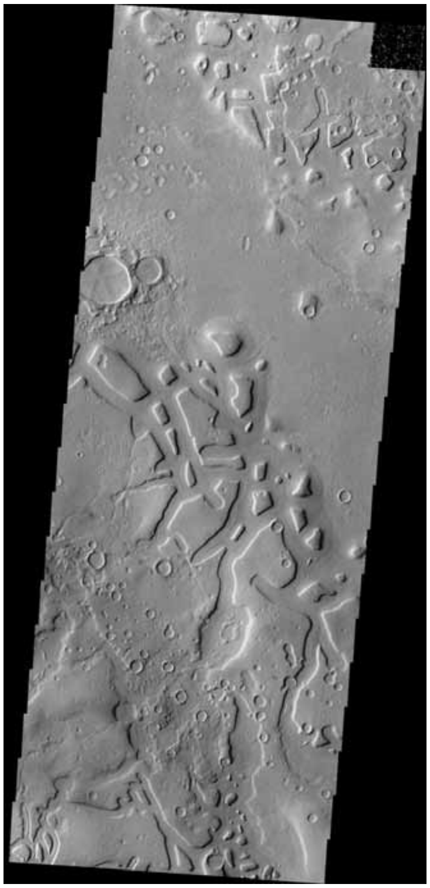

Figure 16. The region on the margin of Terra Sabaea showing several areas of chaos, as imaged by the Mars Odyssey spacecraft (NASA). Regions of mesas and channels are termed chaos.

> explain valley networks, but erosion by liquid water is now almost universally viewed as the primary cause." (Carr, 2006, p. 139)

Galofre et al. (2020) have claimed that some of the VNs formed from subglacial erosion when the area was glaciated. But precipitation is required for glaciation and there should be evidence of extensive glaciation in the southern highlands where most of the VNs are located. There is no evidence of glaciation to be found.

Most researchers believe VNs were eroded by running water, but there is controversy over the amount of running water and the climate conditions needed for their formation. Although some tributaries that start abruptly would support groundwater sapping, it is unlikely that groundwater discharges could erode the long VNs.

What Was the Climate Like?

VNs are assumed to form in a warm, wet climate during the long Noachian, but the young VNs present a conundrum for their origins (Carr and Malin, 2000). So, uniformitarian scientists claim the younger VNs formed in a brief warm, wet period.

The main resistance to an origin by water is the climate models indicate that it is very difficult to warm Mars. Some researchers believe there is something basically wrong with the climate simulations, since the evidence requires precipitation and warm conditions to have existed at one time. This is also supported by other evidence, such as degraded craters in the Noachian period but pristine craters in the Hesperian and Amazonian (Craddock and Lorenz, 2017). But this scale of degraded craters could be due to circular reasoning in that degraded craters are assumed to be old and pristine craters young.

Outflow Channels

Outflow channels, unlike VNs, are found outside the southern highlands (Carr, 2006, pp. 131–144), and commonly flow down the topographic dichotomy into the northern plains. Outflow channels are wider and show bedforms that VNs do not (Gullick, 2001).

Outflow channels vary in size. The largest, Kasei Valles, shown in Figures 3 and 7, is over 400 km across, over 2.5 km deep, and about 2000 km long (Carr, 2006, pp. 113–131), much larger than Grand Canyon. Kasei Valles has features like the Channeled Scablands, with three dry cataracts, 120 m high, such as Dry Falls, Washington, USA (Oard, 2004, 2014). Kasei Valles also has longitudinal scours and tear-drop shaped hills (Figure 3), common in the Channeled Scabland (Figure 2). Outflow channels *start full size* at the beginning, have little width change, and few tributaries. The majority of planetary geologists believe they were carved by huge floods, although some think such floods impossible. Researchers are divided on whether they formed from one large, or multiple smaller floods (Conway et al., 2011). Estimated flows range from 10^4 to 10^9 m^3/s, the latter for a single, large flood. These discharges compare to the Lake Missoula flood discharge of about 3×10^6 m^3/s. The amount of erosion of Kasei Valles is estimated to be 7×10^5 km^3, which at a 1:1 ratio of water to eroded sediments represents a water volume of 4.8 m Global Equivalent Layers (GEL) (Carr and Head, 2015).

The relatively rare outflow channels all terminate in the northern lowlands. They are most prominent around the Chryse basin, south of which lies the huge Valles Marineris. Several outflow channels start near the two largest volcanic provinces of Tharsis and Elysium (Roda et al., 2014). Because of the low atmospheric pressure, floods on Mars would flow faster, farther, and be more erosive (Conway et al., 2011). Some outflow channels are believed to have formed quickly, such as the channel from Aram Chaos into the Chryse basin, and some planetary scientists believe its formation took place in one flood over tens of days from a collapsed lake (Roda et al., 2014). Many outflow channels start at chaos regions, depressions that are about 4 km deep, 20–120 km wide (but up to 250 km wide) that contain a large number of undeformed tilted blocks, mesas and channels as shown in Figure 16 (Oard, 2017; Roda et al., 2017). Some chaotic terrain is up to 7 km deep (Meresse et al., 2008). It appears that, "The channels simply start at a hole in the ground, with no obvious catchment area" (Carr, 2006, p. 114). The origin of chaotic terrain is unknown (Meresse et al., 2008). Other outflow channels issue forth from rifts or grabens. The origin from chaos regions and grabens indicates a *groundwater* origin for the outflow channels, which is extremely perplexing.

There are many problems with explaining outflow channels having been cut by huge floods, including a source and indications that the water originated below the ground (Gallagher and Bahia, 2021; Leverington, 2021).

One major challenge is that most outflow channels are dated in the Hesperian, based on crater counting, when the climate was thought to be cold and dry (Carr and Malin, 2000). Planetary scientists also stretch a few outflow channels into the Amazonian based on crater counting (Salvatore and Levy, 2021). Cassanelli et al. (2015) even stretch some outflow channels back into the late Noachian. The dating of outflow channels from the late Noachian into the Amazonian requires underground reservoirs that need constant recharging by water over billions of years. Other researchers believe they formed mostly in the Amazonian, also based on crater dating (Rodriguez et al., 2015). This variable timing gives us some indication of the subjectivity of crater dating, since one would expect the outflow channels to be cut at about the same time. As a result, some think that the outflow channels formed during climate conditions similar to today on Mars (Carr, 2012), while others believe there were short periods of a warmer, wetter climate (Ramirez and Craddock, 2018).

Gullies

Gullies are the third type of Mars channels. They generally start from an amphitheater-shaped erosion feature and travel down a steep slope. Gullies are representative of several other similar features thought to be evidence of recent liquid-water flow (Conway and Stillman, 2021). They are mostly meters to a few tens of meters wide and hundreds of meters long as shown in Figure 17. They are sometimes as long as 7 km (Bauley et al., 2016). Gullies are dated Late Amazonian, since there are very few, if any, impact craters on them. They have been observed forming today from orbiter images (Goldspiel and Squyres, 2011). They often start on the crests of central peaks, on isolated mesas, and the rims of craters. Because liquid water is not only unexpected on isolated high areas, and the climate is presently very cold and dry, these gullies present a problem for uniformitarian scientists. This implies the gullies must have formed when the ground was unfrozen, pointing once again to a warm, wet climate sometime within the late Amazonian; however, the late Amazonian was supposedly a time when Mars was cold and dry (Goldspiel and Squyres, 2011). Because of these difficulties, many researchers attribute the gullies and similar features to dry flows (Dundas, 2021), such as debris flows (De Hass et al., 2015).

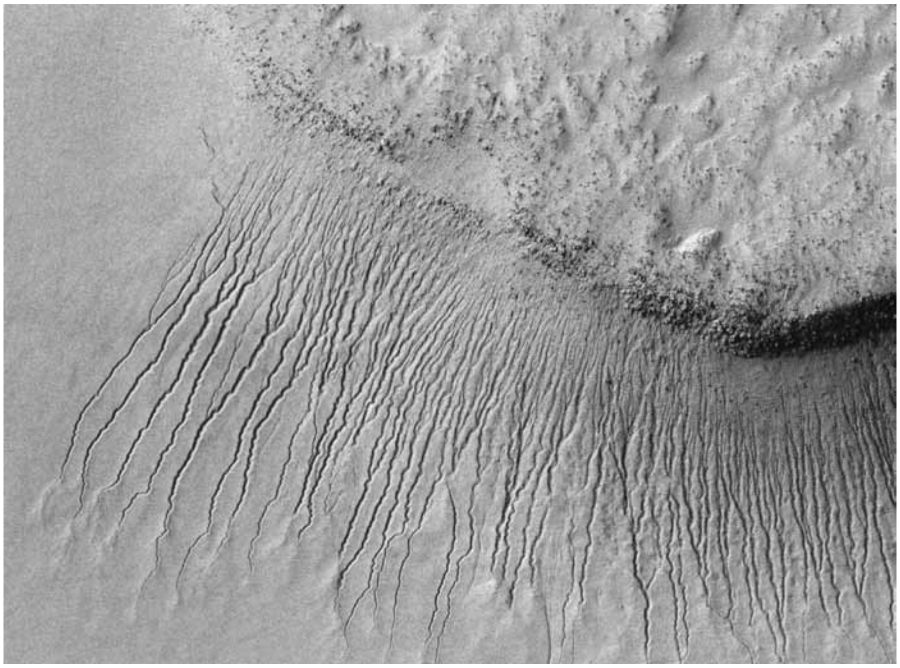

Figure 17. Mars Reconnaissance Orbiter showing many gullies on a scarp in the Hellas impact basin (NASA/JPL-Caltech/University of Arizona).

Summary

As with the exploration of other bodies of our solar system, Mars has also produced numerous unexpected discoveries. The greatest are the large, apparently water-carved outflow channels and numerous, narrower valley networks. If outflow channels were carved by one flood, the required flow rate would have been up to 100 times the flow of the Lake Missoula flood on a planet with no liquid water. Climate models have only heightened the mystery, since they predict a cold, dry climate throughout Martian history.

In order to understand the cause of Mars flooding, I summarized the major features of the planet, including the mysterious crustal dichotomy with its low elevation and thin crust in most of the Northern Hemisphere as compared with high elevation and thick crust in the Southern Hemisphere, the evidence for an early magnetic field, evidence for precipitation including glaciers and ice sheets, the numerous impacts, and significant volcanism. The uniformitarian crater dates are very important to the secular beliefs of Mars history, and the geologic history of Mars has been divided into four major periods.

Valley networks show several unusual features. They are formed almost exclusively in the southern highlands; often start full-size and continue down-gradient with little change in width; have a patchy distribution; exhibit immature drainage patterns; follow the surface topography; likely cut by water; and suggest a warm, wet climate. Outflow channels are just as mysterious in that they appear to have been caused by immense floods that initiate from underground, start full size at the beginning, have little width change, and possess few tributaries. Gullies are more recent small-scale erosional features that could indicate water erosion or erosion by dry mechanisms.

The likelihood of floods on Mars brings up a number of questions that will be answered in Parts II and III. It will be shown that these questions are difficult to answer within uniformitarian planetary science but can be explained within Biblical Earth history.

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Notes from the Panorama of Science

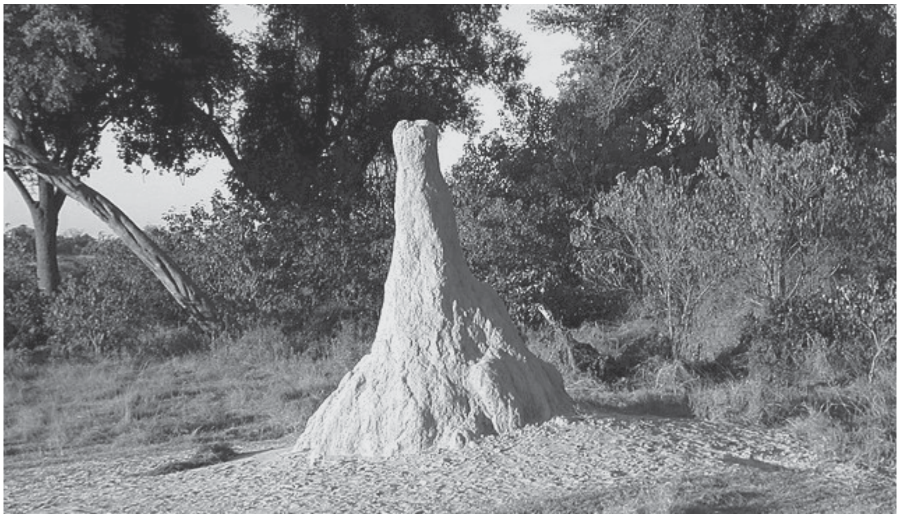
Rapid Relay of Sound Vibration Alarms: Headbanging Termites!

"For if the trumpet gives an uncertain sound, who shall prepare himself for the battle?" (1st Corinthians 14:8)

Headbanging termites are alarming, literally!

Termites dwell in moisture-regulated (and "air-conditioned") mounds much larger than their little (about a centimeter-long) bodies. When termite mounds are structurally breached and attacked by hungry predators (such as aardvarks or pangolins or ants), some termites (often called "workers," responsible for food acquisition) flee, while other termites (often called "soldiers," some of which serve as "sentinels") defend the colony's homestead, by rushing to perform emergency repairs or by rushing to counter-attack the invaders, perhaps by swarming upon and biting whomever the invading threat is. Those defensive sentinel-like termites, who "sound the alarm," communicate quickly.

> Kirchner explains that the African termite, *Macrotermes natalensis*, forms large colonies in subterranean mounds and operates on a caste system. The workers use the mound's maze of corridors to access the outside world to forage for food. As these outdoor excursions can take them over 10 m away from their colony, they are accompanied by another caste—the solider termites. In addition to protecting them, these soldiers will drum home warnings of an impending attack to the distant colony should a hungry aardvark appear. (Stead, 2013)



> Communicating over long distances is difficult; for example, the sound of our voices can rarely be heard or understood further [sic, farther] away than 100 m. Yet, long before the invention of the telephone or e-mail, humans were successfully communicating over hundreds of kilometres. Take, for example, the Great Wall of China, where soldiers alerted each other of an impending attack using smoke signals. Although this remarkable ability to communicate over long distances is said to be unique to humans, Wolfgang Kirchner and PhD student Felix Hager, from the University of Bochum, Germany, found out that some species of termites have also mastered the skill. (quoting Kirchner and Hager, 2013, p. 3249)

This a quite an "alarming" report, by Nicola Stead (Stead, 2013), pardon the pun.

Yet this alarm—which may be transmitted several meters (if necessary) is not accomplished by one sentinel termite's loud broadcast; rather, the alarm is communicated throughout the mound's inside "gallery" chambers and tunnels (including the honeycombed subterranean chambers, tunnels, and fungus "gardens") of the mound by a relay of warning signals.

Thus, the signaling is drastically important when a mound-invasion crisis occurs. Some termites rush away in flight. Other termites rush toward the emergency site, to provide needed defensive actions.

As 1st Corinthians 14:8 illustrates, transmitted signals provide coded messages, intended to influence message recipients (see also Johnson, 2011). Likewise, animal populations employ diverse communication modes (Moon, 1962; Johnson 2020a, 2020b). This demands intelligent communication systems that are pre-programmed into all of the termites, so that the threatened termites can react purposefully to such suddenly hostile environments (Johnson, 2011).

As humans, we can relate to such environmental crisis situations. For ages humans have used a chain-like series of relay signals, to rapidly communicate danger (or distress) across long distances. The idea of relaying a warning by signal fires (relay beacons) appears in J.R.R. Tolkien's "Lord of the Rings" fiction.

However, in real-world history, Vikings used relay signal fires to communicate impending dangers—as illustrated in the "Saga of Håkon the Good," in Snorre Sturluson's classic Viking history *Heimskringla, or The Lives of the Norse Kings* (Monsen, 1990, Chapters 20–22, pp. 91–92).

But how do headbanging termites accomplish this warning behavior, and why?

Unlike the term "headbanging," used to describe repetitious head-jerking to bass guitar beat rhythms in heavy-metal rock music, headbanging termites literally bang their heads upon the "floor" (mound substrate), emitting pulsating sound and vibrational signals toward nearby nestmates (Choi, 2013; Stead, 2013).

The "why" is purposeful design, by the termites' Creator (the Lord Jesus Christ), Who programmed these small insects to actively communicate warnings unto one another—for their populational survival in this fallen world from predatory attacks (due to sin-cursed conditions on Earth, that Christ foreknew Adam's sin would trigger)—exhibiting the ongoing reality of Romans 5:12 and 8:20–22 (Gitt, 2007; Johnson, 2011).

Like other creatures of the world, big and small, headbanging termites (e.g., *Macrotermes natalensis*)—are cleverly constructed to communicate important messages (Moon, 1962; Hager and Kirchner, 2013; Sherwin, 2016; Johnson, 2020a, 2020b).

> The signals consist of trains of pulses with a pulse repetition rate of 10–20 Hz. The galleries have physical features that promote vibrational communication and are used as channels for long-distance communication. In M. natalensis, the signal propagation velocity is ~130 m s^{-1} and the signals are attenuated by ~0.4 dB per centimetre distance…. Workers respond by a fast retreat into the nest and soldiers are recruited to the source of vibration. (Hager and Kirchner, 2013)

But who could imagine—much less purposefully invent—an underground warning communication system, operated by centimeter-long sentinels, who knock their noggins upon the ground—repeatedly, rapidly—to sound the alarm? (Choi, 2013; Hager and Kirchner, 2013; Stead, 2013; Sherwin, 2016).

> Kirchner's initial work on termites' long-distance warnings began in the Ivory Coast but because of the political situation he decided travel to South Africa with Hager to carry on his work. As termites are difficult to find outside their colonies, the duo [i.e., Hager and Kirchner] opened up the central chamber of a termite mound and used high-speed cameras to capture in detail how soldiers warn others of unwelcome intrusions. They saw the soldiers raising their heads upwards before bashing them into the ground at speeds of 1.5 m s^{-1}.
>
> Using carefully embedded accelerometers to detect [*Macrotermes natalensis* termite mound] vibrations, the duo found that the *M. natalensis* termites drummed their heads rapidly, 11 times per second.
>
> Each head bang generated vibrational pulses where the ground vibrated with acceleration amplitudes up to 0.7 m s^{-2}; this approximately corresponds to a 70 nm movement at a frequency of 500 Hz.
>
> 'Once we had described the signal, the next step was to look at signal perception—what intensity does the signal have to have in order to be recognisable for another individual?' says Kirchner. To do this, they carefully placed termites into Petri dishes and measured their responses over a range of vibrational frequencies and displacements. They found the termites were most sensitive to frequencies around 500 Hz, as long as the movement of the dish's surface was more than 0.012 m s^{-2} (the equivalent of a miniscule 1–2 nm movement).
>
> Satisfied that the soldiers were producing a vibrational signal that other termites could pick up, Kirchner says: 'We looked at how a signal is transmitted from the individual into the soil, how much is it attenuated with distance and how fast can it travel physically.' Mimicking a vibration pulse and placing accelerometers at set distances away from the signal, the team found that the vibrational wave could travel up to 171 m s^{-1}. They found that the vibrations were attenuated by 0.4 dB cm^{-1} and calculated that after just 40 cm the ground would no longer vibrate enough for other termites to pick it up.
>
> However, drumming signals can be picked up at much further [sic, farther] distances. Kirchner concludes that the only way this could occur is if there's social transmission [i.e., cooperative relay, like a chain of dominos] of the signal. He likens it to a game of Chinese whispers, where one termite passes on the message to the next, and so forth. Only, in this case, the message is not distorted and it's drumming loud and clear—danger ahead! (Stead, 2013)

Astonishingly, that auditory-vibrational alarm is relayed, from termite to termite, in mere seconds, like a chain of signal fires! (Compare Monsen 1990 with Hager & Kirchner 2013.)

Yet headbanging termite sentinels do what is impossible, impossible apart from God—they repeatedly strike their heads against the ground of subterranean "galleries" (ventilated nest-mound chambers and networked tunnels, connected to underground "fungus farm" gardens), making woodpecker-like rapid-drumming series of sounds and vibrations (Choi, 2013; Stead 2013; Sherwin 2019).

> Fungus-growing higher termites [especially *Macrotermes natalensis*] build long subterranean galleries that lead outwards from the nest to foraging sites. When soldiers are disturbed, they tend to drum with their heads against the substrate [i.e., floor] and thereby create vibrational alarm signals. (Hager and Kirchner, 2013)

This illustrates how these termites practice ***continuous environmental tracking***, followed by sentinel termite decisional responses. This can be outlined as: information/data intake → built-in logic system/programming for reacting to received "if/then" information → selected responses, that match the situation, ultimately for enabling creature "filling" of specific environment/situation habitats (Guliuzza, 2019).

Thus, the teleology of such sensing → interpreting → reaction series is obvious to see, for those "with eyes to see" God's design for "filling" this habitat.

And this is necessary, because in Africa's savannahs (Choi, 2013), even termites have predators!

How will termites know danger has arrived? The termite mounds are gigantic—they tower in heights impressive to humans, yet compared to the termites themselves their homestead mounds are veritable skyscrapers! In fact, comparing the size of those mounds, to the termites who build them from spit and mud, is like comparing adult humans to twice the height of the Empire State Building (Choi, 2013; Johnson, 2019; Sherwin, 2019).

Also, termite nest-mounds themselves are admirably ventilated, plus termite nest-mound architecture is magnificent in general, as a *hidden-in-plain-view* feat of engineering science (Sherwin, 2019). So, when predatory aardvarks or pangolins (or even ants) break into aerated termite nest-mounds, to consume termites, jeopardized termites need a practical warning alarm security system (Choi, 2013; Hager and Kirchner, 2013). How will at-risk termites warn nestmates to flee?

> The investigators witnessed the soldiers rapidly banging their heads on the ground about 11 times per second, with signals each capable of spreading nearly 15 inches (40 centimeters). Soldiers that received the warning ran to assist their nestmates, while workers retreated. Comparable results were seen with a similar African termite species belonging to the genus *Odontotermes*. The soldiers responded to drumming by drumming themselves. This can spread the alarm much the same way soldiers at the Great Wall of China alerted others by using smoke signals during the day and beacon fires at night, thus spreading the signal along the length of the wall. (Choi, 2013)

Because predatory "home invasions" often occur with rushes of air currents, it is unsurprising (for creationists, who expect to see rational aspects of programmed "filling" of changing environments) that sentinel termites (who are continuously tracking their often-changing environmental conditions) react instantly and defensively to sudden puffs of air (Hager and Kirchner, 2013; Stead, 2013). Such cues of mound-breach danger must be addressed by rapid communication of the peril.

> Defending an extended nest system requires a communication system to inform nestmates in remote parts of the gallery about attacks and holes in the nest wall. The use of vibrational alarm signals that can be rapidly transmitted over long distances would allow fast retreat and defence reactions and would clearly be advantageous. (Hager and Kirchner, 2013)

Accordingly, termite researchers—using high-speed cameras and audio-recording technology—intrusively squirted puffs of air into termite nest-mound material, to trigger (and measure) sentinel "soldier" termite headbanging (Hager and Kirchner 2013). Such headbanging reactions, to air-puff perturbations, can be measured quantitatively, to identify how quickly and how loudly such alarm signals are given headbanging (Hager and Kirchner, 2013). Thus, we can see one of God's "wonders without number" (Job 9:10), thanks to high-tech mound surveillance equipment.

But most of us don't use such high-tech surveillance equipment to record or to analyze the high-speed headbangings of underground termites in Africa.

However, we all can appreciate how the Lord Jesus Christ providentially planned, programmed, and produced these diminutive detritivores—mostly ignored by us, yet not by Him—as those humble headbanging termites illustrate Christ's creative imagination and bioengineering (Revelation 4:11).

Obviously, evolutionary accidents cannot explain—much less invent—such noggin-knocking communicators' design, development, and deeds.

Headbanging termites are alarming, yes, yet we can also admire their purposeful communications as energetic exhibits of Christ's glory as Creator (Revelation 4:11; Psalm 148:10).

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J.D., Th.D., D.Min.

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Stead, N. 2013. Headbanging termites send out smoke signals. *Journal of Experimental Biology* 216(17):1, citing Hager and Kirchner research (noted above); https://journals.biologists.com/jeb/article/216/17/i/11590/headbanging-termites-send-out-smoke-signals.

Letters to the Editor

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Globally Correlative Precambrian Strata

Reed (2008a) questioned the value to Flood geology of the assumption that "…*rock units can be ordered by reference to concentric layers of synchronous time that are globally correlative*," which assumption he said is the "…*key to the geologic timescale (and modern stratigraphy*) …." Dr. Reed suggested that various factors "… make it unlikely that *globally correlative synchronous* time periods can be readily and practically identified in the rocks" (Reed, 2008a, p. 256; emphases added). Regarding Dr. Reed's view, I suggested (Hunter, 2008) that continentally correlative Flood strata sequences are essentially *globally correlative* and *synchronous*, in response to which Dr. Reed challenged me to

> "…demonstrate one *empirical globally correlative rock unit*, unconformity, or *similar horizon* that clearly demonstrates *temporal synchronicity* based on a clearly defined, *logical set of criteria* consistent with the *Biblical narrative* of the Flood and readily *identified in the field*" (Reed, 2008b, p. 146).

Herewith I address each of the five details raised in Dr. Reed's challenge as follows:

1. "*…empirical globally correlative rock unit, …or… horizon…*"

I refer Dr. Reed to Figure 1 herein which is a compilation of twenty-one lithostratigraphic columns through Precambrian sequences throughout the globe compiled by Soviet geologist Professor Lazarus J. Salop. Professor Salop was head of the Precambrian Geology Department of the All-Union Geological Research Institute, Leningrad, USSR. Salop's work on the Precambrian is endorsed by Alan M. Goodwin, of the Department of Geology, University of

Toronto, one of the foremost authorities on the global Precambrian (Goodwin, 2000). In Salop's book *Geological Evolution of the Earth During the Precambrian* (Salop, 1983), he published some seventy-five lithostratigraphic columns through Precambrian sequences on all continents except South America and Antarctica.

Having ruled out palaeontological methods and radiometric dating as valid methods of correlating Precambrian strata, Salop used what he called the "*…geohistorical…methods*" to subdivide and correlate Precambrian sequences throughout the globe. The "*…geohistorical…methods*," Salop explains, involve the accumulation and interpretation of factual or "*empirical*" geological data to elucidate recurrent "*empiric regularities*" in the Precambrian geologic record. Precambrian subdivision, Salop notes, "…can be established on the basis of specific types of formations…typical of *definite stages of geologic evolution*" (Salop, 1983, pp.7–8; emphasis added).

The sharply defined boundary in the upper Paleoproterozoic between mafic and felsic lavas and overlying sedimentary units at twelve locations on four continents, shown in Figure 1, constitutes an "*…empirical globally correlated…horizon…*". Less distinct, but nonetheless real, is the globally correlated boundary between Katarchean (part Hadean) massive metabasites and tuffs and overlying metabasites with interstratified marbles, calc-silicate carbonate rocks, and tuffs at nine locations on three continents, also shown in Figure 1.

2. "*…temporal synchronicity*"

Within the compressed timeframe of the Flood cataclysm, temporal synchronicity of the two globally correlated horizons discussed, cannot be established accurately by any intrinsic characteristics of the rocks. I suggest however, we might reasonably ask if, at the global scale, could the two globally correlative horizons shown in Figure 1 be anything but synchronous, and, is the onus upon synchronicity deniers to demonstrate they are not synchronous?

Regarding the "*…uniformitarian geologic periods…*" Reed recognizes "*…a unidirectional order in the sequence*?" (Reed, 2002, p. 229; emphases added), and Salop (1983) notes "… *the geohistorical principle* … acknowledges *advancing physical and chemical evolution* of the planet…" and that "…the geologic processes that occurred were of… *progressive* nature" (Salop, 1983, p. 8; emphases added). The early Precambrian stratigraphic record (Figure 1) shows unidirectional and irreversible lithological and chemical variation, the result, I believe, of a "one-off" never-to-be -repeated catastrophic event (Hunter, 2020, 2022). The same is probably true for the complete geologic record. If the Precambrian, and perhaps the complete stratigraphic record, is the result of progressive extrusion of material from the Earth's mantle (see 4. below), there may be some uniformly changing chemical or isotopic signature in the geologic record that might allow accurate timing ("*…a logical set of criteria*") for the establishment of temporal synchronicity. Notwithstanding the fact that radiometric dates were not used to establish the correlations shown in Figure 1, similar correlations can be established, very approximately, using radiometric dates.

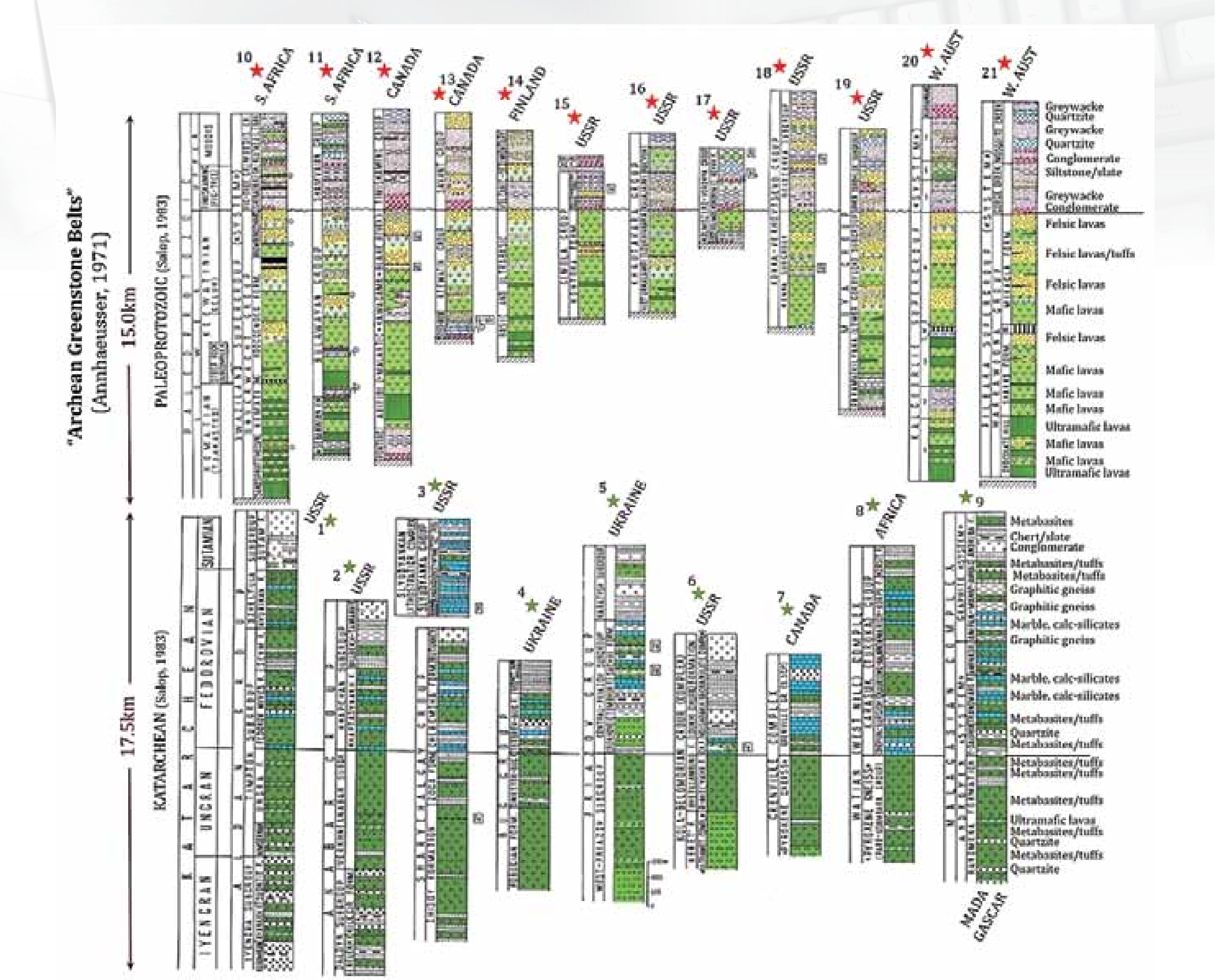
Regarding the origin of the Phanerozoic geologic record, in my 2008 Letter, I entertained "…the possibility that the complete geologic record may have been deposited in the first forty days…" (Hunter, 2008, p. 142). I now see the Phanerozoic being deposited during Days 40 to 150 (Hunter, 2020, 2022) with the twelve Phanerozoic periods (Cambrian to Quaternary) being deposited at an average of 9.0 days per period, a much slower deposition rate than the Precambrian, due to restricted extrusion from the mantle after Day 40.

3. "*…temporal synchronicity*" based on ***a "…logical set of criteria*"**

As far as I am aware no "*…logical set of criteria*" has yet been proposed to accurately date global correlations such as those shown in Figure 1. A "*…logical set of criteria…*" for "*…global correlation*" This could be Salop's "*…geohistorical… methods*" (see 1. above), which involve the accumulation and interpretation of factual or "*empirical*" geological data (i.e., lithologies, etc., absent fossils and radiometric dating) to elucidate recurrent "*empiric regularities*" in the Precambrian geologic record.

4. "*…consistent with the Biblical narrative of the Flood*"

Froede and Oard (2007) astutely observed that "*Our perception of the Flood shapes how we define the rock record.*" (Froede and Oard, 2007, p. 4; emphasis added). Our "*…perception of the Flood*" is our *Flood model*, derived from "*…the Biblical narrative of the Flood*," which model determines how we interpret the global stratigraphic record. I interpret the "*…Biblical narrative of the Flood*" according to a Gravitational Decompression-Recompression Genesis Flood Geologic Model (Hunter, 2020, 2022, 2023) wherein God is considered to have initiated the Genesis Flood cataclysm by temporarily reducing gravitational force throughout the Universe. Decompression of the created, hot ("*sub-solidus*") water-saturated interior of the Earth I posited initiated adiabatic decompression melting, viscosity reduction, water exsolution, and diapiric uprise and extrusion of mantle material onto the Earth's surface. No heat input or temperature rise was required to initiate adiabatic melting of the mantle. The Precambrian rock record and copious water ("*…the fountains of the great deep*"—Gen. 7:11) were extruded from the Earth's mantle during Day 1 to Day 40 of the Flood cataclysm. The rate of Floodwater-level rise on the Earth's surface decreased ex-



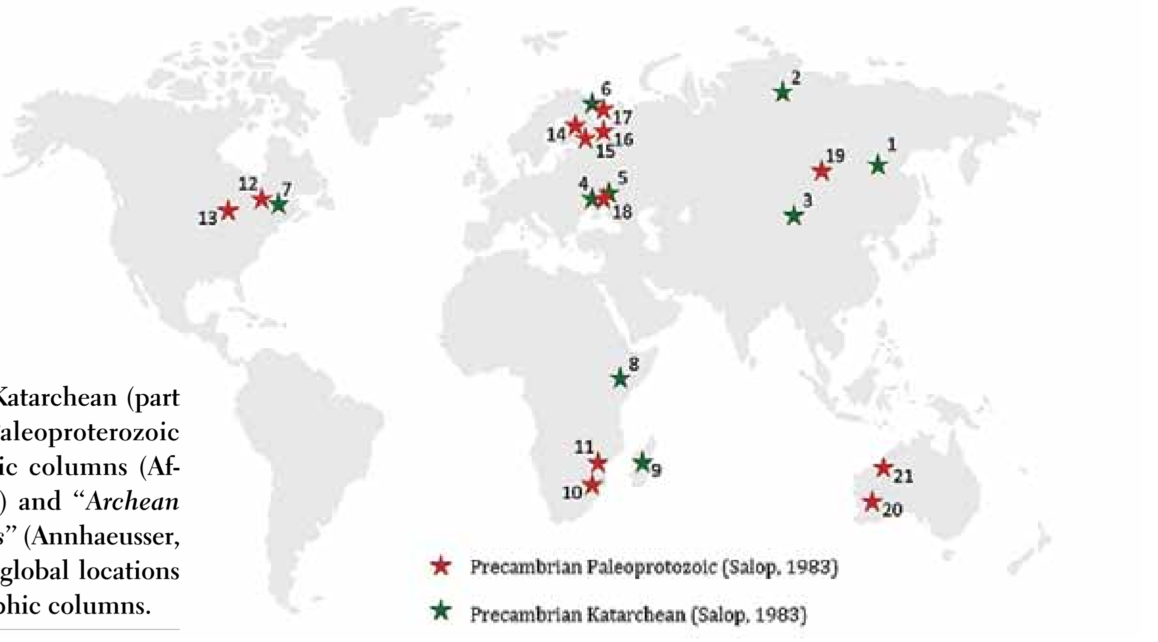


Figure 1. Top: Katarchean (part Hadean) and Paleoproterozoic lithostratigraphic columns (After Salop, 1983) and "*Archean Greenstone Belts*" (Annhaeusser, 1971). Bottom: global locations of lithostratigraphic columns.

ponentially until on or near Day 40, due to progressive depletion of the mantle water source. On or about Day 40, the mantle was partially recompressed, by a partial restoration of gravitational force, causing partial solidification of the mantle and consequent severe reduction of water exsolution and extrusion. Day 40, or thereabouts, is "flagged" in the Precambrian rock/fossil record by the "*pre-Ediacaran*" and "*Ediacaran*" metazoan and "*Cambrian Explosion*" fossil assemblages, which were dumped out of the Floodwaters due to a sudden loss of buoyancy, when the Floodwaters reached their maximum level. Movement of material that now comprises the continental Precambrian cratons and shields was thus firstly vertically upwards, from the mantle, and then horizontally outwards, from the Precambrian shields.

In positing vertical movement of material from the mantle, the Gravitational Decompression-Recompression Flood Geologic Model differs substantially from models which posit horizontal movement of Floodwaters and material across the continents. The Catastrophic Plate Tectonics (CPT) model posits that "…earthquake-induced sea waves with *ocean- to-land movement* redistributed sediment toward continental interiors" (Austin et al., 1994, p. 610; emphasis added), and Reed implies horizontal movement of water and material when he describes the Flood process as involving "…onset, *transgression*, highstand, *recession*, end…" (Reed, 2008b, p.143; emphases added).

5. "*…readily identified in the field*"

The lithological units shown in Figure 1 have been readily identified in the field, globally, and independently, by thousands of geologists, over some 60 years since the mid 1960's (Salop, 1983; Goodwin, 2000).

Conclusion

On the basis of 1 to 5 above, I must concede that accurate temporal synchronicity of the two horizons shown in Figure 1, cannot, as yet, be established by any intrinsic characteristic in the rocks; it is however obvious that global correlation is established. Our capacity to perceive synchronicity of deposition of these two horizons, I believe, depends on our *Flood model*, which determines our perception of *Flood processes and products*. As Dr. Reed rightly notes, in Flood models that posit the global stratigraphic record being deposited by horizontal movement of water and materials across continents, "…continent-wide synchronous units would not be logically possible until *highstand*" (Reed, 2008b, p. 145; emphasis added). In the Gravitational Decompression-Recompression Genesis Flood Geologic Model (see 4. above), the global stratigraphic volcano-sedimentary record is deposited by movement of material, firstly vertically from the mantle onto the Earth's surface, and then horizontally on all continents, simultaneously. Synchronicity then, is understood in terms of Flood processes, not through any intrinsic characteristics of the rocks.

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

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Creation Research Society

History—The Creation Research Society was organized in 1963, with Dr. Walter E. Lammerts as first president and editor of a quarterly publication. Initially started as an informal committee of 10 scientists, it has grown rapidly, evidently filling a need for an association devoted to research and publication in the field of scientific creation, with a current membership of over 600 voting members (graduate degrees in science) and about 1000 non-voting members. The *Creation Research Society Quarterly* is a peer-reviewed technical journal. It has been gradually enlarged and modified, and is currently recognized as one of the outstanding publications in the field. In 1996 the *CRSQ* was joined by the newsletter *Creation Matters* as a source of information of interest to creationists.

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.

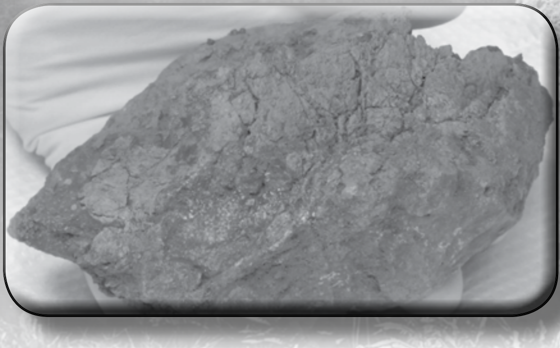
Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the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

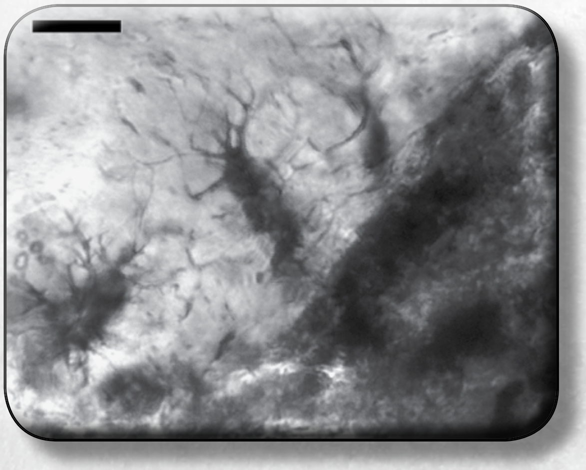
1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.
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

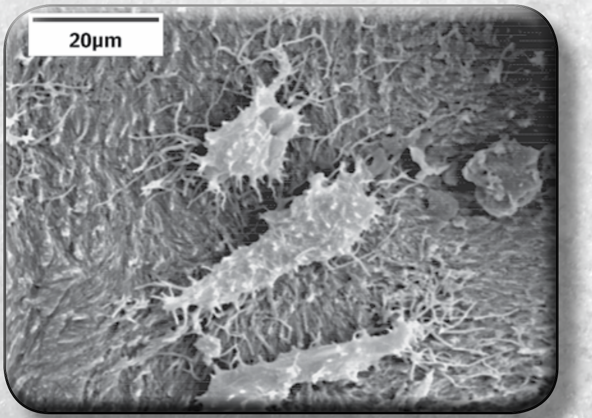
Investigation of Dinosaur Intact Natural Osteo-tissue



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.

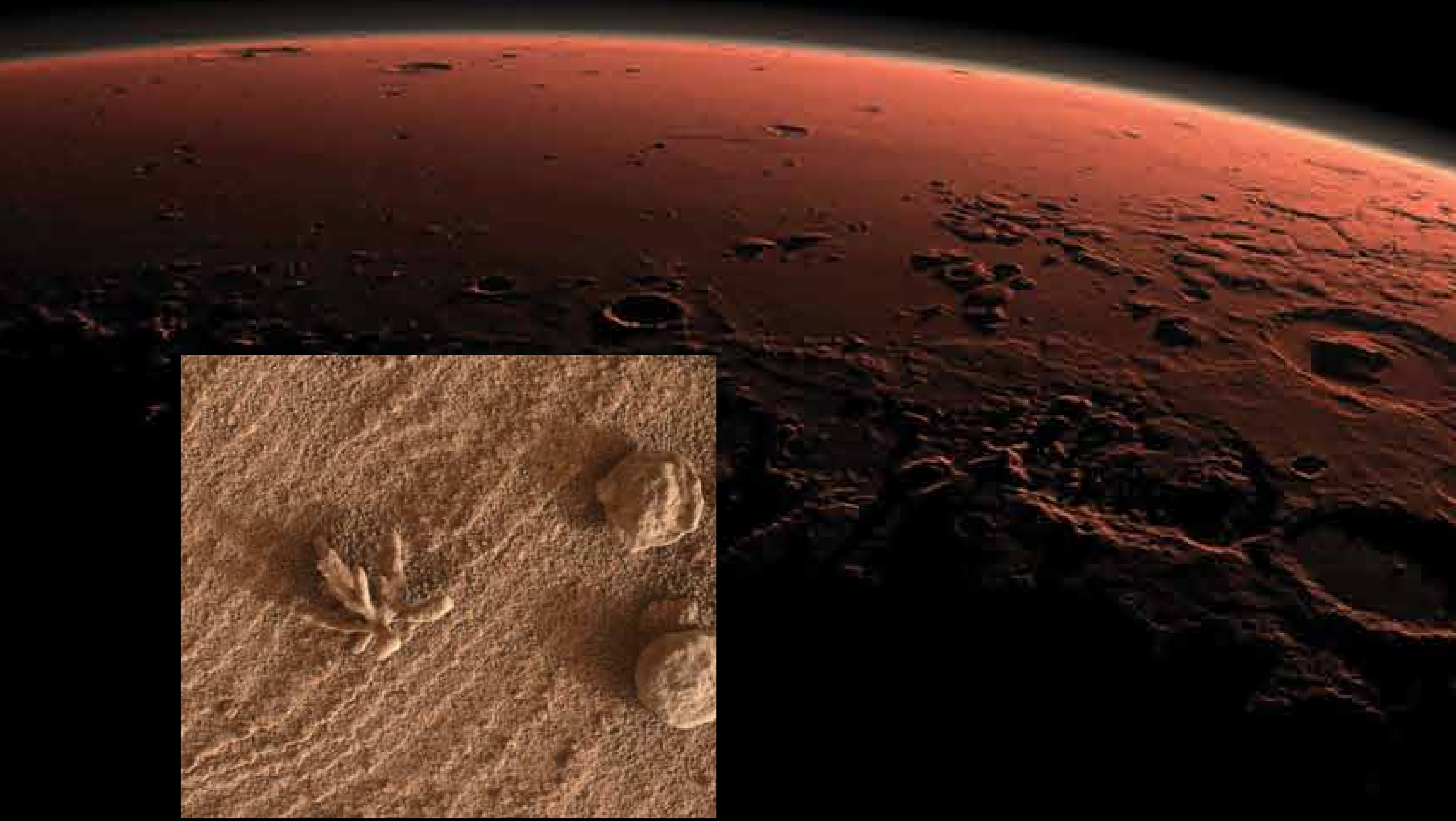
The Creation Research Society began its iDINO research initiative for the purpose of studying soft tissue in dinosaur fossils. The first phase of the project detected pliable, unfossilized tissue in a brow horn of a *Triceratops*. Within this tissue were intact osteocytes (bone cells). Some results from 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.



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