What Is the Meaning of the Floods on Mars?

Part III: Mars Floods Explained Within Biblical Earth History

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Abstract

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

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

Introduction

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

Accepted for publication Nov. 1, 2023

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

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

Crater Dating Highly Inaccurate Within Uniformitarian Deep Time

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

Do Not Know Total Cratering History

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

Table I. The four periods of secular Mars history.

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

Numerous Anomalous Results

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

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

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

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

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

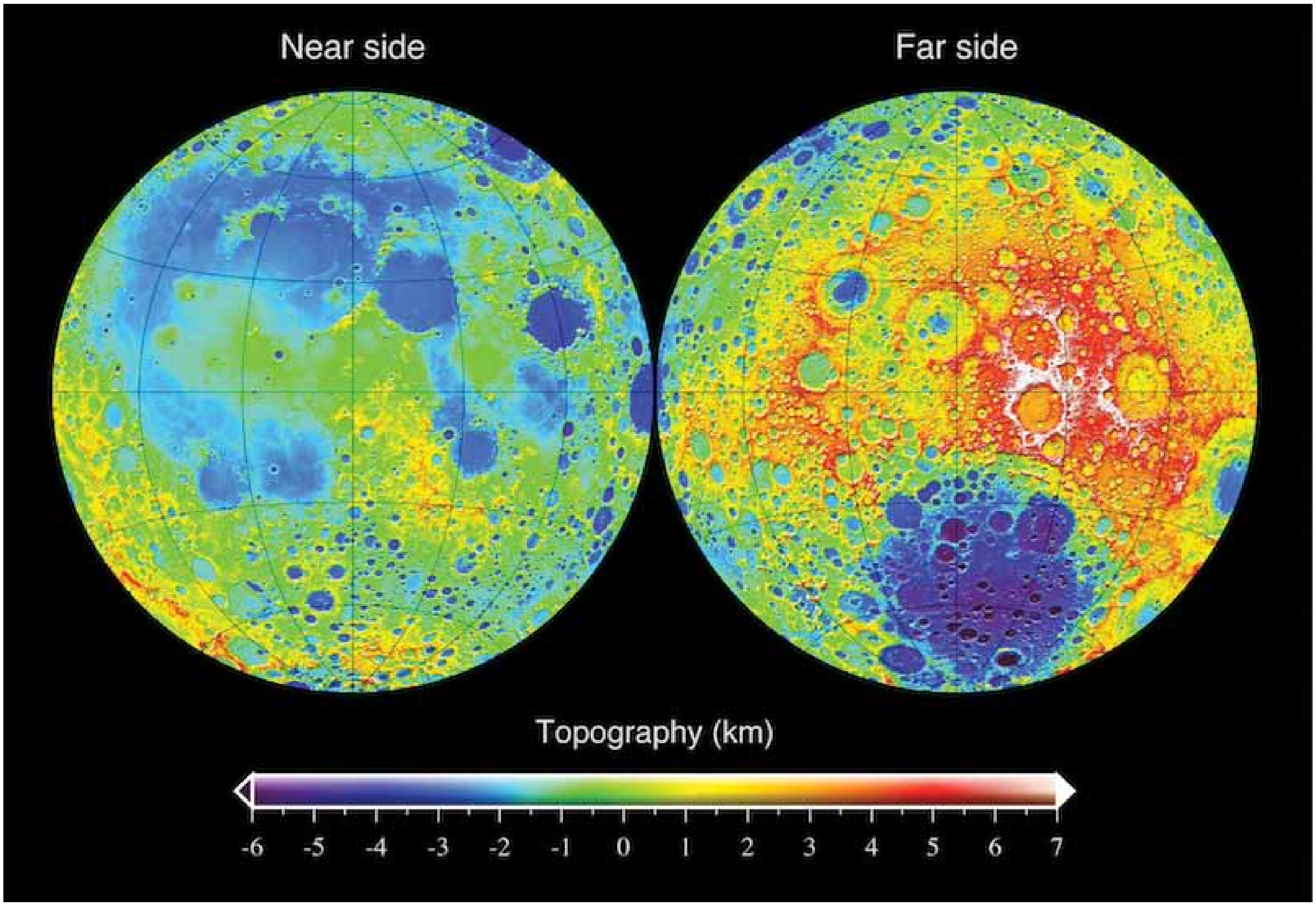

Figure 1. The color-coded topography of the Moon obtained from the Lunar Orbiter Laser Altimeter in two Lambert equal area images projected on the near and far side hemispheres (Mark A. Wieczorek, Wikipedia Commons CC-BY-3.0). Except for South Pole/Aitken, the large impact basins are on the near side.

Some Astronomers Admit Crater Dating Inaccurate

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

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

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

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

The Day-4 Cratering Hypothesis

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

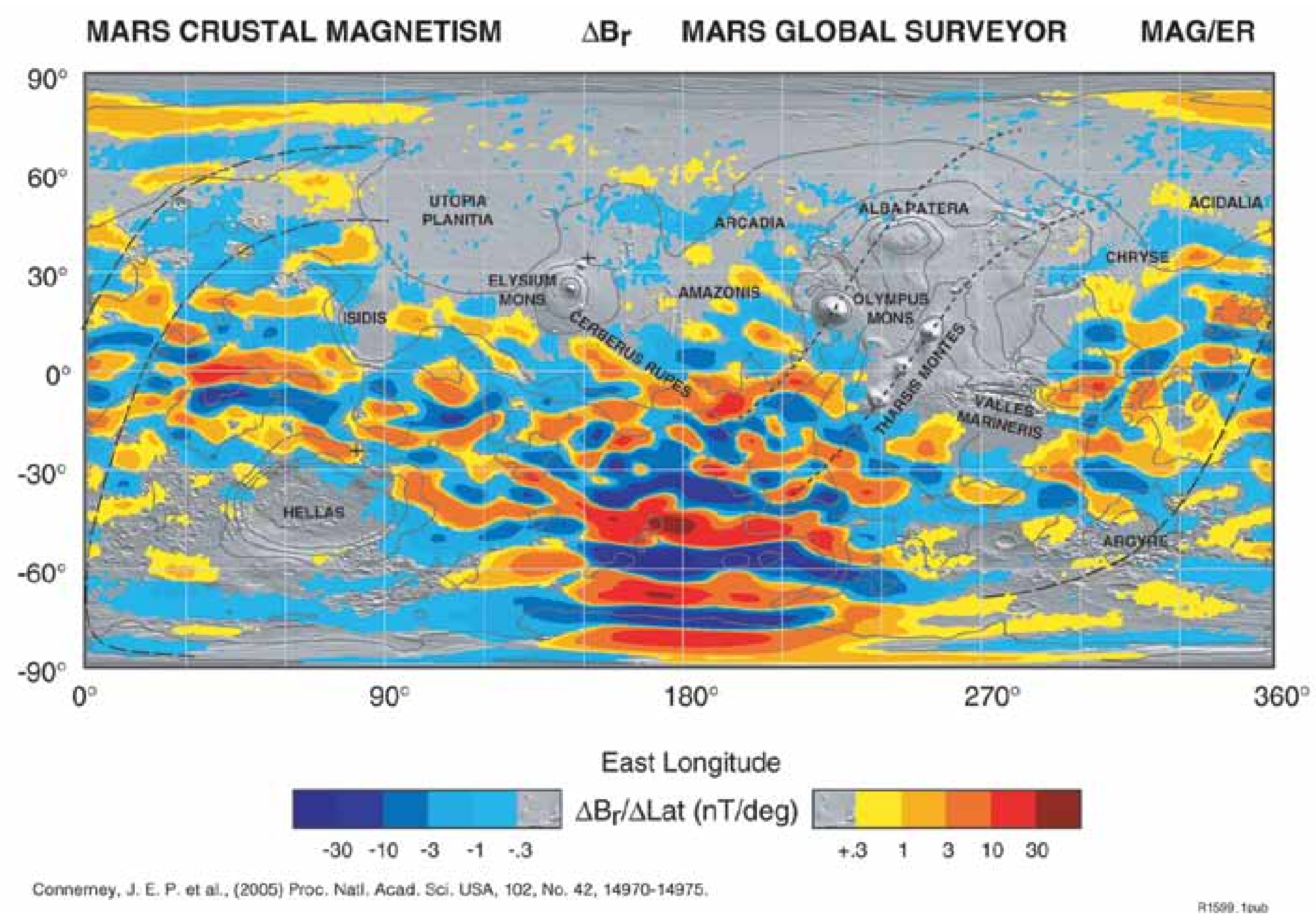

Figure 2. Map of Mars crustal magnetism (NASA). Notice the alternating positive and negative anomalies and that some areas have little or no magnetism.

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

Day-4 Cratering Hypothesis Extended to Mars

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

Large Impacts Destroy Magnetism

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

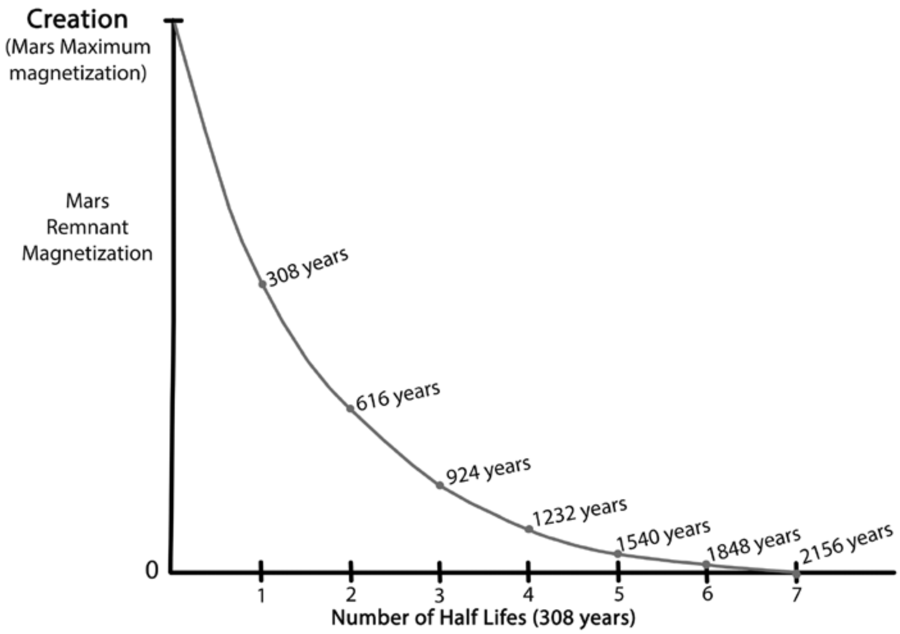

Figure 3. Decrease in Mars magnetism with a half-life of 308 years over 7 half-lives after Humphreys' communication (drawn by Melanie Richard).

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

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

Impact Timing of the Decay of Mars' Magnetic Field

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

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

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

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

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

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

Magnetism of impact craters greater than 300 km in diameter provides a clock with respect to the decay of the magnetic field, assuming a crater's magnetization was not altered later (Lillis et al., 2013a; Vervelidou et al., 2017). As it turns out, the craters *do* have very weak magnetism (Vervelidou et al., 2017), indicating that the impacts occurred just before the magnetic field died around 1500 to 2100 years after the initial creation of the magnetic field. The maximum magnetic signatures in the inner half of the four largest impact craters are shown in Table II and are similar, indicating a similar time of impact. The numeric average of their magnetization is 0.145 A/m.

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

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

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

Why Not Large Impacts on Earth?

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

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

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

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

Climatic Deductions from the Day-4 Cratering Hypothesis

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

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

Impacts and Volcanism Can Provide Needed Water Quickly

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

The impacts apparently ended quickly, explaining why flood features (Baker, 2001), some minerals (Squyres and Knoll, 2005), subsurface ice, and ice sheets exhibit few craters.

Evidence for Young Ages

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

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

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

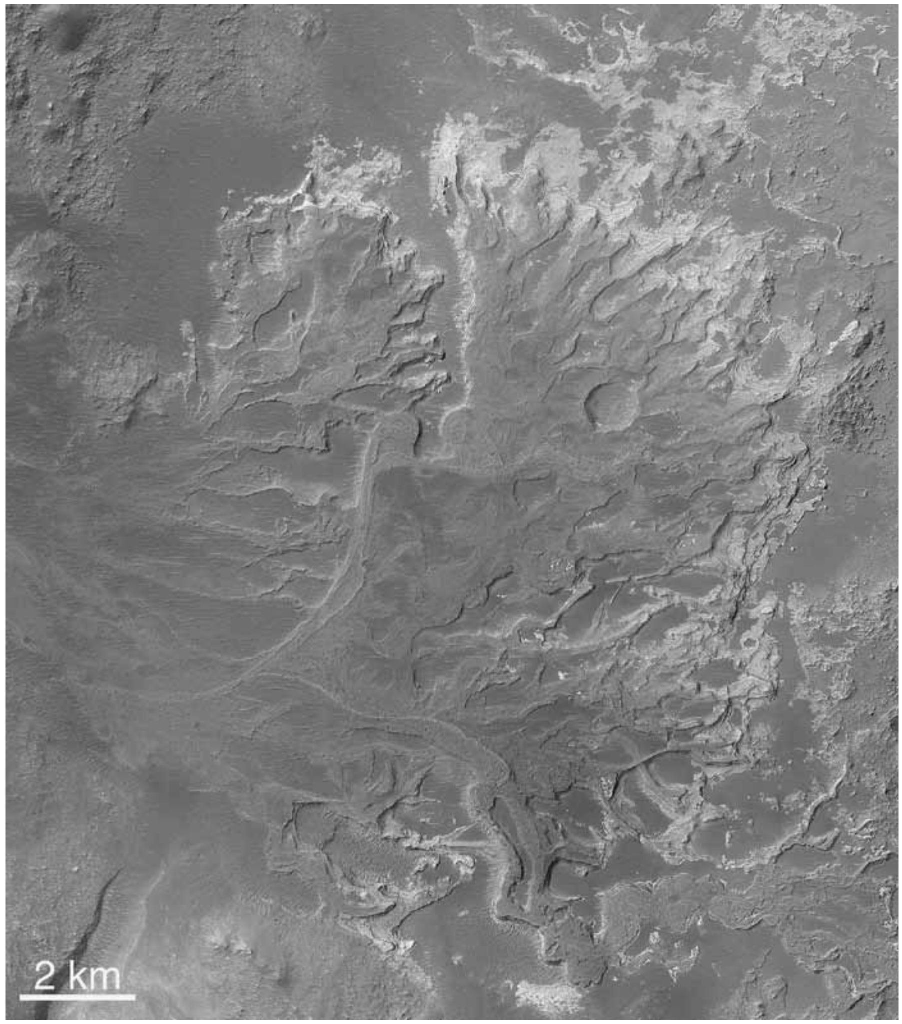

Figure 4. The Eberswalde delta on Mars (NASA). Note the meanders with cutoffs, now seen in inverted relief from wind erosion.

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

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

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

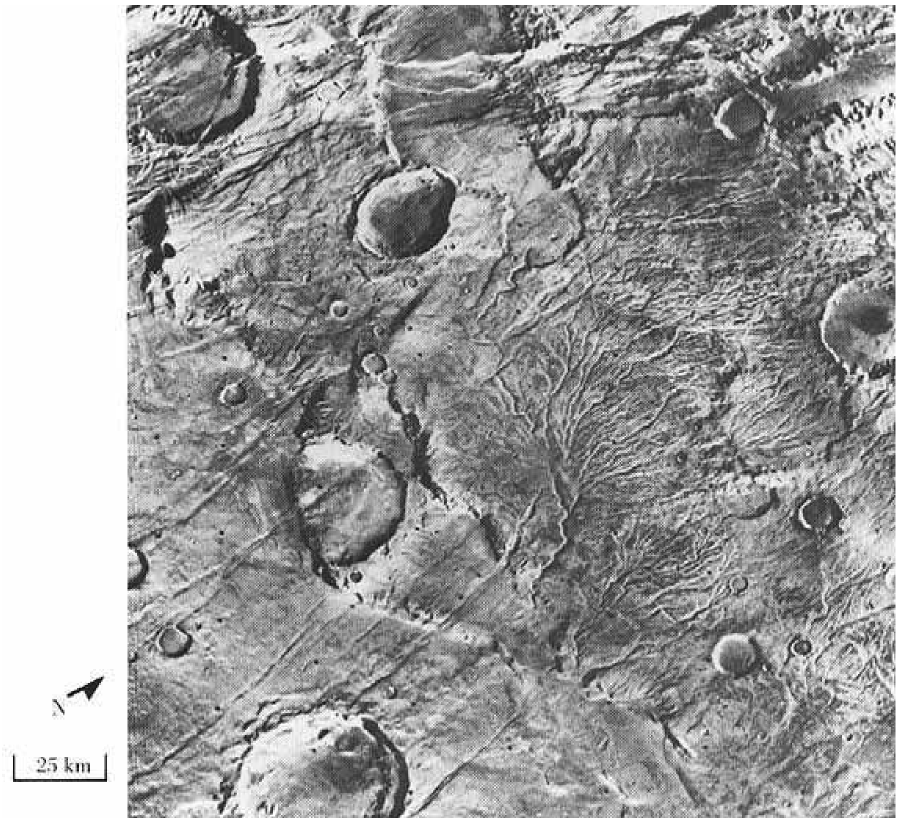

Figure 5. Branched valley network as seen by Viking Orbiter (Jim Secosky, Wikipedia Commons PD NASA). Field of view is roughly 200 km across.

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

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

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

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

How Did the Valley Networks Form?

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

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

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

The Evidence for Groundwater Explained by Precipitation

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

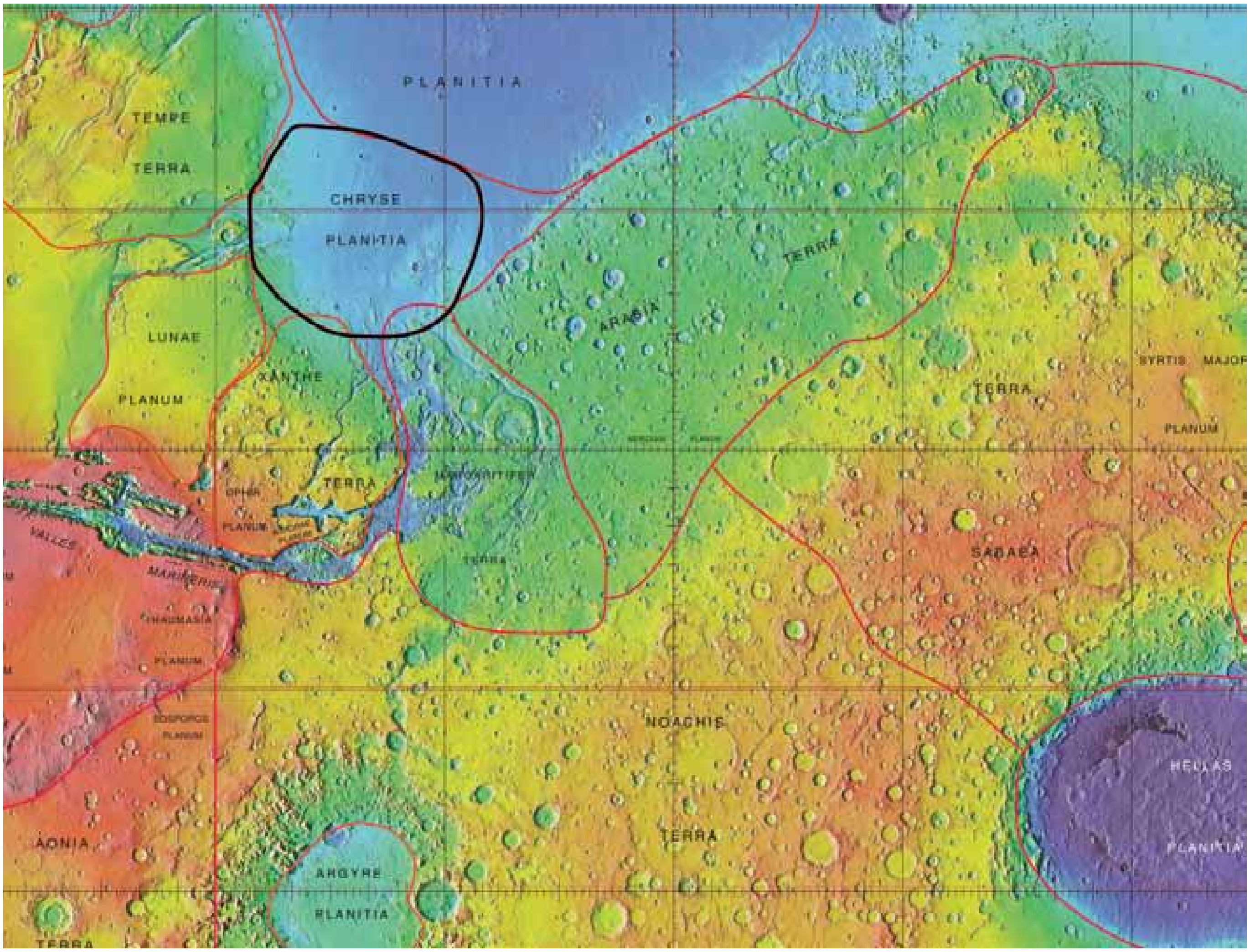

Figure 6. Chryse Planitia, in the black outline, in relation to surrounding areas color coded with blues and purples of low altitude and red and brown for high elevations (NASA).

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

Some Valleys Formed by Breached Lakes

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

Impacts and/or Volcanism Can Account for VNs

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

VNs Not Necessarily Formed at 30°S

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

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

How Did the Outflow Channels Form in Biblical Earth History?

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

Lakes in Valles Marineris

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

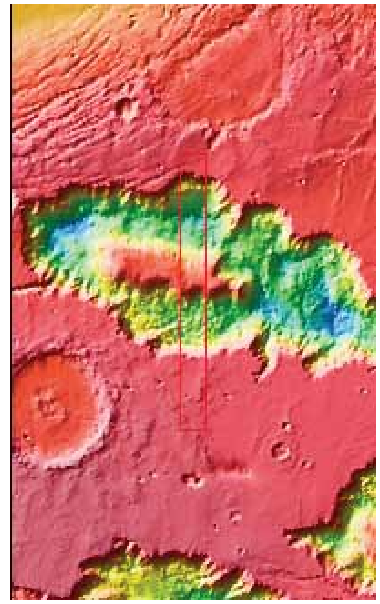

Figure 7. Hebes Chasma, a northern isolated chasma north of Valles Marineris. Blues and purples are low altitude and red shows high elevations (NASA). It is 319 km long, 130 km wide, and up to 8 km deep. The middle elevation is Hebes Mensa, a large remnant of layered materials, left after the catastrophic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

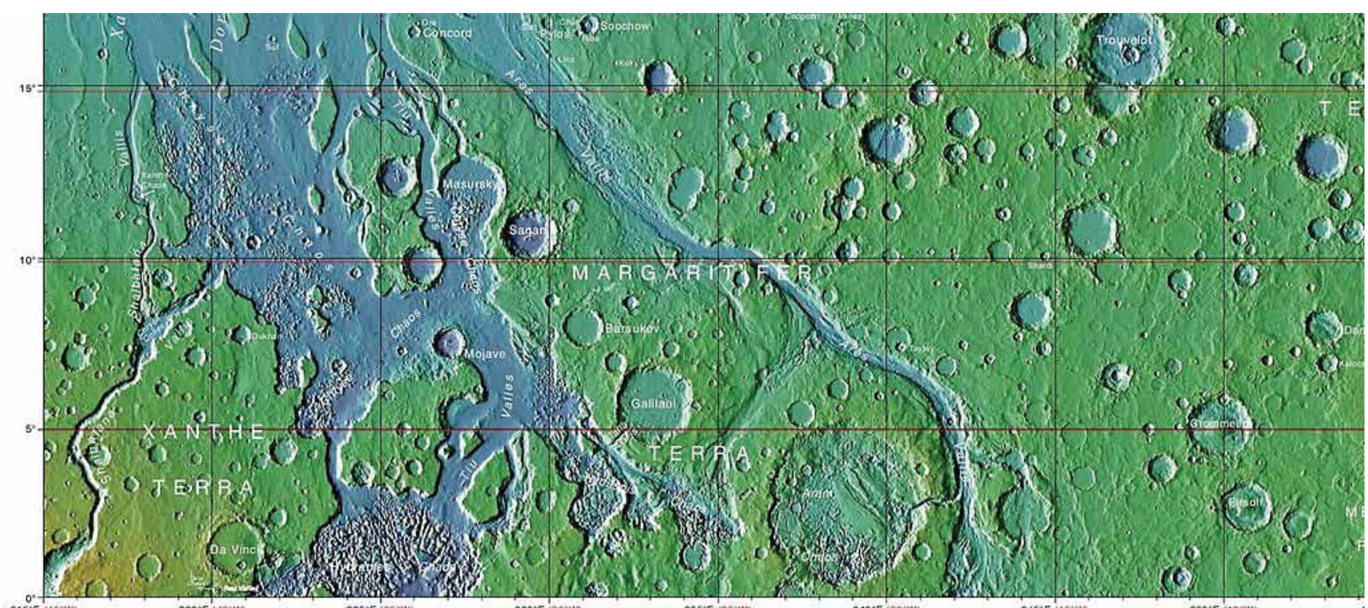

Figure 8. Topographic map of Oxia Palus region of Mars. Blues are low elevations and greens high elevations. Note the chaos regions and valleys, including Ares Vallis and Aram Chaos in the middle of the picture (Jim Secosky, Wikipedia Commons PD USGS).

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

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

Floods from Valles Marineris

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

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

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

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

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

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

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

How Much Water?

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

Where Did the Water Go?

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

Very Little Water Lost to Space

Recent estimates suggest that the water could not have escaped into space, even given billions of years (Kurokawa, 2021; Scheller et al., 2021). The thermal loss in 4 billion years is only 3 to 25 m GEL (Jakosky, 2021). Within the Biblical timescale, almost no water could be lost to space.

Water Incorporated into Hydrated Minerals

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

Water Absorbed into the Subsurface

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

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

Did Water End Up in a Northern Ocean and Frozen?

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

Where Did the Thick Atmosphere Go?

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

Discussion and Conclusion

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

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

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

Our detailed knowledge of Mars' surface is very recent, yet it appears that the planet experienced impacts, volcanism, and catastrophic floods. These can be related to Biblical history in that numerous impacts occurred on Day 4 followed by Flood impacts, some of which were very large. These Mars impacts accompanied by volcanism, possibly caused by impacts, can be the cause of the surprisingly large floods on Mars. Impacts should be considered in any Flood model for Earth.

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