Geologic consequences of a global Archean ocean – the Big Hurricanes Theory

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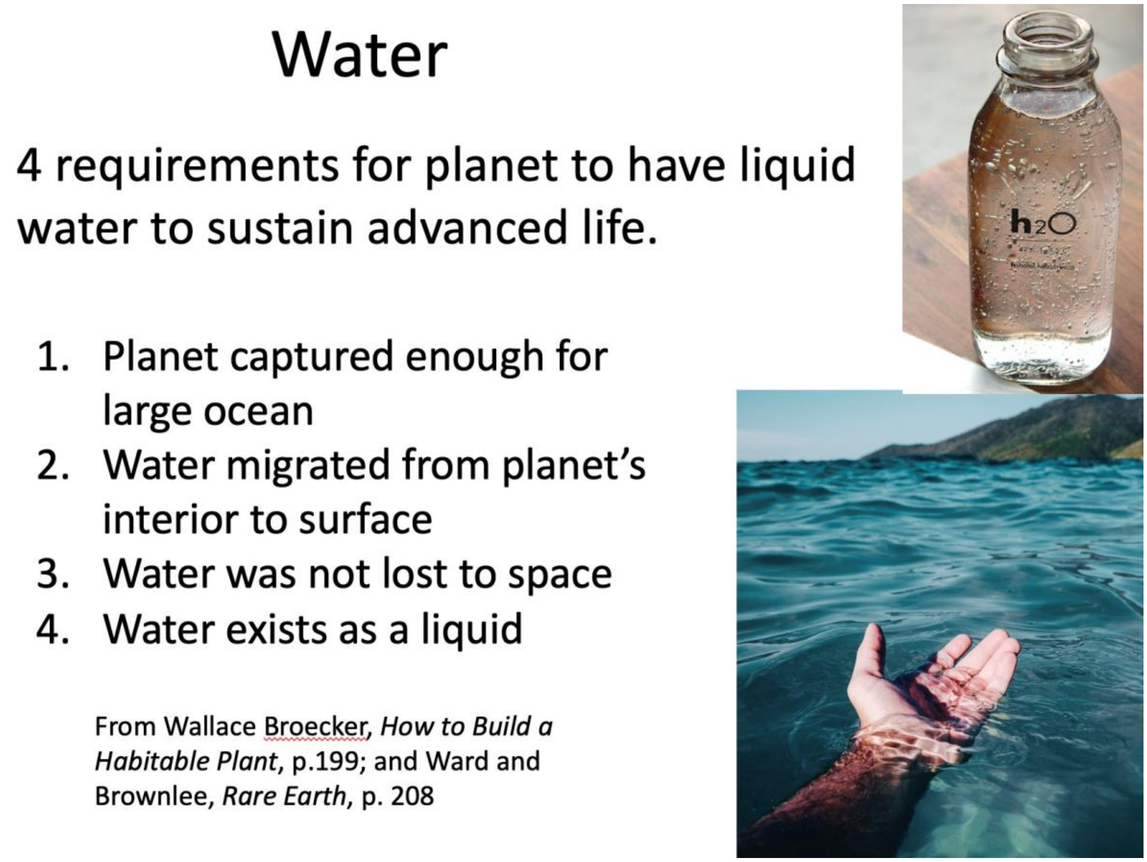
Abstract

The proto-Earth began as a melt because of zillions of meteorite collisions and heat coming from radioactive elements that caused melting of much of the Earth's rocks and eventually resulted in an iron core with an outer silicate mantle. Its early atmosphere probably contained nitrogen, carbon dioxide, hydrogen sulfide, methane, ammonia, little to no free oxygen, and certainly not enough water to condense to form a global ocean as deep as the present oceans. The volume of the Earth's oceans accumulated slowly over geologic time scales with trace water molecules in the mantle which came to the Earth's surface via basalt volcanic eruptions to produce an early shallow, global, ocean covering. The proto-Earth likely spun rapidly with more than 600 days in a year. The hotter mantle facilitated plate tectonics that caused the sliding around of small continents to collide and form giant continents in repeated cycles. Methane was produced by methanogens in the mid-Archean and moved into the atmosphere as a greenhouse gas that facilitated powerful hurricanes. The greater oblateness of the Earth and the greater Coriolis effect made the erosive power of the hurricanes greater

than what occurs today. The formation of cyanobacteria that photosynthesized and produced oxygen changed how processes occurred during the Archean because oxygen was a poison that killed the methanogens. Oxygen accumulated into the atmosphere and changed its composition to consist of nitrogen, oxygen, carbon dioxide, and water vapor. The greater amounts of erosion by the stronger hurricanes likely explains how the Great Unconformity was formed in the Grand Canyon. Eventually, the progressive arrival of water by basaltic eruptions through geologic time and the growth of continental shields deepened the water in the Earth's oceans, and the percent coverage of the oceans on the Earth was reduced from 90% in its shallow early occurrence to 71% in its present covering. Accompanying all these processes are the production of magmatic granitic plutons, metasomatic granites, myrmekite formation, Po-halos in biotite, the increase of the saltiness of the oceans, and creation of some kinds of lamprophyres. This article is significant because it shows that the Earth began with a gradual increase of water in the oceans and that violent hurricane storms likely caused the extensive erosion of its Precambrian rocks. This can be called "the Big Hurricanes Theory."

Introduction

Wallace Broecker (1998) described what is necessary for a habitable planet, and a chief requirement is water. He lists four requirements in **Figure 1** that shows (1) enough water for a large ocean, (2) the water migrated from the planet's interior to its surface, (3) water was not lost to space, and (4) water exists as a liquid. The Earth meets those requirements, but what seems to be published now is not exactly what is described in these 4 requirements. That is, many investigators seem to think that the Earth began with an ocean deeper than the present ocean, but the geologic evidence and processes described in this article indicate that such a belief is not true.



Water

4 requirements for planet to have liquid water to sustain advanced life.

1. Planet captured enough for large ocean
2. Water migrated from planet's interior to surface
3. Water was not lost to space
4. Water exists as a liquid

From Wallace Broecker, *How to Build a Habitable Plant*, p.199; and Ward and Brownlee, *Rare Earth*, p. 208

Figure 1. Water requirement for Earth. (Source of image with permission, Ken Wolgemuth)

In **Figure 2**, it is shown that the original Earth contained nitrogen, carbon dioxide, water, hydrogen sulfide, methane, ammonia, but no free oxygen.

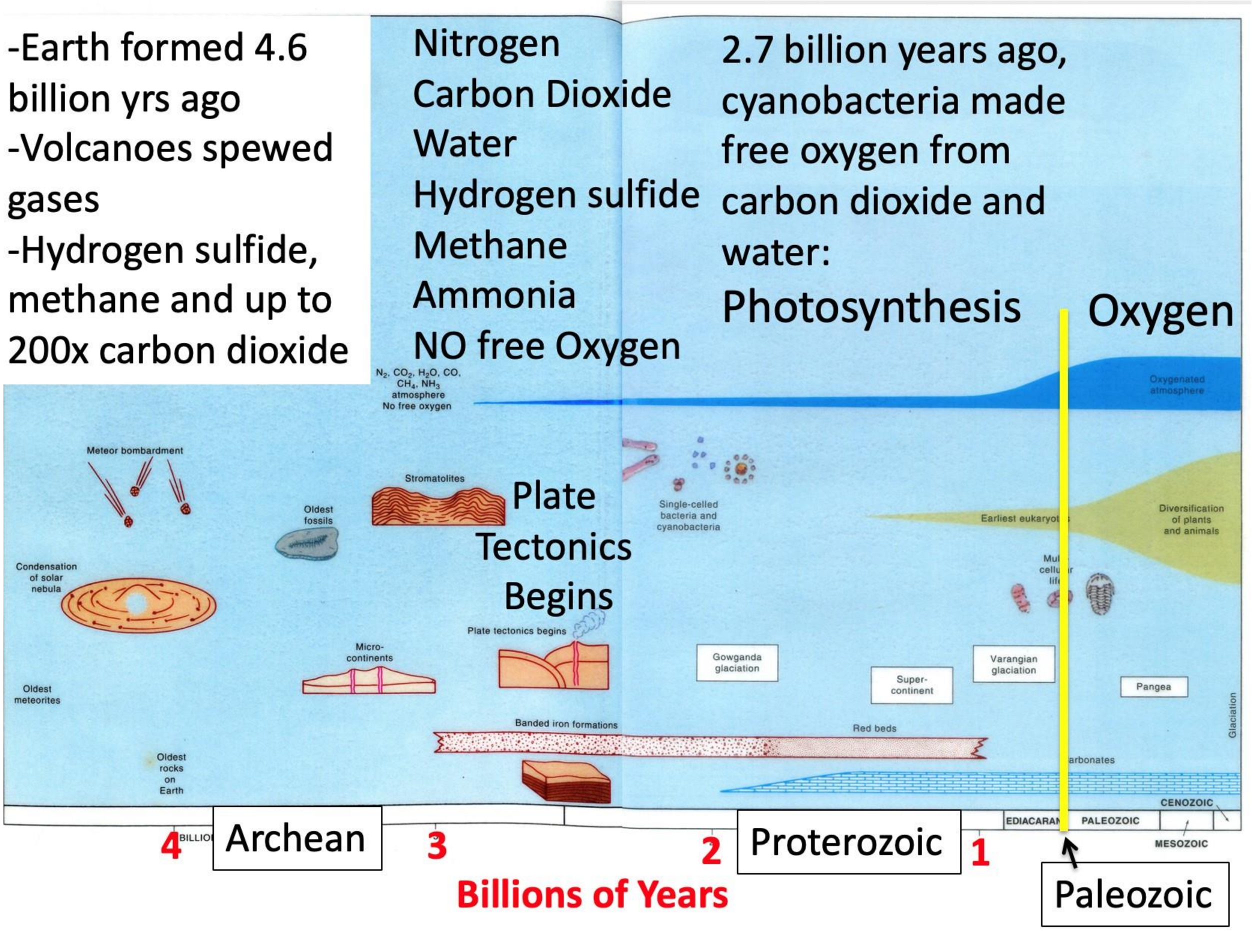


Figure 2. Gases spewed from volcanoes that came from the interior of the Earth. (Source of image with permission, Ken Wolgemuth)

The distribution of Archean rocks on the five continents on the Earth shows their wide extent in isolated tiny islands (**Figure 3**). These Archean rocks have ancient ages of their formation being created 4,000 to 2,500 million years ago. (See **Appendix**) Their wide scattered extent gives the impression that they were once surrounded by more than 90 percent water in an ocean covering the surface of the Earth's global area.

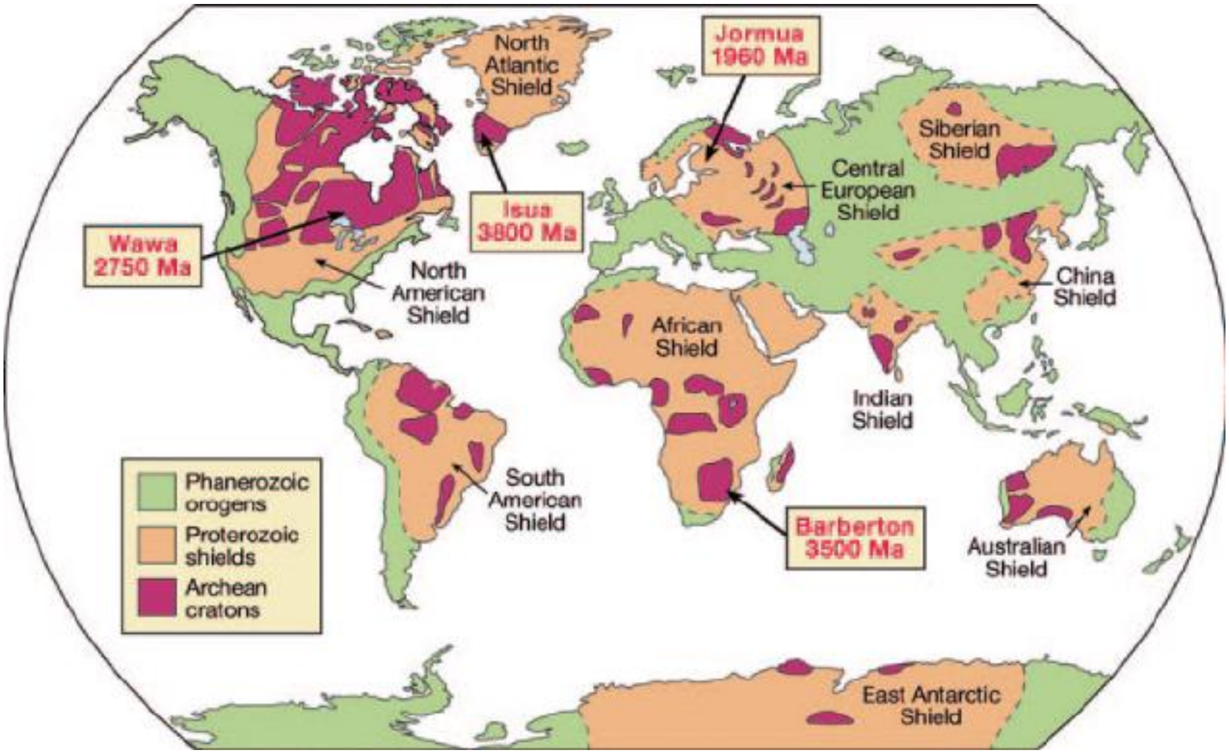


Figure 3. Distribution of Phanerozoic orogens (green), Proterozoic shields (orange), and Archean cratons (red).

On that basis, various investigators seem to believe that the Earth was mostly covered with water during the Archean Eon with oceans deeper than the present oceans (Doug et al., 2018; Drake, 2005) and some portions of these ocean waters were recycled between the Earth's mantle and the surface through geologic time that re-distributed some of this water among different reservoirs.

But the geologic records I suggest are misleading, and I have put in italics places that I question the interpretations that have been made by other investigators or I have said "supposed" or "supposedly" in italics to indicate interpretations that I question that they are true statements.

Some of the *supposed* evidence for the existence of more voluminous oceans is based on the relatively high ^{18}O content of the water (Smithies et al., 2021). (*This high ^{18}O content likely has nothing to do with evidence for the oceans being more voluminous but merely reflects that the ocean waters were warmer, creating relatively more evaporation of water molecules containing the lighter ^{16}O isotope and enriching the ocean waters in the heavier ^{18}O.)* To constrain the volume of Earth's early oceans, the water storage capacity (maximum water content) of the mantle as a function of mantle potential temperatures (T_p) was modeled by Doug et al., 2018. These investigators compiled high-pressure, high-temperature experimental data on water storage capacities for major rock-forming minerals and fitted a thermodynamic model to these data. The mantle's total water storage capacity was computed as a function of depth along a series of adiabats for T_p = 1500-2000 K, on the basis of mantle mineral phase assemblages that were calculated from the thermodynamic code HeFESTo.

These investigators found that the water storage capacity of the Earth's mantle decreased significantly with increasing temperature due to the temperature-dependent water storage capacities of mantle minerals. The mantle water storage capacity is 2.2 ocean masses at present with T_p = 1600 K, yet it was only 0.7 ocean masses (1.5 ocean masses smaller) in the early Archean with T_p = 1950 K. If assumptions are made that 1-2 ocean masses of water are stored in the mantle at present on the basis of geochemical and geophysical constraints, the additional water in the mantle today would have resided at the surface in the Archean and formed early oceans of larger volume (*supposedly in my view, but not necessarily so*). The ocean volume and fraction of flooded continents were estimated using continental freeboard modeling. For a broad range of model parameters, the continents were shown to have been largely flooded at $T_p > 1800$ K, which is consistent with the rock record (e.g., the abundance of subaqueous flood basalts in the Archean. Their results suggested that the oceans of the early Earth were more voluminous, and their volume is constrained by a variable mantle water storage capacity, essentially by mantle temperature. These investigators also found that more voluminous surface oceans might have existed if the actual mantle water content today is > 0.3–0.8 ocean masses and the early Archean Tp as ≥1900 K.

I suggest that mantle minerals, such as Mg-sursassite, Mg_2 $2Al_3(SiO_4)(Si_2O_7)(OH)_3$ *in Earth's interior (Ohtani, 2015) that has OH as part of its chemical formula, are not likely the source of water that eventually diffused up in the mantle to cause basalt melts to form and which later caused the explosive eruption of water-bearing basalt lava and ash from volcanic vents. That is, this OH is structurally bound and not free to migrate. More likely the sources of mantle water for basaltic eruptions are free* H_2O *or OH molecules in the interstices or crystal boundaries between iron-magnesium silicate minerals. Probably, although the amount of water in the original mantle was only in trace amounts, the volume of the mantle is enormous so that once there was 4 to 5 times as much water in the mantle as the volume of water in the world's oceans now.*

According to current theories, the proto-Earth was formed by zillions of impacts of meteorites, and the energy produced during the collective bombardment of these meteorite masses and the heat released from the decay of radioactive elements would have melted the whole proto-Earth so that heavy iron atoms sank to form its core, and this proto-Earth would have had magma oceans. *Supposedly,* subsequent outgassing, volcanic activity, further meteorite impacts produced an early atmosphere of nitrogen, carbon dioxide, and water vapor. Then, after these gases in the atmosphere had accumulated over millions of years and after significant cooling, the water vapor would have condensed to form the Earth's first oceans. Then, *supposedly*, the Earth during the Archean Eon was mostly a water world, but that it had a continental crust that was mostly under an ocean deeper than today's oceans.

But the laws of atmospheric physics indicate that such an atmosphere could not have held as much water as would have created oceans that would have had greater volume than the water volume in the present oceans. Moreover, ***Figure 1*** *suggests that water was not lost in space that would reduce the supposed original volume to its present volume and that the water actually came from the Earth's interior.*

It is true that when the Archean began, the Earth's heat flow was nearly three times as high as it is today (**Figure 4**), and it was still twice the current level at the transition from the Archean to the Proterozoic (2,500 Ma). (See **Appendix**.) The extra heat was (a) partly remnant heat from the zillions of meteorite accretionary bombardments, (b) from the crystallization of the iron core, and (c) partly from the decay of radioactive elements. As a result, the Earth's Archean mantle was significantly hotter than today (Galer and Mezger, 1998).

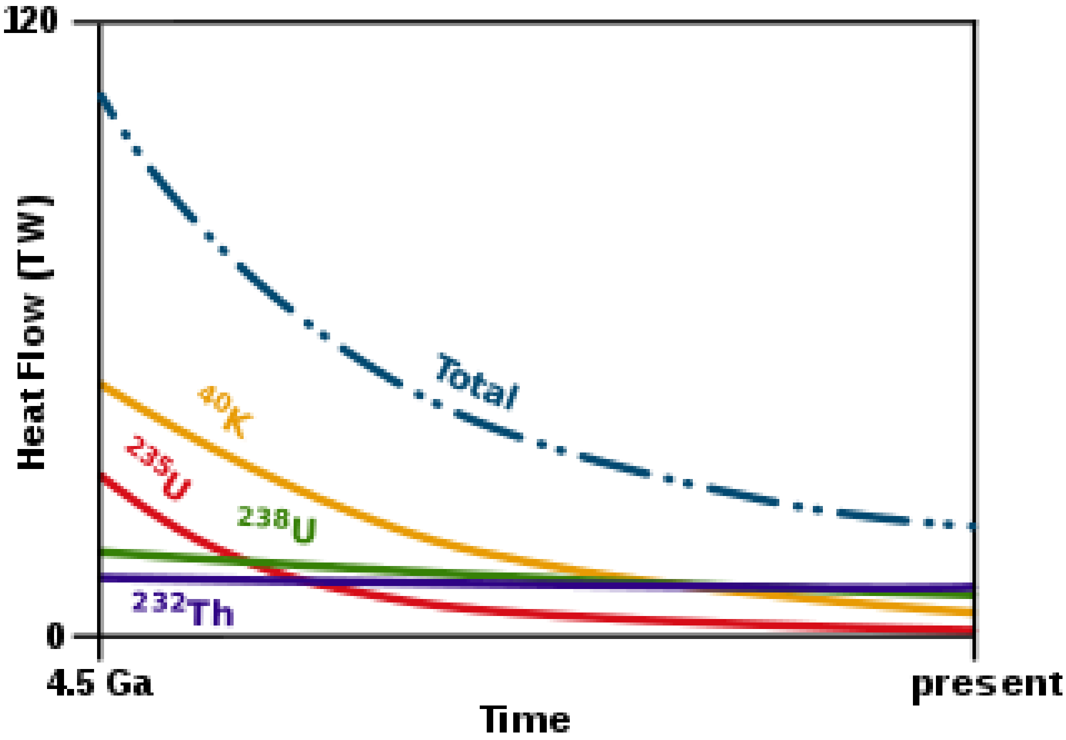


Figure 4. The evolution of Earth's radiogenic heat flow over time (Source: Radiogenic nuclide https://en.wikipedia.org/wiki/Radiogenic_nuclide

In the Archean islands that are shown in **Figure 3**, granitic rocks dominate in voluminous plutons of granite, diorite, layered intrusions, anorthosites, and monzonites, but some felsic rocks occur in extensive lava flows. In many places strongly metamorphosed *supposedly* deep-water sediments, such as graywackes, shales, volcanic sediments and banded iron formations, occur. Carbonate rocks are rare, which suggests that the oceans were more acidic because of dissolved carbon dioxide. Greenstone belts are common and consist of alternating units of metamorphosed mafic igneous and sedimentary rocks and felsic volcanic rocks. The metamorphosed igneous rocks were derived from volcanic island arcs, whereas the metamorphosed sediments represent *supposedly* deep-sea sediments eroded from the neighboring island arcs and deposited in a forearc.

Plate tectonics likely produced large amounts of continental crust, but the *supposedly* deep oceans of the Archean probably covered the continents entirely. Only at the end of the Archean did the continents likely emerge from the ocean (Bindeman et al., 2018). The rest of the Archean continents have been recycled (Korenaga, 2021). Evidence from banded iron formations, chert beds, chemical sediments and pillow basalts demonstrates that liquid water was prevalent and *supposedly* deep oceanic basins already existed.

A possible new interpretation

Previous investigators have insisted on their belief that the Archean Eon represented a time in which the whole Earth was covered with water and that the volume of this water was greater in deep oceanic basins than what occurs in the present oceans. This does not make good geological sense. The proto-Earth was not formed by impacts of water-bearing comets that had lots of water in them but by meteorites that consisted mostly of iron and of iron- and magnesium-bearing silicates, and any water in these iron rich meteorites would have boiled off into space at the very high temperatures that resulted from their impacts. Therefore, no water would have been immediately available to produce deep oceans of water. The clue to this fact is what is observed on the Moon which has the same age as the Earth and which has little to no water on its surface or in its minerals, as is evident from the samples collected by astronauts. Therefore, what geologically makes sense is that the water in oceans of Archean age only appeared gradually in time by being brought to the Earth's surface during basaltic eruptions, and the volume of this water also only increased gradually. On that basis, first oceans appeared when plate tectonics began that allowed trace amounts of water to emerge during basaltic eruptions and the first oceans that covered the first crust were quite shallow and only became deeper with time as more eruptions of basalt occurred. On that basis, the questions to be asked are what are the geologic factors that accompanied the creation of the ocean waters during the Archean Eon and what happened following the early formation of shallow ocean waters?

Geologic factors that affected events in the Archean and subsequent younger aged rocks

The **first** is that in the mid-Archean the first life that was formed were methanogens (*Euryarcheota*) that generated methane as a waste product of metabolism, and this methane would be added to the atmosphere. The first atmosphere could have consisted of nitrogen, carbon dioxide, perhaps a little methane, but almost no water or oxygen. Therefore, throughout the Archean methane was constantly being added to the Earth's atmosphere by the methanogens and increased in amounts at the same time that the amount of water increased in the oceans. During this time the mantle and crustal rocks (most of which were underwater) were relatively hot as indicated in **Figure 4**, but methane is a greenhouse gas and, thereby, would also heat the atmosphere that would cause the water in the oceans to be warmed and much hotter than occurs today.

The **second** is the speed of rotation of the proto-Earth. Collins (2023a) found that corals are particularly useful for calculating ancient day lengths and tidal patterns (See: https://www.theatlantic.com/science/archive/2016/02/fossilized-coral-calendar-changes-leap-day/471180/). Presently, the daily rotation of the Earth takes roughly 24 hours, and the Earth takes about 365 days and six hours to orbit the sun. But days used to be much shorter. Hundreds of millions of years ago, the Earth rotated 420 times around its axis in the time it took it to orbit the sun, rather than 365+ days. (See **Appendix**.) Corals from the Silurian Period (444-419 million years ago) show 420 little lines between seasonality bands, indicating that a year during that period was 420 days long. Corals from the Devonian Period, a few million years younger, show that the earth's spin had slowed down to 410 days per year. Projecting back in time could mean that in the Archean Eon the Earth's spin rate could have been such that there were more than 600 days in a year.

A **third** is that the greenhouse effect of methane in the atmosphere warms the ocean water that in turn results in powerful hurricanes as is observed in the present time. The hurricanes during the Archean likely would have been more powerful than category 5 in scale with winds moving much, much more than 156 mph. Such winds generate circular waves that would have very large amplitudes between troughs and crests of waves (**Figure 5**).

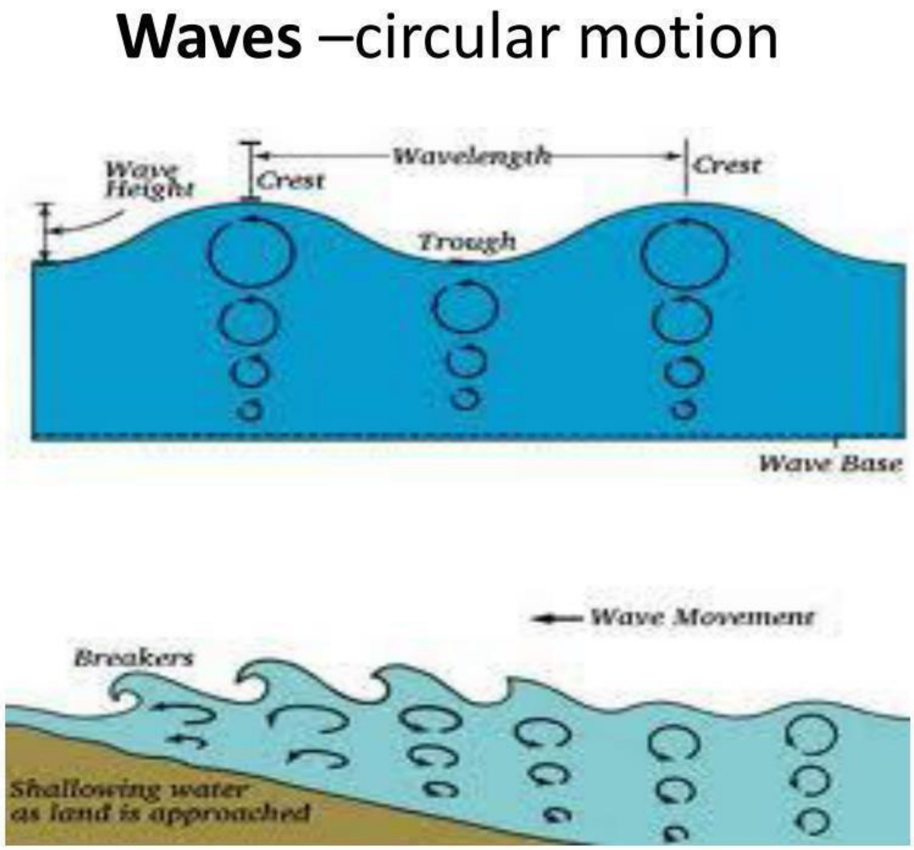


Figure 5. Circular motion of waves.

The **fourth** is that the Earth's high spin rate would result in the proto-Earth being an oblate spheroid with its diameter at the equator larger than it is now. This greater oblateness in combination with faster spinning could result in more flowage in the relatively hot plastic mantle so that circular convection cells of up-rising less-dense volumes in mid-ocean centers and down-movements of denser, colder, subducting crust could result in relatively faster plate tectonics than in later plate tectonic movements, which in turn would facilitate basaltic eruptions of water-bearing lava (**Figure 6**).

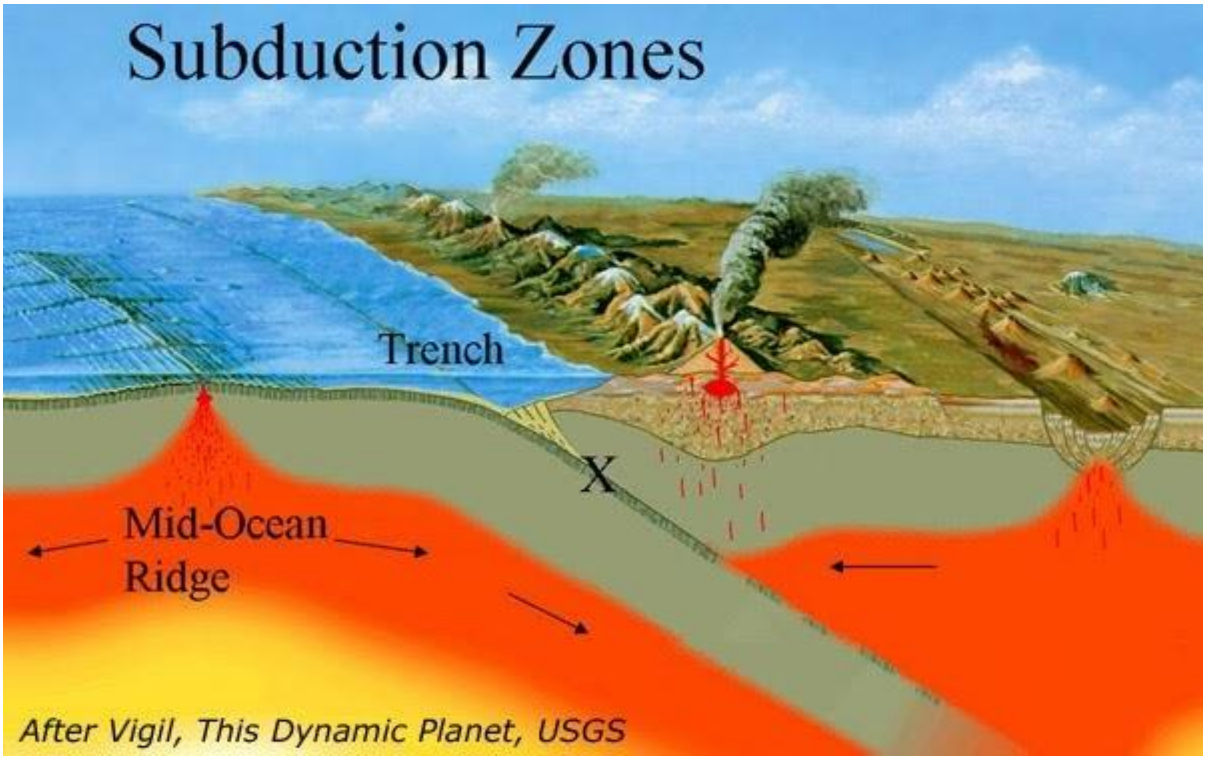


Figure 6. Subduction zones in plate tectonics. Basalt lava emerges in mid-ocean spreading centers and in island arc volcanoes above a subducting slab.

The high spin rate and greater oblateness would also make the Coriolis effect even stronger that would produce waves of even higher amplitude than have been observed in today’s hurricanes.

The **fifth** is that at some point a mutation occurred in methanogen bacteria such that a new species of life (cyanobacteria) was formed that used sunlight energy in photosynthesis to produce a waste product of oxygen. This oxygen then began to move into the Earth’s atmosphere following the Archean Eon in the beginning of the Proterozoic Eon 2,500 million years ago. But not all of this oxygen reached the atmosphere because the early oceans had much dissolved ferrous iron in it, and the oxygen reacted with this iron to produce layers of red-banded hematite deposits (Collins, 2022a) (**Figure 7**).

Figure 7. Banded iron formation; red hematite alternating with white jasper.

Eventually, most of the iron was removed from the ocean waters, and then the oxygen increased in the atmosphere at the end of the Proterozoic Eon and the beginning of the Paleozoic Era about 541 million years ago (See **Appendix**) when marine life began to evolve that used the oxygen for energy and released carbon dioxide as a waste product (**Figure 8** and **Figure 2**).

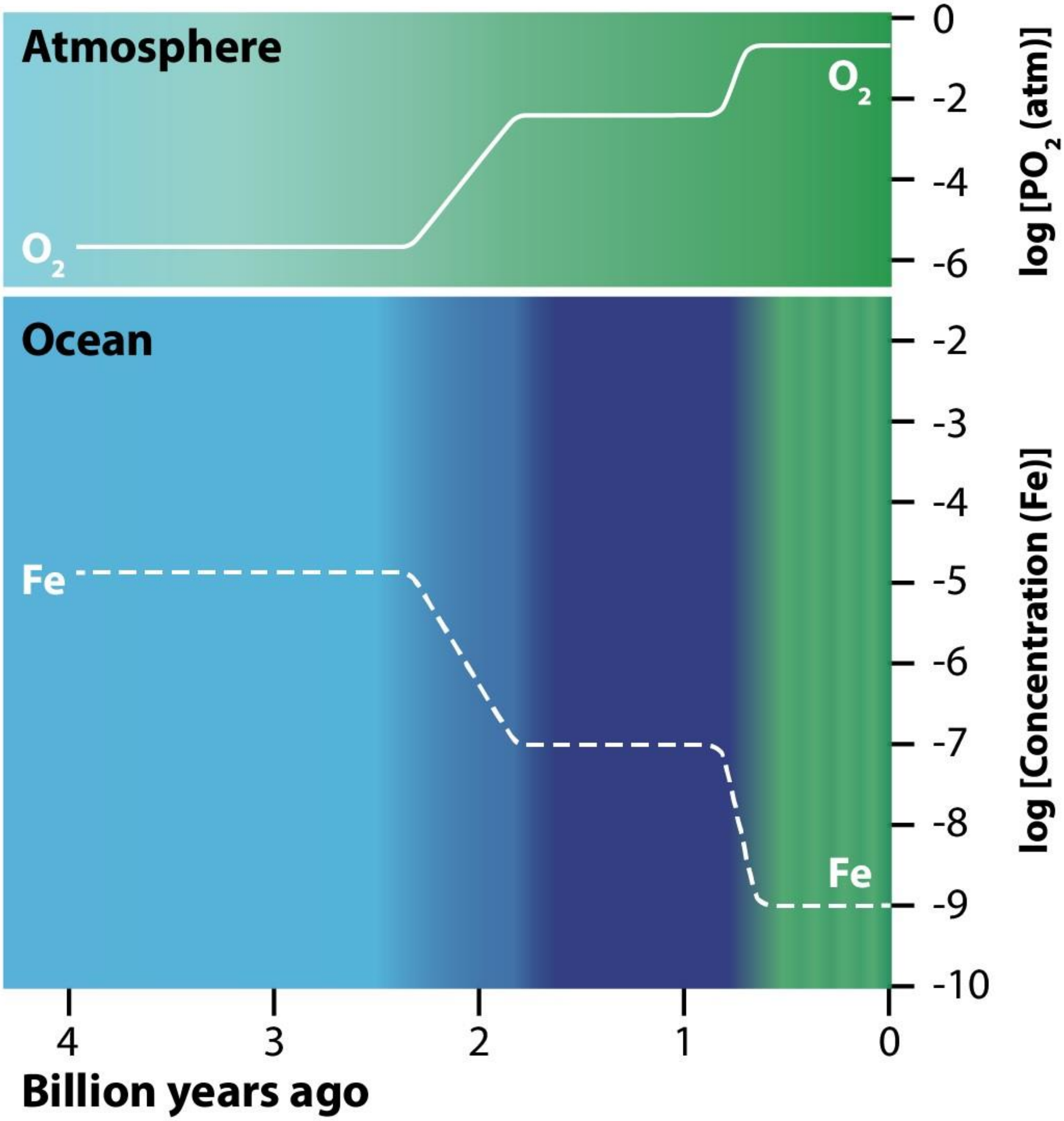


Figure 3. Diagram showing atmospheric P_{O2} (top curve) through time beginning less than 4 billion years ago. Source of image: (Anbar, 2008)

A **sixth** is that during the Archean Eon, from 4,000 to 2,500 million years ago, more violent hurricanes were raging over the oceans, but beginning about 2,500 million years ago, when photosynthesizing cyanobacteria were formed that produced oxygen, geologic processes began to change. That is, oxygen was poisonous to the methanogens and killed most of them except for those in deeper parts of the oceans. Therefore, less methane was rising to accumulate in the atmosphere. Instead, oxygen began to accumulate. What methane existed in the atmosphere was mostly destroyed by lightning. On that basis, the new atmosphere consisted of nitrogen, carbon dioxide, oxygen, and water vapor which cooled the ocean waters so that Ediacaran life could form and mutate to become the various species of marine life in the oceans, such as sponges, clams, snails, trilobites, brachiopods, corals, etc., and on up in the evolutionary process to other life forms, eventually to mammals and humans. Therefore, although hurricanes continued, they were less powerful and less frequent than in the Archean Eon.

A **seventh** is understanding how all the above six factors affect the continental masses that were formed during the Archean Eon.

Figure 3 shows the locations of Archean rocks in the cores of continental shields in various places around the world, but **Figure 9** shows that in North America, adjacent to the Archean rocks there are other bordering rock provinces that represent concentric provinces of progressively younger ages until the outer Appalachian, Ouachitas, and Cordilleran provinces occur. This same growth pattern in continental size occurs to produce the large continent sizes that are shown in **Figure 3**.

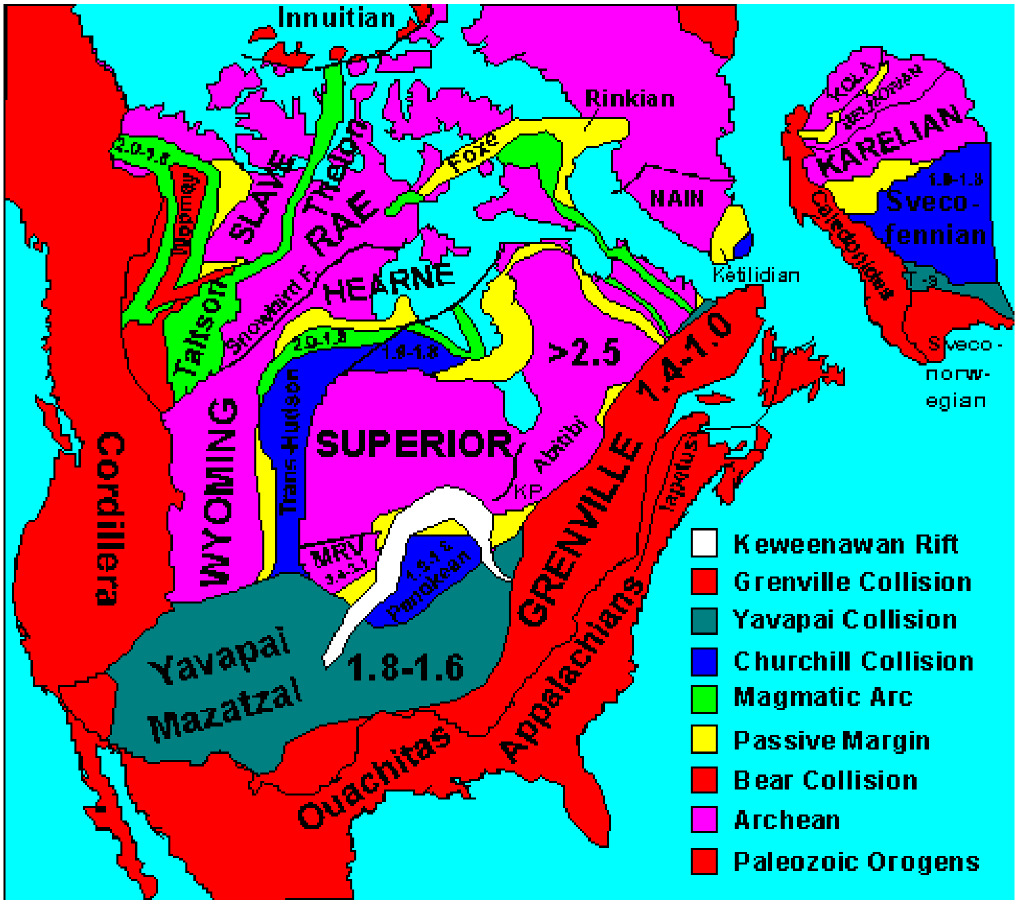


Figure 9. Locations of various provinces of different geologic ages.

Shown in pinkish red on **Figure 9** are the Archean rocks that are labeled as Wyoming and Superior that are greater than 2.5 billion years old. The Wyoming and Superior rocks represent the roots of former horizontal wide surfaces of former continents (similar to that shown in **Figure 3** but smaller in width) that were once surfaces covering a large percentage of the Earth's surface. The sliding of these continents during plate tectonics caused these rocks to collide and to be uplifted, thrusted, and folded into high mountains of shorter width (smaller surface areas), and during that process these folded rocks were intruded by plutonic igneous rocks. Eventually, these rocks were eroded down to their roots over millions of years of time, and much of these Archean rocks were subducted to produce other continental masses that repeated the sliding of continents around to create giant continents that were then split apart into smaller continents that slid across the ocean to re-collide and make a giant continent again. **Figure 9** shows that this happened at least in five repeated times of erosion, deposition of sedimentary layers, deep burial, metamorphism, collision, intrusion of plutonic igneous rocks, and erosion of these rocks to add to the shield areas. On that basis, the continental masses grew in size so that the percentage of land coverage increased while the surface coverage of the oceans decreased progressively from 90% to 80% and finally to 71% at the present time. During this time water was still emerging from the mantle in basaltic eruptions, and, therefore, the ocean waters deepened with time.

The **eighth** to consider is the erosion processes that were occurring during the seven other factors described above. In **Figure 5** that shows the circular motion of storm waves, it also shows what happens when these waves come in contact with shallow areas adjacent to the continental boundaries where they spill forward as crashing waves. The rush of water in such crashing waves, when impacting and colliding with rock cliffs with rock fracture openings, would cause air in these openings at 1 atmosphere pressure to be compressed to tens of atmospheric pressures as the weight of water in the massive waves moved quickly into these openings or fractures. That compression could explosively tear cliff rocks apart. Furthermore, it is well known that during strong winter storms, storm beaches are produced in which rocks are thrown out of the crashing circular waves to toss them more than 100 feet beyond where waves normally wash up on a beach. Therefore, the amount of erosion of continental rock borders in the Archean Eon by violent hurricane waves could have been very extensive by the pounding of these thrown-rocks hitting the rock cliffs. Likely, this is the way that the eroded surface, called the Great Unconformity, was produced in the Grand Canyon in which this eroded surface extended across the North American continent (**Figure 10**).

Figure 10. Great Unconformity – the erosional surface (mid line across width of image) between overlying, nearly-horizontal, sedimentary Paleozoic Cambrian rocks and dipping, underlying Precambrian rocks in the Grand Canyon.

That is, the methane-rich atmosphere and warmer ocean waters that caused frequent and powerful hurricanes persisted until near the end of the Precambrian and produced the wide erosion surface that is the Great Unconformity. This means that more than 600 million years of strong erosion occurred before the Cambrian rocks were first deposited 541 million years ago and ***when the methane-rich atmosphere changed to an oxygen-rich atmosphere*** (**Figure 2 and Figure 8**) and ***when the strong, many-hurricane-produced erosion ceased***. Such a strong erosion model is contrary to the belief by some young-Earth creationists that the Great Unconformity was produced by Noah's flood. A one-year flood event could not have possibly produced that amount of erosion, but millions of years of "rock-poundings" produced by huge hurricane waves could have produced such an extensive eroded surface that is the Great Unconformity (**Figure 10**). Geologic evidence clearly shows that the sediments in the Cambrian Tapeats Sandstone that overlie this erosional unconformity were not derived locally from the Precambrian rocks but came by stream transport from distant sources (Collins, 2022b).

Of course, hurricane storms also produce a huge amount of rainfall on continental land surfaces. Therefore, some of the erosion of the land in the broad extent of the Great Unconformity would also have been by rushing streams.

Also, less frequent tsunamis than hurricanes, moving through the ocean waters, would have created large amounts of erosion because of giant waves produced by periodic jumps of subducting oceanic slabs in trenches (**Figure 6**). That happens when there is a sudden drop of 10 to 20 feet of the ocean surface when a slab moves quickly downward under the ocean water. Immediately, after the sudden drop of the water, the ocean starts to level itself and sends a tsunami wave racing at 450 mph across the ocean with a huge circular motion (**Figure 5**) that could increase in its amplitude to 50 to 100 feet high when crashing on a distant shore and do tremendous amounts of erosion of the shore rocks.

Moreover, (a) because the Earth was spinning much faster in the Archean Eon and in the younger Precambrian than occurs now and, thereby, had more days in a year and (b) because of the greater oblateness of the Earth, water rushing in and out of estuaries and river mouths in tides would have been more frequent in a year than occurs in tides of today. If such higher and more powerful tides arrived at a shore at the same time as storm, wind-blown surges of water arrived with their higher amplitudes, even more erosion would have happened to the continental rocks. Tidal erosion effects have also been noted in Paleozoic rocks (Mitchell, 2022).

The **ninth** is the recognition that other geologic processes accompanied what occurred during those processes that affected the rocks of Archean Eon age and the rocks of the following younger ages included in the above eight factors. They include the following five topics.

(1) **K in granitic rocks**. Because K is a very large element (ion), it is unstable in the mantle minerals whose elemental components have smaller ionic sizes in their crystal structures and when water moves upward through the mantle above subduction zones as shown in **Figure 6** to cause basaltic melts, the K ion moves with this water to create the granitic rocks that eventually form the foundations of the continents in shield areas.

(2) **Chlorine ions in the oceans.** The chlorine ion also has a very large ionic size, and it also moves up in the rising water in HCl and is part of the vapor that accompanies the steam that explosive emerges from the vents of basalt volcanoes. These chlorine ions in HCl rain down to be added to the ocean waters. That is, in the Archean Eon, the ocean waters would have been initially fresh water and only became saltier (marine; added sodium chloride) progressively through time to its present saltiness (Collins, 2006).

(3) **Metasomatic granites and myrmekite**. Most granitic plutons have a magmatic origin, but some have a metasomatic (chemical replacement origin below melt temperatures). Such granitic rocks are formed from already crystallized (solid) igneous rocks, such as diorite, that have been deformed and micro-fractured so that hot, hydrous fluids can bring in K to replace plagioclase feldspar crystals with K-feldspar (microcline or orthoclase) and bring in Si to replace biotite, hornblende, and pyroxene with quartz. In this replacement process former igneous textures are preserved, and the metasomatic granite has the appearance of looking as if it crystallized from magma. An example of K-feldspar replacement of plagioclase is shown in **Figure 11** (Collins, 2021a).

Fig. 11. Microcline (black and grid-twinned) replacing zoned, albite-twinned plagioclase with parallel alignment of twinning. Remnant Ca-Na zoning of plagioclase can be seen (top center) inside microcline (black) of former plagioclase crystal whose long dimension once aligned toward the upper right of image. (Source of image, Lorence Collins)

In some places, incomplete replacement of plagioclase occurs and where that happens, myrmekite is formed and becomes a clue to the metasomatic origin of the granite when found in thin sections (**Figure 12**).

Figure 12. Myrmekite (center) consisting of plagioclase feldspar (light gray) enclosing tiny, tapering, branched crystals of quartz (white, grading to black). Biotite mica (lower right side; tan and brown). Top and left side (light gray) is potassium feldspar (K-feldspar). The "wartlike" myrmekite projects into the K-feldspar. Image was photographed at 40x magnification, and the width across the image is 4.5 mm as viewed under the microscope. (Source of image, Lorence Collins)

On that basis, this part of the ninth factor occurs where, after solidification of primary igneous plutons, they may still rise plastically and mechanically up through the crust to be deformed and micro-fractured to allow metasomatic fluids to change them into secondary granitic rocks. A summary of research on this topic is in (Collins and Collins, 2012).

(4) **Po-halos in biotite**. Where metasomatic granites are formed that contain myrmekite and which also contain abundant radioactive uranium (U-238) in uraninite or zircons --- radioactive Ra-222, Po-218, Po-214, and Po-210 may also be released in deformed rocks in the hot, hydrous fluids moving through the micro-fractured rock and migrate to micro-fractured biotite crystals that are recrystallizing and form Po-halos in the biotite (Collins and Collins, 2021; Collins, 2021a; 1997) (**Figure 13**).

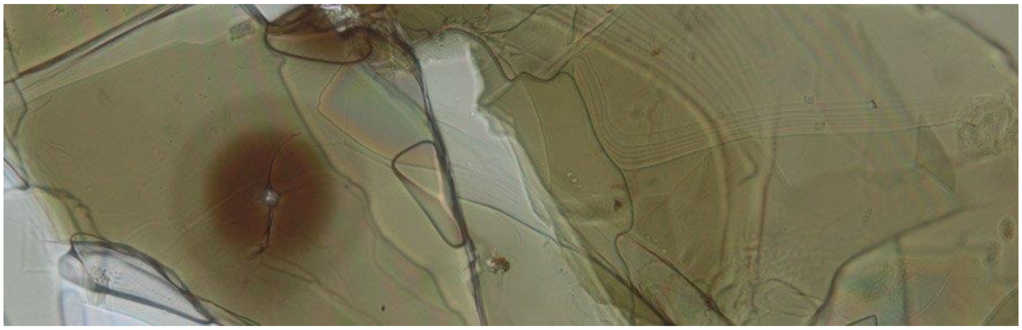


Figure 13. Po-214 halo in biotite mica. (Source of image, Lorence Collins)0

(5) Creation of lamprophyres. Also, where myrmekite-bearing, metasomatic, granitic rocks are formed by introduction of K and Si into micro-fractured diorite, the fluids that move through the diorite that is being converted into granite carry away some of this K as well as Ca and Mg, and these fluids then move up in the crust to lower pressure sites where these elements are precipitated in lamprophyre dikes or lava flows (Collins, 2023b) (**Figure 14**).

Figure 14. Lamprophyre dike (dark gray) from the Piégut-Pluviers main quarry from the Piégut-Pluviers granodiorite (common facies) in the Central Massif, France. (Courtesy of Rudolf Pohl)

> These kinds of lamprophyre rocks are different from those that are derived from a deep mantle source in plumes or pipes that are rich in Mg and commonly contain phlogopite and diamonds (Scott Smith, 2008; Mitchell, 1994, 2021) or which are associated with carbonatites (Gwalani et al., 2016; Coulson et al., 2003).

Summary

Essentially, there is zero evidence that the globe of the Earth was completely covered by ocean water deeper than the oceans that occur on Earth today. What is logical is that the Earth began by the gravitational attraction of zillions of meteorites whose collisions with each other produced so much heat that the proto-Earth completely melted, and abundant iron in this melt sank to form an iron core. The remaining melt that consisted mostly of iron, magnesium, silicon, and other metallic elements formed an outer silicate-rich magma in a thick outer mantle. The atmosphere surrounding this proto-Earth probably contained nitrogen, some carbon dioxide, and little to no free oxygen, and certainly not enough water to condense to form a global ocean deeper than the depth of the present world oceans. In time, after cooling, a crust was formed and eventually, different concentrations of heat in the mantle caused circular convection movements to occur that resulted in plate tectonics. Trace amounts of water in the mantle rose toward the Earth's surface and produced basalt melts that explosively erupted in volcanoes that expelled basalt lava and ash and released this water in steam that cooled, condensed, and began to form a shallow ocean. On that basis, the first exposed land were volcanoes in some places that extended above the top of a shallow ocean.

This proto-Earth was spinning rapidly so that there were more than 600 days in a year, and its rapid spinning caused it to have an oblate spheroidal shape whose diameter at the Earth's equator was much wider than the diameter of the present Earth at its equator. Weathering of volcanic rocks and stream erosion produced sediment that filled basins and increased the width of continental deposits. Then, because the early Earth's mantle was 2 to 3 times hotter during the Archean Eon than in the present mantle, the rapid spinning of the Earth facilitated plate tectonics because of the hotter and more plastic mantle rocks. On that basis, crustal rocks in small continents were slid around to collide and make giant continents which then split apart to make small continents again and to widen the ocean water between these small continents again. Then, these continents slid around the Earth's surface to collide again to make another giant continent, and this cycle was repeated in multiple times during the geologic history of the Earth.

In the mid-Archean, methanogens were created that produced methane as a waste product, and this methane rose to accumulate in the Earth's atmosphere. Because methane is a strong greenhouse gas (stronger than carbon dioxide), the energy in light coming from the sun was trapped in the atmosphere which in turn heated the ocean water. Consequently, because of (a) the spinning of the Earth, (b) the great oblateness of the Earth, and (c) the greater Coriolis effect due to the oblateness, these relationships caused powerful hurricanes to be produced that strongly eroded the borders of the continents. This process continued throughout the Archean for 1,500 million years (4,000 to 2,500 million years ago), when the Proterozoic Eon began.

The beginning of the Proterozoic Eon began when a mutation occurred in a methanogen species to form cyanobacteria that photosynthesized to produce oxygen as a waste product. This oxygen was a poison to the methanogens and rose to start to fill the Earth's atmosphere. However, the early ocean had a lot of ferrous iron dissolved in it. Therefore, the released oxygen mostly reacted with this iron to form red-banded iron deposits (Collins, 2022a) (**Figure 7**).

Eventually, most of the iron was removed from the ocean waters in these banded iron layers. Therefore, from then on, the oxygen was enriched in the Earth's atmosphere, and most of the methane that was once there was destroyed by lightning. Then, the atmosphere consisted mostly of nitrogen, oxygen, carbon dioxide, and water vapor and little methane. With the oxygen present, life on Earth then evolved to use the oxygen to make the various marine life that eventually evolved to become fish, amphibians, reptiles, and mammals.

What is significant about what happened in the Archean Eon and subsequently in the Proterozoic is the recognition of the greater degree of erosion that must have resulted from the likely existence of powerful hurricanes with categories much greater than 5---much stronger than what takes place today and which must have had giant waves of greater amplitudes than occur today that crashed on rocky cliffs on continental margins and explosively tore the rocky cliffs apart by compressed air in fractures and which pounded the cliffs with stones thrown out of the circular crashing waves (**Figure 5**). Furthermore, added erosion by water rushing in and out of estuaries by rapidly moving higher and more powerful erosive tides occurred more often than now because of the fact that the year in Archean and ancient Precambrian times had more days in it than the 365 days in a year that occur now. This great amount erosion likely explains how the Great Unconformity was produced with its broad erosion surface extending across the width of North America that could not have been produced by the supposed erosion during the one year of Noah's flood waters.

All the above are accompanied by other processes, such as (a) production of magmatic granitic plutons that became the cores of the continents in shields, (b) creation of metasomatic granites that contain myrmekite, (c) the increase in the chlorine and salt content of the oceans, (d) formation of Po-halos in biotite, and (e) production of some kinds of lamprophyres in dikes and lava flows.

Conclusion

The Archean Eon began 4,000 million years ago with the formation of a shallow ocean that covered the proto-Earth with a methane-free atmosphere. Ultimately, through geologic time a deep ocean was produced in the Proterozoic Eon with the progressive addition of warm water and a relatively-hot methane-rich atmosphere. That atmosphere generated frequent violent hurricanes that eventually caused the erosion surface on continental rocks that became the Great Unconformity (**Figure 10**). Noteworthy is the fact that the Great Unconformity is underlain mostly by the Vishnu Schist that is composed of quartz-mica schists, pelitic schists, and meta-arenites. Because mica has a hardness of 1 on the Mohs hardness scale, the Vishnu Schist would be relatively easy to erode. Also in the Grand Canyon area is the Unkar Group that contains layers of quartzite and basalt that are more resistant rock types and that resistance would cause the Unkar Group to stand at higher elevations above the unconformity. These rock types could also provide the hard rubble that would enable erosion of the Vishnu Schist by (a) “pounding it” with thrown rocks and (b) the grinding effects of hard rocks sliding back and forth and up and down on beach faces and in bedrock “rubbings” of boulders in surface stream erosion. The violent hurricanes continued until oxygen arrived when most of the methane in the atmosphere disappeared at the end of the Proterozoic Eon. This can be called “the Big Hurricanes Theory.” When the oxygen arrived, that is when the further evolution of animal life began with the Ediacaran life in the youngest Precambrian and in the Paleozoic Era with the Cambrian Tapeats Sandstone, 541 million years ago.

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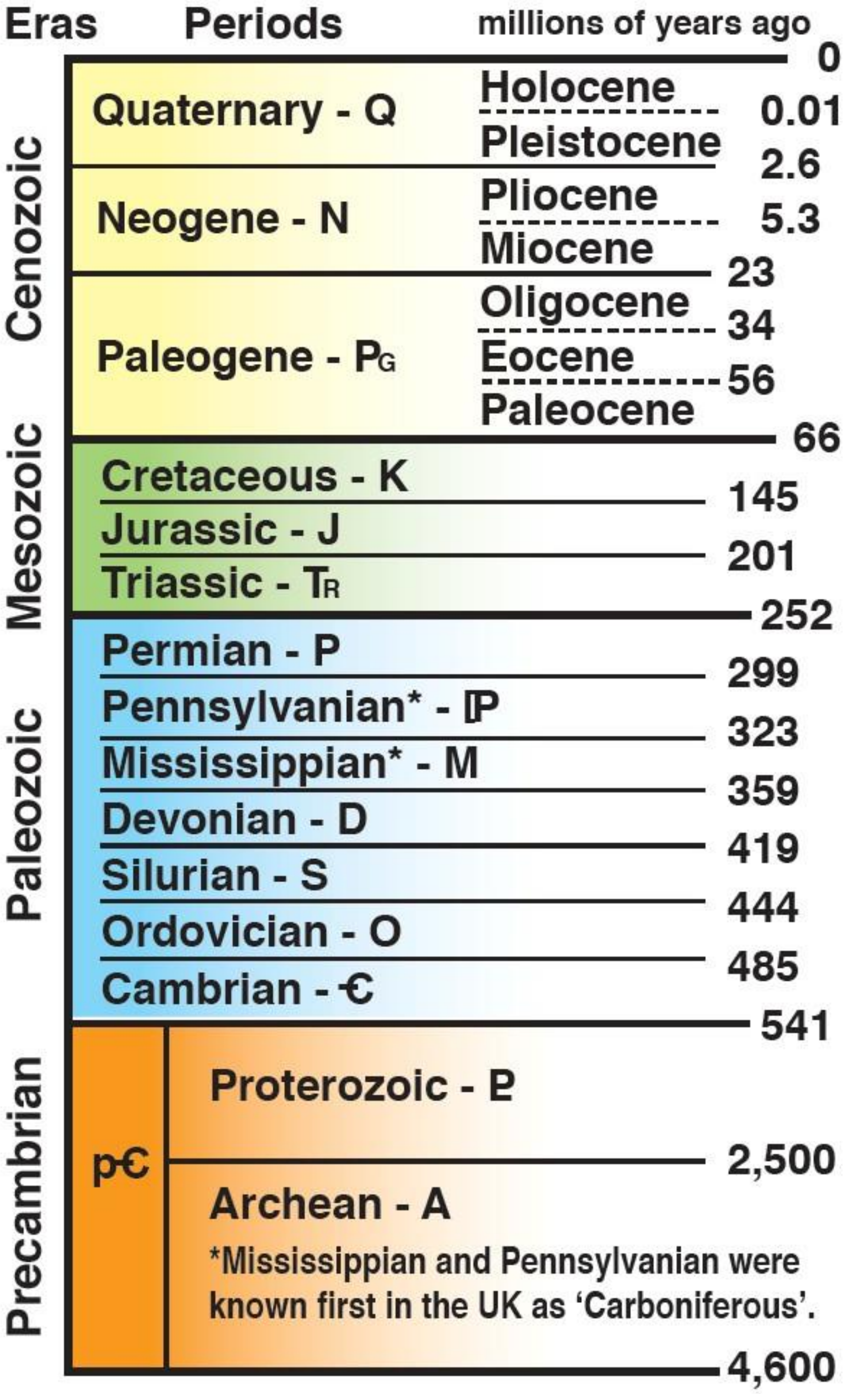
Geologic Time Scale



Eras	Periods		millions of years ago
			0
Cenozoic	Quaternary - Q	Holocene	0.01
		Pleistocene	2.6
	Neogene - N	Pliocene	5.3
		Miocene	23
	Paleogene - Pɢ	Oligocene	34
		Eocene	56
		Paleocene	66
Mesozoic	Cretaceous - K		145
	Jurassic - J		201
	Triassic - Tʀ		252
Paleozoic	Permian - P		299
	Pennsylvanian* - ℙ		323
	Mississippian* - M		359
	Devonian - D		419
	Silurian - S		444
	Ordovician - O		485
	Cambrian - Ꞓ		541
Precambrian	pꞒ	Proterozoic - Ᵽ	2,500
		Archean - A	4,600

*Mississippian and Pennsylvanian were known first in the UK as 'Carboniferous'.