November 8, 2021

News and Notes

Before going to with more on the Archean Eon, here are a few items from the news that I thought were interesting:

Missing Persons

- Doing geology can be dangerous, an update on a missing geologist in Arizona: New details released in disappearance of Daniel Robinson.

Recent Geological Papers

- Here is a compilation of recent geological papers by the Geological Society of America (GSA) released in October: New Geology articles published online ahead of print in October. This one, from the list, relates to the Great Oxygenation Event at the end of the Archean Eon.
- Discussion on past periods of climate change On ancient Earth, it never rained but it poured, original paper in *Nature* here (behind pay wall).
- Another interesting article: Ancient Exploding Comet Likely Source of Vast Glassy Rock Patches in Chilean Desert; the original research article in the GSA publication *Geology* is here. The timing, about 12,000 years ago, looks to be very close to the Younger Dryas Event.
- Research on the Ediacaran: High-precision geochronology reveals high-resolution Ediacaran timescale.
- Related to today's discussion on the Archean Eon: A Simple Recipe for Making the First Continental Crust.

Volcanoes

For all current news on volcanoes, check out Worldwide Volcano News and Updates, here are some other stories on volcanoes:

- From the United States Geological Survey (USGS) Photo and Video Chronology – Kīlauea.
- Spain's La Palma Volcano Continues to Erupt and Spew Ash; related Ash Cloud Worsens Air Quality - La Palma.
- That's reassuring: Unnerving Study Reveals There May Be No Warning For The Next Supervolcano Eruption; the original research paper is here.

Earthquakes

- Latest earthquake news from the USGS here.

- Earthquakes in Canada.

Energy and Nuclear

- Nuclear energy has issues: Is it green, or forever toxic? Nuclear rift at climate talks.
- From the U.S. Energy Information Administration (USEIA): Added transnational oil pipeline capacity could reduce crude oil shipped by rail. There are real safety issues with transporting petroleum by rail. What we should do in Canada is process **ALL** the oil produced in our country and export only finished product that's surplus to our own needs. This would keep maximum value of the product here.
- Also from the USEIA: Use of electricity in houses to grow more quickly in developing economies. Not mentioned is that much of this increased demand will be met by coal.

Mining

- Gemfields finds largest emerald to date at Zambia mine.
- New gold mine in British Columbia: Enormous open pit mines emerging at KSM.
- In a lithium squeeze, biggest producer 'going as fast as we can', demand driven by increasing electric vehicle production; related: The commodity boom is starting to push battery prices higher.
- Just a reminder: Engine of civilization, fueled by mining.

From Out of this World

- Solar storms can disrupt technologies on Earth NOAA issues Alerts, Watches and Warnings; but it can make for spectacular aurora displays.
- Earthquake or mars-quake? Summer Could Be Earthquake Season on Mars.

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The Archean Eon, Part 2

It is difficult to generalise about the conditions during the Archean Eon. As you can see in Figure 1, not only was it a long time ago, lasting from 4.0 to 2.5 billion years (Ga) ago, it was also a long period of time in itself, 1.5 Ga ago.

Let that sink in for a moment before we go on to look at those conditions.

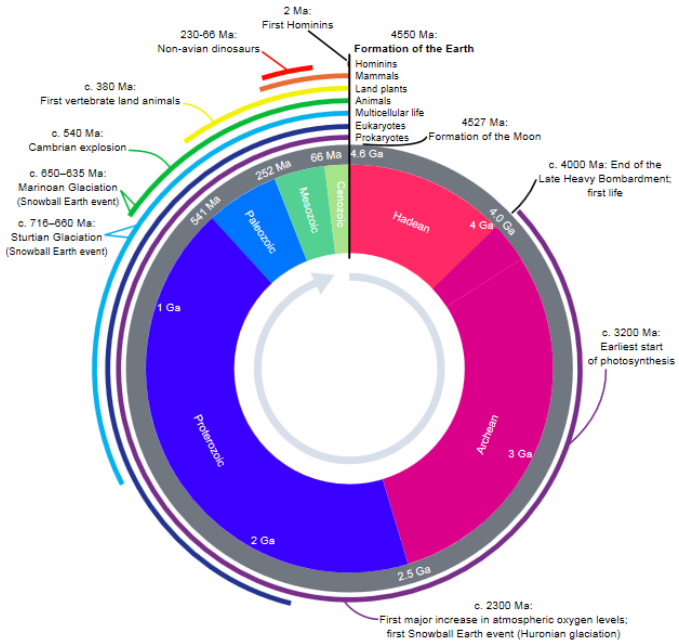

Figure 1 - Geological Time Scale Clock
Credit: Woudloper, public domain

Overall, the conditions on the Earth during the Archean Eon were very different than today. First, the Moon's orbit was closer than it is now and, while this helped to stabilize the Earth's wobble, it also lead to much stronger tidal forces that there are now. Also, the Sun was less luminous, perhaps with only 70–75 percent of the present luminosity. However, surface temperatures were comparable to today because of the makeup of the atmosphere, mostly nitrogen methane and carbon dioxide with no free oxygen. Methane is a strong greenhouse gas and the Earth's atmosphere retained a lot of the heat that did come from the Sun. A consequence of the low oxygen content of the atmosphere would have been no ozone layer and thus anything not underwater would have been subject to harsh UV radiation.

Figure 2 - Artist's Impression of the Archean
Credit: Tim Bertelink, Creative Commons Attribution-Share Alike 4.0 International license

Based upon research into the Eon, the main events of the Archean seem to be the following:

- The appearance of liquid water and the first oceans.
- The beginning of plate tectonics.
- The appearance of life, the evolution of photosynthetic organisms and the increase in free oxygen in the atmosphere.

Let's look at these events.

The First Oceans

Figure 3 - An artist's concept of the early Earth
Credit: NASA, public domain

As we saw in our discussion of the Hadean from October 25, there is some reason to believe that much of the Earth's water arrived with the impact of comets during the Late Heavy Bombardment. However, until the earth cooled enough, the water remained in the atmosphere as vapour.

Once the temperature of the Earth dropped to the point where liquid water condensed out of the atmosphere, the Mother Of All Rain Storms began, lasting perhaps for hundreds or thousands of years. When the rain stopped falling, most of the Earth was covered with water, with very little above the waves.

The new ocean had strong tides due to the closer proximity of the Moon in those days. The strong tides and active weather probably wore down any land that poked above the waves.

There is a good video on the first oceans on YouTube, here.

The Beginning of Plate Tectonics

Although there are many disagreements on the details, geologists nowadays generally agree that the tectonic regime during the Archean was unlike that of the present. Tectonic activity may have been more vigorous in the Archean because the Earth was much hotter and consequently there was a faster rate of recycling of crustal material. This greater activity may have prevented the early formation of cratons until the mantle cooled and convection slowed down. An alternative line of thought is that at time, the oceanic crust was too buoyant to subduct, thus preventing tectonic movement from starting. Research and controversy continues on the beginning of plate tectonics in the Archean.

The origin of the continental crust is also subject to controversy. One group of geologists maintain that there were no large continents until late in the Archean and that there were only small protocontinents that could not coalesce into larger units due to the high rate of geologic activity. Another group of geologists argue that during the first 500 million years of Earth history, the continental cores grew to their present volume. Since then, the continental cores have generally been nearly constant in size. They note that throughout most of Earth history, continental material has been recycled back to the mantle at subduction or collision zones, balancing crustal growth. Recent research suggests that the felsic cores of the continents arose, in part, due to chemical interaction between the nascent oceans and the early crust, largely made up of peridotite.

The mechanism of continental crustal growth is also a subject for controversy. Some argue that in the absence of plate tectonics, the felsic cores of the protocontinents formed at hotspots rather than subduction zones. Calling this process "sagduction", i.e. which refers to partial melting in downward-directed diapirs, they postulate the production of intermediate and felsic rock from a variety of mafic magmas. Others describe the formation of granite in oceanic island arcs and convergent margins in the plate tectonic process that they contend have operated since the start of the Archean.

It gets complicated.

The Appearance of Life

Once there was liquid water and warm temperatures, the conditions for life were possible. The earliest evidence for life in Archean rocks is apparently biogenic graphite in meta-sedimentary rocks in Western Greenland, dated to 3.7 billion years old. We know little about the origins of life or its early evolution. Speculation ranges from life originating in tidal pools, or next to volcanic vents under the ocean or even from outside the Earth through the process of

Panspermia. While it is likely that we shall never know for sure, research continues and theories continue to be proposed. Here is what we generally agree on:

It is likely that the earliest life consisted of single celled organisms: bacteria and archea. These early organisms were anaerobic, that is their metabolism did not use oxygen. This is consistent with what we know about early conditions in the early oceans. There was probably little or no life on the land that poked out the ocean, if only because there was no ozone layer to protect the life from harsh ultraviolet radiation.

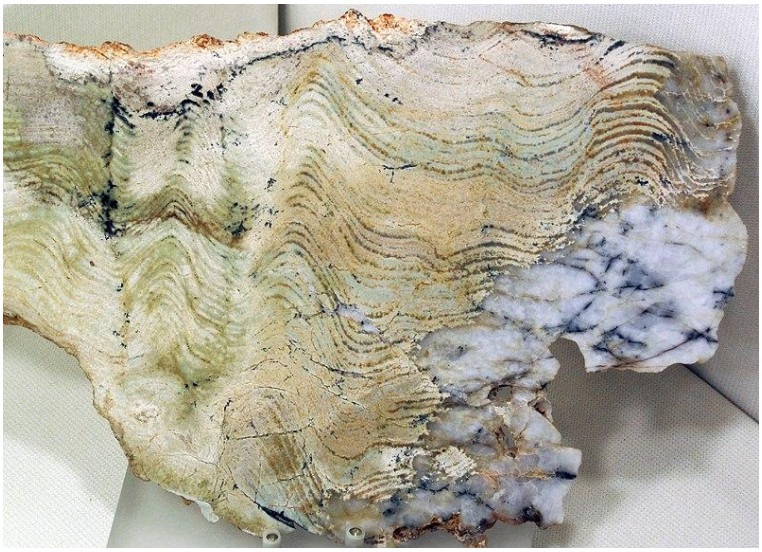

Figure 4 - Stromatolite from Western Australia
Credit: James St. John, Creative Commons Attribution 2.0 Generic license

One consequence of the evolution of life in the Archean was the appearance of cyanobacteria, also called blue-green algae. One of the things that cyanobacteria do is create stromatolites. These are formations of calcium carbonate excreted by the cyanobacteria. The rock in Figure 4 is from the Strelley Pool Formation in Western Australia and dated to the Paleoarchean, 3.35-3.46 Ga. Interestingly enough, stromatolites are found growing today on the coast of Western Australia.

Cyanobacteria are amazing organisms. They are hardy and difficult to kill. If they need nitrogen for their metabolism, they fix it out of the air. One thing they do superbly is photosynthesis, that is, using the energy of sunlight to power their metabolism and releasing free oxygen as a by-product. Once these little critters got working, the amount of oxygen in the atmosphere began to increase and the anaerobic organisms were doomed to living wherever oxygen concentrations were low.

One of the consequences of the presence of free oxygen in the ocean and atmosphere was the creation of banded iron formations, the earliest of which are in the Archean. There is more discussion on banded iron formations in my positing of February 8, 2021.

The Great Oxygenation Event

The build up of free oxygen in the atmosphere due to the action of cyanobacteria was a key condition that carried on into the Proterozoic Eon that followed. We'll discuss The Great Oxygenation Event, 2.3 Ga ago, in our upcoming discussion on the Proterozoic Eon.

Standard Caveat

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.