February 14, 2022

More on the life of St. Valentine here and the history of Valentine's Day, here.

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News and views

Before going on to a look at the Mississippian Period, let's look at some news items I thought were interesting.

Research

- Scientists Reveal Superionic Secrets of Earth's Inner Core; the Earth's inner core is 'superionic', a state of matter somewhere between solid and liquid, study suggests.
- The Younger Dryas Event at the end of the Pleistocene/beginning of the Holocene: 13,000 Years Ago, a Firestorm Covered 10% of Earth's Surface, Triggering an Ice Age.
- It's just the flu: A Sneezing Dinosaur? Fossil Reveals Deadly Flu-Like Illness in a Sauropod.
- Paleontology: Weird, Extinct Animal Species Identified in First Such Finding in Over 100 Years.
- Pleasant thoughts: There's a Bunch of Bacteria Having 'Sex' in Your Gut, And It's Wilder Than We Thought.
- Contaminant hydrogeology, from the United States Geological Survey (USGS): USGS Finds PFAS in Untreated Well Water Across Delaware, research document here.
- Scientists Discover 100-Million-Year-Old Fossil Flowers Preserved in Amber.
- Modern human incursion into Neanderthal territories 54,000 years ago at Mandrin, France.
- Why do cats and dogs rub their butts on the floor?

Plate Tectonics

- Stress transition from horizontal to vertical forces during subduction initiation.
- Mantle plume and rift-related volcanism during the evolution of the Rio Grande Rise.
- The rise and demise of the Paleogene Central Tibetan Valley.

Volcanoes

- Geology Hub channel on YouTube: This Week in Volcanoes.
- Also on Geology Hub: The Recent Megaeruption in California; The Rockland Caldera.
- Pink pumice key to revealing explosive power of underwater volcanic eruptions.
- Hawai'i phones capture data in Tonga volcano blast.
- Volcanoes of the World.

Energy and Mining

- Potential new play: Macro-seepage based potential new hydrocarbon prospects in Assam-Arakan Basin, India.
- Re-processing mine tailings may become more economical: High yields of rare earth elements recovered from mine, e-waste, research paper here.
- The French have got it right: Make Way For The French Nuclear Power Renaissance.
- As Germany's Green Dream Becomes A Nightmare, Asia And Russia Power Ahead With Nuclear Power.
- Why EV Batteries aren't being recycled.

Mineralogy and Pretty Rocks

- Clays are fascinating: Like diamonds, clay soils are forever.
- From Maclean's: How a Quebec rock-collector amassed a multi-million-dollar 'national treasure'; h/t Warren S.

Addictions

Don't take my coffee away!!!! The Latest Verdict on The Future of Coffee Is Here, And The News Is Not Good.

Credit: someecards

Upcoming Events

- Online seminar from the American Geosciences Institute, February 24, 2022: Geologic Names and Usage: A Guide to Stratigraphic Nomenclature.
- Annual meeting of the Geological Association of Canada: GAC-MAC Halifax 2022.

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The Mississippian Period

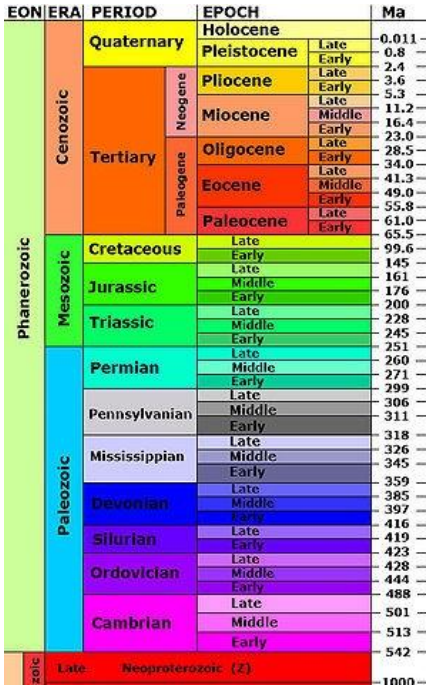

Figure 1 - Phanerozoic Time Scale
Credit: Modified from File: Geologic time scale.jpg, United States Geological Survey, public domain

The period of time between the end of the Devonian Period (358.9 Mya) and the beginning of the Permian Period (298.9 Mya) is called the Carboniferous Period in Europe and much of the rest of the world. However, in North America it is divided into two geological periods: the Mississippian Period (358.9 to 323.2 Mya) and the Pennsylvanian Period (323.2 to 298.9 Mya). Since I live in North America (and this my web log) I am going to follow the North American convention.

The reason for the divergence in how the Carboniferous Period is looked at has to do with geology. In Europe, the formations between the end of the Devonian and the beginning of the Permian are a more-or-less continuous sequence of lowland continental deposits, often containing coal, hence Carboniferous. In North America, however, there are distinct differences between the older Mississippian formations and the younger Pennsylvanian formations. The Mississippian age formations in North America tend to be marine carbonate rocks whereas the Pennsylvanian age formations resemble the European Carboniferous formations.

In this week's web log, we'll look at the world of the Mississippian Period, the subdivisions of that Period, and a mineral deposit type associated with Mississippian rocks. Next week we'll

look at life in the Mississippian Period.

The World of the Mississippian Period

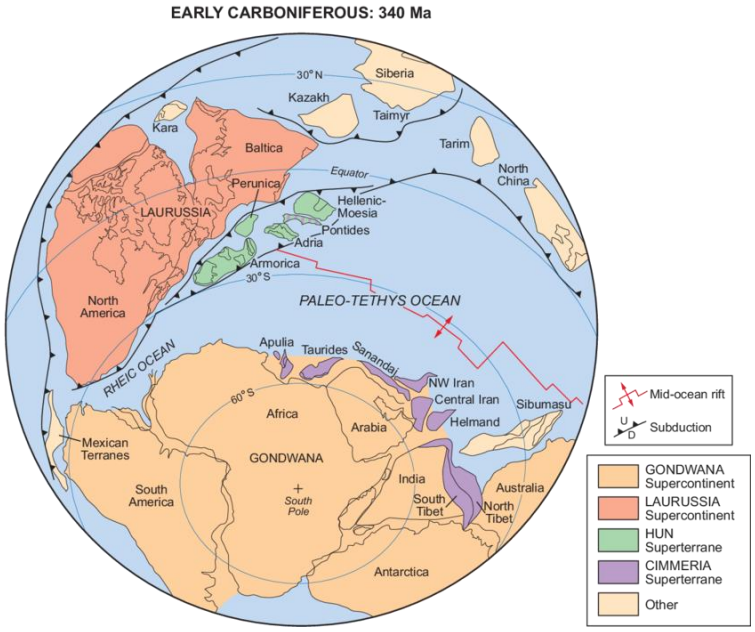

Figure 2 - Plate Tectonic Reconstruction of the Mississippian
Credit: Ruban, Dmitry & Al-Husseini, Moujahed & Iwasaki, Yumiko. (2007). *Review of Middle East Paleozoic Plate tectonics*, GeoArabia. 12. 35-56. 10.2113/geoarabia120335

Overall, during the Mississippian Period, tectonic movement had caused the cratons of the world to coalesce into two main agglomerations, Euramerica (also known as Laurussia, and Gondwana. In Euramerica, major mountain building (orogeny) in the Allegheny Orogeny in the Appalachians, in the Variscan Orogeny in what is now Europe, in the Innuitian Mountains in northern Canada, and in the Antler Orogeny in what is now the southwest United States. In what is now Central Asia, the Central Asian Orogenic Belt continued to develop.

In between the major continents were two major oceans: the Panthalassa Ocean and the Paleo-Tethys Ocean. Also, much of Euramerica was covered by epicontinental seas as the result of high sea levels, marine transgression. (The right hand column in Figure 3, below, shows the pulse of sea level change during the Period). In what is now North America, is was a period of widespread deposition of carbonate rocks. Elsewhere in Euramerica, there were extensive delta systems and lagoons, ideal conditions for the deposition of coal.

Small glaciers formed in Gondwana during the early Mississippian. These glaciers generally melted way in the middle Mississippian only to reappear at the end of the Period.

Average global temperatures in the Mississippian Period were generally high: approximately 20 °C (68 °F). By the end of the Mississippian, however, cooling reduced average global

temperatures to about 12 °C (54 °F). With the deposition of huge quantities of coal, atmospheric carbon dioxide levels fell from roughly 8 times the current level in the Mississippian to a level similar to today's by the end of the subsequent Pennsylvanian Period.

Subdivisions of the Mississippian Period

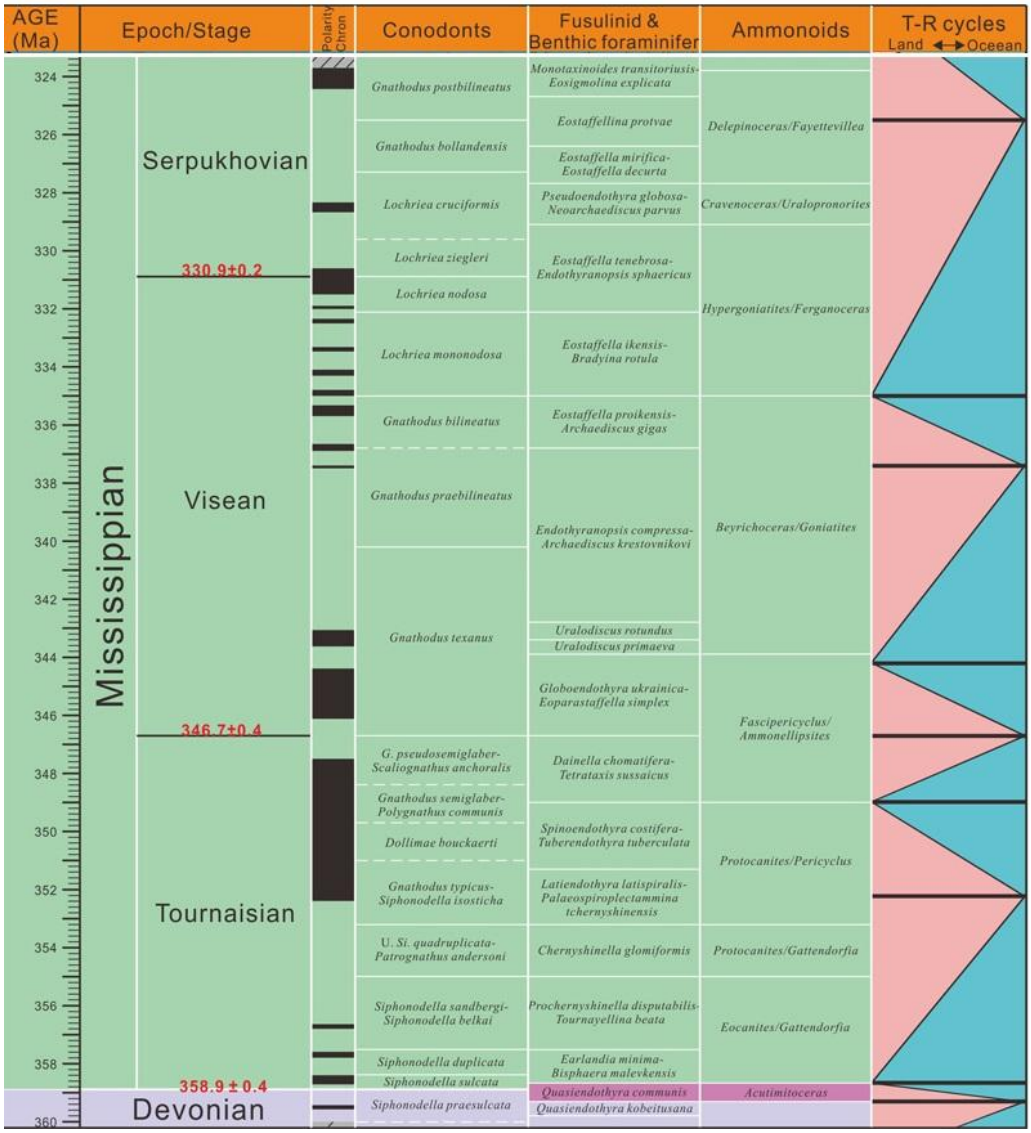

Figure 3 - Subdivisions of the Mississippian Period
Credit: International Subcommission on Carboniferous Stratigraphy

The Mississippian Period is divided into three Epochs:

- Serpukhovian (330.9 to 323.2 Mya);
- Visean (346.7 to 330.9 Mya); and
- Tournaisian (358.9 to 346.7 Mya).

The **Serpukhovian Epoch** is the final epoch of the Mississippian. Proposed by the Russian geologist Sergei Nikitin in 1890, it was named after the after the city of Serpukhov, near Moscow. The base of the epoch is defined by the first appearance of the conodont *Lochriea ziegleri* and the top of the epoch is defined by the first appearance of the conodont *Declinognathodus nodiliferus* the in the lower Bird Spring Formation, Nevada. Other fossils that appear near the end of the Serpukhovian include the foram *Globivalvulina bulloides*, and ammonoids of the genus *Homoceras* and the ammonoid species *Isohomoceras subglobosum*.

The **Visean Epoch** lies in the middle of the Mississippian Period. It was proposed by by Belgian geologist André Dumont in 1832. Dumont named this stage after the city of Visé in Belgium. The base of the epoch is marked by the appearance of the first appearance of the fusulinid species *Eoparastaffella simplex*.

The earliest, lowest, epoch of the Mississippian is the **Tournaisian**; André Dumont named it after the after the Belgian city of Tournai in 1832. The base of the epoch is marked by the first appearance of the conodont *Siphonodella sulcata*.

Mississippi Valley-Type Lead-Zinc Deposits

Figure 4 - Galena in Calcite, Annabel Lee Mine, Hardin County Illinois, USA
Credit: James St. John, Creative Commons Attribution 2.0 Generic license

This is good place to discuss Mississippi Valley-type lead-zinc deposits (MVT), also called Carbonate-hosted lead-zinc ore deposits. MVT are an important class of mineral deposits that are found in carbonate rocks such as Mississippian aged limestone and dolomite. Minerals found in MVT deposits include metal sulphides such as sphalerite, galena, pyrite, barite and marcasite. Non metallic minerals such as quartz and fluorite also occur in MVT deposits. The minerals that make up the carbonate rocks, dolomite and calcite, occur in these deposits as country rock or gangue minerals.

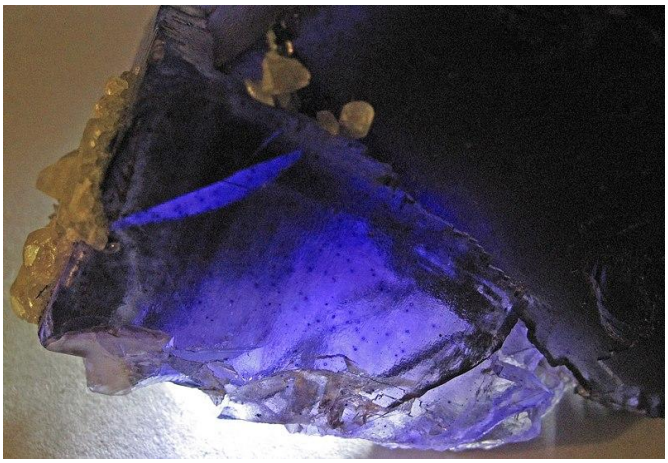

Figure 5 - Fluorite from Cave-in-Rock, Illinois, USA
Credit: James St. John, Creative Commons Attribution 2.0 Generic license

Other than the dolomite and calcite, how did the minerals found in MVT deposits get into the already deposited carbonate rocks? It's an interesting process that requires three things:

1. A source of dissolved ions;
2. A source of heat to enable groundwater to dissolve the ions; and
3. A groundwater gradient to transport the dissolved ions to where they could be deposited in cooler conditions.

Mountain building episodes, such as the Allegheny Orogeny in the Appalachians, provided these things. Groundwater infiltrating the newly rising mountains encountered hot rocks and dissolved such things as, calcium, copper, fluoride, lead, silica, sulphate, and zinc ions. It is easier to dissolve minerals in hot water than cold. The groundwater would also accumulate organic carbon or even kerogen, the predecessor to petroleum. The hot groundwater, in the range of 75°-200°C, then flowed downhill through the rocks into the carbonate formations, where they encountered cooler conditions.

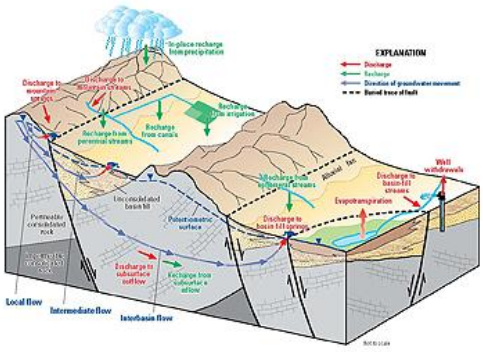

Figure 6 - Groundwater Flow
Credit: USGS, public domain

This is where things get interesting. The chemical conditions in the limestone and dolomite are very poor in oxygen, so called reducing conditions. In these conditions, anaerobic bacteria live today, even at great depths in the earth, and probably did so during the Paleozoic. (Remember these little critters have been around since the Archean, they are pretty resilient.) Some of these anaerobic bacteria live by metabolizing sulphates, so called sulphate-reducing bacteria. As part of their metabolism, the sulphate-reducing bacteria use organic carbon, or petroleum, to convert sulphate ions into sulfide ions, gaining energy in the process. The sulphide ions will combine with hydrogen ions, to make hydrogen sulphide and with the dissolved metal ions to make metal sulphides such as the sphalerite, galena, pyrite, barite and marcasite noted above. These metal sulphides can precipitate out of solution in the pores of the carbonate rocks. Also, under the right conditions, dissolved calcium and fluoride will combine to form fluorite, calcium fluoride and dissolved silica will precipitate out of solution as quartz.

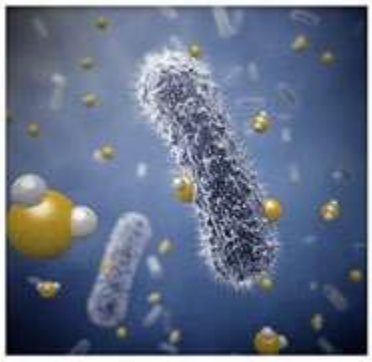

Figure 7 - Sulphate Reducing Bacteria
Credit: ResearchGate, March 20, 2014,
Study reveals new insights into sulfate-reducing bacteria

It's an interesting example of natural processes showing the interplay between living things and geology.

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.