January 16, 2023

News and notes

Before going on to talk about the events of the Quaternary Period, here are some news items that I thought were interesting.

Research

- Plate tectonics in the twenty-first century; Phys.org summary here.
- Diamonds and plate tectonics: Extreme redox variations in a superdeep diamond from a subducted slab; Phys.org summary here.
- Geophysics: Sensing whales, storms, ships and earthquakes using an Arctic fibre optic cable; Phys.org summary here.
- Petrology of minerals in the mantle: Periclase deforms more slowly than bridgmanite under mantle conditions; Phys.org summary here.
- From the Jet Propulsion Laboratory: Scientists and satellites make sense of Earth's subtle motions.
- Sedimentology research: Grain shape effects in bed load sediment transport; behind a paywall, Eureka alert summary here.

Paleontology

- Human paleontology: Middle Holocene Siberian genomes reveal highly connected gene pools throughout North Asia; Eureka alert summary here.
- Patagonian dinosaurs: New records of Theropoda from a Late Cretaceous (Campanian-Maastrichtian) locality in the Magallanes-Austral Basin, Patagonia, and insights into end Cretaceous theropod diversity; Phys.org summary here.
- Fossils in amber: The largest amber-preserved flower revisited; Phys.org summary here.

Glaciers and Climate Change

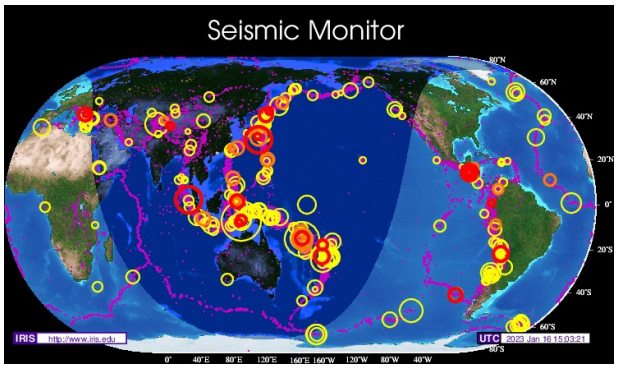
- Antarctic glacier: Episodic dynamic change linked to damage on the Thwaites glacier ice tongue; Phys.org summary here.
- Arctic climate change over time: Exploiting SMILEs and the CMIP5 Archive to Understand Arctic Climate Change Seasonality and Uncertainty.
- Freshwater Transport Over the Northeast Greenland Shelf in Fram Strait.

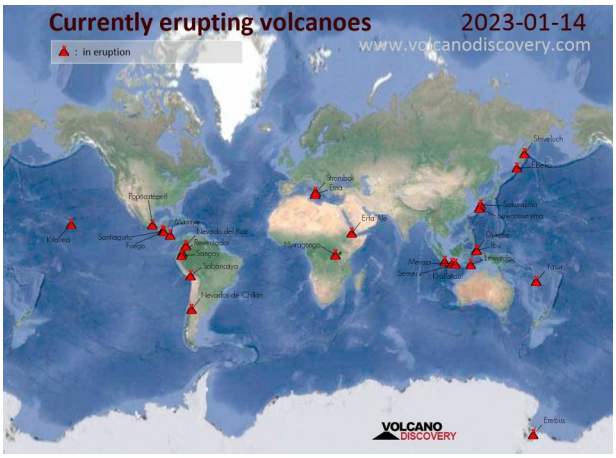
Mining and Energy

- Crooks: Robbers pull off multimillion-dollar copper heist in Chilean port.
- Europe’s largest rare earths deposit found in Sweden.

- Interruptions: Powerful Explosion Rocks Natural Gas Pipeline Connecting Lithuania And Latvia.
- From the United States Energy Information Administration (USEIA): EIA expects U.S. gasoline and diesel retail prices to decline in 2023 and 2024.

Volcanoes, Earthquakes and Geohazards





Seismic Monitor Link **Active Volcano Map**

- More on the Hunga Tonga-Hunga Ha'apai volcano, from Phy.org: A year on, we now know why the Tongan eruption was so violent. It's a wake-up call to watch other submarine volcanoes.
- Magma Chamber Detected Beneath an Arc Volcano With Full-Waveform Inversion of Active-Source Seismic Data; Phys.org summary here.
- Earthquake research: A More Realistic Earthquake Probability Model Using Long-Term Fault Memory; behind a paywall, Phys.org summary here.
- Landslides: Cascading climate disasters: Atmospheric rivers over California's wildfire burn scars raise fears of deadly mudslides.

Geologists in the News

- The Life of Mary Anning, Fossil Collector of Lyme Regis: a Contemporary Biographical Memoir by George Roberts.

Portrait of Mary Anning with her dog Tray
Credit: Credited to 'Mr. Grey' in Crispin Tickell's book 'Mary Anning of Lyme Regis' (1996). public domain, on display at the Natural History Museum, London.

January 3, 2023

Events of the Quaternary Period – Climate and Glaciation

The biggest event of the Quaternary Period were the great glaciations. In this week's posting, we'll look at the period's climate history and the history of the Pleistocene glaciations. Next week, we'll focus on the big event at the end of the Pleistocene, the Younger Dryas Event. In two weeks, we'll look at the concept of the Anthropocene as a new epoch in the Quaternary where human activity dominates the planet. After all that, we'll look at the fossils from the Quaternary.

Climate During the Quaternary

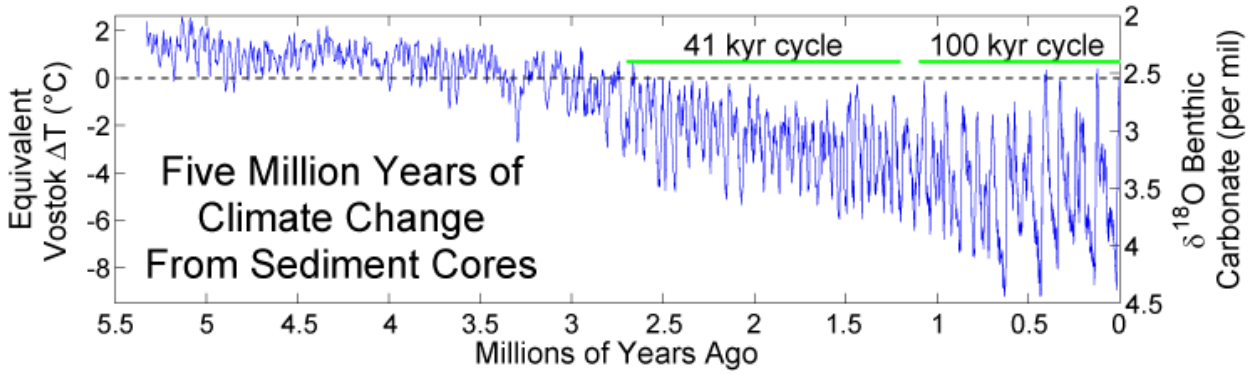


Figure 1 – Five Million Years of Climate Change
Credit: Robert A. Rohde, Creative Commons Attribution-Share Alike 3.0 Unported license
Based upon data from Lisiecki & Raymo, 2005

The Quaternary Period began 2.58 million years ago (Mya) so the chart in Figure 1 shows the climate transition from the Neogene Period during that time.

First question: how do we know this? There are a few ways to measure past climates, these include:

- Studies of ice cores from glaciers such as the North Greenland Ice Core Project and the Australian Antarctic Program;
- Climate history from ocean sediments and lake sediments;
- Dendrochronology, the study of tree rings.

Each of these techniques relies upon some kind of "signature" of climate left in the natural record. In the case of dendrochronology, the key is the growth rings, their width and the cellular characteristics. In the case of sediments and ice, one of the most useful tools is stable isotope analysis.

For example, oxygen comes in three natural isotopes ^{16}O, ^{17}O and ^{18}O in proportions in the proportions 99.76%, 0.04% and 0.2% respectively. When combined with hydrogen to make water, the vapour pressure of water made with ^{16}O is higher than the vapour pressure of water containing ^{18}O. This creates a temperature dependency for the $^{16}O/ ^{18}O$ in the snow that falls on glaciers and this ratio can be used as climate temperature proxy. Similar techniques can be used for the analysis of sediments.

The second question that comes to mind is: what causes these climate changes? The climate change from the Neogene to the Quaternary seems to have been caused by the changes in the geography of the Earth. Plate tectonics resulted in the closing of the gap between North and South America, this changed the flow of ocean currents and the flow of heat from equatorial to polar regions; one result of this change was the glaciation of Antarctica. Plate tectonics also raised mountains, such as the Tibetan Plateau the Greenland uplands. The rise of Greenland made an area amenable to the accumulation of glaciers. The rise of the Tibetan Plateau increased erosion of rock, thus increasing the removal of carbon dioxide from the atmosphere and lowering the overall temperature. Finally, once the stage had been set for glaciation, the rhythm of glaciation and de-glaciation was controlled largely by astronomical cycles, i.e. the Milankovitch cycles.

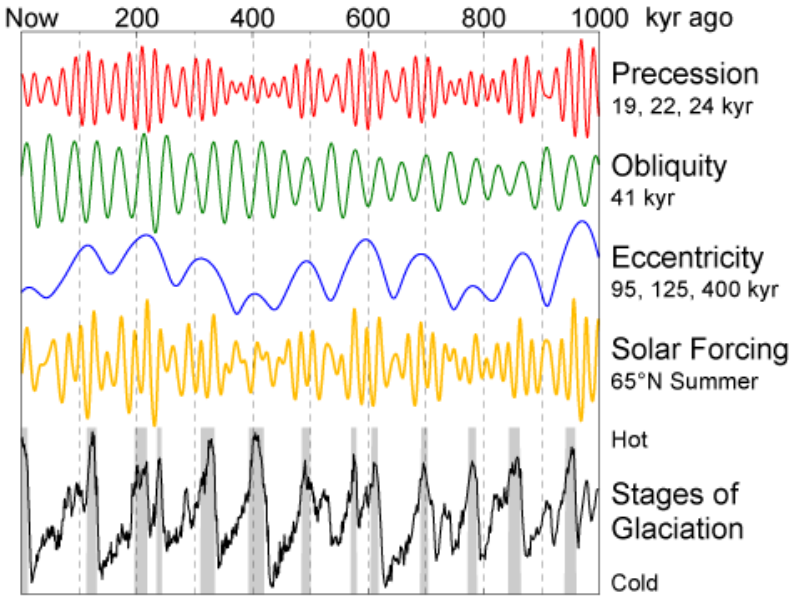


Figure 2 – Milankovitch Variations
Credit: Robert A. Rohde, Creative Commons Attribution-Share Alike 3.0 Unported license

Glaciations

Many, many studies have been done of glaciations in the Alps, Great Britain, Northern and Eastern Europe as well as North and South America. Each area had its own glacial geology, and consequently, geologists developed different names for the various stages of the glacial times. Table 1, below, is compilation of many different studies, originally shown here. In Table 1, I have shown the glacial intervals from the current, Holocene Epoch, to the oldest.

Legend for Table 1	
Extensive interglacial (similar to Holocene)	**Moderate Glaciation**
Extensive glaciation (similar to Last Glacial Maximum)	**AC = Ambiguous correlation**
ka = thousands of years before present	

Table 1 – Quaternary Glaciation

Marine Isotope Stage (MIS)	Time ago (ka)	Regional names						Global age / epoch
		Alpine region	Great Britain	N. Europe	E. Europe	N. America	S. America	
MIS 1	present-14	(Holocene)	Flandria	Flandria (Holocene)	(Holocene)	(Holocene)	(Holocene)	Holocene
MIS 2	14-29	Würm/LGM	Devens/ Dimlington	Weichsel/LGM	Valdai	Wisconsin/ Vashon	Llanquihue/LGM	Late Pleistocene ('Tarantian')
MIS 3	29-57	Würm	Devens/Middle D.	Weichsel/Middle W.	Valdai	Wisconsin	Llanquihue	
MIS 4	57-71	Würm	Devens/Middle D.	Weichsel/Middle W.	Valdai	Wisconsin	Llanquihue	
MIS 5a	82 (peak)	Würm	Devens/Early D.	Weichsel/Odderade	Valdai	AC	AC	
MIS 5b	87 (peak)	Würm	Devens/Early D.	Weichsel/Rederstall	Valdai	AC	AC	
MIS 5c	96 (peak)	Würm	Devens/Early D.	Weichsel/Brørup	Valdai	AC	AC	
MIS 5d	109 (peak)	Würm	Devens/Early D.	Weichsel/Herning	Valdai	AC	AC	
MIS 5e	123 (peak)	Riss-Würm	Ipswich	Eem	Mikulino	Sangamonian	Valdivia	
MIS 6	130-191	Riss	Wolston	Saale/Drenthe Warthe	Dnieper/ Moscow	Illinois	Santa María, Casma	Chibanian
MIS 7	191-243	Riss	Wolston Aveley	Saale/Dömnitz Belvedere	AC	Pre-illinois		
MIS 8	243-300	Riss	Wolston	Saale/Fuhne	AC	Pre-illinois A?		
MIS 9	300-337	Mindel-Riss?	Wolston Purfleet	Holstein?	Likhvin	Pre-illinois		
MIS 10	337-374	Mindel?	Wolston	Elster?	Likhvin?	Pre-illinois A?	Río Llico Colegual?	
MIS 11	374-424	Günz?	Hoxne	Holstein Cromer/Rhume?	Likhvin	Pre-illinois		
MIS 12	424-478	Günz Mindel?	Anglia	Elster Cromer?	Oka	Pre-illinois B	Caracoles Río Frío?	
MIS 13	478-533	Günz	Cromer	Cromer	Oka	Pre-illinois		
MIS 14	533-563	Günz	Cromer	Cromer	Oka	Pre-illinois C		
MIS 15	563-621	Günz	Cromer	Cromer	Muchkap	Pre-illinois		
MIS 16	621-676	Günz	Cromer	Cromer / Don	Don	Pre-illinois D		
MIS 17	676-712	Günz	Cromer	Cromer		Pre-illinois		
MIS 18	712-761	Günz	Cromer	Cromer		Pre-illinois E?		
MIS 19	761-790	Günz	Cromer	Cromer		Pre-illinois		
MIS 20	790-814	Günz	Cromer	Cromer		Pre-illinois E?		Calabrian
MIS 21	814-866	Günz	Cromer	Cromer		Pre-illinois		
MIS 22	866-900	Günz	Cromer	Cromer		Pre-illinois F		
MIS 23-63	900-1800	Danube	Beeston	Bavel Menap Waal Eburon	Krinitsa Tolucheevka	Pre-illinois G Pre-illinois H Pre-illinois I		
MIS 64-103	1800-2600	Biber	Paston Bavents Bramerton Thurnian Ludham Pre-Ludham	Tiglian C5 Tiglian C4 Tiglian C3 Tiglian B Tiglian A Pre-Tiglian	Khapry Verkhodon	Pre-illinois J Pre-illinois K		Gelasian

Winding it Up

There is a lot to look at in Table 1, if you care to follow the links (if they don't work in the on-line entry, open the PDF in the archive). We'll look at the dividing line between the Pleistocene and the Holocene, the Younger Dryas Event, next week.

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.