MASS EXTINCTIONS OF PREHISTORIC LIFE

by Dave Millis

Originally planned to be called "How do they know" and limited to subjects such as water temperature through time and borders of ancient land masses, I extented it to mass extinctions and added a couple essays on my own.

Introduction

Prehistoric life! Very complicated. I read a book "Prehistoric Life." A variety of authors and editors and published by DK. Looks like a picture book. It isn't. Starts about 3.5 billion years ago and ends with humans. Explains land masses, ie. plate tectonics. Explains climate, atmosphere, ice ages, greenhouse mode. Explains absolute age of rock strata. Explains water temperatures and ocean currents. Looks like a fossil picture book. It's much more.

I knew some of this story before I read the book. Everyone who reads it would claim the same. This report or program or... starts with an explanation of the physical science of measuring things like water temperature 400 million years ago and age of rocks using Uranium 235. Then several sections on mass extinctions. Last, are some stories that are true and others that are speculation.

The intent is a description in layman terms. Such as, Calcite rather than calcareous. Might be bad English, I don't care. It's clearer.

Kingdoms

When I was a kid there were two kingdoms, plant and animal; and they were debating whether fungi was a third kingdom. Now, there are at least 28. As a result, kingdom is no longer the top category; it's now domain. There are 3 domains: bacteria, archaea, and eukarya.

Bacteria have 10 kingdoms, each unique but with the common properties of single cell and no defined nucleus. There are several million species.

Archaea have single cell structures, no defined nucleus, and alternate ways of obtaining energy. Thus, they inhabit environments hostile to every thing else, but use chemosynthesis to make food from metal ions, hydrogen and carbon. There are 3 kingdoms.

Eukarya: at least 15 kingdoms and all have cells with well defined nuclei. Four of these kingdoms are Red seaweed, Brown seawees, Plants, and Fungi. There is still some debate about how to tell these apart. The fifth is us, that is animals. The

current definition separating us from plants, etc., is that animals have to consume other organisms and are multi-celled. The other 10 kingdoms are protists and they do expect to find more protists. Some of them are a little like plants, some like animals, and some like fungi; but always a litte diffrent from them. And all of them are single-celled.

That adds up to 28, for now. Bacteria and Archaea each have several million species. Eukarya have about 2.5 million species; 1.5 million animal species.

Special Fossils

Three kinds of secial fossils are type, index and key. There may be more kinds. Type is the easiest to describe as it is the first fossil of a new species. It is rarely the best, just the first. It's importance depends on whether a better specimen is found. It remains THE type fossil.

Index fossils were most important during research before radioactivity was discovered. It is still important, especial to amateur collectors. To the scientists their information has been checked, rechecked, double checked, and known so well that when a new fossil show up, they immediately know when it lived. This is aided by both knowing which fossils are the older (or younger) (relative age) and the absolute age of the rock strata. Some fossils from this group become key fossils, but first how were index fossils used.

The relative ordering of fossils from oldest to newest is done by matches of the same specie in rocks from different parts of the world. Sometimes, more than one specie is needed to do this, but the result is that fossils not found at one site but found at the second site can be ordered into a record of life. Virtually, the entire record is known to some extent. A problem arises when the index fossils live too long leaving overlaps in the record. Refinement continues.

I need to tell you a story and then explain the difference between the way scientists and amateurs collect. And then make a point.

One of the dinosaurs, brontosaurus, was removed from the specie list. Then put back on the list a few years later. Comparisons of the known fossils indicated it was really a diplodocus. A new find indicated it was in fact a unique specie. The whole point of this story is that the new find had been in storage for years. Most new finds are found in storage at schools and institutes. Scientists typically collect everything they can as quickly as they can because they have to get back to work, which typically does not allow time to analyze all the fossils. Amateurs work differently.

This might be an amateur's story. He collects trilobites. He has some of

the index fossils and wants to find trilobites he doesn't have. He checks a rock layer to determine if the trilobite he wants is up or down and digs accordingly. Other fossils found might be good and he might save them for any number of reasons, but once he gets the trilobite, it's time to move to a different level/site. Index fossils are thus, important to amateurs and "old Hat" to scientists.

The third kind of special fossils is called key. Key fossils are most important for a variety on reasons. Only two are described: Glossopteris and short-lived plankton.

Glossopteris is a plant that likes to have its roots in cold water. The appearance or dissapearance on this fossil designates shore line. Mostly, used to delineate the border of Gondwana and the break-up into Australia, Antartica, Africa, South America, and India, it also designates latitude.

Any creature that exists for only a geologic short time designates age and accordingly, reduces the overlap in the geologic record. In particular, diatoms and fors evolve often, even if the habitat doesn't change. That sentence needs to be explained.

Evolution proceeds at different rates for different reasons. Not to say anything bad about Darwin, but gradual evolution is too slow; we know this now. The impetus that spurs evolution is habitat change which causes the lost of species and leaves gaps for other creatures to evolve to fill. In the last 50my, ice events have caused extinctions followed by diversity. So, now there are many more species than ever before.

Another example is the initial mass diversity 542mya. One or more of the kingdoms of the domains, bacteria and archaea, took about 3 billion years to increase the oxygen content of the atmosphere to the critical point at which time marine life exploded. In a "geologic microsecond" many of the major groups still alive today evolved. Once the niches were filled the evolution rate decreased.

Adding to the concept that new habitat spurs evolution, here's comments on the work of Alfred Wegener and Mesosaurus (the first land retpile to evolve to live in the ocean.) His work, proposing continental drift, published in 1915 indicated South America and Africa were joined. The impetus for this evolution was probably new sea habitat as the two continents separated.

Only four key fossils are required to substantiate that Gondwana included what is now South America, Africa, India, Australia and Antarctica. The two not already named are Cynognathus and Lystrosaurus, terrestrial reptiles.

Ocean Temperature

The temperature of ancient oceans is preserved in calcite and silica. Understanding how requires knowledge of life that creates the mineral and isotopes of oxygen.

First, oxygen normally contains 8 protons and 8 neutrons, but a small percent of oxygen has two extra neutrons making it heavier. the ratio of all oxygen is constant throughout the history of earth. This is true because oxygen is too heavy to escape gravity. Whatever is here stays here and any amount arriving from space is trivial.

Next, the difference between chemistry and physics is very important. The abundant oxygen will be called O-16 and the rarer but also very stable will be O-18. Chemistry treats them equally; it does not matter which is present when the creature creates a molecule of calcite or silica. Life and creature represent names of whatever kingdom has one or more species that build minerals as part of themselves. Grow might be a better word. Physics is different.

In physics, the evaporation rate or O-16 and O-18 are different. O-16 evaporates faster at all temperatures but O-18 is sluggish and very slow at colder temperatures. During an ice age, the ratio of O-16 to O-18 is high in the ice and lower in the ocean. This difference is measureable.

The second part is understanding the life that preserves this data. That means a mineral located in a place where it will not be changed.

Four sources need to be discussed; plankton, foraminiferans, diatoms and shells.

Plantkon

Checking three different sources yielded three different defifnitions. Plankton is Fossil Algae, Fossil plants and animals, and Fossil amoeba (new spelling is ameba.) My definition is inclusive; any single-cell life floating in the ocean and capable of creating a mineral structure that is part of itself.

Foraminiferans

Using my definition above, Foraminiferans (fors) are plankton in calcite shell cases. Calcite isn't as good as silica but is readily available. Fors have another property quite useful; they evolve quickly. They go extinct in as little as 500k years, thus accurately dating fossils in the same layer.

The rates at which evolution happens is discussed later, but I believe fors are always high because they are located in the top layer of sea water and are exposed to radiation from space and because they are single-cell.

Diatoms

Diatoms create silicate structures. Silicates resist change as good or better than everything else. Even SiO_4 without a positive ion will stay intact, regardless of which positive ion is there and of course, SiO_2, quartz, is very stable.

Whether diatoms are algae, plant or animal depends on which book you read, but they are single-cell and are included as plankton.

Shells

Many groups of animals create shells and most are calcite. Sometimes fossil preservation is so complete that even the original patina is present. Accurate water temperature might be gotten from these. Some animals create aragonite shells which are likely to be useless, but preservation may have altered them to calcite. Chitin shells are even more risky.

Absolute Age

The relative age of rocks are determined by position and index fossils. Newer rocks are deposits on top of older rocks. Absolute age is measured by uranium. Two factors to describe are radioactivity and zircons.

Radioactivity using carbon 14 is generally known. Carbon 14 decays too rapidly for Archeology and Paleotology and is useful in anthropology, only. Uranium exists as two isotopes, 235 and 238. U238 decays too slowly. U235 has a half-life of about 700k years (700,000 years.) Decay goes through a few steps some of which are also slower than C14, but stops at lead 207, (Pb207.) The ratio U235 to Pb207 yields absolute age. Now, where do we find U235 that stays in place for a billion years.

Zircons

Zirconium is a rare earth element but fortunately it is the most common rare earth element. Zircon is a neosilicate, $ZSiO_4$, that has an open structure just the right size to hold a uranium atom. Once it is in the crystal lattice is stays there. Zircon crystals are slightly radioactive. The ratio of U235 to Pb207 tells us the actual age of the zircon. Now,

zircons are not found in fossils but in igneous rocks. So, what is the good news.

Fossils in rock layers between two layers of igneous rock pinpoints the age of those fossils and presence of an index fossil absolutely dates the fossil and thousands of others as well. A key fossil would be even better. Type, index and key fossils are described later.

None of my books address where to look for fossils between two layers of igneous rock. I would speculate finding a volcano near the ocean, where creatures got buried between eruptions, to be one place.

Greenhouse and Icehouse

Throughout earth's history, Carbon dioxide has been in a general decline. About 540mya is was 18%, now it's about 0.5%. However, there have been some remarkable ups and downs. When up, earth is in greenhouse mode; when down, icehouse. That's where we are today, icehouse. This condition has persisted since the extinction of the dinosaurs but is in no way the result of that meteoritic event. It was started by plate tectonics changing the ocean currents and breezes (rain.) So, icehouse started about 55-60mya. There was one other icehouse era starting in the Carboniferous and ending in the early Triassic. That's about 50my making icehouse about 110my out of the 540my that marine life florished.

Land Masses

Many land masses appeared and dissappeared or coalesed and so there a lot of obsolete names for land masses. Two are still widely known: Gondwana and Pangea.

Gondwana existed before 542mya when marine life first evolved. Without fossil evidence, earlier plate tectonics are uncertain. Since then it has moved about but mostly remained in the southern hemisphere. It was comprised of S. America, Africa, India, Australia and Antarctica. When it covered the south pole it caused a massive drop in ocean levels. More details about this are in the Mass Extinction between the Devonian and Carboniferous periods; a very complex extinction. Later, it became the southern half of Pangea and began to break up about the same time as the northern half of Pangea did; the break-up began in the Triassic and contined through the next two periods (Jurassic and Cretaceous.)

Pangea began to form in the Permian period and reached maximum size in the Triassic. At that time, there was more land mass on earth than any other time in earth's history, because the ocean levels were so low. Pangea stretched from pole to pole, which affected the ocean currents and

weather patterns.

Continents that exist today appear in the literature at different periods and North America appears in the Triassic. Siberia was a continent with an earlier history going all the way back to the Ordovician and kept growing and coalesed into Asia. Europe appears in the Jurassic.

Gondwanaland is a name of dubious value. The only reference of value is as a name given to the pieces of Gondwana during break-up.

Section 2: MASS EXTINCTIONS

Recent mass extinctions

What is a mass extinction? Is there a percentage of species that have to disappear before it's called a mass extinction? There have been many small extinction events and 5 major ones. At the end of the Cretaceous, the event probably happened in a year. The event that ended the Devonian took 20my. Ice is one factor in most events including 3 of the major ones. For that reason ice ages are described first.

There is ample fossil evidence showing serious ice events throughout the history of earth. Even while the earth is in greenhouse for millions of years, ice events happen. These events are not trivial like the last 4 that happen in the last 100,000 years, but 100,000 years of ice every 1 to 2 million years with only 20,000 years of warm-up separating events.

Ice ended the last 5 mini-mass-extinctions. These ended the Paleocene, Eocene, Oligocene, Miocene, and Pliocene. The Pleistocene is more complex as humans are involved. So, in simplistic terms, it gets too cold for many species and they go extinct. Then the ice melts and the remaining species rapidly evolve to fill the habitat left vacant. What is most remarkable is mass diversification, earth has more species after each extinction. This has happened repeatedly so that today there are more species than ever!

This paragraph is about half fact and half guess. About 2 million years ago large animals evolved to be able to deal with the cold. They include well known mammoths and mastadons. Also, the saber-toothed cat that hunted in packs like lions do today. Rhinos, hippo-sized koala, European deer with 11 and 1/2 foot antlers, 12-foot flightless birds, the blue whale, camels, polar bears, muskox, and more all evolved to deal with the cold. Warm weather killed off most of them, because it narrowed the habitat suitable to them. Man helped with some of them, but that only speeded-up the process. Polar bears are in real trouble because the ice is melting. They could starve on shore while waiting for sea ice to form.

Devonian Mass Extinction

There have been 5 serious mass extinctions in earths history and Devonian is the most complex. We will start with this so the rest will be easier to explain.

1. First and most important thing to remember is that it took at laest 20 million years to happen. These sequential happenings are listed non-sequentially as some reoccurred. The picture is still being refined. Older references are probably out of date. The end of the Devonian was 345mya (mya - million years ago), now it is 359mya. Further refinement is likely.

2. Ocean levels dropped about 1000 feet has a huge ice pack covered Gondwana. The continental shelves around the world formed but warmer times melted enough ice to flood the land again and again.

3. When the ocean was low, the extra land interferred with the weather by obstructing the ocean currents and ocean breezes (rain.) Zonal weather developed; unlike today, storms did not move warm air to higher latitudes or colder air toward the equator.

4. Plants (trees especially) evolved during the Devonian and covered the land. This probably the main reason the carbon dioxide level dropped from 10 percent to 1 percent in the Carboniferous. Trees also added to the polution in the ocean; coral reefs are adapted to grow slowly in nutrient poor water. High nutrient levels poison reefs. Oxygen levels in the ocean were reduced by the polution, too.

Extra note: Offshore oil occurs because trees grew on the new lands.

5. Marine habitat was reduced. Here's a relavent fishermans story. I fish the Florida Keys and on rare occasions travelled across the reef then the continental shelf and usually stop at the drop-off. Here's how it goes. Water depth for the first 6 miles drops slowly to only 40 feet where the coral reef and lots of fish live. After that its deep sea fishing where the fishing is near the surface. An oxymoron but true. Most fish whose names you known like Mahi Mahi, Mackerel, Tuna, Marlin, and Sailfish; spend most of their time less than 50 feet down. Swordfish are different. From the reef out the continental shelf drops more of less uniformly and extends about 20 miles out (In other places it might extend much farther.) Water depth increases rapidly reaching 2000 feet precipitously. This effectively reduces the amount of shallow water for marine species to the point of crowding. Mass extinction was thus caused by lost habitat. You might catch a swordfish in 1000 feet of water at night, but day time try 2000 feet. I never fished for them.

6. Water temperatures in the ocean were about what they are today. The results are not entirely clear to me but this is much colder than any other period older than the Paleogene, 65-56mya. I have another fishing story about localize mass extinction in the Florida Keys. About 8 to 10 years ago, the Keys had a cold snap that reduced the water temperature to the 40's for 10 days in the shallow water near the fishing bridges. Fish died by the millions, except for two species: gray snapper and pinfish. Offshore species were not affected; the gulf stream brings in warm water from the Carribbean. Most of Florida bay was also hit hard. Species that disappeared number in the hundreds. The prolific grunt (all 9 species) gone. The entire parrotfish family including the wrasses - gone. The rest of the snapper family that live in shallow water - gone. The next year a few grunts showed up; it took a year for them to wander 6 miles from the reef. Took 2 years before parrotfish came back and some species are still missing from the bridges.

I suspect that much or the marine life extinguished near the end of the Devonian was a combination cold water and reduced habitat.

OK, that's the complex answer. Here's the ironic answer. A mass extinction occurred at 370mya, in the middle of the late Devonian. The old end date for the late Devonian was 345mya. The coal beds were already being layed down by then. But moving the end of the Devonian back to 359mya doesn't answer anything. A mass extinction still occurred 11 million years too early. The old date, 345mya, coincides with the drop in carbon dioxide from 10 percent to 1 percent. The 25 million years between 370 and 345mya was a time of incredibly wild swings in land masses and climate changes. And just to confuse the situation a bit more, there was a 20 million year gap where very few fossils were put down. This gap is called Romer's Gap. It occurred at the start of the Carboniferous. We know for sure that the plants and animals were vastly different after Romer's Gap. We suspect the drop in water temperature and decrease in carbon dioxide caused rapid evolution to fill the new habitat.

Devonian times to Carboniferous times may have been a double mass extinction. Speculation on the 370mya extinction are ice or meteoric collision. No answer at this time.

Ordovician Extinction

Near the end of the Ordovician, vertebrate animals were just getting started and were the most evolved. Typically, they were less than two inches in length making them smaller than the invertebrates. Icehouse was the cause of the extinction. 50 percent of species dies off.

In the Silurian, temperatures returned to normal relatively quickly. At

no time in the previous two periods had ice happened and so the life was not "hardened" to cold water. The species that lived must have adapted quickly.

Permian to Triassic Mass Extinction

During the Permian the ice pack on Gondwana was all but melted. Ocean levels rose and temperatures began to get hot. Pangea had formed. Reptiles evolved to have mammal-like features and evolution would eventually make mammals. Dinosaur had not appeared, but therapods had.

Siberia caused the extinction, because it produced just about the largest vulcanism in earth's history. Ash and sulfur dioxide gas poluted the ocean. The air wasn't much better. 95 percent of marine life and 70 percent of land life was extinguished. This was the worst extinction.

The Triassic begins with lots of new habitat. The ocean was 100 degrees and the land was warmer. There were no ice caps. and water at the poles was warm year round.

My speculation: I believe the massive vulcanism in Siberia was caused by the massive redistribution of mass from Gondwana ice to ocean water. When that ice melted Gondwana would have risen; the land always rebounds from ice packs. The maximum pressure on the earth's crust would have been the opposite side of earth, Siberia. There should have been underwater vulcanism, too. Perhaps these will be discovered or have been but I just don't know it.

Triassic to Jurassic Mass Extinction

During the Triassic (50my) greenhouse conditions returned with a "vengence" (as they say.) After 35my extinction began and contiued for 15 million years. Icehouse plants and animals were replaced with greenhouse plants and animals. The land dried up. Vast desert lands became home to dinosaurs able to traverse long distances to find food. Ocean levels rose to about 600 feet higher than today. It got hot!

Ocean currents flowed east/west or more likely west to east. Gondwana had already split from Pangea and it broke up in several pieces, too. India moved north, leaving a gap between two pairs of contients. South America and Africa were just starting to split, as was Australia and Antarctica.

Anyone who suspects dinosaur were warm blooded should note that they never got cooled off! More likely, extinction occurred because older species became lethargic and easily caught.

Cretaceous Disaster

We all know that an asteroid or comet, meteorically destroyed the dinosaurs. But, there is evidence that an ice event had started the mass extinction. There is no evidence suggesting mass extinction would have happened anyway, though some have suggested it.

The evidence is based on the disappearance of 7 species of Fors, short for foraminiferans, in a million years. This rate is not too high for one of the many ice events that have happened in the last 542my. Fors are single-celled life that has a calcite structure. Oxygen 16 and 18 give us the ocean water temperature and calcite contains oxygen. Some books indicate that Fors are algae; others, plants and animals. I like to just lump Fors and diatoms with plankton in general.

Certainly, the presence of iridium proves the meteoric event. Jumping back to the Devonian extinction 370mya in the middle of the late Devonian, either a meteoric impact or an ice event was the cause but which is correct is unknown. I'll vote for the impact.

Wyoming Valley Coal Deposits

The story behind the creation of these coal fields is complex and shocking. The plant matter that became coal grew during ice ages. Here's how it worked.

The orbit of earth around the sun changes slowly by the gravity of Jupiter and Saturn, and to a much less extent by everything else. It takes 1 or 2 million years to get into a more ellyptic orbit; that's our best guess for timing.

Serious ice ages lasting for perhaps 100,000 years occur. They are followed by 20,000 to 30,000 years of warmer weather. Then more ice, etc. During the ice mode, the ocean level drops and earth has more land (low lands). The extra land interfers with ocean currents and accordingly ocean breezes and the weather becomes Zonal. That is, it stays hot at the equator and tropical nearby, but the weather systems do not mix temperatures with higher latitudes.

Trees proliferate in the tropics for thousands of years, before the ice melts and sea water comes back and buries the plant matter. This happens many times over millions of years. These sediments become shale while the plant matter becomes coal.

In the wyoming valley which stretches more or less from Carbondale (wonder

where that name came from) to Wilks Barre, there are at least 12 layers of coal with thick layers of shale between them.

Animal size

In the last 56 million years animal size has become dramatic and temporary. Repeated long duration ice ages has allowed a species to develop larger animals to cope with cold weather but not the other way around. Why? I don't know?

But I have observed what happens with whitetail deer. Their size depends on their latitude and altitude. Bigger deer live farther north. The dimnutive Key deer lives only on Big Pine Key in the Florida Keys. DNA says they are the same species, but you have to bend down to pet them on the back. Locally, 140-pound deer dressed are large, but you might shoot a 200-pounder in the adirodacks.

About 1 or 2 million years ago, an extended ice age caused animals to evolve to be larger to deal with the weather. Larger animals have proportionaly less skin than small animals and therefore less heat loss. Animals we all know about are Mammoth and Mastodons. Another, the saber-toothed tiger hunted in packs like lions. Others include giant beavers, rhinos, hippo-sized koala, giant sloths, deer with 11 1/2 foot antlers, 12-foot flightless birds and an 11-foot predator, arctodus. Also, horses evolved to their current size but disappeared from North America. Their extinction is most cases was because they were too large when the ice melted. That is, not enough habitat toward the poles. This process is continuing and the over-sized polar bear mighht be the next to go. Muskox are also at risk.

Author's Notes

The Orbit of Earth

Earth's orbit is the most important information that we need to understand preh.istoric life and evolution. We know that about a million years ago the orbit varied from 91 million miles to 94 million miles. We know that the gravity of Jupiter and Saturn caused this. We don't know how much more ellyptical the orbit can become.

Ice events in the past are frequent (geologically speaking) and sever. Much more sever than recent history suggests. Kepler discovered the mathematics of orbits. Subsequentially, two equal areas swept by an object in orbit take different amounts of time, depending on the part of the orbit. So, when earth is closest to the sun it moves faster to sweep the same area it sweeps when farther away.

Earth currently has an orbit that varies from about 92.5 to 93 million miles. It is closest to the sun in winter in the northern hemisphere. So, the northern winters are less sever than southern winters. Also, northern summers are cooler than southern summers. The differences are measureable. How different would it be when the orbit of earth varies from 91 to 94? What orbital extremes would cause the kind of extinctions we know happened?

Global Warming

It is obvious we are having an impact of the weather but can we throw earth back into a greenhouse mode? Does it matter?

Trick question number 1. How much would the ocean level rise if all the ice on the arctic ocean melted? Answer: Zero, floating ice displaces the same volume of water when melted.

So, it's the ice packs that are important. There is enough ice on Greenland to raise the level about 50 feet. Disasterous for ocean front property but not to humans. If all the ice on Antarctica melted it would raise the level another 200 feet. Disasterous for ocean front property, but not to us.

What is dangerous to us would be excessive temperature rise. Is this possible? No one knows for sure but here's something to think about. Earth history indicates that 80 percent of the last 500 million years was spent in greenhouse mode. When Pangea stretched from pole to pole; ocean currents were seriously interrupted. Then when it split apart, it got hot and the currents flow east/west. That's not likely to happen. There are currently 4 places where cold water flows toward the equator and 4 places where warm water flows away from the equator.

Trick question number 2. Which country does the most to prevent global warming. Answer: Panama, the Pacific would readily flow into the Atlantic if Panama sank. Even now some gets through the locks to the Atlantic.