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Global Warming... Compared to What?

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As you know, I am a geologist. I am also an optimist. I thought I should say this right up front because one of the things I am optimistic about worries some people, namely change in the natural world. This hot ball of rock we live on is changing. The world continues to evolve. **Continue** is the key word here. If we do not see the long-continuing processes, we may imagine that we are experiencing a singular event at a singular time in history, and that other times were static.

Along with the fear of change, in the minds of some, is the fear that a change will be catastrophic in some way. Today catastrophes are certainly fashionable. We hear alarmist assertions that are unbelievable, but the public buys them at least in part because the public does not have comparative data. People have no way to compare the claimed damage and its impact on the fragile world with historical changes and their effects. Note the emotional overtones in "damage" and "impact" versus the calmer and more evaluative connotations of the words change and effect. And watch out for the word fragile when the item turns out to be quite resilient. So my subtitle is "compared to what." I offer data about climate changes, both cooling and warming in time before people were significant, changes much bigger than the slight warming during this century. There are independent indicators showing several kinds of changes without catastrophic breakdown. .

Fig. 1

The first figure shows North America about 18,000 years ago, in other words 180 centuries ago. I am going to give most numbers in centuries because people have a feel for a century; some of us will live a century. The map is taken from the fine book by Andersen and Borns called **The Ice Age World.** At the time of this map about 25% of the land surface of the planet was covered with glacier ice. Today about 10% of the land is covered with ice, 5,000,000 square miles in Antarctica, over 600,000 square miles in Greenland, and some smaller ice caps. But every continental mass has glacier ice now, today, so we are not out of the last ice age yet, though we have been coming out of it irregularly for these 180 centuries. Observe in Alaska how little ice there was. It covered only mountain ranges. The Brooks Range had an ice cap, and glaciers still exist there today. But ice never reached down northward to the Arctic shore of Alaska, even to the Arctic shore of today, let alone the shore then, 180 centuries ago. .

With so much ice on land, there was less water in the oceans. World sea level was down 400 feet below today's sea level. I should say 120 meters because we should use the metric system and thereby join the twentieth century before it is too late. .

This change in sea level has implications one might not think of. Where is the sea floor less than 400 feet below the present water surface? About a million square miles between Viet Nam and Java, and connecting to the Philippines. Almost another million square miles around the north rim of Australia and connecting to New Guinea. The Persian Gulf was a river valley. Dry land, not ice, reached across from France to Ireland, but the ground was too cold for snakes. A big piece of land was out of the sea along the north coast of Siberia and across to Alaska, shown in the second figure in white .

Fig. 2

Well, a million square miles here, a million square miles there, pretty soon we are talking real land, maybe 16% more land then than now. I call this to your attention because of its implications for coral reefs. Almost every single reef on earth today was dry land when there was more ice. I return to this in a minute. .

Think about the change in sea level of 400 feet since the latest great ice sheets began to melt away 180 centuries ago. Three years ago NOAA, the National Oceanographic and Atmospheric Administration (I worry about a federal bureaucracy administrating the oceans or even thinking it can, but never mind), anyway, NOAA announced that during the twentieth century sea level rose six inches. I didn't see anything to compare this with. If you suppose the world was static until the industrial revolution, then six inches in a century sounds like something. But a rapid mental calculation will tell you that 400 feet in 180 centuries is 4 feet in 180 years which is **26 inches** per century for 180 centuries, irregularly to be sure but **26 inches** on average for 180 centuries. This puts global warming and melting ice caps in a different light. .

The reefs around the Hawaiian Islands have an interesting story to tell about sea level changes during the last half million years, in other words the last 5,000 centuries. As you know, the islands are a string of volcanoes younger toward the east. They sink into the ocean as they cool. The third figure is part of the big easternmost island, named Hawaii, shown in brown.

Fig. 3

On its gently sloping shelf off to the northwest, the black lines on the ocean floor are 200 meters, about 660 feet, depth of water. To the west is deep ocean. The red bands are reef terraces now drowned beneath the sea. The graph in the lower left shows ages of these reef terraces in centuries. The sixth one is not indicated. Reefs grow only near sea level, and they grow away from shore into the waves. These old, older, and oldest reef terraces are wonderful. They are the natural reactions of the reef animals and plants to two different truly earth-scale processes. Sea level went down hundreds of feet as glacier ice grew on land during ice-age expansion. And the island sank at about the same rate, so the reef was thriving for hundreds of centuries--hence the wide terrace. As ice melted in the waning ice age time, sea level went up, but the island continued to sink, so the reef was lowered into the dark and died. When the next ice age started, a new reef thrived closer to the present shore, It is a happy coincidence that sea level went down at about the same rate as the rock sank, and another happy coincidence that it happened so many times and datable times that we can understand it .

These drowned reef terraces demonstrate something beyond just the several ice ages. The Deputy Executive Director of Greenpeace in the United Kingdom wrote in December, 1997, "average increases of 1-2°C [are] the levels at, and above which, ecosystems and human systems would show rapid, severe and irreversible changes." But the reef came back, like Dr. Suess's cat. The reef terraces prove the Greenpeace alarmist statement wrong. We have had greater than 2° shifts in temperature, both cooling and warming, several times without deleterious effects on the fragile ecosystems. Change, yes, but obviously not irreversible.

Now let us look in more detail at the latest ice age. How much cooler was the planet 180 centuries ago? A lack of agreement here comes from measuring different things at different places. The surface water temperature in the North Atlantic was about 10°C (18°F) colder, but the southern ocean surface was only about 3°C colder during the last few ice ages, as shown in Figure 4.

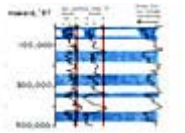

Fig. 4

Fig. 5

Fig. 6

I colored Howard's ice times in blue and present temperature in red, given as 0. As another example, the Sahara in North Africa was a savanna with flowing streams and big mammals 300 centuries ago and the same again 120 centuries ago, but in between it was semi-arid. During that time gap, at the greatest extent of ice, Nevada had dozens of natural lakes (Figure 5). And Figure 6 shows that the present Great Salt Lake in Utah is a mere shadow of the 1000-foot deep fresh water lake 180 centuries ago. Climate belts did not migrate north and south with parallel margins like lifting your belt and letting it fall again. .

With changes in the climate came equally large changes in the flora. Another map from Andersen and Borns (Figure 7) shows the situation in Europe about 200 centuries ago. The Caspian Sea was then an overflowing fresh-water lake. The orange color represents Arctic tundra with little foliage. Along the Mediterranean coast were evergreen forests. In between had low plants but with few trees. With amelioration of climate trees spread across Europe.

Fig. 7

The rate of spread of pines, beech trees, and oaks has been determined by counting the abundance of pollen and seeds in swamps and lakes across Europe for several times. On Figure 8 the numbers in the corners of the maps are centuries ago. The colors plot abundances at 2%, 10%, and more than 50% in green for pines, red and brown for oaks and beech trees. For scale, Norway is 1000 miles long. The white in Sweden 10,000 years ago is remaining ice. We see here that beeches and oaks expanded northward at the barely believable rate of hundreds of feet per YEAR! Don't misunderstand this; big oak trees did not pick up and walk north, but the acorns were spread by wind, streams and squirrels.

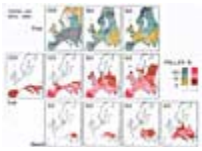

Fig. 8

The pine cones tell a different story. In the upper left, the map shows that pines were far the dominant species over much of Europe 100 centuries ago though absent 100 centuries earlier on the tundra. Thereafter the pines were pushed out by the deciduous trees. Note that the pines were not pushed out by farmers; oaks and beeches are not cash crops. These maps are from Huntley and Birks with hundreds of data points for many other species too.

I have not seen a good pollen summary for North America, but other kinds of data exist. Fresh water ostracodes in lakes in Minnesota indicate a general warming for the last several thousand years. However, changes in water chemistry, probably related to changes in drainage patterns during those hundred centuries, also affected the ostracodes. A gross example of drainage changes as the ice sheet melted back from the region of the Great Lakes is illustrated in Figures 9 through 11.

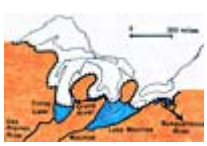

Fig. 9

Fig. 10

Fig. 11

Fig. 9 **Fig. 10** **Fig. 11**

By 60 centuries ago, in the last figure, ice was finally gone from the St. Lawrence Valley. The region was still so depressed by the former weight of ice that the low drainage for Superior, Michigan, and Huron was across Lake Nippissing to the Ottawa River and into an arm of the sea shown in green, including what are now Lake Ontario and Lake Champlain. My point in going through this evolution is that temperature has not been the only natural variable over time.

Look at the different kinds of evidence we have now about climate and related change:

1. Widespread deposits from glacier ice several times in half a million years
2. Sea level changes of hundreds of feet over long times
3. Carbon isotope shifts indicating surface ocean temperature shifts
4. Migration of flora by counting pollen and seeds in swamp deposits, datable by 14C back 40,000 years and by other methods farther back
5. C02 and methane in bubbles in Antarctic and Greenland ice showing changes of these in the atmosphere, data probably smoothed over a century
6. Uplift and tilting of land, apparently from release of weight of ice
7. Especially interesting are historical records.

An important observation here is that these are independent changes measured in independent ways, but they all point to large and small and fast and slow changes in climate. .

There is no such thing as "normal" climate. One can calculate an average for this or that factor, but over what interval? NOAA uses 1960 to 1990 as their average, apparently because they have good world-wide data. If they used 3,000 years, they might find that 1998 and 1999 were cooler than average. Two thousand years ago olive trees grew in the Po plain, too cold today. In 1085 the Norman census in England noted grapes for wine. Two hundred sixty years later, at the time of the black plague in 1348, almost all farm land had turned over to sheep herding because the climate was so much colder. Note colder, not caused by fossil fuels or even people. When the plague came to London in 1660, Isaac Newton went to his uncle's farm and saw an apple drop, but there were no grapes, and the climate is still not warm enough for grapes. Before the election a few years ago, the British Labour Party put out a manifesto pledging "to lead the fight against global warming." But Britain was warmer 900 years ago than it is now.

To summarize, the globe is warming. But unlike what the alarmists would tell you, the warming has been going on for 180 centuries, not just the 180 years of the industrial revolution. The changes have been fast and slow, some quite fast indeed, but certainly not caused by us. And if the doomsters are right that 2°-3° temperature change causes irreversible damage, we have had constant catastrophe for half a million years. We cannot go back to some idealized yesteryear. Anyway, what year would you pick? .

People are so numerous that we are a geologic agent, no doubt about it. Think of irrigation, putting lots of water vapour, a greenhouse gas, into the atmosphere. But try to keep things in perspective. We do not make the sun rise and fall, and we do not make ice ages come and go. So instead of trying to stop the world, I recommend that we try to adjust to the ongoing, continuing changes: .

Because some of you might not agree with my view---no harm in that---I offer a page of references so you can look up the data for yourselves.

A few references to climate changes in recent geologic history, with some comments

Andersen, B.G., and Borns, H.W., Jr., 1994, The ice age world: Oslo, Scandinavian University Press, 208 p. Various independent kinds of data show several big changes in Earth's climate during the last few tens of thousands of years and continuing.

Bond, Gerard, et al, 1997, A pervasive millenial-scale cycle in North Atlantic Holocene and glacial climates: Science, v. 278, p. 1257-1266. Abrupt temperature shifts of a few degrees centigrade have been occurring for 30,000 years with a periodicity thought to be 1500 ± 500 years and continuing into the present; we seem to be in a warming trend

with a periodicity thought to be 1500 ± 500 years and continuing into the present; we seem to be in a warming trend of these natural oscillations.

Houghton, John, 1997, Global warming: the complete briefing: Cambridge University Press, 251 p. Selects data to conclude that we are warming the world above what he calls "normal" though his Figures 4.4 and 4.7 show large changes in Earth's climate during the last 150,000 years with concurrent changes. in C02 and methane of 50%

Howard, W.R., 1997, A warm future in the past: Nature, v. 388, p. 418-419. The interglacial interval around 400,000 years ago was warmer than our recent interglacial climate so far; our orbital characteristics now are similar to those also.

Huntley, B., and Birks, H.J.B., 1983, An atlas of past and present pollen maps for Europe: 0-13,000 years ago: Cambridge University Press, 667 p. & maps. Successive tree species migrated north across Europe at about 100m/year.

Lamb,H.H., 1972 and 1977, Climate: past, present and future: London, Methuen, volume I 613 pages, volume II 835 pages. A heavy-hitting assemblage of data available a quarter of a century ago about changes in climate over millenia.

Lamb,H.H., 1982, Climate, history and the modern world: London, Methuen, 387 pages. A charming collection of anecdotes, historical records, and science to show changes in climate, weather, and pollution over time.

Lambert, J.M., et al, 1973, The Norfolk Broads: Roy. Geographical Soc., Research Series, No. 3, 153 pages. The Broads are now bodies of water, marsh, and some meadows along the Bure, Waveney and Yare Rivers. The valleys were beneath low tide in Roman times but above high tide by the Domesday Books (1086 AD). In 1100s and 1200s peat was quarried from them, but the quarries. filled with water in winter storms during the 1300s. By 1500s some of these artificial lakes were fish farms. Submersion continues, presently at about 1.6 mm/year. Note that these are historical records of change.

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Payette, Serge, et al, 1989, Reconstruction of tree-line vegetation response to long-term climate change: Nature, v. 341, p. 429-431.

Rognon, P., 1987, Late Quaternary climate reconstruction of the Maghreb Paleogeography, Paleoclimatology & Paleoecology, v. 58, p. 11-34.

Stahle, D.W., et al, 1988, North Carolina climate changes reconstructed from tree rings: A.D. 372 to 1985: Science, v. 240, p. 1517-1519.