Panel 6: Brunhes Normal and Ice Age (780 ka to now)

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Earth's geomagnetic polarity has been "normal," i.e., pointing close to the north rotation pole, for the last 780,000 years (since 780 ka); this is the Brunhes normal polarity chron **(A)** which, rather unusually, has not been interrupted by any short reversed intervals.

The Geological Time Scale 2012 **(B)** expands the very youngest part of Earth history, so that the Tarantian, corresponding to the most recent glacial advance, and the Holocene, the post-glacial times in which agriculture and civilization have developed, are now visible. The name "Quaternary" has an ancient pedigree in geological nomenclature, dating back to the beginning of the recognition that rocks record Earth history. Giovanni Arduino (1714-1795) divided the rocks in Italy into a sequence — Primary, Secondary, Tertiary, and Quaternary. The first two names went out of use long ago, but Tertiary remained in use until it was replaced by Paleogene and Neogene, and it is still used informally. Only Quaternary remains a formal Period, and in GTS 2012 the Quaternary has been expanded, to begin at 2.6 Ma, rather than at 1.8 Ma, as in GTS 2004 (Panel 5).

The Brunhes normal polarity chron includes most of the time of the major Quaternary glaciations, each lasting about 100 kyr, for which the oxygen-isotope temperature curve based on benthic forams[1] **(C)** shows a saw-tooth pattern, with slowly expanding northern-hemisphere ice sheets followed by rapid deglaciation. This saw-tooth pattern makes sense, for ice sheets can expand only as fast as evaporation and winds can bring in new snow, with the ice meanwhile flowing to lower elevations and melting; by contrast, there are no restrictions on how fast a glacier can melt when the temperature rises. The peaks and valleys in the temperature curve are numbered with the Marine Isotope Stages (MIS: odd for warm, even for cold); these mark the ca. 100-kyr cycle, except for stages 3 and 4, which were numbered early on.

The geological events of this time interval are dominated by the abrupt endings of glacial advances, which are identified as Terminations and numbered with Roman numerals **(D)**. Picking the exact age of a termination is subjective, because it took some time for each ice sheet to disappear; one well-known set of age picks is shown here,[2] but other picks have been suggested.[3] One non-glacial event that may be of great importance is the super-eruption of the Toba Volcano in Sumatra — an event so enormous that it has been suggested to have caused a major bottleneck in the history of humanity.[4] Dating of the Toba eruption has not been easy, but seems to be converging on a date of 73.9 ka.[5] Also shown is the date of the Barringer impact crater in Arizona, not a geologically significant event, but a beautifully preserved and easily visited young crater, and a reminder that impact events continue to the present.

In the time interval of this panel, the only hominid species are *Homo sapiens* and earlier members of genus *Homo* **(E)**. The lines of ancestry among these species are controversial, and the pattern shown here is the simpler of two alternatives portrayed in a figure by Rightmire (2007);[6] the more complicated version shows the additional species *H. antecessor* and *H. rhodesiensis*. This diagram shows how the closely-related Neanderthals were contemporaneous with *Homo sapiens*, but does not show the critical information on where each species was living at a given time; that information is given in the next time line of this panel.

The story of human migrations out of Africa **(F)**, as currently understood, is quite remarkable. The first humans left Africa for Eurasia as early as about 1.8 Ma, based on the findings of fossils of probable *H. erectus* at Dmanisi in the Georgian Caucasus, dating from 1.77 Ma.[7] Thus *H. erectus* must have lived in Eurasia through the entire sequence of 100-kyr glacial cycles corresponding to the Brunhes normal polarity chron. There is as yet no evidence for other Out-of-Africa migrations until the departure of *H. sapiens* about 60 ka, during the most recent glacial age.

There are two possible routes for humans to have escaped the African homeland — neither of them easy.[8] One route is across the narrows at the southeast end of the Red Sea, which the Arabs call Bab-al-Mandab (the Gate of Grief), made narrower still by sea-level draw-down during the last Glacial. The other route is across the Sahara. This would not be practical at the present time, but during times of more rain (pluvials) the Sahara was well watered and would have attracted nomads from the areas to the south. When the Sahara dried out between pluvials, the Saharan nomads would have been driven out both southward and northward, with the latter people then able to cross the Sinai into Eurasia. This is the Saharan Pump hypothesis.[9]

Of the characteristics that distinguish humans from other animals **(G)**, language and tool use are to some extent ambiguous, for whales may have some form of language, and chimpanzees and some birds make use of simple, found tools. Fire may be the most unambiguous, for all humans make intentional use of fire, and no other species does. Language, before writing, leaves little or no trace, and its history before a few thousand years ago remains completely obscure. The earliest human tools, perhaps made of wood, would rarely survive in archaeological excavations, but stone tools, immune to destruction, have long been the basis for assigning early human sites to a sequence of intervals — early, middle, and late Paleolithic, and then the Mesolithic, and Neolithic, and then the Bronze and Iron Ages.

The history of fire use has been less discussed, but is very interesting if rather difficult to assess, because charcoal found in excavations may or may not have been formed by intentional fire use. It has long been assumed that *Homo erectus*, living in glacial-age Eurasia, would have had to use fire in controlled ways in order to survive. However, a recent review has carefully evaluated the evidence, as shown in here in the red histogram, and found no indications that fire was used habitually by human in Europe prior to MIS 11, a little before 400 ka.[10] This surprising result suggests that *H. erectus* humans were able to live in glacial Europe without controlled fire use!