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On the possibility of cyclic recurrence of ice ages during the Neogene

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Theoretical preliminaries

The ice age, according to an earlier interpretation also known as the legendary biblical diluvium – featuring ice sheets and troughs of glaciers expanding far to the south – was an era when woolly rhinoceros and mammoth, cave bear and wolf existed and the primitive man appeared (*Figure 1*).

Cooling of the climate as a component of the fundamental global environmental change, is caused by the rhythmic alternation of glaciations and ice-free periods. Time intervals of the accumulation of permanent (inland) ice sheet are called global ice ages. There might be different reasons behind the emergence of ice ages. A multitude of concepts can be classified into two major groups (BERGER, A.L. 1989, FAIRBRIDGE, R.W. 1972).

The first group includes extraterrestrial theories, which attribute glaciations to astronomical phenomena. Some scholars ascribe global climate change to the decreasing energy of solar irradiation while others hold that these fluctuations are caused by the irregular distribution of cosmic dust.

The recurrence of ice ages of long duration (in the Proterozoic, Carboniferous, Permian and on the Neogene–Quaternary boundary) is often explained with the cosmic year (repeated about every 190–200 million terrestrial years). Cosmic year is the period of the Sun's orbit around the centre of the Galaxy, when the former passes the section situated remotest from the latter and characterised with minimum star density. It is the time when cosmic winters occur. According to SHCHUKIN, I.S. (1969) if the world ocean is claimed to be 3 billion years old, 15–20 cosmic years culminating in glaciations must have occurred since its emergence.

Terrestrial explanations form another group of concepts on the occurrence of ice ages. Continental drift and polar wandering advocated by WEGENER, A. (1915) belong to this category. In the first place WEGENER, A. tried to give an explanation to Paleozoic glaciation. He claimed that the continents had converged around the present day southern coast of Africa and an Antarctic ice cap formed. Further hypotheses are linked to the Gulf Stream. The stream is thought to have deflected westward, to the North American coasts and its warming effect diminished to a large extent. According to others (ENQUIST, F. 1916, EMILIANI, C. 1967) sea level oscillations have been responsible for glaciations in global scale.

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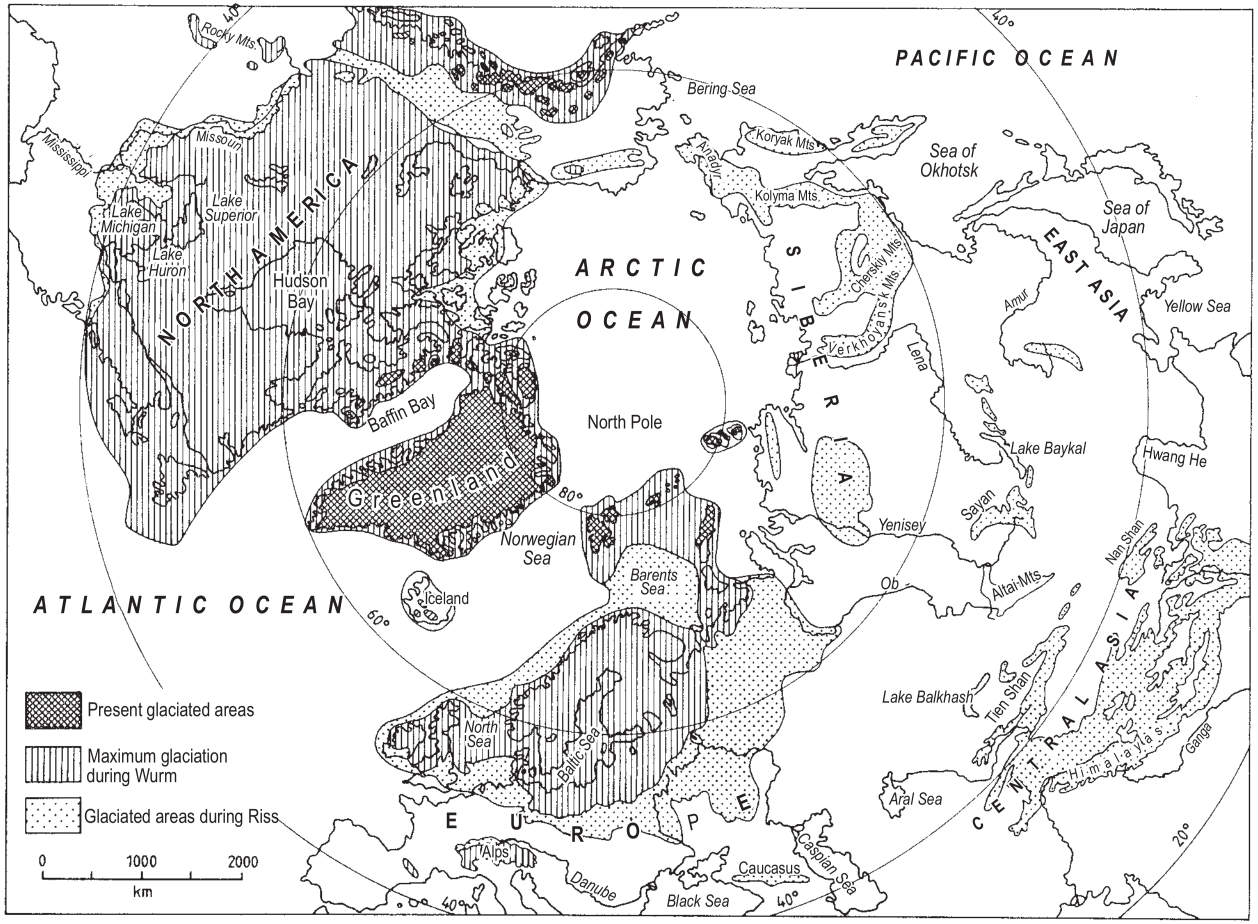


Fig. 1. Glaciated regions in the Northern Hemisphere at present and during the Pleistocene

Main triggers of ice ages

In my opinion one of the main causes of the occurrence of ice ages (similar to the concepts of Wegener, A. and Du Toit, L.–Alex, L. 1970) should be sought in plate tectonic events. Once a continent of considerable extension moves to the area either of the South Pole or of the North Pole, the negative radiation balance (albedo) boosts cooling and it triggers accumulation of snow or ice.

Antarctic has recently played a similar role like the central part of Gondwanaland (an ancient continent) did during the Permian glaciation (*Figure 2*). At that time the spatial pattern of glaciation could be similar to the present conditions around the North Pole. As a result of plate tectonic events the Antarctic drifted towards the South Pole by the late Oligocene. A significant accumulation of ice could occur 30–32 million years ago probably followed by similar events during the Miocene (between 25 and 5.3 Ma B.P.). The ice accumulation at 7.5 Ma B.P. formed a single-pole Antarctic ice sheet, which could be twice as extensive as the subsequent inland ice in the Pleistocene epoch. Plate tectonic movements and a considerable fall of the level of the World ocean had contributed to the closing up of the Strait of Gibraltar and finally resulted in the Messinian Salinity Crisis, leading to the formation of anhidrite and thick salt beds (Hsu, K.J.–Ryan, W.B.F.–Cito, M.B. 1973). This was the time when the Pannonian Lake filled up and eventually desiccated. In the Carpathian Basin and environs desert crusts had formed and giraffes lived.

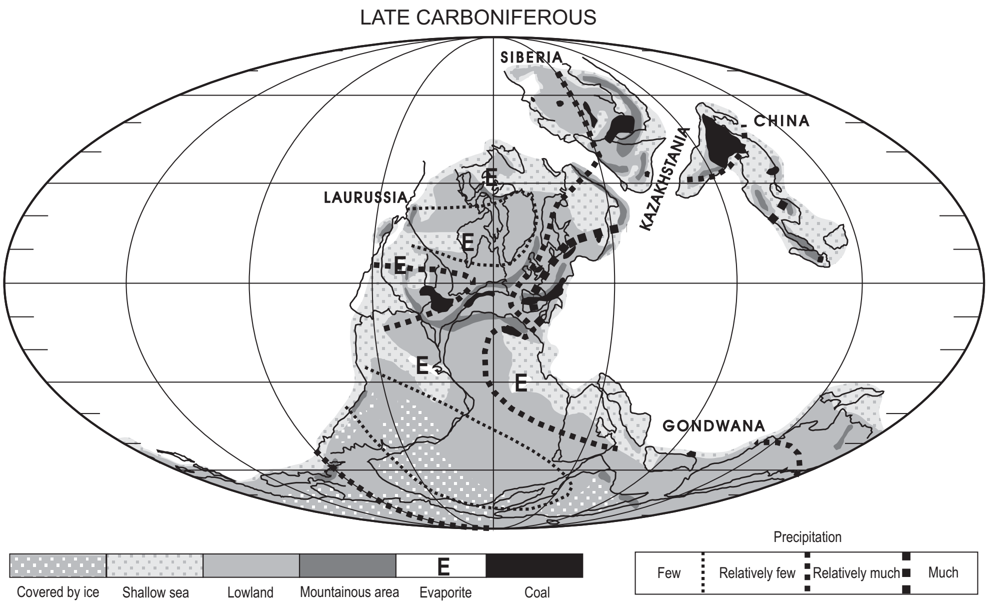
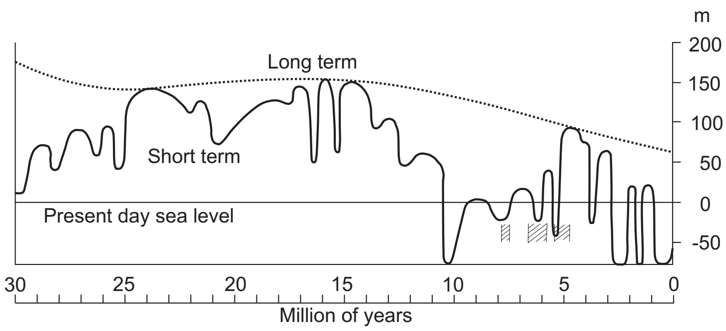


Fig. 2. Configuration of continents in the late Carboniferous with shallow marine and flatland terrestrial areas, mountain ranges, evaporite and coal occurrences and with the distribution of atmospheric precipitation

According to the evidence provided by K/Ar datings ca 4.4–3.5 Ma B.P. the ice cap in the western part of the Antarctic had melted and the water temperature along the coast was 8–10°C higher than the present day value. At the same time the level of the World ocean had stabilised ca 60 m higher in comparison with the present day one. As a result of this transgression the Strait of Bering had opened up (Zubakov, V.A.–Borzenkova, I.I. 1990). This was the time of red clay formation in the Carpathian Basin and in the East European Plain.

Remarkably, the glaciation of the Antarctic starting 30–32 Ma B.P. as the advent of the Neogene global ice age proceeding up to now was followed by rhythmic geological events (17–18, 13–14, 7.5–6 and 1.4–0,1 Ma B.P.), which were confined to lowering water levels of the world ocean (Haq, B.U.–Hardenbol, J.–Vail, P.R. 1987). The author thinks that the interpretation of this process together with glaciations might be an adequate concept – provided the drop of the level of the World ocean is proven to be the consequence of the formation of huge masses of ice (Schweitzer, F. 2003) (*Figure3*).

The last global cooling in the Northern Hemisphere could be associated with the appearance of inland ice in the environs of the North Pole, later (i.e. ca 1.7–1.2 Ma B.P.) followed by cooling within the temperate zone and growing continentality. As a result, a rhythmic alternation of cooling (glacials) and warming (interglacials) ensued. Probably the evaporite cycles in the northern Appennines (10 such cycles are known) taking place during the Messinian Salinity Crisis should be considered climatic events of similar rank like those at the end of Lower Biharian and in the Upper Biharian. This latter interval appears to be part of the Pleistocene (Kretzoi, M. 1953).



Late	Early	Middle	Late	E	L	
Oligocene	Miocene			Plioc.		Ple.

Fig. 3. Eustatic sea-level oscillations during the past 30 million years of geohistory and their relative extent (after Haq, B.U.–Hardenbol, J.–Vail, P.R. 1987). Comparing global sea minima (5.2; 6.3; 7.8; 10.4 Ma B.P.) with hiatuses identified on the northern shelf of the Pannonian Basin (5.4–4.6; 6.8–5.7; 7.9–7.6 Ma B.P.) and with the age of the hiatus represented by the regional discordance surface separating the synrift and postrift sediments with changing duration from place to place (10.5 m yr B.P.) there is a remarkably close correlation

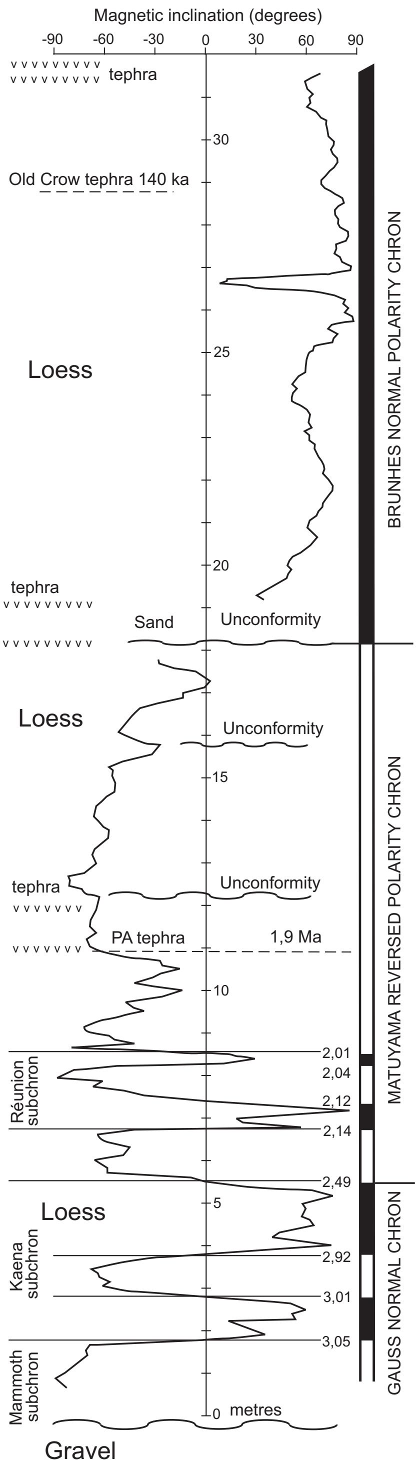


Fig. 4. Magnetostratigraphy of Gold Hill Loess at locality 6. Oriented samples collected at 10 cm intervals, two per level; inclination curve smoothed by using three-point running average. AF demagnetization at 200 Oe (peak) for normal samples and 300 Oe for reversed samples. Old Crow tephra was not recognized at this site, but was identified at this stratigraphic level during gold mining operations when bluff was farther south. Identification of tephra was established by petrographic and geochemical criteria (Westgate et al., 1985)

During the Pliocene the warm and humid climate of Csarnótánum (4.2–3 Ma B.P.) indicated with red clay formation and macromammal fauna rich in tapires and pandas changed abruptly under the impact of cooling. First it had changed into the dry and warm climate of Villányium (3–1.8 Ma B.P.) with the Kislángium fauna represented by camel and ostrich. The climate turned dry and cold during the Lower Biharium (with mammoth, woolly rhinoceros, cave bear, beaver etc.). These stages are distinctly separated from the Pliocene and also from the Villányium as a whole (Kretzoi, M. 1953).

Prior to the 1960s the Pliocene–Pleistocene boundary – often referred as the Neogene–Anthropogene boundary, also used by many specialists in Hungary as the boundary between Upper Pannonian and Quaternary – was drawn at 0.6 Ma B.P. which coincides with the advent of Gunz glacial. Since then several earlier stadials of Gunz were identified and some traces of previous glacials – Donau (Eburon), Biber (Pretegelen) – were found, the duration of the Pleistocene were extended back, though unambiguous evidence of (e.g. Eburon) glaciation could not be presented. So many researchers claim glaciations reaching back to 2.5 Ma B.P., moreover in some areas even earlier (e.g. in Alaska the boundary is drawn at 3 Ma B.P.) (*Figure 4*).

The extension of the Pleistocene was corroborated with the fact that the appearance of Early Man generally was put to the advent of the Quaternary (The Olduvai site is 1.7–1.8 Ma old).

The Pliocene–Pleistocene boundary was fixed by the International Stratigraphical Commission in the Vrica profile in Calabria at 1.8 Ma, confined to the Olduvai paleomagnetic event.

Pleistocene glaciations

The first indication of global cooling (still excluding glaciation) was the appearance of animal species in the Mediterranean hitherto typical of the North Sea. Based on this evidence the water of the Mediterranean Sea began to cool down ca 2.3–2.2 Ma B.P. and an exchange of water masses started between the Atlantic and Mediterranean basins.

At that time subtropical climate still prevailed in the Mediterranean but the appearance of *Globarotolia inflanta* and (under the impact of the cold Norwegian current) *Hyalinea baltica* indicated the forthcoming change. This occurred 1.8–1.4 Ma B.P. (Funder, S. et al. 1985) correlated with Lower Biharium in the Carpathian Basin.

Neither the above mentioned species nor lemmings and *Canis arvensis* identified by Kordos, L. (1987) from the Esztramos site in Hungary and nowadays encountered in Boreal environment can be sufficient to draw the Plio-Pleistocene boundary or to claim them indicators of the advent of the ice age. Easterbrook, D.J.–Boellstraft, J. (1981) and Funder, S. et al. (1985) maintain that at that time in the Northern Hemisphere the Gulf Stream penetrated deeply into the Arctic Ocean. The basin of the latter was ice-free as recorded by the profiles on Greenland and those at the Cape of Copenhagen. *Portlandica arctica* along the Chukchi Peninsula and Seward Coast provides similar evidence (Funder, S. 1985).

Let either 2.4 Ma or 1.7 Ma be accepted as the Pliocene–Pleistocene boundary, the level of the World ocean did not sink under the effect of polar and marine ice formation during the early glacial epochs. Following the Csarnótánum (4.5–3.0 Ma B.P.) featuring red clay formation, treeless steppe vegetation prevailed over the continental Europe – including the Carpathian Basin and its surrounding. The Kislángium fauna with ostrich fossils, gravels at Ercs (Hungary) with elephant finds, travertine sequences along the margin of Gerecse Mountains, as well as the formation of what was called warm loess by Obruchev (at Dunaalmás, Szekszárd, Dunaföldvár, Titel and Slankamen) can be correlated with this period. Also Lishi loess of China and the lowermost horizons of Tiraspol and Nikolaev loesses in Moldavia belong here. System of fissures confined to the fault lines dissecting the Hungarian middle mountains and filled with reddish clay or terra rossa in Villány Mountains, at Süttő and Beremend and similar sequences beyond the Carpathian Basin (Dalmatian coastline, Island of Susak) formed at that time.

Within the Pleistocene the first impact of glaciation, the advent of the Ice Age can be put to 1.2–1.0 Ma B.P. (the boundary of Lower and Upper Biharium by Kretzoi, M.) and continued with cyclic alternation of glacial and interglacial environs until recently.

At the boundary of Lower and Upper Biharium extensive glaciers appeared in the mountains of Scandinavia eventually forming a huge ice cap. This mass had merged with the ice sheet of Greenland and this contiguous and 2–3 km thick inland ice covered the northern territories of Europe and North America. The so called lower Gori layers containing crystalline boulders and characterised with Odessa-Taman fauna are confined to the boundary between the Lower and Upper Biharium. Some experts try to assign these horizons to the Olduvai event but there are even more researchers to date them 1.1–1.0 Ma B.P. Paleontological finds in the Carpathian Basin confirm the latter concept. Whoolly rhinoceros, reindeer, moose elk, musk-ox, bison and mammoth dominated the fauna during the Upper Biharium. That was the time when pale yellow so-called cold loesses with interbedding chernozem-like paleosols and fluvial terraces I to V formed. Periglacial processes of relief sculpturing, responsible for the present-day topography of the Carpathian Basin were dominated by cryoplanation and solifluction.

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