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THE PHYSICAL ENVIRONMENT DURING THE LATER QUATERNARY IN MID-WESTERN EUROPE

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After the findings of Schmerling and Boucher de Perthes some fifty years of consternation followed on the mysterious environment in which Early Man lived in Mid-Western Europe. The proof of a succession of glaciations in the Alps by Penck and Brückner brought the happy solution of periglacial climates with permafrost alternating with warm interglacials. And Milankovitch found an explanation of these cycles and at the same time a securing chronological framework.

After mid-century patient description and analysis of profiles in different environments made it clear that is was not that simple. The application of advanced sedimentology, pedology and most important palynology revealed important trends and oscillations in the warm and cold phases. Correlations became more and more hazardous. Then sediment cores in the ocean floors showed that these oscillations were systematic and world wide. Detail and understanding grew with the stupendous analysis of thick ice masses, tending to establish a universal oscillation curve. Most important is that the cores of sediment and ice deliver a continuous record. On the contrary our profiles on land register sedimentation on some moments, depending on the environment, and are stable on others and eventually weather and are submitted to erosion on others. Hiatuses represent in general much more time than the sediments. Nevertheless the stratigrapher will try at the end to make a correlation of his layers with the continuously refined general curve and present an elaborated chronological statement. It is understandable that for prehistorians this time conclusion is most important, but for other scientists, and for many prehistorians also, the understanding of the local environment at that moment has even more appeal. We review some environments.

A preliminary remark concerns the general insolation. The Milankovich parameters change de mean temperature not drastically. And the use of qualifications as arctic and polar for our pleistocene environment are very misleading. Never existed in mid-western Europe conditions were snow melted only during two month a year like Spitsbergen now. Nor had prehistoric man to cope with 6 month of winter darkness like Inuits now.

Variations of geographical parameters are responsible for considerably enhancing the primary change. Displacement of the winding Gulf Stream to the south is of prime importance. Continentality increased due to the retreat of the ocean on the shelf, more especially the diminished cold North Sea with icebergs. Further modulation through changing pressure systems: oceanic air to feed the ice masses and katabathic extremely cold and dry air flowing from them. It is evident that even more than now the Loire must have been a striking limit with the deep tempering ocean then also close by.

Permafrost has been the trade-mark of the periglacial climate. However it has been exceptional. Imagine the yearly thawing producing a soaked mud over the permafrost which would flow above 2-3° of slope. Flanders with its soft Cenozoïc strata would have been really flat. Certainly it happened, but for short periods. We know it best from the last Weichselian glacial.

The last forest soil of the Rocourt-complex ends with a taiga which is abruptly killed off. Lumps of the well preserved humus horizon are floated down-slope and only preserved in depressions. Above 1-2° of slope we never found it. The completely leached E-horizon of the taiga soil is washed in pipes of melting soil-ice lenses. Deep ice-cracks mm-thin are filled with humic inluvium from the soil top. It is a very cold spell with permafrost because deep seasonal frost can not saturate the topsoil due to the yearly drainage of it. It was very short because no important ice features or cryoturbations developed. We estimate the duration of this permafrost tundra at a millennium.

The last layer of the next Hesbaye Member is a thin humic horizon with a few shells, 14C-dated at 28.000 BP. It is immediately followed by hugh cryoturbations and massive ice wedges of tundra polygons. The whole landscape is activated, also by the thermokarst at its close; on slopes erosion by solifluction is such that never any Hesbaye sediments were observed and that all traces of the earlier interglacial soil are eroded. The permafrost is followed by a strong deflation time and by a characteristic humic soil, twice 14C dated at

21.400 BP. This allows to estimate that this most imported permafrost tundra lasted around 4 millennia. It corresponds to the beginning of MIS2. The grèzes littés of the Côte de Meuse register this permafrost, but the Upper Rhine Graben seems devoid of it, as are the lowlands south of the Loire. The natural wine limit? To stress the importance of these 4.000 years we must realise that this was enough for the Wurm Glaciers to flow out of the Alps and the Weichsel Ice to reach over the Baltic.

The humic soil is followed by the massive arrival of the Brabant loess and at its base are found straight cracks >6m deep, only 3-4cm wide above, filed with this loess. They were dry frost cracks filled with the powdery dust. Summer thawing produced only slow creep responsible for the typical plications, tongues, of the soil horizon. This permafrost which may have lasted only a few centuries was certainly less cold than the preceding. Indeed frost penetration in winter was helped by the absence of snow cover due to the extreme continental conditions. And in summer insolation was reduced considerably by the dust storms brought in by the katabathic winds.

Did the Younger Dryas refrigeration reach permafrost conditions, as some advocate? We never observed morphological activity needing permafrost and are not convinced that the "pingo's" of the Ardennes summits need it. But certainly conditions came close in this last cold pulse.

The three permafrost phases of the last glaciation total about six years and take approximately 1/10 of the time. Furthermore the three are very different and without modern equivalent. The first may come close to climatic conditions of Tirol at 2500m, the second of the wetter French Alps at 2600m, for the third the Gobi is too lovely.

The next most classic periglacial environment is the aeolian: deflation and accumulation. Deflation areas need to be vegetation free. Apart from focal sources, as dry falling river-beds, this needs harsh conditions. Late and short snow free areas will tend to stay too wet; in dry continental spells with maximal katabathic winds will deflation be dominant. Pebble floors are abundant in the cover-sand area, but penetrate only in the northern loess area at the base of the Kesselt suite. Further south local deflation is shown by strings of lyophylised chalk granules. Its total importance is shown by the huge amounts of sand and silt blown to the south.

Accumulation of sand has two distinct facies. The pure aeolian sand has a homogenous appearance because the transporting winds tend towards the same velocity. Grain thick coarser laminae show local deflation. The mineralogy of this Wildert cover-sand shows its allochtonous, so distant provenance. It is coeval with the Brabant loess. The other facies is more stratified, with silt laminae, structures like adhesion ripples and activity of sheet-wash. The designation niveo-eolian stresses the influence of melting snow cover. These St.-Lenaarts Sands fill depressions and are interspersed with humic and peaty horizons. These episodes occur between the first two permafrost tundras. Rivers, even small ones, play an important role as the saltation jumps are too short to pass them. The sand is incorporated in the river charge and either evacuated or blown out of the braid-plains down-stream in typical wind walls. This results in a very compartimented landscape in which rivers form the limit of aeolian sediment types.

In the dry second half of the Younger Dryas aeolian activity was again dominant. Local deflation by south-western winds blew up parabolic dunes which indicates that enough vegetation, including birch, subsisted to counteract a very different aeolian activity.

Loess sedimentation presents the same differentiation. The lower Hesbaye loess is dominantly layered and greyish brown. It often fills erosion gullies and is then rich in washed-in shells and can have a very high content of worm-pearls. Micro-erosion is rare so loess-wash is suggested by snow melt waters on still frozen surface. In general this loess is patchy, fills depressions and contains strings of material washed or crept in from the hill tops: sand, fossils, pebbles.

The Brabant loess is very different: yellowish and powdery suggesting lyophilised complete dehydration of the grain films; strong carbonate content, never dissolved with perfect micro-foraminifera; rare phantoms of stratification in a mantle draping the relief, only absent on exposed hill tops. In the type area is devoid of shells or pearls and seems azoic, the classic interpretation of a loess-steppe being too friendly.

A third loess environment is the Lafelt loess probably blown out of the Warthe outwash plains at the end of MIS6. It occurs as an 8m thick body preserved on the Kesselt plateau. The loess has the composition of the Brabant loess but is now completely layered in mm-thin laminae deformed in continuous tufur structures. This suggests a snow-cover whose melt water could trickle off without any sign of erosion. Some kind of low vegetation like mosses seems necessary. In it occur at least four whitish horizons 10-15cm thick underlain by an ochrous band with a reticular pattern. In the top centimetres occur loess shells, while the leached horizon has many thin worm canals and their pearls. This abundant live needs a vegetation, with lots of lichen as the leaching without complete decalcification is interpreted as due to lichenic acids. No permafrost existed and the ice-wedges are from superposed tundra polygons about 100 Ka later. We interpreted these short rhythms as due to some non-astronomic forcing. They may be safely seen as Dansgaard-Oeschger events.

Snow has been already mentioned many times but it is worth special consideration. We recall its direct effects in nivation benches s known in the Ardennes and its fundamental role in the explanation of asymmetric valleys. And in the resulting sediments, grèzes littés, produced by night frosts at the rim of declining snow banks and evacuated down-slope by the melt waters. Snow modulated climate varieties as now in the D-climats. Early snow will hamper frost penetration into the soil; thick snow will insulate for permafrost, refresh spring and shorten the growing season.

One might surmise that in humid cycles half the precipitation falls as snow; it would be measured in meters. It melts in a short time, hastened and increased by rain. This leads to high run-off, which in the low order watersheds has even a diurnal rhythm. The work of the ensuing sheetfloods will depend on the cohaesion of the soil and the density of the vegetation. Cryopediments developed rapidly on loose sands or frost-sensible rocks. And rivers reached their maximal transport capacity. When measured by the work achieved snow must be considered as the most important factor in the periglacial environment.

Stability phases leading to surface weathering and soil formation have been shown to represent very short episodes. This does not mean that beyond these vegetation was lacking. In Hesbaye times valley filling contain so often organic layers that they have been called Peaty Loams. The same is true for sandy rivers in which numerous debris horizons occur. All these layers contain masses of thin twigs from Ericaceae and prostrate willows, with enrolled leafs. Armeria and numerous mosses are common. These layers are not related to climatic optima but represent sedimentological hasards of channels and swamps in which these light debris could be floated. They show that vegetation was always present, but low and adapted to the snow cover.

In strong contrast is the short Bölling/Alleröd oscillation which reached forest stage and the best formed soil. In fact it is the real beginning of the Post-glacial and prehistoric man has experienced it that way.

The long lasting interglacial reached forest climax and consequent soil development. The greatest surprise were the findings of Woillard that the last interglacial consisted in fact of the succession of three nearly identical vegetation developments. This allowed to understand a lot of problems in the corresponding Rocourt Soil. Prehistorians should be well aware that for obscure reasons the Eemian is mostly limited to the oldest of these phases and base their understanding on the divisions of MIS5. The begin of periglacial conditions coincides with the important marker produced by the enstatite volcanic eruption, begin of MIS5/a.