Changing Environments During the Younger Dryas Climatic Deterioration: Correlation of Aeolian and Lacustrine Deposits in Southern Czech Republic

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ABSTRACT. In this contribution, radiocarbon dating is adopted as the tool for inter-correlation between two different sedimentary records - the lacustrine and aeolian deposits. The Younger Dryas climatic deterioration is reflected in the lacustrine pollen record as the decline of pine-birch forest and the expansion of open herb communities. Opening of the landscape resulted in increased aeolian activity and the formation of prominent sand dunes. Also the input of wind-blown material to the lake basin has been identified.

KEY WORDS: Late-glacial, biostratigraphy, vegetation history, palaeoclimatology, aeolian activity.

Introduction

The lacustrine sediment profile under study in the Czech Republic is a unique example with extensive and well-stratified Late-glacial record. High sediment-accumulation rates permitted the detection of brief Late-glacial climatic oscillations, so that comparison can be made with numerous results from western and north-western Europe, where the basic biostratigraphic and climatostratigraphic concepts have been developed (e.g. Mangerud et al., 1974; Watts, 1979).

In this contribution, our attention is focused on one particular period of the Late-glacial, the period of significant climatic deterioration during Alleröd/Younger Dryas transition. As postulated by Ruddiman and McIntyre (1981) and later recognised in terrestrial records within the areas adjacent to the North Atlantic (e.g. Lowe et al., 1994; Walker, 1995), the Younger Dryas climatic reversal can be ascribed to large-scale shifts in the position of the oceanic Polar Front, which had amphi-Atlantic or even global effects (e.g. Peteet, 1995). This event had profound effect mainly on periglacial areas, which are generally most sensitive to all climatic shifts. Glacier-front readvance, reactivation of permafrost in some areas, and acceleration of aeolian activity were the most prominent consequences on the abiotic level. On the biotic one, forest retreat connected with steppe/tundra reinvasion was probably the most important feature.

Methods and material studied

The study site is situated in South Bohemia in the flat landscape of the Třeboň Basin. Limnic sediments of the former lake Švarcenberk (its maximum extent was 1400 x 400 m and maximum depth about 10 m) are overlain by peat, which formed after its terrestrialisation. The lake has drained into nearby Lužnice River. Along the river floodplain, numerous aeolian deposits are situated. One of the biggest and most prominent sand dunes is situated near village Vlkov, 1200 m from the former lake basin. Its relative height over surrounding terrain (6 meters), its size (60 x 80 m), and the unvegetated character makes it a prominent structure.

The extension and stratigraphy of the former lake basin was studied by coring in a 100m x 100m grid. The core in the centre of the lake basin was selected as a standard profile. Sediment description follows the system of Troels-Smith (1955). The stratigraphy of "Vlkovský přesyp" sand dune was studied in an open ditch. The samples used for pollen analysis were prepared by a modified acetolysis method. (Faegri and Iversen, 1989). For the construction of the pollen diagram, pollen percentage values were calculated on the basis of the AP+NAP pollen sum, excluding only aquatics. The pollen diagram was zoned using three different constrained classification procedures implemented in the computer program ZONE (Lotter and Juggins, 1991). Radiocarbon analyses were carried out by the Radiocarbon Dating Laboratory, Department of Quaternary Geology, Lund, Sweden. AMS method was applied to all samples after treating with HCl and NaOH. Age calculation is based on a ^{14}C half-life of 5568 years. All dates are expressed in uncalibrated ^{14}C years BP. Grain size analyses of aeolian sands samples were performed by sieving under wet conditions. Organic matter from lacustrine sediments had to be removed in 30% H_2O_2 before ultrasound grain separation.

Results and analyses

Alleröd/Younger Dryas transition as recorded in Švarcenberk lake deposits

The Late-glacial Interstadial (Bölling/Alleröd period) starts with the rise in *Salix* pollen percentages. Willow shrubs probably formed the belt in front of expanding *Betula* forest-line (Gaillard, 1985; Hoek, 1997), so high values of *Salix* may be expected in advance of birch forest formation. Indeed, tree birch became dominant in the pollen spectra in favour of non-arboreal pollen, *Salix*, and *Pinus* shortly after. An open character of birch forest can be inferred from the pollen diagram, for most of the heliophyllous herbs typical for steppe and tundra communities (e.g. *Betula nana, Atremisia, Thalictrum*, grasses) are still abundant. In the aquatic environment, abrupt climatic amelioration caused the expansion of submerged macrophytes, especially *Ceratophyllum demersum*. During the second half of the Interstadial period, *Betula* pollen percentage decreases from 40% to about 20% and *Pinus* increases up to values around 60%. The resulting forest cover became more closed, as reflected by a decline in all open-communities indicators. *Filipendula, Typha latifolia, Nymphaea*, and *Nuphar* appeared in and around the lake, pointing to minimum July temperatures at least 12 °C (Huizer and Izarin, 1997). The subdivision of the Late-glacial

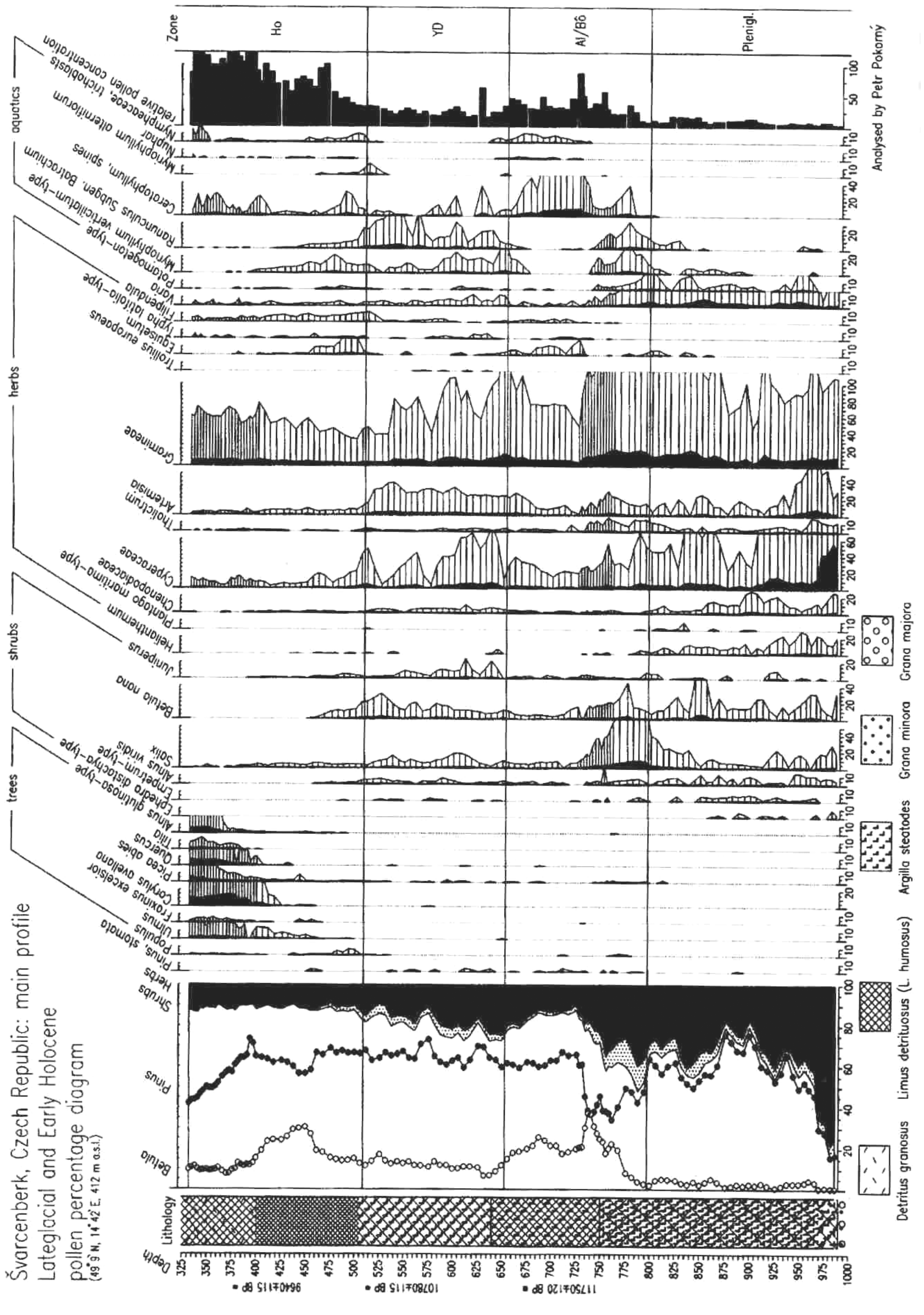

Fig. 1. Pollen percentage diagram comprising the period under discussion. Only selected taxa are included.

Interstadial period into *Betula* and *Pinus* phases is probably for climatic reasons. The first, presumably more "oceanic" phase can be correlated with Bölling period, while the more "continental" second phase can be ascribed to Alleröd. ^{14}C date in the younger part of the second phase (11,750 ± 120 BP) confirms this correlation. The start of the Younger Dryas period is characterised by decreasing values of *Betula*, whereas *Pinus* percentages are generally the same if compared with the preceding Interstadial zone. This suggest that climatic cooling did not result in complete deforestation. The pine woodland only became somewhat more open, as obvious from increasing percentages of *Alnus viridis, Salix, Betula nana,* Chenopodiaceae, and *Artemisia*. Similar increase, but even more prominent, is recorded in *Juniperus* curve (juniper is a heliophillous shrub). Vegetation change reflecting climatic deterioration is recorded also in the lake: *Ceratophyllum* spines values decrease, Nympheaceae trichoblasts and *Nuphar* pollen is even completely lacking in favour of massive occurrence of *Myriophyllum verticillatum* and *Ranunculus* Subgen. *Batrachium*. The presence of *Typha latifolia* pollen in the entire zone can be considered the proxy for minimum July temperatures of at least 12 °C (Iversen, 1954; Ammann, 1989), i.e. the same as inferred for the preceding Interstadial period. The upper limit of the Younger Dryas chronozone is dated to 10,780 ± 115 BP. After the onset of the Holocene period, decrease in all upland non-arboreal pollen types is the result of a new forest expansion.

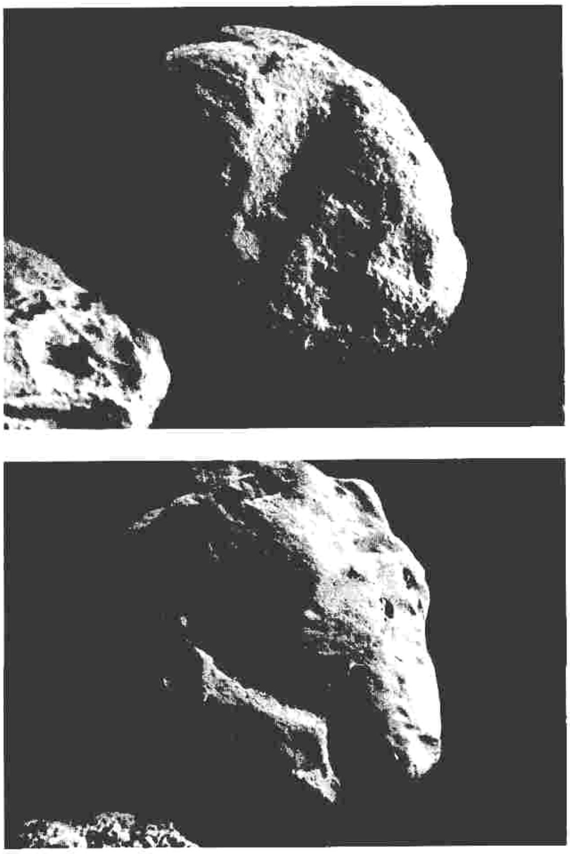

Fig. 2. SEM photographs of quartz grains from sediments of aeolian origin: (above) Vlkov sand dune; magnification 100x, (bottom) Švarcenberk Lake sediments, YD horizon; magnification 120x.

Sand dune near Vlkov, its stratigraphy and correlation with lake deposits

The stratigraphic investigation of the sand dune near Vlkov has revealed a fossil soil developed on the surface of fluvial sands and gravel and buried under aeolian sand formation. A distinctive layer of pine charcoal fragments occurring in the surface of the fossil soil has been radiocarbon-dated 11,260 ± 120 BP. The formation of the sand dune must have occurred after that date, i.e. in the very beginning of the Younger Dryas period. The dune is composed of medium-grained sand (the content of 0.25–1 mm fraction is 70–75%). The grain surface show features typical for aeolian sands (Fig. 2). Coarse sand and fine gravel admixture, as well as the roundness degree indicate very short aeolian transport. The presence of aeolian material has been studied within clastic admixture in lacustrine sediments of the Švarcenberk Lake as well. This fraction was studied in detail from samples with highest content of inorganic matter, composed of clayey fine silt. In the basal layer (depth 9.9 m), containing about 5% of sand, the aeolian quartz grains were present. In samples from the horizons corresponding the YD period (depth 6–7 m, sand content less than 0.5%) grains with surface typical for aeolian sands were found as well (Fig. 2). Additional samples are being evaluated to confirm the increasing aeolian activity at the beginning of YD more precisely.

Discussion and conclusions

The Younger Dryas as a biozone is widely recognised over the most of Europe. At the site under present discussion, clear evidence of climatic deterioration is ascribed to Alleröd/Younger Dryas transition. Proxy evidence suggests that this climatic deterioration was rather increase in continentallity than decrease in summer temperatures (see also Ammann, 1989). Reconstructed minimum July temperatures are at least 12 °C for the YD period: The same values are suggested e.g. for western Poland (Walker, 1995).

The formation of extensive aeolian deposits in the area under study is dated to the beginning of Younger Dryas chronozone. Aeolian material had settled directly on the soil surface. This situation resembles conditions in The Netherlands, where the "Usselo soil layer" formed during the Alleröd period of lower aeolian activity. "Usselo-layer" has been dated from surface charcoal fragments to between 11,400 and 10,300 BP, with average date around 11,000 BP (Hoek, 1997). These results resemble those from sand dune near Vlkov, where a radiocarbon date 11,260 ± 120 BP has been obtained from very similar stratigraphic situation. The formation of soils during the Alleröd period required stable climatic conditions with less aeolian activity and relatively dense vegetation cover. On the other hand, the formation of aeolian sand dunes required more severe climatic conditions and sparse vegetation cover. Evidence for increased aeolian activity during the YD accord well with the results of pollen analysis, which point to a certain opening of the forest cover.

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Late Pleistocene Climate Changes in the Ukraine Territory (Based on Clay Matter Analysis Data)

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ABSTRACT. Development of nature in the territory of Ukraine in the Upper Pleistocene was characterized by the contrasting conditions. It led to alternation of warm and cold stages. Change of environmental conditions is fixed in mineral composition of clay matter in deposits. In different regions of the flat area of Ukraine, mineral composition of the clay matter (< 0.001 mm) of palaeosols and loesses of the Upper Pleistocene stages were investigated by a complex of methods. Mineral mass of loesses and loess loams is poorly weathered, it has 10–20% of silt and the hydromica-montmorillonite composition of the clay matter that prove cold (periglacial) climatic conditions of these deposits formation.

Palaeosols of the Upper Pleistocene are largerly clayed (28–45% of silt), they are characterized by the polymineral composition and chemical forms of weathering of the clay matter. Minerals of the smectite group (an indicator of temperate and warm conditions), mixed layer hydromica-montmorillonite formations are dominant; kaolinite, quartz, calcite and gypsum accompany them. Time and space variations of mineral composition of palaeosols and loesses are connected with the repeated changes of climatic conditions from periglacial to warm and arid in the Ukrainian area in the Upper Pleistocene.

KEY WORDS: climate, loesses, palaeosols, clay matter.

Introduction

The Late Pleistocene nature development was characterized by the change of warm and cold climatic conditions that led to alternation of stages of the intensive soil formation with stages of loesses formation. In the territory of Ukraine, 7 palaeogeographical stages (3 warm and 4 cold) of the nature development in the Late Pleistocene (Veklich et al., 1984, 1993) were recognized. The Upper Pleistocene lower boundary passes through the foot of the cold Tyasmin (ts) stage deposits (170 ka BP).

Palaeosols and loesses of various age differ by a number of signs (type, thickness, colour, morphology, granulometric, chemical, mineral composition, etc.) that proves various environments, climatic first of all, during separate palaeogeographical stages.

Predominant accumulation of this or that mineral depends on initial material and stage of weathering that in its turn is stipulated by a number of physico-chemical factors of the environment. Processes of mineral mass transformation are usually connected with climatic conditions. Intensity and direction of weathering processes depend on temperature regime, quantity of atmospheric precipitation in different seasons.

The formation and changes of mineral composition of loess-soil formations in the territory of Ukraine are defined by land-