Lake Sediments in Bulgaria – Palaeoenvironmental Records

The lakes in Bulgaria are distributed mainly along the Black Sea coast and the River Danube and in the highest parts of the Rila, Pirin and Rhodopes Mountains. A number of lakes remain in the interior lowlands, but they have undergone considerable changes as a result of human activity.

The lake sediments have usually accumulated without interruption, and comprehensive investigation of these makes it possible to reconstruct the palaeoenvironment and changes in the plant cover and the animal kingdom on a local or regional scale and to evaluate the scope of human impact. A dozen existing and former lake basins in different floristic regions of the country have been investigated to date, and the resulting palaeoecological data provide valuable information on the natural environment since the last glaciation and changes in the hydrological regimes of the lakes.

The present paper discusses some of the results obtained from a research programme aimed at the comprehensive investigation of the sediments of three lakes located in different parts of the country and at different altitudes (Fig. 1).

Lake Durankulak

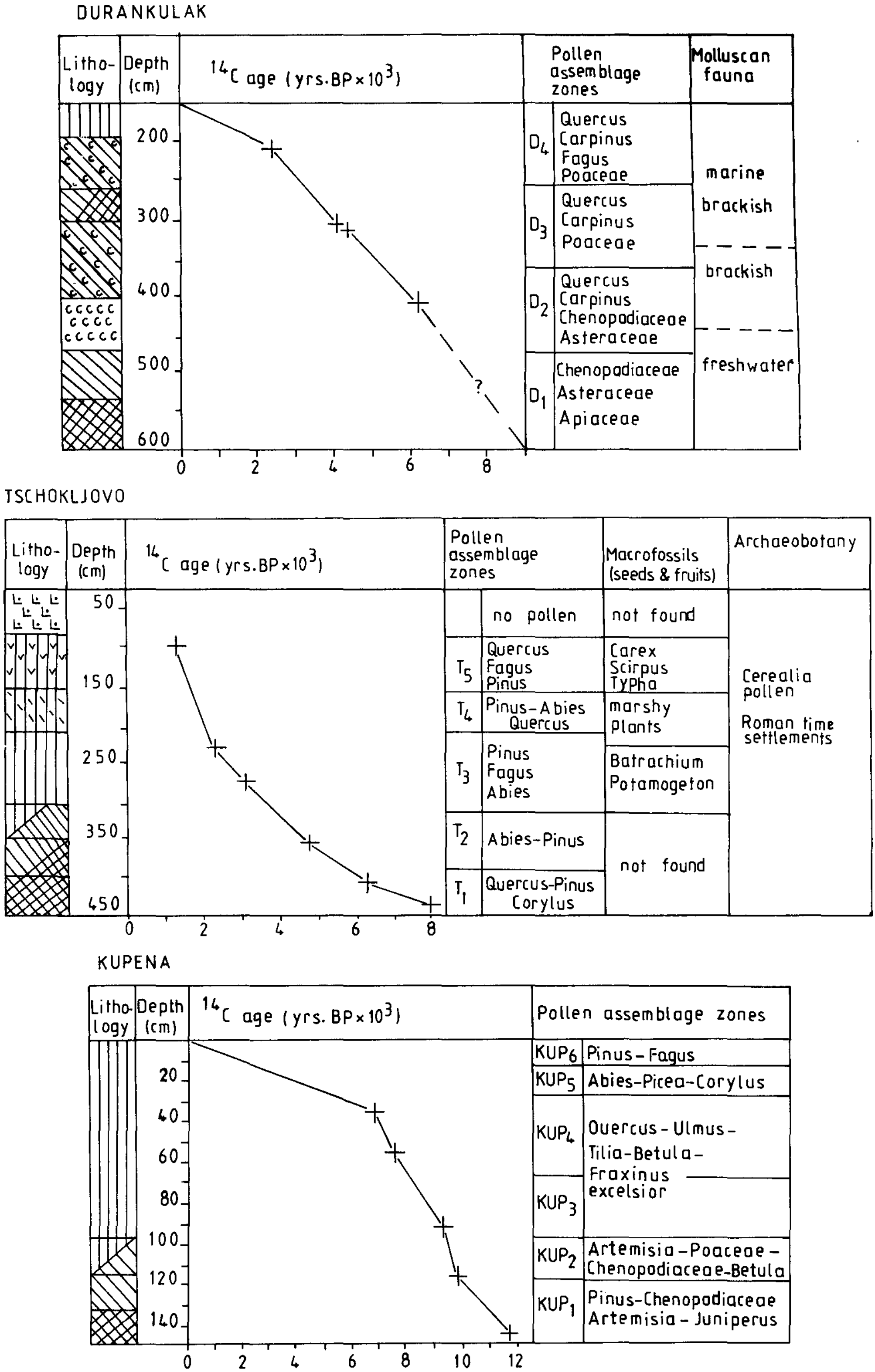
This coastal lake is situated in the southern Dobrudza area of NE Bulgaria, close to the shore and separated from the sea by a strip of sand about 150 m wide. The lake is a closed liman with a water surface of about 3.4 km, an average depth of 1.4 m and a salinity of about 2 ‰. The surface is rarely covered by ice in wintertime. The climate is continental, with a comparatively low annual precipitation of 460 mm. The lake is surrounded by xerophytic herb communities and arable land.

Palaeoecological examination of two cores has allowed the Holocene vegetational history to be reconstructed from fossil pollen analyses (Bozilova

Fig. 1. Map of Bulgaria, showing the sites discussed. N1 : Lake Durankulak ; N2 : Tschokljovo marsh ; N3 : Kupena mire.

and Tonkov, 1985 ; Bozilova, 1986 ; Bozilova and Atanasova, 1990), determinations of the mollusc fauna (Shopov and Jankova, 1987) and the abundant archaeobotanical evidence stretching back to Neolithic times (Bozilova and Filipova, 1986 ; Bozilova and Tonkov, 1990).

The main results obtained from the second core, with a number of radiocarbon dates, are summarized in Fig. 2. The sediments were deposited during the Holocene and are rather heterogeneous, reflecting local hydrological changes and a marine influence. The bottom layers consist of clay and gyttja which accumulated in Boreal times, after 9000 B.P. The mollusc fauna is composed mostly of freshwater species with some brackish ones, pointing to typical liman sedimentation with periodical infiltration of sea water. The pollen record of this period (paz D^1) indicates a vast spread of xerophytic steppe herb communities dominated by Asteraceae-Chenopodiaceae-Poaceae species with a few trees of *Quercus, Corylus* and *Tilia*. The overlying sediments grade to detritus and detritus-gyttja deposited during the Atlantic. The abundance of mollusc fragments and disintegrated rock particles suggests temporary drying out of the peripheral parts of the lake. The link with the sea was seriously interrupted at one point, as indicated by the character of the mollusc fauna, while the input of freshwater remained at the same level. The fossil pollen record for that period marks a transition from steppe to forest-steppe plant communities characterized



Figs. 2-4. Summary of the results of palaeoecological investigations carried out on sediments from Lake Durankulak (2), Tschokljovo marsh (3) and Kupena mire.

by the spread of *Quercus* and *Carpinus betulus* groups in suitable habitats with sufficient moisture. The local population has been interfering with the natural vegetation in the vicinity of the lake since Eneolithic times, including cutting of the sparse forests at several points in time.

The sedimentation rate has remained more or less constant throughout the Holocene despite changes in the character of the sediments. The character of the vegetation did not change markedly during the Subboreal, which coincides in general with paz D^3, but the fluctuations in *Quercus, Carpinus betulus* and *Fagus* could be explained by increasing human influence. This is confirmed by the general occurrence of the typical pollen indicators of human presence *Triticum* and *Hordeum* in the sediments related to the Bronze Age and the beginning of the Iron Age. The alternation of detritus-gyttja with clay-gyttja and a corresponding mollusc fauna tolerant of a higher salinity leads us to assume a connection with the sea.

Phragmites peat began to accumulate in historical times, from 2200 B.P. onwards, so that the uppermost sediments appear not to be so rich in pollen and mollusc fragments. The palynological evidence reflects the formation of a recent vegetation cover around the lake, namely the appearance of xerophytic herb communities of secondary origin as a consequence of widespread deforestation. This accumulation of peat marks the last stage in the formation of the sediments of Lake Durankulak, as also observed in other coastal lakes, Lake Varna and Lake Shabla-Ezeretz.

Tschokljovo marsh

The largest inland mire in SW Bulgaria occupies an area of 1.8 km in the central part of the Konjavska Mountains, at an elevation of 870 m. It was formed at the site of a tectonic depression. The uppermost peat layers were used intensively for peat cutting for more than twenty years after the basin was drained. The slopes of the surrounding hills are nowadays covered by *Quercus* and *Fagus* forests. Large areas of land close to the marsh have been taken over for cultivation.

The project for investigating the sediments preserved in this marsh included analysis of the pollen contained in two cores covering the last 8000 years (Tonkov and Bozilova, 1992), determination of plant macrofossils (Chakalova *et al.*, 1990) and sediment descriptions combined with radiocarbon dating (Tonkov, 1985). A short summary of the application of these methods with respect to palaeoenvironmental reconstruction is presented in Fig. 3.

Preliminary field observations on the sediments from an open section followed by subsequent analysis in the laboratory showed the presence of a number of sediment types derived from local hydrological changes and successive overgrowing by a mire vegetation. Deposition of the sequence analysed here began about 8000 B.P. with the accumulation of a hard grey clay containing traces of lake gyttja. Total fossil pollen is comparatively low and no macrofossils are preserved. The character of the sediment and the slow accumulation rate reflect the existence of a lake with a relatively high water level until 4700 B.P. The pollen represents a small number of herbs, including hygrophytes and hydrophytes, while the samples suitable for analysis are dominated by arboreal pollen (*Quercus, Corylus, Pinus* and *Abies*). Two distinct forest phases may be distinguished during the long period of time from 8000 to 4700 B.P., the first a *Quercus-Corylus-Pinus* assemblage which lasted till 6300 B.P. and the second an *Abies-Pinus* assemblage connected with dominance by conifers. The lack of macrofossils is matched by low quantities of herb pollen, for plant fragments are found only sporadically.

The clay is overlain by a transitional layer almost 50 cm thick and composed of clay-gyttja and peat. This layer is important from a stratigraphical point of view, since it marks the start of the accumulation of sedge peat, indicating a lowering of the water level and the establishment of optimal conditions for the spread of a mire vegetation.

Under conditions associated with the humid Subatlantic climate and as a result of the natural overgrowing of the lake after 3000 B.P., rapid accumulation of sedge and reed peat began. The zone of peaty layers is humified to varying degrees and is rich in herb and tree pollen. The identification of pollen of many herbs such as *Potentilla, Parnassia, Filipendula, Polygonum, Menyanthes* and *Carex* is confirmed by the observation of the corresponding seeds and fruits.

Changes in sediment type are observed in historical times. On the one hand the peaty layers had become more stable, which allowed the immigration of alder and willows and the deposition of fen-carr peat, while on the other hand the deposition of coarse, unhumified peat led to poor preservation of pollen grains in quantitative terms.

The surroundings of the mire are rich in archaeological monuments from Thracian and particularly Roman times, and the population has interfered greatly with the forest cover, leading to the disappearance of the conifers (*Abies* and *Pinus*) and destruction of the oak forests. It should be mentioned that a number of pollen types regarded as reliable indicators of human influence, *Centaurea cyanus, Plantago lanceolata*, etc., are found regularly in the peat from 1800 B.P. onwards, their appearance coinciding with the overall decline in arboreal pollen, pointing to large-scale deforestation. This resulted in turn in the accumulation of eroded material, a hard lake marl, in the uppermost parts of the sequences analysed. This layer varies in thickness but in any case contains virtually no pollen grains.

Kupena mire

The third example of palaeoecological evidence obtained from lake sediments comes from one of the few sites with a continuous Late Glacial and Holocene sequence, a former lake basin about 400 m long and 200 m wide which is nowadays overgrown with a swamp vegetation. It is located at an altitude of 1300 m in the « Kupena » National Reserve in the western Rhodopes Mountains. Two cores were analysed for fossil pollen within a few years of each other and the information supplemented with two series of radiocarbon dates (Bozilova *et al.*, 1989 ; Huttunen *et al.*, 1992).

The mire is today surrounded by *Pinus sylvestris* forest with an admixture of *Fagus sylvatica, Picea abies, Betula pendula* and *Juniperus communis*. One of the aims of the research was careful analysis of the sediments. Since the cores and corresponding pollen diagrams in principle show some minor differences in stratigraphy, the second core was taken as a reference (Fig. 4).

The sediments which accumulated between 12,000 and 10,000 B.P. (paz KUP_1) are composed mainly of hard grey silty gyttja which was difficult to penetrate with the coring equipment and was overlain by peaty gyttja. The radiocarbon date of 11,875 ±310 B.P. proved the Late Glacial age of the sediment, which appeared to be rich in both regional and local pollen. Regular finds of the pollen of a number of water plants such as *Potamogeton, Myriophyllum, Lemna* and *Isoëtes* spores confirms the existence of open water of optimal depth and trophic conditions. Reconstruction of the surrounding vegetation points to a characteristic « siècle montagne steppe-forest » type dominated by *Artemisia* and Chenopodiaceae species and with stands of *Pinus, Betula* and *Juniperus*.

An important point in the stratigraphic sequence of both cores is the sharp change in the character of the sediments at the Late Glacial/Holocene transition. The hard silty clay gives way to peaty gyttja with traces of sedge peat in Preboreal times (paz KUP_2). Thin bands of brownish peat were observed at some places in the gyttja material representing that interval in time in the first core, resembling laminated sediments to some extent. These probably originated as a result of the seasonal distribution of sedge communities during short periods with a favourable climate. On the other hand, the pollen assemblages indicate a re-advance of the Late Glacial communities at the expense of the forest cover until 9400 B.P., very probably caused by a decrease in humidity.

The sedimentation rate was relatively high from the Boreal to almost the end of the Atlantic (ca. 5500 B.P.), and the accumulation of sedge peat gradually caused the water plants to disappear. The major proportion of the fossil pollen of terrestrial species originates from *Quercus* and the broad-leaved elements accompanying it, *Tilia, Ulmus, Fraxinus excelsior* and some *Corylus*.

The character of the sediments did not change at the transition to the Subboreal, but the sedimentation rate decreased sharply. This peculiarity is also observed at many other sites in the mountainous areas of the country, probably due to the dry climatic conditions prevailing for most of the Subboreal (Bozilova, 1986). There are relatively few pollen spectra belonging to the period of intensive dynamic changes in the forest cover (paz KUP_5) which ended with the appearance at open sites in the western Rhodopes of a number of demanding arboreal taxa such as *Abies, Carpinus betulus, Fagus, Picea* and *Corylus*. The last phase in the succession coincides with historical times, when the vegetation took on its present appearance. The incidence of charcoal particles in the sedge peat increases, which is not only a climatic response but also has anthropogenic implications. There is also a pronounced increase in cereal pollen values (*Hordeum* and *Triticum*), but no other evidence of human impact.

The examples discussed above provide some impression of the formation and accumulation of lake sediments in Bulgaria in post-glacial times. The existence of sediments that differ in composition and colour is quite obvious, but the reasons for them are more complicated. Mostly deposition follows a seasonal rhythm connected with changes in the hydrological regime and biological productivity, the latter determining the origin and deposition of the various sedimentation types. Sediments which are rich in marl are very often encountered, because of the calcareous rocks and soils (Tschokljovo marsh), and sometimes the lamination is due to the seasonal development of diatoms and the presence of inorganic compounds produced by micro-organisms (Lake Durankulak).

Human activity and subsequent erosion has also altered the minerogenic influx into the lakes. Such sediments can rarely provide a basis for chronological conclusions, but they do serve as reliable evidence for the degree of human impact. Finally partial lamination is observed in some lake and marine sediments. It is still not known whether this is due to annual cycles or other causes, which restricts the usefulness of such sediments as chronological markers.

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