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The new pollen core Lake Durankulak-3: a contribution to the vegetation history and human impact in Northeastern Bulgaria

Elena Marinova
Laboratory of Palynology, Department of Botany, Faculty of Biology, Sofia University "St. Kliment Ohridski", 8 Dragan Tzankov bd., 1164 Sofia, Bulgaria
Correspondence to: draka@gmx.de

ABSTRACT

Pollen analysis was conducted on a 340 cm core from Lake Durankulak (NE Bulgaria) supported with 5 AMS dates. The sediments were retreived from the area between the western lake shore and the Great island – both places of human occupaion since the Late Neolithic (5400-5300 cal BC). According to the AMS dates the accumulation of sediments rich in pollen started at the transitional period between the Chalcolithic and the early Bronze Age (3800-3350 cal. BC). By that time open xerothermic vegetation with patches of steppe elements had dominated the landscape around the lake. The subsequent increase in arboreal pollen corresponds to the Early Bronze Age (2919-2392 cal BC) together with the first maximum of the anthropogenic pollen indicators. The next period of pronounced human influence documented in the pollen record is related to the Late Bronze Age and the Antiquity (2000 – 600 cal BC). The modern period is indicated by the appearance of *Zea mays* pollen in the uppermost samples. The new palynological information is compared with previous studies from this area.

Key words: Pollen analysis – Human impact – Bronze Age/Iron Age – Lake Durankulak – NE Bulgaria

INTRODUCTION

The vegetation history of the Black Sea coastal area in Northeastern Bulgaria has been intensively studied during the last two decades. Pollen diagrams covering the last 8000 years were published from the following freshwater basins: Lake Duran-ulak (Bozilova and Tonkov 1985, 1998), Lake Shabla-Ezeretz (Filipova 1985) and Lake Varna (Bozilova and Beug 1994). These diagrams generally demonstrated a long period of uniformity in forest compo-sition for the greater part of the Holocene interrupted by distinct phases of human activity (Bozilova and Beug 1994). In addi-tion, the palynological studies on marine sediments off the coast revealed that the main stages in forest development that followed the lateglacial steppe period were completed in the Early Holocene (Shopov et al. 1992; Atanassova 1995; Bozilova et al. 1997, *etc.*). In the inland of Northeastern Bulgaria, Lake Srebarna area, xerothermic oak forests were developed ca. 6000 BP. and their degradation started with the Bronze Age human occupation (Lazarova and Bozilova 2001).

Previous to the present, two pollen cores were analysed from Lake Durankulak (Bozilova and Tonkov 1985, 1998). There are many factors which make this lake an interesting site for palynological research. Its location allows to trace in detail the environmental changes in a sensitive area that has archived the characteristics of the transformation steppe/forest. The evidence of human occupation near the lake begins since the Neolithic (Todorova 1985;

Todorova and Vaisov 1989; Dimov 1990). It contains valuable information related to the anthropogenic impact on the surrounding environment around the prehis-oric site till nowadays. The new pollen core Durankulak-3 was analyzed for plant macrofossil and pollen content.

The sediments studied were retreived close to the prehistoric site. In the present paper the main results of pollen analysis are discussed in attempt to throw additional light on the vegetation history and the human impact particularly during the Bronze and Iron Ages. This new palyno-logical information is compared with the previous studies and the available archaeo-logical data as well.

The study area

Lake Durankulak is situated at the Black sea coast in Northeastern Bulgaria (Fig.1). It is separated from the sea with a 200-300 m wide sand dune. The lake is about 3 km long, the deepest areas are about 3,8 m. The water is slightly brackish with salinity of 2‰-4‰) and meso- to eutrophic. There are two islands. The lake is situated in two Miocene limestone depressions of Sarma-tian age. The lake originates from an estuary that was closed in the Late Pleistocene – Early Holocene (Popov and Mishev 1974).

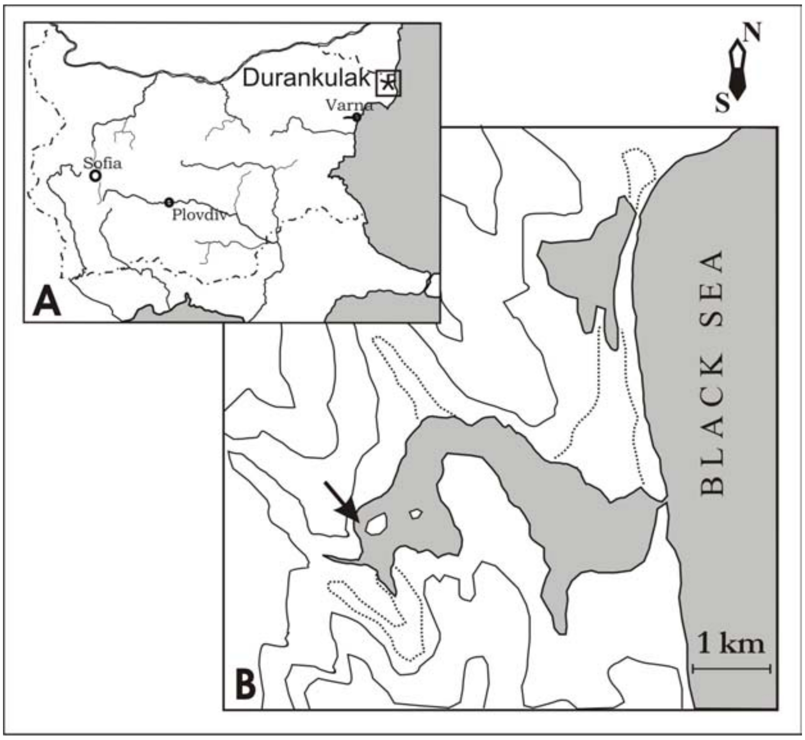

Fig. 1. Maps showing - **A:** The wider geographical context of the study are; **B:** Lake Durankulak and the coring site (marked with arrow) located between the western shore and the large island

The climate of the area is determined by the strong continental influence and the nearness of the sea. The prevailing winds are north-eastern and the annual precipita-tion is 450-500 mm with a maximum in June and a minimum in February. The mean January temperature is around 0°C while inland it drops to -2°C (Georgiev 1994). The most common soils are the cher-nozems. Several vegetation types are found in the surroundings of the lake: xerothermic forest-steppe and steppe, psammophyte and halophyte vegetation on the sand dunes and the shore, fragments of flooded forests along the rivers, hygrophilous and water vegetation. A profound description of the main plant communities was given in an earlier publication (Bozilova and Tonkov 1998). The reed formation in the peripheral parts of the lake is dominated by *Phrag-mites australis, Typha latifolia*, *T. angusti-folia* and *Schoenopletus lacustris*. The hyg-rophilous vegetation is represented by

Alisma plantago-aquatica, *Glyceria maxi-ma*, *G. fluitans*, *Butomus umbellatus*, *Lythrum salicaria*, *Calystegia sepium*. (Kotchev et al. 1983).

MATERIAL AND METHODS

Core and lithology

The sediment core Durankulak-3, 340 cm long, was taken in September 1999 from the narrowest place between the western lake shore and the large island with a square-rod piston sampler (Whrigt 1991) (Fig.1). Advantageously of such coring device allows to retreive coring segments 1 m in length, to prevent the compression of the sediments, and to establish a continuous control over the coring process (Berglund 1985).

The lithology of the core is shown on Table 1. In the interval 280-340 cm the core reached the loess underground. The transi-tion from clay to clay-mud is recorded at level 250-240 cm and above it the pollen grains are well preserved. At depths 149 cm and 221 cm two shell layers are visible. The first layer is distinct, 2 cm thick, and the second one is seen as a shell enrichment. These two layers promote the comparison with the previous studies of Bozilova and Tonkov (1985, 1998) where such layers were also documented.

Table 1. Lithology of core Durankulak-3

Depth (cm)	Type
0-17	Grey-brown mud
17-80	Black-brown *Phragmites* peat
80-137	Dark brown mud with thin sand layers
137-146	Calcareous mud
146-150	Shell-layer
150-203	Dark grey-brown mud
203-220	Black-grey clay mud
220-222	Shell enrichment
222-272	Black-grey clay mud
272-288	Loess rich in organic matter
288-340	Loess

Pollen analysis

The samples for pollen analysis were taken at 5-cm intervals, and processed according to the standard method of Faegri and Iversen (1975). The clay admixture was removed with an ultrasonic sieve (10 μm). The pollen types were determined using the reference collections of the University of Bonn and Sofia University-Laboratory of Palynology, and the keys in Beug (1961), Faegri (1993), and Moore, Webb and Collinson (1991). Up to 1000 pollen grains of terrestrial pollen were counted per sample. In the interval 215–240 cm where the pollen concentration was very low about 700 pollen grains of terrestrial plants were counted. The pollen concentration below 240 cm was under 5% and the majority of pollen grains were corroded. The pollen sum (PS) for percentage calculations was based on AP (arboreal pollen) + NAP (non-arboreal pollen).

The results of pollen analysis were plotted with the help of TILIA and TILIA.GRAPH 1.2 program (Grimm 1991) as a simplified percentage pollen diagram with selected taxa (Fig. 3). Three local pollen assemblage zones (LPAZ) were established by means of stratigraphi-cal constrained cluster analysis.

Radiocarbon dating

Five samples from the lower part of the core were submitted for AMS-dating. The radiocarbon dates were obtained in the Leibnitz Labor für Altersbestimmung und Isotopenforschung, University of Kiel, Germany (KIA 12339 to KIA 12343). The dates have been calibrated using the program CALIB rev 4.3 (Stuiver et al.1998) (Table 2). The dating of terrestrial plant material with the accelerator method is more precise compared to the dating of bulk sediment (gyttia) or shells. This method was chosen to date this part of the diagram where the first anthropogenic indicators start to increase.

Table 2. Results of radiocarbon measurements of core Durankulak-3

Lab. №	**Depth (cm)**	**Age BP**	**Age cal. BC (±2σ range)**	**Material dated**
KIA 12339	170	3904±29	2469-2292	partly charred wood
KIA 12340	172,5	3908±31	2471-2292	charred wood
KIA 12341	180	4198±30	2885-2843; 2645-2644	partly charred wood
KIA 12342	182,5	4153±35	2880-2618; 2593-2582	wood, *Gallium* fruits
KIA 12343	187,5	4191±33	2885-2835; 2649-2630	partly charred wood, *Mec* fruit

RESULTS

Three local pollen assemblage zones (LPAZ) were distinguished in the pollen diagram (Fig. 3). Their pollen stratigraphy is briefly presented:

LPAZ Dur 1 (240-183 cm ; Asteraceae - Poaceae - Cenopodiaceae)
In this zone NAP is prevailing with ca. 85%. The dominant group is Asteraceae with 35% (*Cichorioideae*, *Asteroideae*, *Artemisia*, *Centaurea jacea*–type, *Anthe-mis/Achilea*–type), followed by Chenopo-diaceae (30 %) and *Poaceae* (25 %). Other pollen types of importance are *Ephedra*, *Adonis*, *Linum*, *Stachys*-type, Apiaceae, Fabaceae, *etc.* AP is present with low values (20 %). Pollen of *Quercus* (mostly *Q. robur*-type) reaches 5%. Pollen of *Fraxinus excelsior*-type, *Alnus*, *Ulmus*, *Hedera*, *Humulus*, *Lonicera* is well represented. The first anthropogenic indicators appear at the transition to the next zone.

Two subzones Dur 1a and Dur 1b are recognized. In the first one the pollen grains are slightly corroded. Selective pollen preser-vation and low pollen concentration are observed. The partici-pation of Chenopodiaceae pollen is almost equal to that of Asteraceae (ca. 35%). In the second subzone the following anthropogenic indicators are present: *Cerealia*-type, *Triticum*-type, *Polygonum aviculare*, *Plantago lanceolata*-type, *Rumex*.

LPAZ Dur 2 (183 - 96,5 cm; Poaceae-Chenopodiaceae-*Artemisia*)
In this zone AP reaches 40%. The presen-ce of the anthropogenic indicators is noti-ceable. This zone is also divided into two subzones. The first subzone Dur 2a is dominated by *Poaceae* with up to 60 %. The following anthropogenic pollen indicators deserve attention: *Plantago lanceolata*, *Plantago major/media*, *Rumex*, *Polygonum*.

In the second subzone Dur 2a the pollen frequencies of almost all arboreal taxa rise: *Quercus* (20 %), *Carpinus betulus* (up to 12 %), *C. orientalis*-type (7 %), *Fagus* (5 %), *Ulmus* (4 %), *Corylus* (3 %). At level 120-125 cm the first pollen grains of *Juglans* appears.

LPAZ Dur 3 (96,5-10 cm; *Poaceae* - *Quercus*)
In this zone pollen of *Quercus* (parti-cularly *Q. cerris*-type) attains a maximum of 28 %. At level 50 cm the total AP pollen curve declines to 15% at the expense of *Poaceae* 50%, partly *Chenopo-diaceae* (20 %), and *Artemisia* (15 %). Pollen of *Centaurea cyanus* appears at levels 75, 70 and 50 cm. In the uppermost two samples pollen of *Zea mays* is determined. Two subzones Dur 3a and Dur 3b are also recognized. In the first subzone maximal values are recorded for the lianas *Vitis*, *Humulus* and *Hedera*. The curve of *Cerealia*-type reaches 0,8 %.

In the second subzone the pollen curves of *Asteroideae* and Chenopodiaceae rise to 30% and 40 %, respectively. Pollen of *Rham-nus*/*Paliurus*-type is also found. An increase in the participation of several hygrophytes and hydrophytes (*Cypera-ceae*, *Typha*, *Potamo-geton*) is also observed.

DISCUSSION

Vegetation development and anthropo-genic influence

The human occupation in the area of Lake Durankulak had started during the Late Neolithic (5400-5300 cal. BC). A Late Neolithic settlement and an Chalcolithic and Bronze Age necropolis were discovered on the western shore of the lake. On the large island a complex archaeological site dating back to the Early Chalcolithic was also excavated. It comprises cultural layers from the Chalcolithic, Late Bronze Age and Mediaeval (Protobulagrian) settlements, and a Thracian sanctuary (Bojadziev 1992; Dimov 1990). The location of the new core Durankulak-3 close to both archaeo-logical sites provides excellent possibili-ties for correlation of the palynological and archaeological data. An important prerequisite for such compa-rison is the series of radiocarbon dates that falls within the time interval 4191-3904 BP. (2811-2851 cal BC), and is related to the Bronze Age in conformity with the radiocarbon chronology for the bulgarian prehistory (Görsdorf and Bojadziev 1997). The dates indicate that an enlargement of the lake has probably taken place after the Chalcolithic period. Another hint for this suggestion is the Chalcolithic burial place where some of the graves today are under the water surface.

According to the AMS dates the transitional period between the Chalcolithic and the Bronze Age corresponds to LPAZ Dur 1. In this part of the diagram all tree taxa are present with low proportions (AP~20%). Most likely, the source area for arboreal pollen has been the stands of trees distributed along the rivers running into the lake. These patches of woody vegetation were composed of oaks (*Quer-cus*) with some *Ulmus*, *Tilia*, *Fraxinus*, *Alnus,* and lianas such as *Humulus* and *Hedera*. The presence of *Pinus*, *Picea* and *Abies* pollen in the fossil record originates from long distant transport.

The xerothermic herbaceous vegetation with some steppe elements from Poaceae, *Artemisia*, Asteraceae, Chenopodiaceae, *Ado-nis* and Apiaceae*,* with groups of *Ephedra* among them, has dominated the landscape around the lake. At the beginning of this zone, which cor-responds to the transition between the Chalcolithic and Bronze Age, there are almost no anthropogenic indicators, apart from a weak signal of *Cerealia*-type, *Hordeum*-type, *Plantago lanceolata* und *Rumex* pollen. According to the archaeo-logical evidence this transitional period was connected with a decline of the human occupation and invasions of steppe nomads (Todorova 1989).

Considering the previous intensive human occupation of the Hamangia und Varna culture during the Chalcolithic and its duration for more than 700 years (Bojadziev 1992), it seems that the expansion of the steppe elements was favoured by the increasing drought in the period 4000-3500 BP. (Bozilova and Filipova 1986) after the abandonment of the arable land by the local population. Similar situation with drier conditions was also observed for the period 4200-3700 BP. in the Northern Black Sea area, in the south of Ukraine and Russia, along the Dniepr and Don rivers (Kremenezki et al. 1999).

In subzone Dur 1b the curves of the anthropogenic indicators start to rise, with an increase of the secondary anthropogenic indicators, particularly of *Plantago lanceolata* up to 4%. This curve shows that some pasture activities took place in the area. At the transition to the next zone an increase of the primary indicators (*Cerealia*-type, *Triticum*-type, *Hordeum*-type) is noticeable. In this subzone, parallel to the intensification of the anthropogenic impact, almost all tree pollen curves decrease, pointing to a decline in the distribution of the local forests. For this subzone two ^{14}C dates were obtained (2463-2396 cal BC. and 2465-2398 cal BC.) and they correspond to the Early Bronze Age. Charred plant macrofossils from the Bronze Age cultural layers of the Durankulak settlement were also studied (Popova 1995). A wide spectrum of cultivated plants, especially cereals, was found: *Triticum dicoccum, T. monococ-cum, T. spelta, T. aestivum, Panicum milliaceum, Hordeum vulgare, Vicia ervilia*. Several charred stones of *Prunus* cf. *avium*, *Sambucus nigra* and *Cornus mas* were also recovered in the studied material.

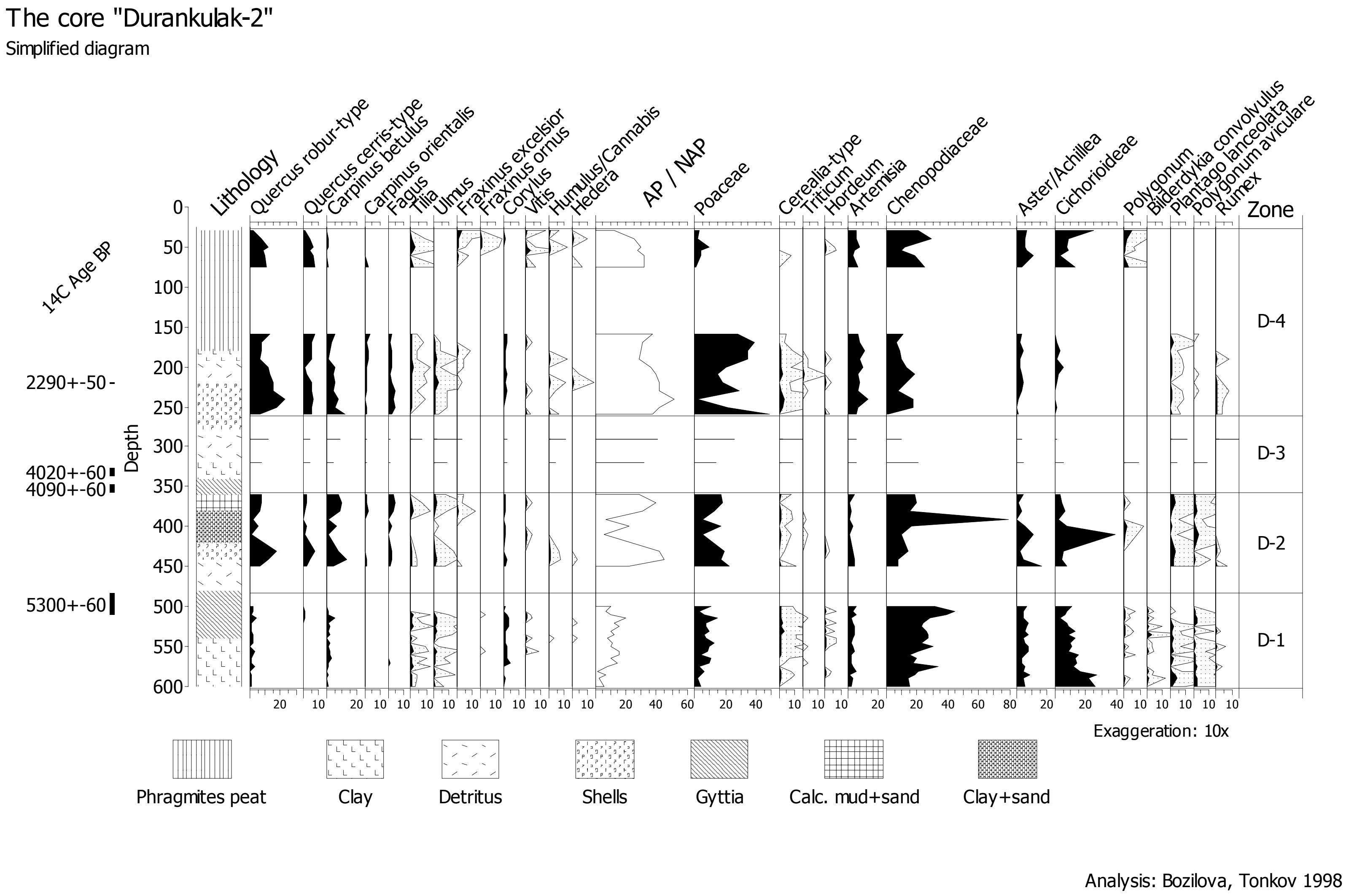

Fig. 2. Simplified diagram of the pollen core Durankulak-2 (Bozilova, Tonkov 1998)

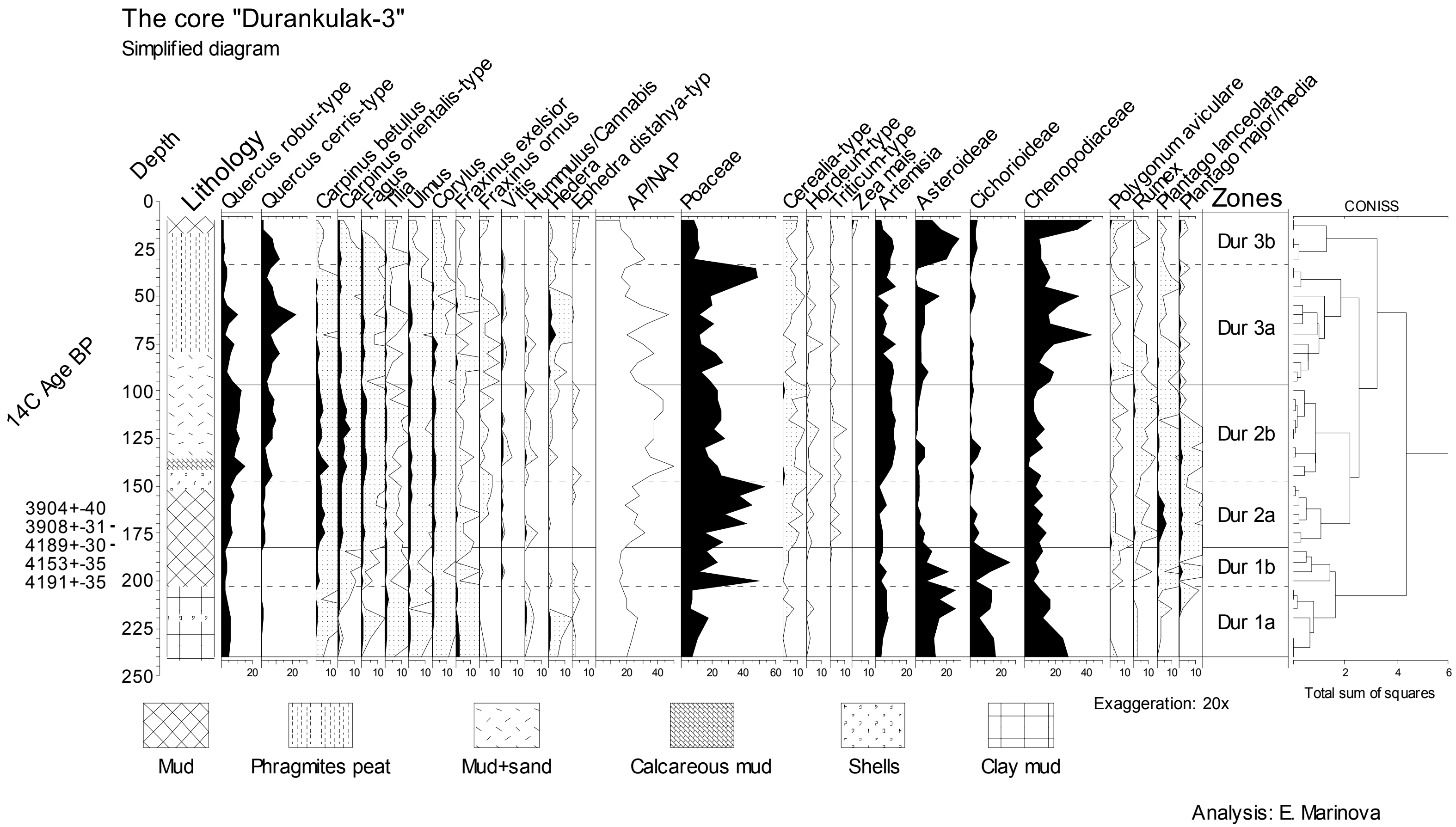

Fig. 3. Simplified diagram of the pollen core Durankulak-3

The next zone Dur 2 is characterised by an increase in arboreal pollen, mainly due to the rise of *Quercus robur*-type, *Q. cerris*-type, *Carpinus betulus* and *C. orientalis*-type. The forests in the surrounding area started to enlarge compared to the previous period. The anthropogenic indicators are well represented in the entire zone.

The first subzone Dur 2a is dominated by Poaceae and Chenopodiaceae pollen. At level 170 cm a peak in the curve of the secondary anthropogenic indicators is registrated. It is formed predominantly on the increase of *Plantago lanceolata*. The available three ^{14}C dates correspond to the second part of the Early Bronze Age (Görsdorf and Bojadziev 1997) (Table 2.).

Subzone Dur 2b is characterised by the highest AP values (up to 60%) for the entire profile. Most probably, the tree vegetation occupied larger areas around the rivers and the lake, represented by *Carpinus betulus*, *C. orientalis* and *Fagus,* together with *Quercus robur* and *Q. cerris*. In the middle of the zone (level 120 cm) a clear maximum of the anthropogenic indicators is registered. For the first time, pollen of *Juglans* is recorded in the diagram. The increase of the secondary anthropogenic indicators such as *Plantago lanceolata*, *Polygonum aviculare*, *Rumex* and *Chelidonium* could be connected with the Thracian settlement and sanctuary that were found on the large island. According to the archaeological data, this period is related to 1200-1050 BC. (Todorova 1985).

The third zone Dur 3 is characterised by a slight decrease of arboreal pollen. Most of the tree pollen curves decline and only *Quercus cerris*- and partly *Q. robur*-type keep higher values reaching up 20%. It could be suggested that this situation represented "islands" of xerothermic oak woods, being regularly redu-ced by the local people, and replaced by xerothermic herb vegetation with steppe elements. A high proportion of AP is still recorded in subzone Dur 3a and at the tran-sition to subzone Dur 3b it starts to decrease. Among the NAP taxa the highest values are recorded for Chenopodiaceae, Poaceae and partly to *Artemisia* and *Asteroideae*.

The find of *Zea mays* pollen is a result of the cultivation of maize as a crop plant from the beginning of the 17th century onwards (Kitanov 1986) so that the uppermost part of the diagram could be assigned to the last 200-250 years.

Comparison with previous studies

As mentioned above, two pollen cores of Lake Durankulak were already studied. They origi-nate from the same area between the western lake shore and the large island. The core Durankulak-1 was taken 10-15 m in north-eastern direction from the present core (Bozilova and Tonkov 1985) while the core Durankulak-2 was recovered 30 m in south-western direction (Bozilova and Tonkov 1998). The results from the first study were revised and improved by the authors. It is tempting and logical to compare the new results with the previous ones published in 1998. For this purpose, the pollen diagram Durankulak-3 is compared to the pollen diagram Durankulak-2 (Fig. 2).

Comparing both diagrams, it should be born in mind that in the study of Bozilova and Tonkov (1998) the pollen sum was based on 250-270 terrestrial pollen grains. The lithology of both profiles shows the presence of calcareous mud with two shell layers. These layers can be used to some extent as a reference point to correlate both diagrams.

The first zone D-1 of core Durankulak-2 is not present in core Durankulak-3. Certain similarities in the course of the pollen curves are observed between zone D-2, and zones Dur 1b and Dur 2a. In both diagrams maximal values of *Cichorioideae* and *Asteroideae* pollen are recorded. Above these maxima, peaks of *Plantago lanceolata* and *P. coronopus* appear and subsequently an increase of arboreal pollen is observed. The AMS dates of Durankulak-3 indicate that this part of the diagram could be related to the Early Bronze Age. In the publication of Bozi-lova and Tonkov (1998), the corresponding part of the diagram was assigned to the Chalcolithic period. The shell layer was dated ca. 4090-4020 BP (2600-2500 cal. BC). In core Durankulak-3 radiocarbon dates of similar age were obtained for the sediments 40 cm below the shell layer. Probably, the differencies are connected with the dating methods applied.

Above the shell layer in both cores an increase of AP is recorded, i.e. in zones Dur 2b and Dur 3a (core "Durankulak-3) and in zones D-3 and D-4 (core Durankulak-2).

Subzone Dur 3b has no analogue in the pollen diagram Durankulak-2.

CONCLUSIONS

1. The new pollen record provides additional information on the vegetation changes and human impact in the area of the praehistoric site Durankulak.
2. The AMS dates reveal that the sediments started to accumulate during the transitional period between the Chalcolithic and the Bronze Age.
3. The first maximum of the pollen anthropogenic indicators refers to the Early Bronze Age, while subsequent peak are registered during the Late Bronze Age, Iron Age and Antiquity. The last maximum is probably connected with the Proto-Bulgarian settlement that had existed during 9^{th}-10^{th} centuries.

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