Evidence for palaeoecological changes in the Bulgarian Black Sea area during the Quaternary include lithostratigraphic and biostratigraphic records from twenty-five marine and coastal cores correlated with available data from lithology, geomorphology, seismostratigraphy, archaeology and radiocarbon dating. A stratigraphic subdivision of the sediments is presented. Tschauudian (Günz), Drevneuxinian (Riss), and Neoeuxinian (Würm) glacial periods and Karangatian (Eemien), and Holocene interglacial periods are identified. Changes in climate and vegetation dynamics are reconstructed.

INTRODUCTION

An investigation of the Quaternary sediments in the Western Black Sea area and of their stratigraphy is of great significance not only for reconstructing palaeoenvironmental changes but also for predicting and preventing unfavourable natural phenomena that could occur during management of land and marine resources. During the past decades much of the lithostratigraphic and biostratigraphic research in this area has focused on the reconstruction of palaeoecological conditions along the coast and shelf zone.

MATERIALS AND METHODS

In the present paper results are given of investigations of 17 cores from the shelf, continental slope, and deep-water zone of the Black Sea together with 8 cores from coastal lakes and river terraces (Figure 1). Various research methods are used including: mollusc and dinoflagellate analysis, spore and pollen analysis, lithology, geomorphology, seismostratigraphy, archaeology, and $^{14}$C radiocarbon dating. Data from surveys conducted between 1980 and 1999 are summarised.
Figure 1 Scheme of the Bulgarian Black Sea Shelf showing the location of cores and seismoacoustic profiles:
1. Boundary between the shelf and the continental slope.
3. Basic tectonic zones: I. Moesian Platform; II. Lower Kamchia Depression; III. Eastern Balkan Range; IV. Bourgas Depression.
4. Location of cores: a) Cores from lake and river terrace sediments; b) Cores from shelf sediments; c) Cores from deep-water sediments; d) Deep-water sounding 380/380A and 381 conducted on R/V Glomar Challenger.
5. Continuous seismoacoustic profiles (CSP).
6. 100m isobaths
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in Table 1 and set against the stratigraphic scheme (Shopov, 1991) for Black Sea Quaternary sediments. Radiocarbon dates are calibrated according to Suwer and Reimer (1993).

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RESULTS AND DISCUSSION

The oldest sediments are of Lower Pleistocene age. They were deposited at the Pliocene/Pleistocene boundary under the conditions of the deep Emonian Regression of the Black Sea when large shelf areas turned into land and the river system was transformed. The Black Sea became a brackish lake isolated from the World Ocean. The sea-level was 70-80 m lower than the present one and the salinity was at 10-15‰ (Chepalyga, 2002). According to the regional stratigraphic scheme these sediments are referable to the earliest (Regressive, Bulgarian phase) of the Lower Tschaudinian (Fedorov, 1982; Shantzer, 1982). They are revealed in the peripheral and in the central part of the Bulgarian shelf. In the region of the peripheral bars the Tschaudinian sediments are seen as a strip lying parallel to the shore and stretching south from Cape of Emine at depths of 80-140 m (Khrischev and Shopov, 1978; Kuprin, et al., 1980) (Figure 2). They are terrigenous shelly and clayey deposits (Krischev and Shopov, 1977; 1978; Dimitrov, 1978; Dimitrov and Govberg, 1978; Kuprin, et al., 1984). The lithological features and faunal content of cores from the Aprilska Structure, Samotino East and Yuriiy Godin provide the following new facts about the Tschaudinian sediments on the Bulgarian Black Sea shelf. They are aleuritic sandy silts with a high clayey-carbonate content. The biogenic component comprises rounded, whole or broken shells of fossilised brackish Tschaudinian species Dreissena rostriformis tschaudae Andrus, Didacna crassa Eichw., Didacna tschaudae Andrus. The presence of shallow-water Gastropod species Turricaspia caspia lincta Mil., T. crimeniana Gol. et St., T. boltowskoji Gol. et St., and T. pseudotiton Gol. et St. is especially significant. The most characteristic feature of the thanatocoenosis studied is the presence of the Pleistocene relict Theodoxus ex. gr. lichordipoly. The poor state and ancient character of the molluscan fauna as well as the presence of Pliocene relicts confirms the Lower Tschaudinian age and a Pont-Caspian type of fauna. The Lower Tschaudinian sediments from the three cores investigated are assumed to be relicts from an ancient shore-line. Tschaudinian molluscan fauna analogous to that described for the Bulgarian Black Sea shelf was also found along the Caucasian shelf in the zone of barrier bars at a depth of 90 m. (Shatilova and Mchedlishwili, 1982; Dimitrov, et al., 1998).

Spore-pollen analysis suggests the spreading of steppe vegetation dominated by Chenopodiaceae, Artemisia, Poaceae, Asteraceae, and Ephedra. Such a vegetation type can be attributed to both cold and dry conditions. Arboreals are presented mainly by Pinus diploxyylon – type as well as by Pinus haploxyylon – type, Picea, Abies, Quercus, Ulmus, Alnus, Fagus. The presence of re-deposited pollen grains of Tertiary taxa such as Taxus, Carya, Cedrus, Taxodium supports the conclusion that these sediments belong to the Lower Tschaudinian. Similar pollen spectra have been referred to
Figure 2. Schematic geological cross-section of the Quaternary Black Sea shelf sediments (after Dimitrov et al., 1998): 1. Unconformity and erosion surface; 2. Holocene; 3. Upper Pleistocene (Neoeuxinian); 4. Middle Pleistocene (Usunlarian and Drevneeuxinian); 5. Lower Pleistocene (Tschaudinian)
the Tschaudinian by Koreneva and Kartashova (1978), Chernysheva (1980), and Shatilova and Mchedlishwili (1982).

Continuous Seismic Profiling (CSP) indicates that the relict Tschaudinian bars and the Neogene deposits near the surface of the marginal shelf zone south of Cape of Emine are closely related to the uplifted tectonic structures of the underwater extension of the Balkan Mountains. During the Lower Pleistocene some structures were underwater banks and isles around which coarse marine sediments were deposited (Figure 3a). On the north in the zone of Dolna Kamchia Depression and the Moesian Platform the Lower Pleistocene sediments are found at significantly greater depth, 57-60 m beneath the sea bottom. At about 74 km from the shore the Tschaudinian layers are situated on the Neogene sediment at an absolute depth of 90 m. Buried bodies of sediment similar in structure and morphology to the external bars can be clearly distinguished on the seismograms of the peripheral zone at depths from 16 to 32 m. Their depth of deposition is correlated with the Tschaudinian layers in the core from the Yuriy Godin Structure. They are probably part of the regressive Tschaudinian complex (Figure 3b). In the zone of the Moaesian Platform the Early Tschaudinian shore-line is controlled by the Eastern Tyulenovo Fault at a depth of 90 m (Krashev and Mikhova, 1990).

The Middle Pleistocene sediments on the Bulgarian shelf are mainly represented by Drevneuxinian and Usunlarian sediments and were deposited during the Riss Glacial. The first phase of this glacial period (Riss 1 Stadial) caused the regression of closed basins of the Pont-Caspian region. During that time Upper Drevneuxinian sediments were deposited in the Black Sea (Khrischev and Shopov, 1979). The stratigraphic position and boundaries of the Usunlarian Regional stage are still debatable. Most of the authors considered that Usunlarian sediments were deposited under the short climate warming during the Riss 1 – Riss 2 Interstadial (Koreneva and Kartashova, 1978; Khrischev and Shopov, 1979; Fedorov, 1982). The second phase of the Riss Glacial (Riss 2 Stadial) caused a general regression in the Mediterranean and the Pont-Caspian Region (Arkhangelskiy and Strakhov, 1938; Fedorov, 1982, Kuprin, et al., 1984). According to Scholten (1974) the bed of the Bosphorus strait reached to the depth of 100 m, but along the Bulgarian shelf data for such a deep regression were not found (Khrischev and Shopov, 1979). In the central part of the shelf, in cores C-3 Apriliska, C-5 Yuriy Godin, and C-2 Northern Structure, the Drevneuxinian sediments cover the Tschaudinian sediments transgressively with a sharp erosional boundary. In the first two cores the Drevneuxinian sediments are carbonates and clays with an uneven distribution of the pellitic component and with some intervals enriched with detritus. The prevailing presence of the typical Drevneuxinian species Didacna crassa parvula Nalivkini, Didacna crassa pontocaspia Eichw., Didacna pallasi Prav., Turricaspia kolesnikoviana Logv. et St., Caspia baere vakanovii Gol. et St., as well as the re-deposited Tschaudinian Dreissena rostriformis tschaudae makes it possible to delimit the lower borders of the Drevneuxinian sediments.
The palynological data testify that during the deposition of these sediments the climate was dry and cold and favoured a steppe vegetation dominated by Chenopodiaceae and *Artemisia*. The continuous presence of *Ephedra distachya* in the pollen spectra confirms the aridity of the climate. Pollen grains in this layer are better preserved than in underlying deposits. Similar pollen data cited Koreneva and Kartashova (1978).

Figure 3. High-resolution reflection profiles at the outer edge (peripheral zone) of the Black Sea shelf: Profile 25 (a) and 22 (b) (after Krastev and Mikhova, 1990): 1. Reflected seismoacoustic horizons; 2. Wedge-like accumulative bodies; 3. Accumulative bars; 4. Tschaudinian buried accumulative bodies; 5. Post-Karangatian – Neoeuxinian surface; 6. Neoeuxinian deposits; 7. Holocene deposits.
According to CSP data the surface of the Drevneeuxinian sediments is traced to isobaths 95 - 97 m. In an almost similar way to the Tschaudinian horizon, in the northern part of the shelf the Drevneeuxinian sediments wedge out at about 6 km from the shore.

The Usunlarian sediments in core C-3 of the Aprilska Structure are represented by sandy-aleuritic clays with many shells of Abra alba Wood., Cardium edule L., and single shells of Hydrobia ventrosa Mont. In the core C-2 of the Northern Structure the euryhalinic Mediterranean mollusks Cardium edule, Hydrobia ventrosa, and the gastropod Turricapia sp. are also encountered together with the Dreissenia polymorpha Pal and the small-sized Paphia rugata (B., D et D.). In spite of the poor taxonomic spectrum the molluscan assemblage suggests increase of salinity of the basin and can be defined as Mediterranean in character. The deposition of the Usunlarian sediments in which it occurs represents a Mediterranean transgression. From that time two transgressions are known in the history of the Black Sea – the Usunlarian and the Karangatian. Most probably the sediments investigated were deposited during the Usunlarian, although data are insufficient to be definite. The high values of the pollen of Pinus diploxyylon-type suggests that during the Usunlarian in the higher coastal areas forests most probably of Pinus nigra existed. At lower altitudes xerophytic herbaceous communities with patches of Quercus, Ulmus, Betula, and Carpinus betulus occurred. These herbaceous communities differ from those of the previous periods. Artemisia remained dominant taxa, while Chenopodiaceae was less abundant, and Poaceae increased. We can assume that the development of such a type of vegetation was due to climatic warming. Similar pollen spectra are described for deep-water sediments by Koreneva and Kartashova (1978).

Both the Drevneeuxinian terrace (at elevations from 45 to 60 m) and the Euxine-Usunlarian terrace (at elevation 35-45 m) have been defined morphologically in the Bulgarian coastal zone (Popov and Mishev, 1974). Only the latter is defined on the basis of its molluscan fauna. Other evidence (molluscan fauna, marine sediments) for the presence of Lower and Middle Pleistocene terraces was not discovered despite detailed surveys along the coastal zone during the Bulgarian - Russian expeditions between 1988 and 1990.

The Upper Pleistocene sediments on the Bulgarian shelf are represented by Karangatian and Upper Neoeuxinian deposits. Karangatian sediments are recognised in almost all Black Sea Region. In the core C-5 Yuriy Godin Structure they lie on the Drevneeuxinian sediments. Aleuritic silts enriched with preserved shells and detritus were deposited on top of the Drevneeuxinian sediments. The dominant molluscan species in these sediments are Corbula gibba Olivi, Mytilus galloprovincialis (Lam.), Rissoa parva (Costa), Bittium reticulatum (Costa), Dreissena rostriformis (Desh), Ebali pointeli (M.), Cardium paucicostatum Sow., C. tuberculatum L., Paphia senescens (Coc.), and Nucula nucleus L. The stratigraphic position of the aleuritic-pellitic silts and the molluscan fauna give reason for referring them to the abyssal facies of the Karangatian basin. The abundant presence of Corbula gibba is the main reason for attributing an Early Karangatian age to these sediments. This dating is supported by the geomorphological position of the core in which they occur. It is
found in the Dolna Kamchia Depression of the peripheral shelf zone at a depth of 85 m. In the Bay of Bourgas (Core C-8) is revealed a rather complete section of Karangatian deposits. Three assemblages in super-positional relations are divided: *Corbula gibba – Rissoa parva – Bittium reticulatum* (Lower Karangatian), *Cardium tuberculatum – Paphia senescens* (Middle Karangatian), and *Cardium edule – Bittium reticulatum* (Upper Karangatian) (Khrischev and Shopov, 1979).

Evidence for the existence of the Karangatian transgressive complex and its correspondence with the interglacial Riss-Würm (Eemian) is found along the Black Sea coast: on terraces at an elevation of 8-12 m (Fedorov, 1963; Popov and Mishev, 1974); in Varna region on terraces at elevation of 10-15 m, and on the right side of the Fandakliiska River on terraces at an elevation of 7-8 m (Krastev, *et al.*, 1990a). Sediments with stenohaline Mediterranean molluscan species characteristic of the Karangatian horizon (*Cardium edule var. umbonata* Wood, *Ostrea edulis* L., *Cerithium vulgatum* L., and others) were also found on the shore of the Varna Lake at a depth of 12 m. The presence of these species which could be found at present only in the Mediterranean Sea and especially the presence of the Karangatian fossil species *Tapes calverti* L. confirm the Karangatian age of these sediments (Kojumdgieva, 1962; 1964; Fedorov, 1982). The radiocarbon analysis of the shells of *Tapes calverti* and *Ostrea edulis* shows the age of 30200±950 yr bp and 39100 ± 900 yr bp respectively (Semenenko, *et al.*, 1976). Close to these dates is the radiocarbon date of 37800± 2200 yr bp obtained from the Karangatian sediments of the western coast of the Kerch Strait (Kaplín, *et al.*, 1977). Unconformity of age determination of one and the same Lower Karangatian (Tobechicskiyan) sediments from the core near the village of Geroevskoe (former Eltigen) was cited by Zubakov (1987). The age of 25700 and 36900 yr bp was yielded by the radiocarbon method, while the age of 57920±500 yr bp – by the Uranium/Thorium method. Palaeomagnetic investigations suggest an anomalous magnetic horizon in the Karangatian sediments comparable with the Blake Episode dated at 127000±8900 yr bp and 125000±5000 yr bp (Krastev, *et al.*, 1990b; Dodonov, *et al.*, 2000). Evidently, all the radiocarbon dates of the Karangatian sediments (usually in the time span of 42000 – 27000 yr bp) are significantly younger and do not show their real age (146000 – 62000 yr bp) cited by Arslanov, *et al.* (1983) and Chepalyga (2002). Probably the differences are connected with the dating method applied.

The palynologic data from the Karangatian sediments along the mouth of the Kamchia River show that during that period the northern part of the Bulgarian Black Sea coastal zone was covered with mixed oak forests. The presence of *Fagus* and *Juglans* shows that the climate was warm and humid (Bozilova and Djankova, 1976). Similar pollen spectra with predominance with broad-leaved arboreal taxa *Quercus*, *Carpinus betulus*, *Ulmus*, and *Fagus*, as well as *Pinus* are established in deep-water sediments of the Black Sea (Koreneva and Kartashova, 1978; Traverse, 1978; Koreneva, 1980) and in western Georgia (Mamatzashvili and Khazaradze, 1973; Tzereteli and Mamatzashvili, 1975).

A comparison between the CSP data from the Nanevska and Elizavetinska Structures allows the Post-Karangatian (Würm) erosional surface to
be traced. Evidence for the lateral shelf expansion is a wedge-like accumulative body genetically connected with the marginal part of the erosional surface and distinguished on the seismograms as a platform steeply tilted towards the abyssal plain (Figure 3b). The absolute depth of the surface of the Post-Karangatian deposits ranges from -30.6 m in the Bourgas Bay to -82.1 m in the region of the Moesian Platform. Their lower horizon reaches -93 m depth in the Dolna Kamchia Depression. The transition of the Post-Karangatian layers in the Bourgas Depression from continental to marine facies is observed on the seismo-acoustic and geological profiles. The sediment thickness ranges from 4-8 m to 10-12 m. East from Core 4 the low-amplitudes and undulating reflections of the records suggest that coarse Post-Karangatian alluvium might be present (Limonov and Krastev, 1990).

Upper Neoeuxinian marine deposits are found below the 30 m isobath in almost all cores on the shelf. In the peripheral shelf zone these deposits are represented by shell detritus, anDaleuritic and clayey silts with a thickness from several centimetres to one meter, which form clearly defined depositional bodies of coastal or barrier type at a depth of 100-120 m (Khrischev and Shopov, 1978). These sediments record the lowest level of the Neoeuxinian Basin.

In the central shelf zone the Neoeuxinian deposits are essentially different in both thickness and composition. According to the CSP data their thickness reaches 31 m within the Aprilska Structure area. In the other regions it ranges between 2 and 12 m inwards and outwards from the central shelf the sediment thickness decreases and wedges out completely. On the seismograms the Neoeuxinian layers are distinguished by poor undulatory stratification characteristic of continental deposits and near-shore marine sediments. Their extent is delimited by the 30 m isobath.

In Core C-3 of the Aprilska Structure the Upper Neoeuxinian deposits cover the Usunlarian sediments transgressively. They are represented by aleuritic and pellitic silt, uniform with obscure stratification and enriched with detritus, which appears as an important component for their lithification. In Core C-2 of the Northern Structure and Core C-3 of the Samotino Sea structure the sediments are clayey and sandy. The Upper Neoeuxinian sediments are referable to the sediments deposited during the Late Pleniglacial (22000-18000 cal. yr BP), the Late Glacial (18000-11500 cal. yr BP), and the Early Holocene (11500-8800 cal. yr BP). In the Bulgarian Black Sea region the Late Glacial sediments are dated to 14610±200 yr bp (17490 cal. yr BP) and 11430±330 yr bp (13340 cal. yr BP)(Dimitrov, 1982). The most characteristic of the Upper Neoeuxinian faunal complex are the fresh-water Caspian molluscan species *Dreissena rostriformis distincta* Andrus. and *Monodacna caspia* Eichwald. The complex also comprises *Dreissena polymorpha regularis* Andrus and *Clessiniola variabilis* Eichw. The presence of the euryhalinous Mediterranean species *Cardium edule, Paphia rugata* should also be noted, because it marks the deposition of sediments at the end of the Neoeuxinian during the Neoeuxinian transgression.

The pollen spectra show the domination of herb communities over arboreal vegetation. The Pleniglacial and the stadials of the Late Glacial are clearly represented by the spread of cold steppe with a predominance of species
of Artemisia, Chenopodiaceae, Poaceae, and many other taxa of Asteraceae. Stands of Pinus, Betula, Quercus, and Corylus were present among the herb communities. Probably the stands of Pinus occupied the higher parts of the coastal plateaux, where the conditions were more favourable for the growth of trees because of increased atmospheric humidity. According to Niklewski and van Zeist (1970) during the glacial not just low temperatures but primarily low humidity was a limiting factor for the development of arboreal vegetation. The composition of the pollen spectra suggests a driest and coldest climate during the Younger Dryas Stadial of the Late Glacial (13000-11500 cal. yr BP), recognized everywhere in Europe as an episode of pronounced cooling (Berglund, et al., 1994; Walker, et al., 1994). The presence in considerable quantity of Pinus diploxylon-type pollen showing two maxima in the Neoeuxinian sediments is probably connected with the spread of Pinus nigra forests onto the lower terrain together with some deciduous taxa: Quercus, Carpinus betulus, Ulmus, Corylus, Tilia, Betula etc. during the interstadials of the Late Glacial - Bølling (15500-14000 cal yr BP) and Allerød (14000-13000 cal yr BP). Some authors (van Zeist, et al., 1975) consider that the spread of the pine forests during the Late Glacial was probably stimulated by the temporary climatic improvement and especially by the humidity rise. During the Late Glacial Artemisia and Chenopodiaceae were largely represented in the terrestrial and lacustrine depositional environment of southwestern and northern Turkey (Bottema et al., 1994), northwestern Greece and Central Europe (van Zeist, et al., 1975) as a result of prevailing cold and dry conditions. Palynological record from the deep basins of the Marmara Sea also suggest high abundance of Artemisia and Chenopodiaceae and cold and dry climate during the Late Glacial (Ganer and Algan, 2002).

The Neoeuxinian sediments are also characterized by a unique dinoflagellate assemblage that consists of two species, Spiniferites cruciformis Wall and Dale, and Tectatodinium psilatum Wall and Dale. This assemblage is similar to the fresh-water to brackish-water New Euxinic Stage assemblage (Unit 3) of Wall and Dale (1974) and to dinocyst assemblage zones B2 and B1c (Mudie et al., 2004). The low diversity is comparable to that stated by Wall et al. (1973) and Mudie et al. (2001;2002). The assemblage is associated with surface sea salinities of less than 7‰ (Deuser, 1972; Wall and Dale, 1974; Mudie, et al., 2001), while Chepalyga (2002) indicated a lower salinity (less than 5‰). According to Wall, et al. (1973) Spiniferites cruciformis and Tectatodinium psilatum are cool-water, low salinity stenohaline species which were common in Late Glacial to Early Holocene sediments. Spiniferites cruciformis also occurred in Late Glacial sediments from the Lake Kastoria, northern Greece (Kouli, et al., 2001) and in brackish-water in the Caspian and Aral Seas (Fabienne, et al., 2003). Most probably the presence of these species is connected with the influx of glacial melt water from the Russian Platform and the Carpathian Mountains (Stanley and Blanpied, 1980; Aksu, et al., 1999; Chepalyga, 2002). The disappearance of cysts of Spiniferites cruciformis and Tectatodinium psilatum in the western Black Sea shelf sediments is dated to 6880±240 yr bp (7650 cal yr BP)(Filipova– Marinova, 2003a) and in sediments from the continental slope to 6135±75 yr bp (7010 cal yr BP)(Atanassova, 1995). Mudie et al. (2001) consider
that the virtual disappearance of *Spiniferites cruciformis* and *Tectatodinium psilatum* suggests the inability of these stenohaline taxa to survive an apparently abrupt salinity change to values of 10-12‰ (Deuser, 1972) or 18‰ (Wall and Dale, 1974). It could be also be explained with the low temperature tolerance of these taxa. Although an abrupt climatic change could result in such a pattern it can also result from unconformity and erosion in the sediments indicating a hiatus because the latest \(^{14}C\) date of Neoeuxinian sediments is 10670 yr bp (12601 cal. yr BP) and the earliest date of Early Holocene is 8080±20 yr bp (8984 cal. yr BP)(Dimitrov, 1982). According to Khrischev and Georgiev (1991) the established regional erosion affects mainly the sediment layers deposited near the Pleistocene/Holocene boundary and correspond to the drastic change in the hydrological regime during the fast sea-level rising and establishing the connection with the Mediterranean. This hiatus shows that the shelf of terrestrial sediments was exposed and eroded at the time of low sea-level and that it was after then flooded by sea-water at some time before 6880±240 yr bp (7650 cal. yr BP).

First single cysts of euryhaline dinoflagellate species *Lingulodinium machaerophorum* (Deflandre and Cookson) Wall and acritarch *Cymatiosphaera globulosa* Takahashi appeared at about 9000 yr bp (10000 cal yr BP)(interpolated date) in the estuary of the Veleka River (Filipova–Marinova, 2003b) and at 9630±540 yr bp (10890 cal. yr BP) in deep-water sediments (Filipova et al.,1989). In shelf sediments they appeared at about 6800±240 yr bp (7650 cal. yr BP)(Filipova–Marinova, 2003b). Wall and Dale (1974) consider that the outflow from the Black Sea to the Marmara Sea was sufficient to prevent marine organisms from entering in large numbers until 7000 years ago when the influence of melt water had declined substantially. According to Chepalyga (2002) the postglacial increase of the Black Sea water level continued until 9000 – 8000 yr bp (10000-8800 cal. yr BP) as a result of the postglacial transgression of the World Ocean that prevent the fresh water outflow from the Black Sea. In some Black Sea cores oxygen isotopic measurements on calcite carbonate suggested the salinity of Black Sea about 5-7‰ during the Early Holocene, while ion diffusion studies (cited by Deuser, 1972) indicated a salinity of ~3.5‰ from 20000-8000 yr bp (22000-8800 cal. yr BP). But most probably an accidental ingress of the Mediterranean sea-water through the Bosphorus also occurred, proved by the finds of single specimens of the euryhaline gastropod species *Hydrobia ventrosa* together with mollusc species *Cardium edule* and *Mytilaster lineatus* (Gm.in L.), single cysts of euryhalinous dinoflagellate cysts *Lingulodinium machaerophorum*, and acritarchs *Cymatiosphaera globulosa* at some levels between 9000 yr bp (10000 cal. yr BP) and 8355±75 yr bp (9380 cal. yr BP) in the core of the Veleka River (Filipova–Marinova, 2003b). The appearance of larvae of *Cerastoderma edule* and some other marine species along the Caucasian shelf during the Early Holocene is also registered (Chepalyga, 2002). This is the difference between the Neoeuxinian sediments related to the Pleniglacial and that related to the Early Holocene. Surface-water circulation dominated by southward export of Black Sea surface waters with little northward
penetration of Mediterranean surface water across the Bosphorus since ~10500 to 6000 yr bp (12400 to 6800 cal. yr BP) is cited by Aksu, et al (2002).

At the boundary Early/Middle Holocene an influx of Mediterranean saltwater and abrupt change in biota occurred. Old Black Sea sediments are characterized by a heterogeneous mechanically formed thanatocoenosis with re-deposited Neoeuxinian Caspian molluscan species (Dreissena rostriformis distincta, Monodacna caspia pontica Eichwald), Mediterranean immigrants (Cardium edule, Hydrobia ventrosa), marine euryhalinous species inhabiting waters with a salinity close to that of today (Mytilus galloprovincialis, Cardium exiguum Gmel., C. papillosum Poli), and contemporary stenohalinous species (Spisula subtruncata triangulata Ren., Pitia rudis Poli, Chione gallina Linne, Nassa reticulata Linne, Scala communis Lam.). There is a change in the dinocyst assemblages after 7600 yr bp (8368 cal. yr BP). The considerable presence of the typical marine euryhalinous species Lingulodinium machaerophorum and the acritarchs Cymatosphaera globulosa show that the salinity of the seawater was higher than it is today. According to some authors (Degens and Hecky, 1973; Wall and Dale, 1974) this can be attributed to influx of saline water, a slowing down in the rate of the sea-level rise, slow overflow of the shelf areas, and considerable improvement of the climate. Ryan, et al. (1997; 2003) proposed, based on evidence that salinification in the Black Sea did not start until 7150±40 yr bp (7921 cal. yr BP), that post-glacial connection between the Mediterranean and the Black Sea occurred as a catastrophic flood of saline water into the Black Sea that rapidly inundated the basin.

Palynological data allows more detailed palaeoecological reconstructions. Unfortunately, because of the unconformity and erosion of sediments at the Pleistocene/Holocene boundary along the western Black Sea shelf palynological data about vegetation dynamics during the Early Holocene are scarce. They came mainly from the investigated cores of the continental slope, abyssal plain and the estuary of the Veleka River (Southern Bulgarian Black Sea coast). The Preboreal and Boreal chronozones (11500 - 8800 cal yr BP) are characterized by the spread of xerophytic herb communities and the rapid migration of arboreal taxa (Pinus, Betula, Quercus, and Ulmus) that survived the severe conditions of the Late Glacial in nearby refugia in the Strandza Mountains (Atanassova and Bozilova, 1992; Shopov, et al., 1992; Filipova-Marinova, 2003b). The first increase of deciduous arboreal pollen is dated at 9630±520 yr bp (10890 cal. yr BP) in sapropel muds from the deep-water part of the western Black Sea (Filipova et al.,1989) and at 9945±160 yr bp (11040 cal. yr BP) in the estuary of the Veleka River. Warming of climate and increase of arboreal taxa from 10737±315 yr bp (12670 cal. yr BP) is also suggested by Shimkus et al.(1977) and Komarov (1983). The distribution of open mixed oak forests during the Preboreal was probably stimulated by the temperature rise and the persistence of the dry continental climate. In addition to Quercus several thermophilous taxa were present in those forests: Ulmus, Tilia, Fraxinus excelsior, Acer. The climatic improvement during the Boreal caused a gradual replacement of the xerophytic herb communities by trees, mainly Quercus, Ulmus, Corylus, and Tilia.
During the Atlantic chronozone (8800 – 5800 cal yr BP) the optimum climatic conditions (high temperature and humidity) were favourable for extensive spreading of the mixed oak forests, the main components of which were \textit{Quercus}, \textit{Ulmus}, \textit{Tilia}, \textit{Fraxinus}, and \textit{Acer}. The most characteristic feature of the coastal zone is the increase of \textit{Carpinus betulus} at 5770±105 yr bp (6560 cal. yr BP) in the area of the Arkutino Lake (Bozilova, Beug, 1992) and at 5650±100 yr bp (6420 cal. yr BP) in the area of the Shabla-Ezeretz Lake (Filipova, 1985). In addition to being part of the mixed oak forests \textit{Carpinus betulus} also formed separate communities at higher altitudes and on northern slopes. In the eastern Stara Planina Mountains hornbeam formed a separate belt (Filipovitch, 1987). The areas occupied by \textit{Fagus} were also enlarged. During that period steppe vegetation was only preserved in the coastal area of South Dobrudzha due to the insignificant increase in humidity, which could not compensate for the rise in temperature and the desiccating effect of the wind. Even during the climatic optimum only steppe forest vegetation existed in this region while in the nearby area of the Srebarna Lake there were mixed oak forests (Lazarova, Bozilova, 2001).

According to the archaeological chronology (Todorova, 1981) the Late Atlantic could be referred to the Eneolithic (6420 - 5910 cal yr BP). Human impact was significant and influenced the natural forest vegetation along the western Black Sea coast (Bozilova and Filipova, 1991; Bozilova and Beug, 1994; Filipova–Marinova and Bozilova, 2003). It is reflected in the pollen diagrams of the coastal lakes in a decrease of arboreal taxa and the presence of cultivated cereals such as \textit{Triticum} and \textit{Hordeum} and of some weeds and ruderal plants such as \textit{Plantago lanceolata}, \textit{Polygonum aviculare}, \textit{Urtica}, and \textit{Centaurea cyanus}. There is no doubt that the degradation of the mixed oak forests during that time is connected with agriculture as well as with the increase in population.

Changes in the forest composition are observed during the Subboreal chronozone (5800-2600 cal yr BP). The most characteristic feature is the significant presence of \textit{Carpinus betulus} and the decrease of \textit{Ulmus}. \textit{Carpinus orientalis} increases, marking the beginning of destructive human activities during the Early Bronze Age (4870-3990 cal yr BP) (Bozilova and Beug, 1994; Bozilova and Tomkov, 1998; Filipova–Marinova and Bozilova, 2003). A humidity increase is observed during the beginning of the Subatlantic chronozone (2600-0 cal yr BP). This is seen in the increase of \textit{Alnus}, \textit{Salix}, and \textit{Fraxinus excelsior} pollen and the formation of flooded forests along the mouths of the rivers running into the Black Sea, dated to 3185±100 yr bp (3380 cal. yr BP)(Bozilova, Beug, 1992). Beech (\textit{Fagus}) forests were spread into the higher regions and into wet ravines. This last stage of vegetation development is connected with the formation of the contemporary plant communities along the coastal zone.

**CONCLUSIONS**
The Quaternary sediments can be subdivided by molluscan, pollen, and dinoflagellate assemblages, characteristic of the Tschaudinian, Drevneeuxinian, Usunlarian, Karangatian, Neoeuxinian, and Black Sea layers. Pollen record reveals the existence of 9 pollen assemblage zones related to Pleistocene/Holocene palaeoclimatic changes - distribution of steppe vegetation during the glacials (Tschaudinian, Drevneeuxinian, and Neoeuxinian), increase in *Pinus* during the Usunlarian and stadials of the Late Glacial (Bølling and Allerød), forests during the interglacials (Karangatian and Holocene). Fluctuations of salinity occurred and the sea-level passed through the stages of marine (Karangatian), brackish-marine (Usunlarian and Holocene), brackish (Tschaudinian and Late Drevneeuxinian), and fresh-water (Neoeuxinian) basins. Enclosed basin existed during the regressive maxima of the Neoeuxinian when the coastline reached to – 100 – 120 m. Sea-level changes were mainly due to the periodic connection with the Caspian and Mediterranean Seas and regional climatic and hydrological processes.

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