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SAPROPELIC, DIATOMACEOUS AND COCCOLITH SEDIMENTS (UNITS IB, IA) OF THE BLACK SEA BOTTOM – GENESIS, COMPOSITION AND PROPERTIES

Holocene Black Sea basin sediments were formed in our opinion in happened geocatastrofic event on the border Pleistocene–Holocene (8–9 thousand years ago). As a result on the Upper Pleistocene lake sediments occur organogenic-mineral (sapropel diatoms and coccolith) marine sediments. The characteristic features of happened catastrophe is the occurrence of hydrogen sulfide charging that conserved the organic matter and protect it from decomposition. Chemical composition and properties of deep-water organogenic - mineral deposits give us reason to Tip of the raw material as an integrated multi-purpose and most notably in agriculture.

The Kalamitian – Vityazevian, Oldchernomorian, unit 2 (Ib) layers in the deep parts of the sea are represented by the so called sapropelic sediments. The term sapropel comes from the Greek *saprós* – rotten and *pëlós* – ooze and was first used by R. Lauternborn in 1901 to designate sediments from lakes rich in organic material and smell of hydrogen sulfide. Lithologically they are very well separated along the contrasting erosive lower and transitional upper boundary with unit 1a (fig. 1). Sometimes they make a transition from the Neoeuxine Ic through a thin “intermediate” layer but in most cases they lie on the erosive surface of unit Ic – carbonate ooze of the seekreide type.

There are also cases when the erosion goes too deep and the sapropels lie immediately on formation 2 – black pelitic ooze with autogenous iron sulfides. The colour of the sediments ranges from dark green to brown. The bulk density of the sediments varies from 1,25 g/cm^3 to 1,30 g/cm^3. The organic matter in the sapropels varies widely from 3–4 to 18–20% . There is a direct correlation between the content of $C_{org.}$ and the depth of the sea. The content of $C_{org.}$ grows with the increase of the depth (fig. 2.).

The sapropels form a single horizon with constant thickness typical of the Black Sea basin. Analogues of the sapropels on the shelf and the upper part of the continental slope are the green aleurite-pelitic oozes with accumulation

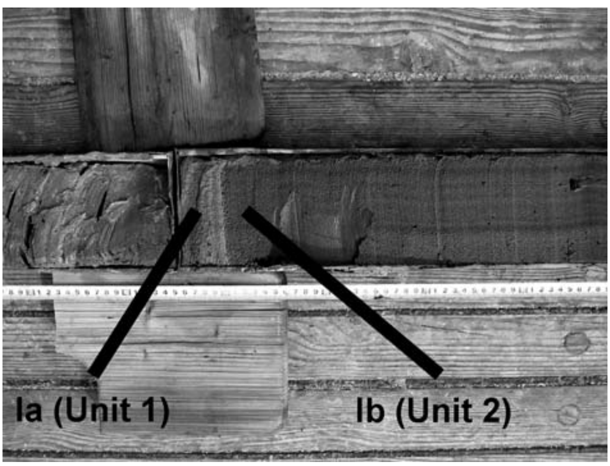

Fig. 1. Contrasting lithological varieties on the borderline of Ia (Unit 1) – Ib (Unit 2)

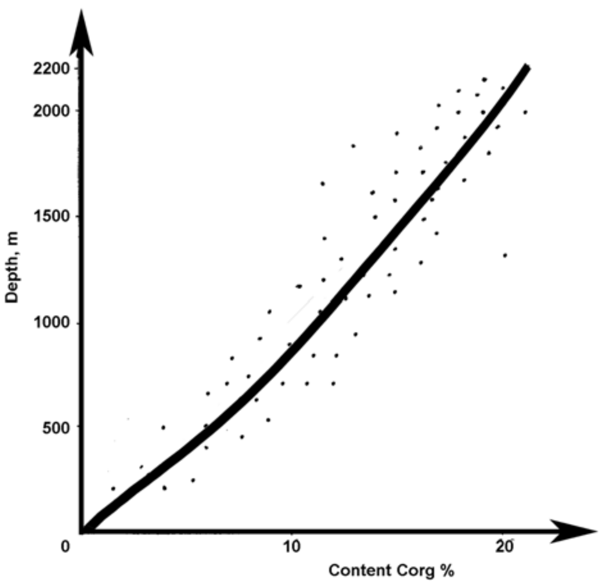

Fig. 2. Distribution of $C_{org.}$ in the sapropels depending on the depth (Dimitrov, Velev, 1988)

of plant detritus and decomposed shells of *Mytilus galloprovincialis*. The transition from aleurite-pelitic oozes to sapropels is facial. The organic matter in the sapropels is of heterogenous origin. They are composed primarily of planktogenic organisms (about 80%) and continental organic matter (20%). The planktonic organisms are well preserved in most cases under the conditions of the hydrogen sulfide zone. The main components of the sapropels are the dinoflagellate cysts, diatom algae, coccolithophorids, peridinea.

The main components of the sapropels are the dinoflagellate cysts, the coccolithophorids, the peridinea. There are frequent occurrences of mass concentrations of fish skeletons. We should also note the high biological productivity of the phytoplankton reaching sometimes 50 g/m^3 but does not exceed 0,7 g/m^3 on average (Morozova-Vodyanitzkaya, 1954; Morozova-Vodyanitzkaya, Belogorskaya, 1957; Сорокин, 1982; Moncheva, 1991, 1992; Moncheva, Velikova, 1999). The dinoflagellates and the diatom algae are particularly developed in the sediments and most widespread in the sapropels are *Peridinium triguestrum*, *Rhizosolenia alata*, *Chaetoceras curvisaetus, Chaetoseras /Spores/* where the latter species represent 70% of all diatoms in the sapropels. Fig. 1. shows the leading complex of diatoms for the sapropels that is almost the same for the Holocene. Analogical species of diatoms also occur in the suspended matter. The admixture of terrigenous organic matter coming from the continent composes up to 20% of the total volume of the organic matter and is represented by small plant detriturs, spore-pollen grains and other matter. A typical reference layer for the Black Sea is the coccolithophorid algae *Braurudosphaera bugelowi*.

The same reference layer affects the “intermediate” layer forming 2–3 interbeds with thickness of 2–5 mm fixing the foundation of the typical sapropel. In one of the best studied drill columns located in the abyssal area at a depth of 2100 m (C-544) the lower part of the sapropel lies with an erosion layer above the Neoeuxinian muds of the seekreide type (fig. 3.). The upper part of the sapropel horizon and the beginning of the coccolith interbeds (interval 60–70 cm) is dated at about 5 thousand years.

The reference layer itself indicates the beginning of the inflow from the Mediterranean as accepted by many researchers (Ross, Degens, 1974; Shterbakov, 1978; Kuprin et al., 1984) whereas Georgiev (1984) insists that it marks the beginning of the hydrogen sulfide contamination. The accumulation

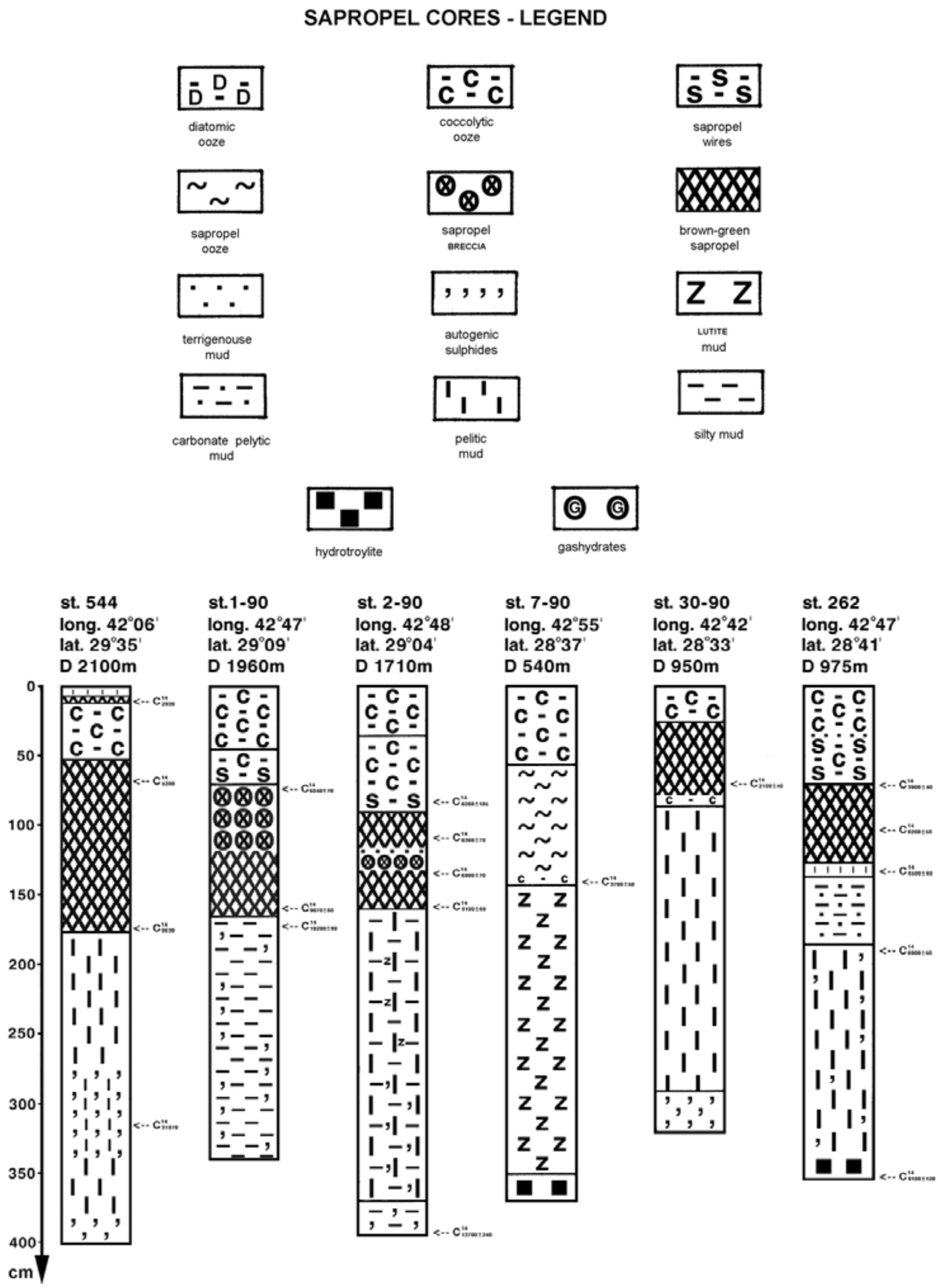

Fig. 3. Cross-sections of deep sea organogenic mineral sediments

of sapropels testifies to a biogenous sedimentation with catastrophic parameters. The paleogeographic picture of the formation of biogenous sediments of such exceptional scale would look like as follows:

· The climate warmed up sharply after a prolonged Wьrmian glaciations fixed within the interval of 10–70 thousand years.

· The level of the World Ocean that was lower by 120–130 m than the modern level 18–20 thousand years ago rose and the inflow of Mediterranean

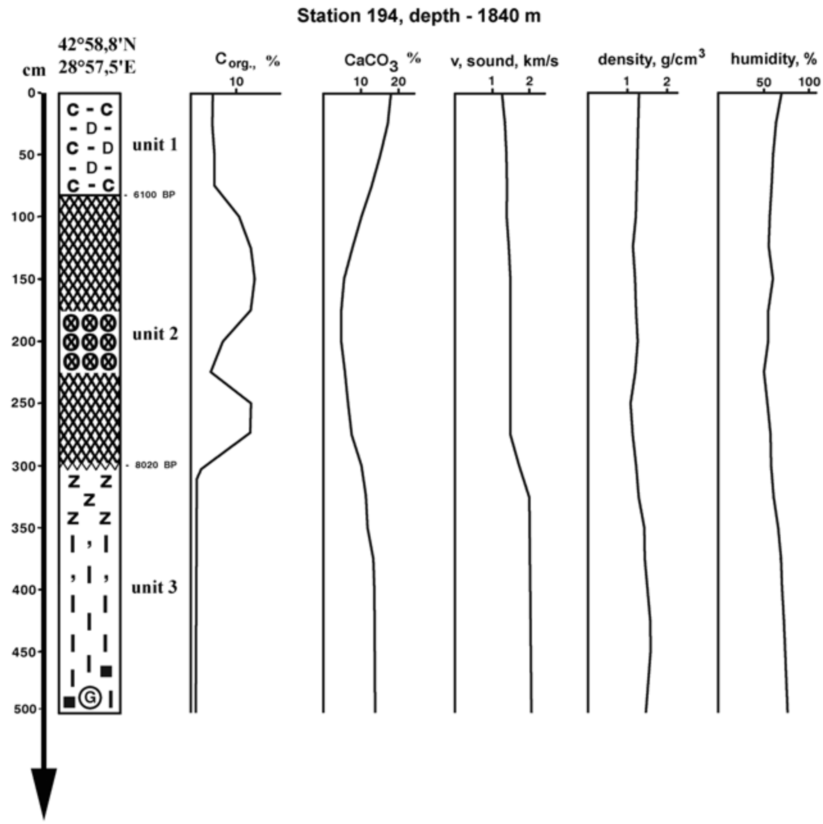

Fig. 4. Lithologic cross-section and main physical and mechanical parameters of C-194, (Dimitrov, 1990), the symbols are the same as in fig. 3

water with salinity of 36–38‰ began through the Bosphorus threshold about 8 thousand years.

At that time the Black Sea was a lake with brackish to freshwater with salinity of about 5–6 ‰ within the boundaries of the Neoeuxinian basin at present-day depths of 90–120 m. The inflowing Mediterranean water about 8 thousand years ago (this event was fixed in C-544 fig. 3.) were more saline and heavier, rich in biogenous components, filled the deep water valley and mixed with the substantially less saline Black Sea water. The consequences of this event were catastrophic for the flora and fauna and this triggered the sedimentation of organogenic mineral oozes with thickness from 45–50 cm to 1–2 m (fig. 3, 4). The sapropels have different thickness in the different morpholithological zones. They are often absent from the continental slope, the slopes and axes of the underwater valleys due to active sliding processes. They are better preserved in the flat places where their thickness reaches 45–60 cm. The thickness of the sapropels is most substantial at the foot of the continental slope, where they reach up to 2 m (fig. 3, 4). The processes of redeposition and brecciation are strongly expressed at the foot of the continental slope (Chochov, 1984; Velev, Dimitrov, Feier, 1992;). Brecciated sapropel often occurs also in the abyssal area particularly around the craters of mud volcanoes (Dimitrov, 1990) (fig. 3, 4).

Particularly strong is the effect of the suspension currents formed in submarine valleys creating a unique cone-like train at the foot of the slope and in the abyssal bottom as well as various picturesque forms of the redeposited material.

Generally, two types of sapropel are distinguished in the cross-sections on the basis of the lithological data. The typical sapropels are micro-layered dense brown-green sediments with “rubber-like” appearance and sectility by layers. In most cases they are permeated by finely dispersed pelite terrigenous mud with thickness of the layers up to 5–6 cm indicating a temporary change of sedimentation conditions. The thickness of the so called typical sapropel is widerly variable – from 15–20 cm to 1 m. The typical sapropels are covered by an amorphous watered sapropel mass with thickness within 30–70 cm. The binomial of the sapropels points to a change in the regime of sedimentaiton and gradual loss of organic matter from bottom up.

The studies of the organogenic component of sapropels show that the nanofossils with organic shell consist of pollen, spores and dinoflagellate cysts (Filipova et al, 1989).

The major component of typical sapropels are the dinoflagellate cysts with organic shells which are not dead fossils but stages of the life cycle of groups of phytoplanktonic organisms (*Pyrrophyta*) and often exceed the amount of coccoliths and diatomea. The sapropels comprise the typical marine euryhaline species *Lingulodinium machaerophorum* and the *acritarchs Cymatiosphaera globulosa* while their appearance indicates a catastrophic change in the temperature of the Black Sea (Coolen et al., 2009). These species are dominant also in the content of modern phytoplankton. Deuser (1974); Traverse (1978); Filipova et. al. (1983) suggest that the sudden disappearance of the freshwater species *Spiniferites cruciformis*, *Testatodinium psilatum* and the appearance of marine microfossils is due to the catastrophic change in the salinity of the basin. Khrishev, Georgiev (1981) established a drastic change of the hydrological and sedimentation regime of the shelf on the basis of the erosion effects on the Pleistocene-Holocene boundary. According to them the Neoeuxinian sediments and their continental analogues were were eroded as a result of the sudden inflow of marine water before 6800 BP. The considerable hiatus of the shelf as well as of the continental slope and the abyssal bottom is due exclusively to the substantial erosion of sediments as a result of the catastrophe. The human presence at that time is disclosed by the presence of cereal pollen such as *Centaurea cynua* (corn-flower), *Plantago lanceolata* (narrowleaf plantain) и *Polygonum aviculare* (common knotgrass) (Filipova-Marinova, 2003).

The mineral component of sapropel mud is represented by a polycomponent mixture of clayey minerals. It is dominated by illite and montmorillonite and smaller amounts of chlorites and kaolinite (Chochov, 1990).

They are sparsely dispersed with single grains of quartz, feldspar, volcanic glass and others. The carbonate minerals are represented mainly by calcite with low content of magnesium and by dolomite, calcite (Georgiev, 1984).

The studies of the distribution of heavy metals in the fraction 0,1–0,05 mm shows anomalous concentrations mainly in the distribution of pyrite-markasite.

The main sediment-forming product in sapropels is the minerals of the pelite fraction that are the successors of the litute in the Neoeuxine basin (Butuzova et al. 1975; Ruskova, Georgiev, 1985; Ivanov, Ruskova, 1986). At the same time, the catastrophic increase in the biological productivity at the beginning of the Holocene led to "dilution" of lutite with considerable amounts of organic matter and formation of a new type of sediments – sapropels.

The content of organic matter is dominated by aliphatic and alicyclic compounds (Vassoevich, 1986). Imprints as well as their mass accumulation of oak leaves (Q*uercus*) and hornbeam leaves (*Carpinus betulus*) are often found in the sapropel layers which shows presence of continental organic matter in sapropels. This is also evidenced by the admixture of structureless dispersed autochthonic organic matter related to the humus. The latter is characterized by high-molecular compounds of condensed and partially hydrated aromatic compounds. This means that the organic matter in the sapropels is heterogenous and consists of a mixture of alochthonic and autochthonic organic matter. It is characterized by high content of easily hydrolyzed substances (12,7–31,7%), bitumoids (2,3–3%), humic acids and relatively high content of insoluble organic matter (56,3–58,1%) (Shterbakov et al., 1978).

The obtained data indicate high content (up to 19,407 мg/g) of amino acids in the composition of sapropels which corresponds to 6,3% of the organic matter (Shnyukov et al., 2003). Many organic compounds related to the normal and isoprene carbohydrates such as pristine, phytane, alkanes, three- and tetraterpenes, as well as carotenoids, carboxylic acids, fatty acids including palmitinic acid, pigments of the chlorophyll group (pheophytin and chlorophyll) were established in the sapropelic sediments. Most of them (vitamins, antibiotics, hormones) are biologically active substances. Interbeds of accumulated fish bones are very often found in the sapropels where the content of P_2O_5 reaches 2,15%, while its content in the overall sapropel mass is 0,12%.

The micro- and macrocomponents of the sapropels are very specific and are a product of the interaction marine environment - hydrogen sulfide contamination – organic and terrigenous component.

The concentrations of the main components (without $C_{org.}$) varies widely: SiO_2 20–50%; $SiO_{2amorph.}$ – 0–10%; Al_2O_3 – 5–16%. The total amount of Si and Al in the red clays, the sapropels and the coccolith oozes have a ratio of 1:0,55:0,23 while their amount in the terrigenous material has a ratio of 1:0,66:0,32 (Gavshin et al., 1988). A slight increase of the average content of Na_2O (2,05%), CO_2 (1,98%), P_2O_5 (0,12%) is registered in the sapropel horizon. The concentrations of Fe, Mn, Ti in the sapropels are close to their content in the sediments lying below (Neoeuxinian – 1c) and above (Oldchernomorian and present-day - 1a+1b)

There is some increase of the content of S-1% and Cl-2,04% in the sapropels which is correlated to the content of $C_{org.}$. All types of sapropelic sediments have a stable content of more than 20 microelements. Some of them (Mo, U, Cu, Zn, Ni, As, Se, Au, Ag and others) often exceed their clarke values in the rocks, the sediments and the soils.

The geochemical features of the different types of sapropelic sediments were established on the basis of the indicative ratios of the oxides: SiO_2/

AL_2O_3, Na_2O/K_2O, FeO/Fe_2O_3 on the asis of the correlation analysis (Blokhina, 1994).

The correlations of AL_2O_3 with K_2O (0.96), MgO (0.81), Fe (0.54), indicate the terrigenous origin of K, Mg and Fe, which migrate in the structure of the silicates. The ratio SiO_2/AL_2O_3 shows predominance of the terrigenous sedimentation in the process of sapropel formation. The same is indicated by the ratio Na_2O/K_2O that changes from 0,62 to 1,74. The lower values show a higher degree of accumulation of the terrigenous component, and the higher values – a leading role of the biogenous sedimentation.

What is typical of the sapropels in the western part of the Black Sea is the dilution by clayey matter and the leading role of the pelite fraction. In conclusion, it should be noted that the mineral composition of the clay component of the sapropels is determined both by the type of the rocks feeding the western part

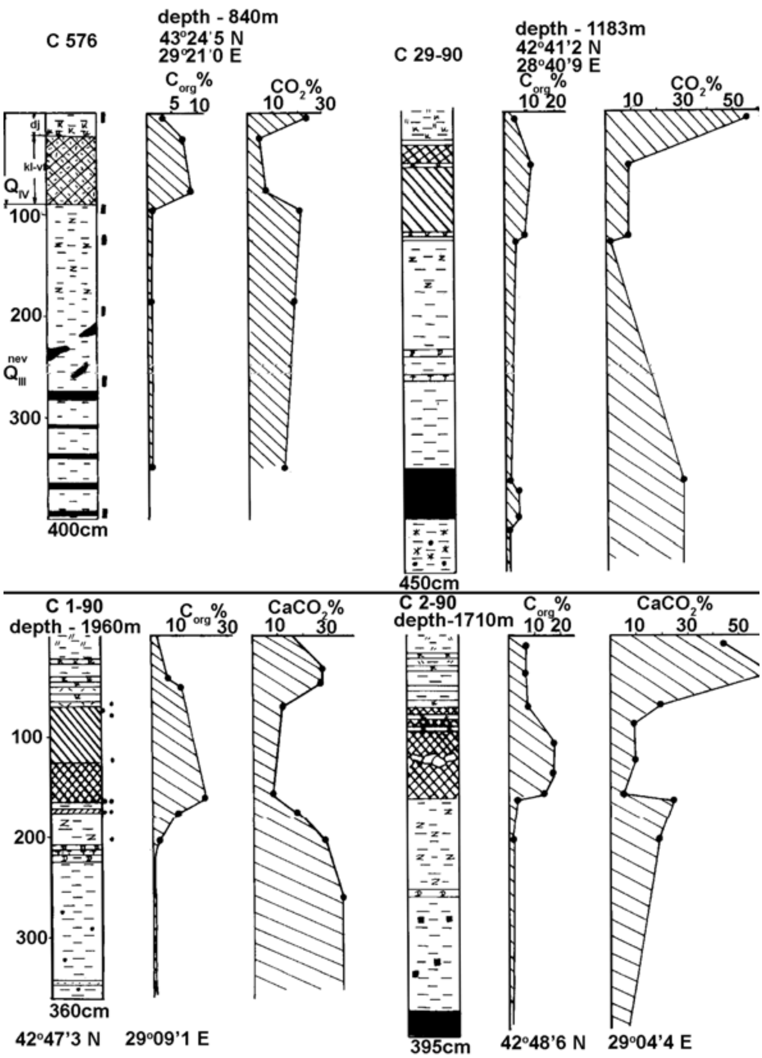

Fig. 5. Lithologic stratigraphic columns and distribution of C_{org}. and carbonates in DSOMS

of the Black Sea and by the material delivered to the bottom by the mud volcanoes.

No estimates have been made so far of the quantity of clayey material delivered by volcano craters yet it could be assumed that its quantity is equal to the quantity of clayey material coming from the land. The terrigenous and endogenic component of the sapropels is a polycomponent mixture of clayey minerals with predominance of illite and montmorillonite and lesser amounts of chlorite and kaolinite. The comparison of the mineral composition of the sapropels sediments with the mineral composition of the sediments lying above them and below them shows that they are closer to the Neoeuxinian lutite than to the diatom and coccolithophorid muds. The sharp rise in the importance of the biogenous component in the sapropels serves as evidence of an ecological catastrophe and a sudden increase in biological productivity. The sapropelic sediments are a product of the dilution of exogenic and endogenic material mixed with considerable quantities of dead biomass.

The organic matter in the sapropels is the majore sediment-forming factor and comprises numerous micro and macrocomponents. The composition of the organic matter differs from the composition of the layers lying above or below by slightly higher content of easility hydrolyzable substances, bitumoids and low content of insoluble residue (Velev, Dimitrov, Feier, 1992). The dispersed amorphous organic matter is composed mainly of planktogenic organisms and bacterioplankton and smaller quantities of continental organic matter.

The sedimentation process during the Holocene is determined by the same factors and analogous sediment complexes that existed during the Karangatian, the Paleogene and the Neogene. They are modern analogues of ancient sediments such as the oil-bearing formations (facies “domanique”) (Velev, Dimitrov, Feier, 1992). In that sense they can serve as a model for reconstruction of the sediment processes during the Cenozoic. The content of carbrohydrates in the sapropels is similar to that of the oil-bearing rocks (Lopatin, Emets, 1987).

The distribution of organic matter in the cross-section of the sapropels shows that the content of $C_{org.}$ is usually higher than that in rubber-like sapropels (fig. 5).

There are also cases where the content of $C_{org.}$ in the upper part of the cross-section is higher than in the middle or in the base. In such cases samples are also taken from the common terrigenous interbeds. The analysis of the current data of content of $C_{org.}$ in the cross-section of the sapropelic ooze s shows stable high content of $C_{org.}$ in the typical dense stratified sapropels. The sapropel horizon is steadily distributed throughout the water area of the basin as shown on the lithofacial map of the Oldchernomorian sediments in unit Ib according to Khrischev et al. (1988) where the facial diversity in the sapropels is well reflected.

The chemical composition of the sapropelic sediments is sharply distinguished from the composition of the underlying carbonate muds (seekreide type) and the coccolith-carbonate Djemetinian muds lying above them. Their content of organic matter varies in a wide range: from 2–3% to 18–20% (fig. 2, 5).

The distribution of organic matter during the different stages of the Upper Pleistocene and Holocene, and more specifically in the Kalamitian sediments,

Table 1

Chemical content of DSOMS
(Dimitrov, Velev 1988; Velev, Dimitrov, Feier, 1992; Shnyukov et al., 1999)

Components	Content (%, from – to)	Average value (%)
$C_{org.}$	3–20	11,5
SiO_2(total)	28–35	31,5
$SiO_{2amorph}$	0–10	5
CaO	1–8	4,5
MgO	2,3–3,15	2,73
K_2O	1.98–2.4	2,19
Na_2O	2,05–2,07	2,06
Fe_2O_3	3,55–5,2	4,57
Al_2O_3	10,4–12,5	11,5
P_2O_5	0,12–0,38	0,25
TiO_2	0,3–0,5	0,4
Chloroform extract at 3% content of C_{org}	0,2–0,5	0,35
Cu	0,01–0,05	0,03

Components	Content (%, from – to)	Average value (%)
Methanol–acetone–benzol extract	0,02–0,04	0,03
Cr	0,01–0,015	0,0125
Mn	0,026–0,047	0,0365
Zn	0,0076–0,094	0,0085
Mo	0,013–0,022	0,0175
Co	0,013–0,018	0,0155
Ni	0,0065–0,0081	0,0073
Li	0,0021–0,003	0,00255
Sr	0,0027–0,0095	0,0061
V	0,0076–0,01	0,0088
Rb	0,013–0,02	0,0155
Se	0,0082–0,0086	0.0084

corresponds to the climatic conditions of the basin (fig. 2). The content of the different components is shown in the table 1 and on fig. 6.

The table shows the considerable variation in the content of the different components depending on the depth distribution of the mud and on the extent of diagenetic changes. The content of sapropels in the Mediterranean (Shimkus, 1981) shows that they are much poorer in organic matter (1.5 – 10%, on average – 5%) irrespective of the similar conditions of their formation.

The organic matter in the sapropels consists of a complex combination of plant and animal products at a different stage of degradation and recombination. Generally, they are divided into bitumoids, hydrolyzable substances, humic substances and unhydrolyzable residue (kerogen).

The chloroform fraction of bitumoids is from 0,2 to 0,5% in dry matter. The bitumoid fractions contain carbohydrates, esters, pigments, organic acids, resins and asphaltens.

The production of chloroform bitumen on the basis of sapropels varies within the boundaries 0,5–2,0% (per dry sample). The chemical composition of the bitumen is the following (mean values): C - 7,3%; H - 10,85%; O_2 - 10,9%; N - 0,8%. The group components of the bitumoid are distributed in the following way: oils - 19–35%; resins - 45–51%; asphaltens - 20–30% (Velev, Dimitrov, Feier, 1992).

The infrared spectra of the bitumoids indicate that their carbon part includes components with linear and branched carbon chains as well as cyclanes. It is interesting that the aromatic carbohydrates are present in very small amounts (traces). The range of normal alkanes comprises components with 14 to 34 carbon atoms and CPI within 1,6-3. The low-molecular carbon part of the

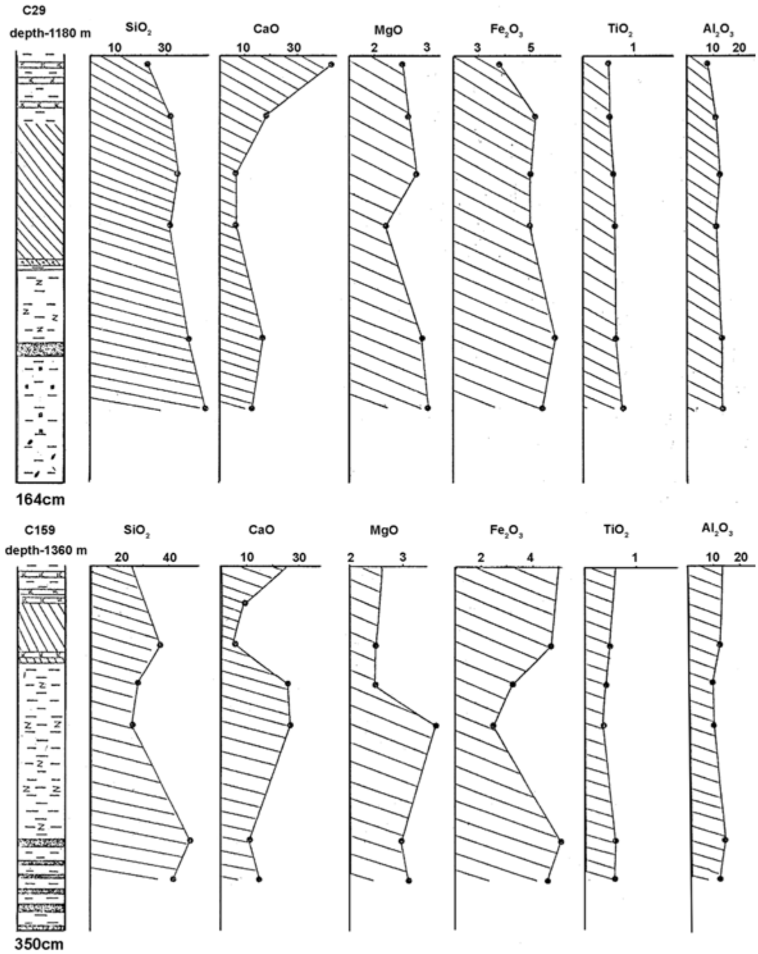

Fig. 6. Distribution of the main components of DSOMS, (Dimitrov, 1990), average value (%), the symbols are the same as in fig. 3

N-alkanes is characterized by CPI values greater than 1. The maximum concentrations of individual N-alkanes is C_{22}, C_{25}, C_{27}, C_{29} and even C_{31}. As a whole the distribution of N-alkanes has highly variable configuration and often has two or three peaks. The ratio between the isoprenoid components pristane and phytane ranges broadly from 0,5 to 1,8 (Velev, Dimitrov, Feier, 1992).

The content of humic acids in the sapropels is low: from traces to 0,8%. The higher indicators are typical of the sediments from the periphery of the shelf and the upper part of the continental slope. The infrared spectroscopy disclosed here the presence of aromatic structures, unlike the case with the bitumoids.

The infrared spectra of the kerogen indicate that, as a whole, the organic matter of the sapropels consists chiefly of aliphatic heterostructures with many oxygen-containing groups characterizing acids and alcohols. The well expressed peak of 1000– 1020 cm^{-1} is correlated to the presence of cycloparaffin structures. What is typical here is the absence of the C=C bond of aromatic rings. Thus it was established that the deep sea organogenic – mineral sediments from the

Table 2. Content of microelements (g/t) in some pelite sediments (Dimitrov, Velev 1988; Velev, Dimitrov, Feier, 1992; Shnyukov et al., 1999)

Microelements	Sapropeloids (Black Sea)	Clay and claystone in the lithosphere	Pelagic red clay	Clays (West Siberia)
V	100–120	130	120	317
Cr	40–110	100	9	160
Co	18–20	20	74	25
Ni	80–100	95	225	173
Cu	50–70	57	250	109
Ga	30	30	20	11
Sr	200–430	450	180	156
Zr	70–90	200	150	210
Mo	80–250	2	27	66
Pb	13	20	80	17
U	14	3,2	1,3	–

seafloor of the Black Sea contain the main soil improvers – humus and clayey minerals. The latter surround the mineral aggregates in the soil, stick them together and form small aggregates that retain moist, absorb cancerogenic elements and help plant roots reach the microorganisms, the nutrient salts and the air.

The microelements contained in the sapropels are an object of intensive studies using various methods: mainly atom absorption and emission spectral analysis. It can be concluded on the basis of the high content of organic matter in the sapropels that they have high content of Sr, U, Mo, Ti and other elements. The concentrations of titanium are within 0,3–0,5%. There are impressively high concentrations of molybdenum varying in different samples from 80 to 250 g/t. The distribution of the main microcomponents is shown on fig. 6 and in table 2.

The results of the general chemical analysis of the Holocene sapropels have considerable deviations from the indicators characterizing the common formation models such as the Neogene clays of the Russian platform, the clays and the claystone from the continental sector of the lithosphere, the pelagic silicite oozes, etc. The composition of the mineral matrix of the sapropels does not differ sharply from the composition of the pelite formations distributed on the continents.

The comparison of the Holocene sapropels to the pelagic formations related to the red clays and the silicite (diatomoceous) oozes shows that they occupy an intermediate position between these two models. Depending on the content of SiO_2, Al_2O_3 and alkaline oxides the sapropels are close to the red clays, and depending on the content of Fe_2O_3 and TiO_2 – to the silicite muds.

The sapropels are a specific product of the conditions of the Black Sea. Many authors (Lopatin, Emets 1987; Khristchev, 1987; Shimkus, Emelyanov,

1990) consider the sapropels as analogues of "oil source rocks", while other (Dimitrov, Velev, 1988) believe they can be used as a possible source of non-traditional raw materials and resources.

The Djemetinian layers end the cross-section of the sediments and are distinguished by Arhangelskiy and Strakhov (1938) as layers formed under conditions similar to present-day conditions. The most important feature distinguishing deep sea Djemetinian sediments is the high carbonate coccolithophorid muds. The studies of the species composition of the coccolithophorids (Moncheva et al., 1999) indicate that the modern sediments and the sediments from the whole period of the Holocene are predominated by the species *Emiliania huxleyi acme*, while the species *Gephyrocapsa carribianica* lie at the basis of present-day layers. The lower part of the modern sediments according to the lithological data is determined by the appearance of the first interbeds of sapropelic sediments or the appearance of the species *Gephyrocapsa carribianika*. According to the absolute datings of the lower part of the pure Coccolith ooze, in C-544, the age is estimated at 2930 ± 110 years. Degens, Ross (1972) point to 3090 ± 130 years – a figure close to the number obtained by the author with regard to the lower part of unit Ia. The thickness of the sediments on the continental slope and in the deep sea depression is from 10–15 cm to 30–45 cm. There are only rare cases of coccolith oozes with thickness up to 80–90 cm. Very often the coccolith oozes are interleaved by thin (1–2 mm) strips of diatom algae. In most case the coccolith oozes are mostly with high carbonate content decreasing due to dilution with terrigenous material. The distribution of the modern deep sea sediments is limited by the ratio between the biogenous and the terrigenous component affected by the local factors of the different morpholithogenetic zones. The main characteristic feature, however, remains the high biological productivity of the coccolith phytoplankton.

The distribution by area is represented in an acceptable way by Khrischev et al. (1988). The lithofacial map does not show the lithofacies of the diatomaceous sediments developed in the southern part of the continental slope, at depths from 180 to about 800 m. This strip occupies an area characterized by marine complexes of diatomea without reaching the Neoeuxinian sediments. The development of "pure" diatomaceous sediments near the Bosphorus region may be explained by the role of the geochemical barrier zones and the ecology of the diatom algae whose biological productivity rises sharply here. This process benefits from the favourable nutritional environment created by the inflow of water from the Sea of Marmara. A field rich in diatomaceous sediments was discovered in the Danube Canyon at depths of 250–600 m alternating with predominant amounts of coccolith oozes. The distribution of macro- and microcomponents in the coccolithophorid oozes is shown on fig. 1, 6. The content of $C_{org.}$ reaches 4–5%, the amount of carbonates fluctuates from 35–40% to 90%.

The coccolith sedimentation designates a new stage in the development of the basin under the conditions of growing eutrophication. The comparative analysis of the coccolithophorid phytoplankton since 1965 indicates a sharp increase in its biological productivity hence its amount in the sediments (Sorokin, 1982).

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Голоценовые осадки Черноморской впадины формировались, по нашему мнению, в условиях геокатастрофических событий, произошедших на границе плейстоцена–голоцена (8–9 тыс. лет тому назад). В результате над верхнеплейстоценовыми озер-

ными осадками залегают органо-минеральные (сапропелевые, диатомовые и кокколитовые) морские осадки. Характерной чертой произошедшей катастрофы является возникновение сероводородного заражения, которое консервировало органический материал и предохранило его от разложения. Химический состав и свойства глубоководных органо-минеральных осадков дают нам основание рекомендовать их как комплексное сырье многоцелевого предназначения, и в первую очередь в области биоземледелия.

Голоценові осади Чорноморської западини, на наш погляд, формувалися в умовах геокатастрофічних подій, які відбувалися на межі плейстоцену–голоцену (8–9 тис. р. тому). В результаті над верхньоплейстоценовими озерними осадами залягають органо-мінеральні (сапропелеві, діатомові та кокколітові) морські осади. Характерною рисою катастрофи, що відбулася, є виникнення сірководневого зараження, що законсервувало органічний матеріал і запобігло його розкладу. Хімічний склад і властивості глибоководних органо-мінеральних осадів дають нам підставу рекомендувати їх у якості комплексної сировини багатоцільового призначення, і в першу чергу – в біоземлеробстві.

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