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LITHOLOGICAL AND MINERALOGICAL STRUCTURE OF ACCUMULATIVE BEACH DEPOSITS OF THE BLACK SEA DANUBE-DNIESTER SEGMENT

(Представлено членом редакційної колегії д-ром геол. наук, проф. О. М. Іванік)

The investigations of accumulative-sand deposits of the Black Sea coastline on the area from the village Liman (Katranka spit) to the village Karolina Bugaz (Odessa region) have been carried out. The length of the coastal line in the study area is close to 85 km. There are a lot of beach areas: spits, beach breaks, beaches on the shoreline. 35 samples were taken and analyzed from all types of beach depressions by the same methodology during the summer period. The sampling was carried out at all accessible for sampling places of beach deposits from the middle part of the near-shore beaches (between the water level and the shore) and at a distance of 5–7 m from the water edge on the headlands and spits in the period when there are no storms. For this purpose we used standard plastic containers with a capacity of 1 liter. The samples were taken from a depth of 30 cm from the surface with a stripping area of 30×30 cm. At each point the description of the coastal zone structure and the character of beach deposits were carried out, which were recorded in the logbook and were connected to the coordinates by GPS system.

Granulometric and mineralogical analysis was carried out. It was determined that fractions 0,25–0,5 mm prevail in the granulometric composition among all types of beach deposits, which makes 66 %, and 0,1–0,25 mm – 30 %. In the smallest quantities there are coarse-grained and aleuro-pelitic fractions. The main places of localization of drilled-grained psammite and aleuropelite fractions are the areas with low influence of coastal tidal processes. However, during the periods of increased hydrodynamic activity (spring-autumn), additional resuspension of material takes place, which leads to displacement of other fractions from the deposits and their transfer to the sea side.

Beach sediments are 90–95 % quartz. Others are calcite, feldspar, technogenic substances. Ore minerals are represented by magnetite, lignite spheroids, ilmenite, acerbic garnets, stavrolite, actinolite.

The main sources of terrigenous material for the formation of beach deposits are the underwater bench, the Dniester river runoff, and coastal abrasion. Decisive in the distribution of sediments is the direction along the coastal current in the direction from Odessa city towards the delta of the Danube.

Keywords: Black Sea, beach deposits, granulometric composition, mineral composition.

Statement of the problem in a general way and its relation to important scientific or practical objectives.

Shoreline sediments are formed at the boundaries of aquifers and dry land. They form as a result of the combined action of many processes, the main ones being coastal erosion of the sea, bringing terrigenous material by river flow and the action of marine hydrodynamic processes. The fluvial and granulometric composition, volume and nature of the distribution of beach deposits indicate the peculiarities of the interaction of certain nutrient provinces, the morphology of the coastline and adjoining areas of the aquatorium. Beach sediments are sensitive to changes in the quantitative and qualitative parameters of runoff, the nature of abrasion and hydrodynamics, and can be used as indicators of certain events or transformational factors of their formation.

The north-western coast of the Black Sea within the borders of Ukraine covers the territory from the Danube delta to the Dnipro-Buzsky estuary, stretching to the distance of 200 km and today is the most promising region to create recreation centers for the population. Natural beaches in this area are the main recreational element and are under the main anthropogenic pressure. However, well-developed and safe beaches are widespread only within the bumps and sandbars.

Investigation of accumulative and beach deposits will enable a geological and ecological assessment of the shoreline condition in the current mode, determine the lithologic and mineralogical composition of solid river flow and assess their contribution to the coastal zone sediment balance, identify possible mineralogical provinces which inhabit the near-coastal part of the Black Sea and identify their main specialization.

Analysis of previous researches, publications and identification of previously unresolved parts of the general problem. Studies of the coastal zone of the western part of the Black Sea began in the late XIX – early XX century. N.I. Andrusov *(Andrusov, 1890, 1927)*, A.D. Arkhangelsky *(Arkhangelsky and Strakhov, 1938)*, and N.M. Strakhov *(Strakhov, 1956, 1965)* studied bottom sediments in the area and clarified the geological structure of the Black Sea basin.

In the second half of the XX century, the Institute of Geological Sciences of the NASU (E.F. Shnyukov *(Shnyukov, 1981)*, V.X. Gevorkyan *(Gevorkyan, 1981)*, M.G. Barkovskaya *(Barkovskaya, 1960, 1963)*, E.Ya. Nevessky *(Nevessky, 1967)*, Z.T. Novikova *(Novikova, 1973)*), the Okhotsk State University (Yu.D. Shuisky *(Shuisky, 1986)*), and the Institute of Mineral Resources of the NASU *(Yurk, 1973)*, conducted systems survey of the shelf of the Black Sea, in which the main attention was given to the mineral deposits. In addition, the morphology of the coastal zone floor, geological structure of quaternary and modern bottom and near-shore deposits were investigated. A result of the mentioned investigations is a voluminous monograph publication "Geology of the shelf of Ukraine": Kerch stream (1981); Matter, history and exploratory methodology (1982); Solid mineral deposits

(1983); Stratigraphy (1984); Liman (1984); Lithology (1985). Three living mineralogical provinces were distinguished within the boundaries of the Black Sea: the Danube River; the Danube-Dniester River and the Dniester-Dnipro River *(Shnyukov, 1983; Novikova, 1973)*. The features of drying and metallogeny of shelf mountain formations were determined. A monograph entitled "Problems of investigating sediment balance in the coastal zone of seas" was published *(Shuisky, 1986)*.

Within the last 20 years beach deposits of the north-western part of the coast (at the Dnister-Danube area) have been investigated by a team of scientists of the Odessa I.I. Mechnikov National University (Yu. Shuisky *(Shuisky and Murkalov, 2012; Shuisky and Organ, 2017)*, G. Vykhovanets *(Vykhovanets, 2014)*, A. Murkalov *(Murkalov, 2011)*, N. Berlinsky *(Berlinsky, 2014)*, N. Fedoronchuk *(Fedoronchuk, 2001),* etc. The main topic of these works is devoted to the study of the mechanism of the accumulation of sediments on the coastal sediments and the description of their morphology. However, the mineral composition and the sources of its formation remain insufficiently studied, especially considering that accumulative and beach sediments are in dynamism all the time. The problem of genesis and accumulation of ore components of coastal deposits, such as gold, magnetite, garnet, ilmenite, etc., also remains unsolved.

Research goal. The main purpose of the present research is to determine current features of the formation of a granulometric and mineral composition of coastal beach beds of the north-western coastal part of the Black Sea in the area from the village Liman (Katran sandbar to the village Vistula). Liman (Katranka sandbar) to the village of Karolina Bugaz (Odessa region).

Factual material and research methods. The factual material was collected during the state administration of the branch of marine geology and siege mining issues of the Ukrainian National Academy of Sciences Center of Ukraine on the theme "Lithological and mineralogical composition of the acumulative coastal marine deposits of the Black Sea (within the borders of Ukraine)".

Samples for lithological and mineralogical investigations were selected during the fieldwork in July 2019 according to the unified methodology. The sampling was carried out on all available sampling locations of beach beds in the middle part of the near-shore beaches (between the water level and the shore) and at a distance of 5–7 m from the water level on the headlands and spits during the period when there were no storms. For this purpose standard 1-litre plastic containers were used. The samples were taken at a depth of 30 cm from the surface with a stripping plane of 30×30 cm (Fig. 1). The coastal zone structure and the nature of the beach deposits were described at each point and logged and geo-referenced by GPS. A total of 35 samples was taken. The length of the coastal zone surveyed was 86 km (Fig. 2).

Fig. 1. Sampling of beach beds

Fig. 2. Schematic diagram of the survey and sampling area

In the laboratory the samples were dried and quenched according to accepted methods. For particle size analysis a 0.5 kg sieve was used. The test was performed on a standard set of sieves with the following fractions (mm): >10; 10–7; 7–5; 5–3; 3–2; 2–1; 1–0.5; 0.5–0.25; 0.25–0.1; <0.1. Each of the obtained fractions was quantified on the laboratory scale to 0.1 g, which were then converted into counts. According to the results of particle size analysis gistograms were created. Electromagnetic and magnetic fractions were distinguished from each fraction by Sochnev magnet, which were subsequently investigated by the MBS 10 microscope, scanning electron microscope and electron-probe microanalysis. Some samples were separated in bromoform to obtain important and light mineral fractions.

Layout of the main study material. Beach sediments are understood as the primary elementary accumulative form of exogenic relief which was formed from coastal-marine deposits in the coastal zone of the sea. Beach sediments are localized, born and develop under the active influence of tidal currents in the coastal zone and subdivided into above-water and below-water parts *(Shuisky and Vykhovanets, 1989)*.

The beaches in the studied area are represented by spits (Katranka, Sasikska), persiques (Dnistrovska, Budakska, Shaganii Alibeii-Burnaska) that comprise up to 80 % of the coastline and by near 20 % of the narrower one.

The barrier necksand beaches are bordered on one side by estuaries (Dniester, Buda, Shagany, Alibeisk, Burnas, Sasik) and on the other side by the Black Sea. Their width varies from several tens of metres to several hundreds of metres and their height above sea level is 1–3 metres. The steepness of the slopes of the transhumance and the seaward slopes is often steeper than that of the estuaries. Two or three shafts can be distinguished in the transversal profile of the headwaters and estuaries, corresponding to the different intensity of the tides. The first bank is located closer to the water surface and has an average height of 0.4–0.5 meters above the sea level, the second one is 8–12 meters above the water surface, with a height of 1–1.4 meters, and the third one is 25–35 meters above the water surface, with a height of 2–3 meters. The latter is the result of significant storm surges that occur here during the autumn-winter period. Sometimes the beach is seen as a separate pile, which is obviously related to the eolian activity along the coastline.

A beach is located in the coastal area between the villages Lebedivka-Kurortne. Their total length is about 18,5 km. The width of the beach is from 2–3 m up to 10–15 m. In some places the above-water part of the beach is absent and then the coastal zone is adjacent to the water level. The coastal zone is a cliff with steep (70–90º) walls up to 20 m high and more, where landslide and landslide processes are actively developing (Fig. 3, 4). The bottom of the cliffs often has a deep niche which is mostly oriented on the north-west, north. They are the result of storm surges from the eastward drift to the westward drift, which is typical for this part of the coastline. The coastline of the near-shore beaches is in general slightly sinuous and straight.

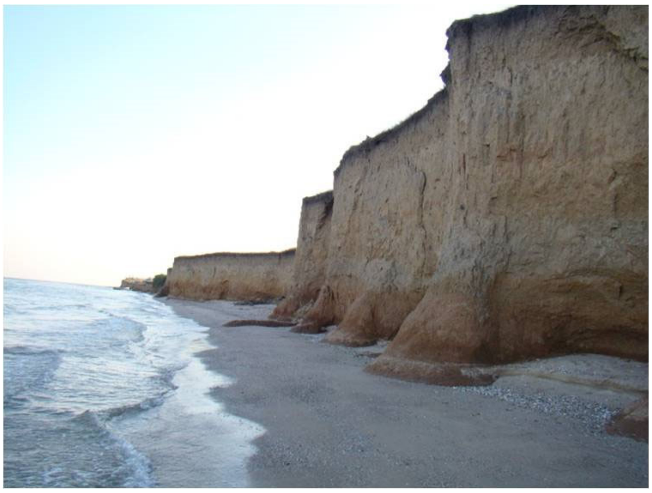


Fig. 3. General view of the coastline in the development area around the beaches

Fig. 4. Typical view of landslide development on the Lebedivka-Kurortny coastal line area

The geological structure of the coastline, which is in direct contact with the sea and is located above its level, involves quaternary deposits. In the area between the villages Lebedivka-Kurortne they are mainly represented by continental facies of forest-like loams, clays and dugout soils with black-brown clays in the bottom (Fig. 5). The above-water part of black-brown clays increases in the direction from Lebedivka to village Karolina Bugaz. These deposits occur on different rocks of Sarmatian, Miocene and Pliocene. The total thickness of the Quaternary deposits together with the underwater part is nearly 36 m, and on the overflow up to 55m *(Zelinsky et al., 1993)*.

In the study area, two major water arteries are located in the Black Sea: the Danube and the Dniester rivers. They deliver a large volume of discharged and terrigenous substances, which partly settle in deltas, estuaries and levees but part of the material flows directly into the sea. Estimates of the flow of these rivers to the Black Sea vary from one author to another one. According to Romanian authors, in the last 155 years the Danube flow averaged 51.2 million tpy (before regulation, 87.8 million tpy) *(Bondar and Blendea, 2000; Jaoshvili, 2003)*. Of this number, about 9–12 % are bottom sediments that settle in the delta and on the arm coast and do not take part in marine sediment accumulation *(Mikhailova, 1995)*. Calculates of the Dnister River flow rate are 1.73 million tpy (2.5 million tpy before regulation) *(Jaoshvili, 2003)*. The Dniester River forms a waterlogged delta, which is drained into the Dniester Estuary. The Dniester is an intermittent freshwater basin where the majority of the Dniester's flow is discharged, with a smaller proportion reaching the aquatorium indirectly.

Within the surveyed area from the north-eastern part to the south-western part along the coast there is a main cyclonic flow, which constantly influences the transfer of the material in the direction from the city Odessa to the delta of the Danube.

The results of granulometric analysis showed that the accumulative beach deposits of the Dniester and Danube segments are dominated by medium grained (0.5–0.25) and fine grained (0.25–0.1) psamite fractions (Fig. 6).

However, it should be noted that in the samples taken from over- and under-ice in the Liman-Lebedivka area the friable and medium-grained fractions are in approximately equal quantities, and starting from Lebedivka to Budatsky Liman the role of the medium-grained fraction grows. This division continues up to the Dniestrovsky Channel. The role of other grains sharply increases in the middle part of the fairway, and from there to the Bugaz River again shows the dominance of medium-grained fraction (Fig. 7).

The coarse-grained (0.5–1 mm) fraction is widespread locally. The amount of grain size is generally insignificant and averages about 2 %. The largest fraction (12 %) is concentrated in the beach sediments between the Buda and Dniester Rivers. The points of maximum concentration of coarse-grained fraction coincide with the points of increasing concentration of medium-grained fraction. The volume of coarse-grained psamite fraction (2–1mm) varies in the range from 0 to 8 %. Its partitioning is not regular, has a local character. Gravel fraction is 2–3mm in size and has sporadic distribution. The maximum concentrations of their concentrations are associated with the accumulation points of coarse psammite fractions.

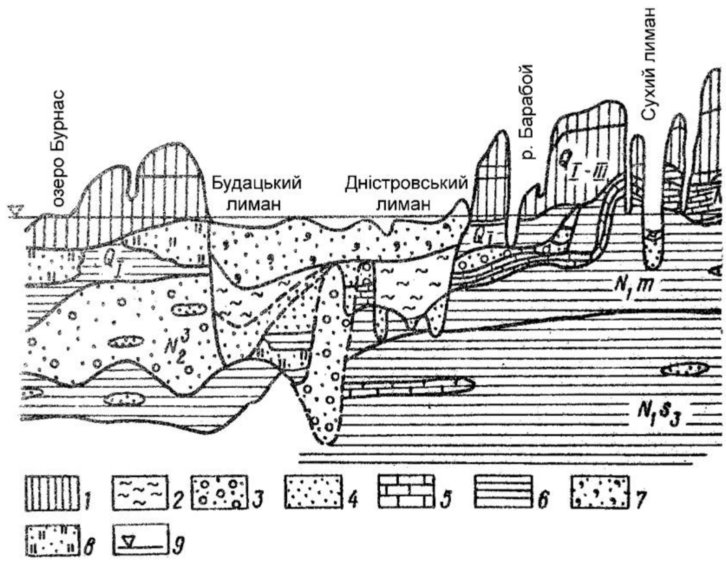


Fig. 5. Schematic coastal geologic cross-section on the Lebedivka-Karolina Bugaz plot.
The following definitions are used: 1 – forest-like loams; 2 – mules; 3, 4 – coarse- and fine-grained sand; 5 – bogs; 6 – clays; 7 – turtle-pebbles; 8 – mules, medium-grained sand; 9 – sea level (*Zelinsky et al., 1993*)

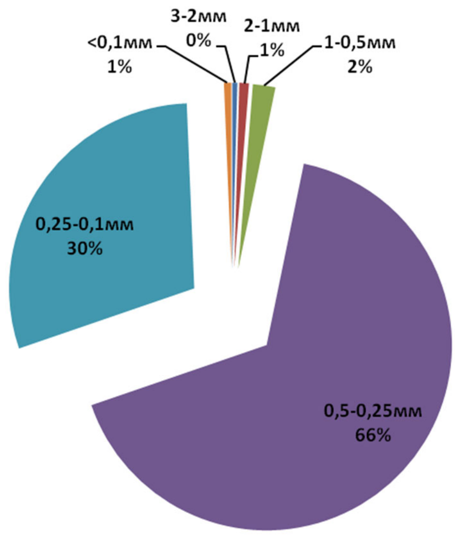


Fig. 6. Overall distribution of fractions in the accumulative beach deposits in the Danube-Dnister part

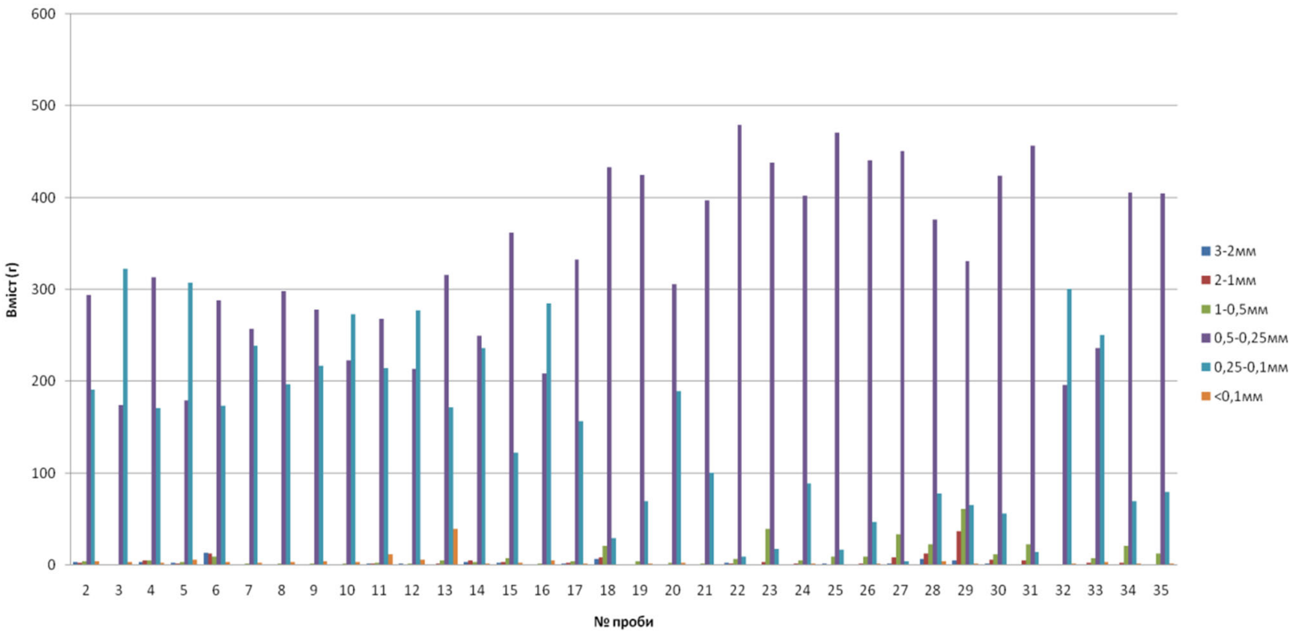


Fig. 7. Granulometric composition of accumulative beach sediments in the area of Liman village (Katranka barrier beach) – Karolina Bugaz (Odessa region)

The content of aleuropelite fraction (<0.1 mm) is also insignificant and varies in the range from 0 to 7 % and has a local character. This distribution indicates an active hydrodynamics in the coastal zone, significant processes of constant interchange and transfer of fine fractions in the territory.

The main places of localization of dry granular psammite and aleuropelitic fractions are areas with low influence of coastal tidal processes. However, during the periods of increased hydrodynamic activity (autumn-winter), additional significant resuspension of material takes place, which further leads to dislodging of other fractions from the deposits. Thus, in the transverse profile, the role of coarse fractions increases in the cross-sectional area between the water level and the third shaft. There is also a load of gravel and pebble fractions.

Also dynamic sorting of the material on all sections of the accumulative zones takes place. Timely drifts, local sand bar like bodies, underwater and offshore coastal barrier beach, over-slope, near-shore beaches are formed with overvaluation of medium-grained fractions at all points of observation.

The mineral composition of the accumulative beach sediments is generally monomagnetic. The main mineral of all types of deposits is quartz. Quartz accounts for an average of 90–95 %, the second-ranking minerals are calcite and calcitic detritus (3–6 %), feldspar (1–3 %).

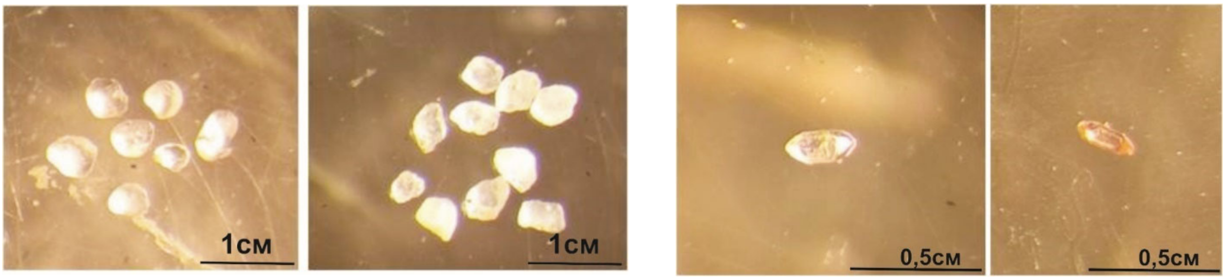
The electromagnetic and magnetite fractions amount to 1–2 % in total. Their greatest volume is fractional 0,25–0,5 and 0,1–0,25 mm, where they are approximately distributed in the same proportions.

In the composition of the magnetic fraction magnetite, iron spheroids, iron technogenic formations, in the electromagnetic fraction – ilmenite, garnets, stavrolite, actinolite were established.

The major part of the low-magnetic fraction is represented by garnets. Besides this in single grains in the samples of zircon, rutile, hydroxide, pyroxenes, biotite, man-made glass and slag are present.

Coarse-clay material (gravel, pebbles) is composed of sandstones, limestones, siliceous nodules.

Most of the quartz (99 %) is dispersed in fractions smaller than 0.5 mm. In fractions 0.1–0.5 mm it is represented by isometrically transparent, well or moderately rounded grains of barren and white color (Fig. 8, a). Some of the grains show inclusions of luminescent minerals – ilmenite and hematite. In fractions smaller than 0.1 mm its compactness decreases sharply and is visible in the form of crystals. These crystals have a typical prismatic-dipyramidal habit and shape. Among the microcrystals there are two widespread color variations: light pink, transparent white (Fig. 8, b).



a b

Fig. 8. Morphology of quartz grains and crystals: 0.1–0.5 mm fraction (a); crystals with a fraction less than 0.1 mm (b)

The detritus is mostly in fractions larger than 0.25 mm. The largest amount falls into coarse-grained and medium-grained psammitic fraction. It is represented by clumps of turtle fragments of continuous or lamellar shape (Fig. 9). The detritus density decreases markedly in the direction of diminishing in size. It is diversified by color and species composition. Fractions >2 mm contain larger sized tortoise snails or their complete forms. They belong to the molluscs Cardium, Venus, Mytilus, Tapes, etc. The amount of turtle detritus in some places on the beach reaches a significant number, but in general decreases as the water level decreases to the beach depth.

Sulphurous calcite grains are opaque, have a rough oval shape and a rough surface and are concentrated in fractions larger than 0.25 mm. In fractions smaller than 0.25 mm their volume is drastically reduced.

a b

Fig. 9. General view of detritus: 0,5–1 mm fraction (a); 1–2 mm fraction (b)

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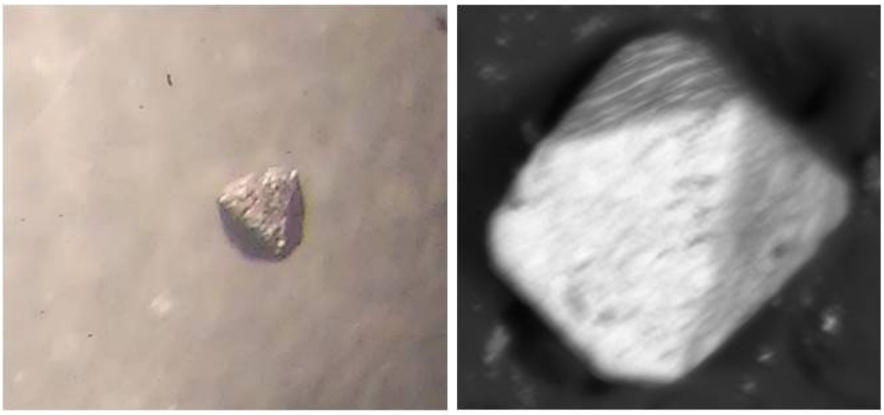
Polish feldspar is represented by rounded, non-porous or opaque prismatic grains of grayish-brown, reddish-brown color. Its distribution into fractions is not regular, but still significant concentrations are observed in other fractions.

Magnetite grains are well rolled, have an oval, close to isometric shape (Fig. 10). The color is brown with different tints due to the oxidation processes and the appearance of a membrane of hydroxides of iron on top. The samples also contain single magnetite crystals of black octahedral gabitus with metallic shine on the faces (Fig. 11).

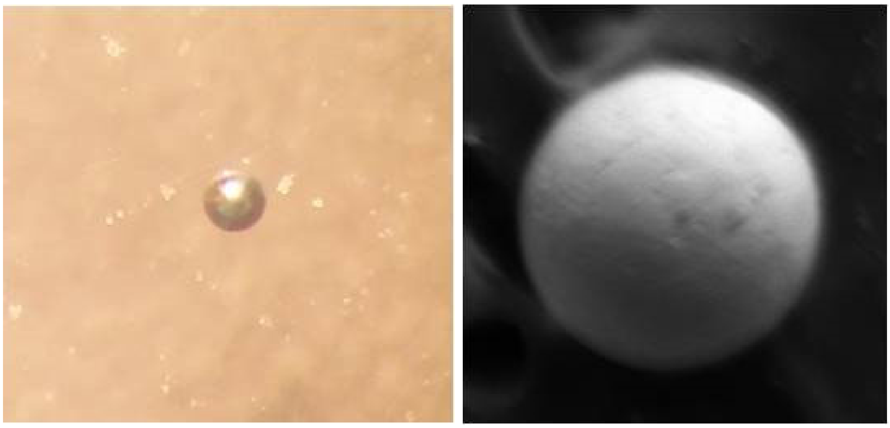
The spheroids are set in fractions of 0.1–0.5 mm. They are diversely spherical, have a precise goblet-like shape with a smooth, glistening surface (Fig. 12). They are composed of 97.7–98 % iron. The impurities components are represented by magnesium, aluminum, silicon (Table 1). These spheroids were found in approximately one third of the investigated samples, where they are found in single units.

Fig. 10. Typical morphology of magnetite grains of 0.5–0.25mm fraction



a **b**

Fig. 11. Octahedral magnetite crystals: binocular (a); electron microscope (b)



a **b**

Fig. 12. Saline spheroids: binocular microscope (a); electron microscope (b)

Table 1

The chemical composition of the volumetric spheres

Sample	MgO	Al_2O_3	SiO_2	FeO	Sum
26_2	0,44	0,26	1,58	97,73	100

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Among garnets, almandine is the most abundant. There are fewer variations between almandine and spesartine, with MnO quantity up to 26 %, and fewer variations between almandine and pyrope with MgO content up to 12 %.

The almandine is mainly represented by transparent, weakly or even uncoated grains with a light pink color (Fig. 13).

Garnets of intermediate composition between almandine and spesartine are marooned, maroon-black in colour and are transparent. They are even more highly rolled than almandine and are more or less isometric grains (Fig. 14).

The garnets of intermediate composition between almandine and pyrope have a rough black-and-white color, are porous and have an isometric shape of grains (Fig. 15).

A characteristic feature of all garnet varieties is their colourfulness, shapelessness and isometric shape.

Ilmenite is represented by nonporous slightly rolled grains of black color with a shiny surface (Fig. 16). It is found in all samples and occupies the second place after garnets.

Stavrolite is found in almost all samples and is quite widespread. Its presence is correlated to some extent with garnets. It is presented by prosoriated, mostly not rolled, more gradually filled grains of brown color of different tints (Fig. 17). It is characterized by the inclusion of other minerals, especially ilmenite, quartz, magnetite and apatite.

Actinolitic crystals are not present in all samples and are not widespread. They are represented by single isolated prismatic-ovoidal green crystals (Fig. 18). A characteristic feature of these crystals is their good preservation, they are not affected by rolling processes and the influence of distant transportation.

Technogenic substances are represented by silicon, aluminium and magnesium alloys. They have a rocky and gastrocutted shape, are opaque and often oxidized on top. They have a distinct metallic glare on fresh scales (Fig. 19). They are present in almost all samples, but their number increases rapidly in the direction from the Danube to the Dniester segment of the coast.

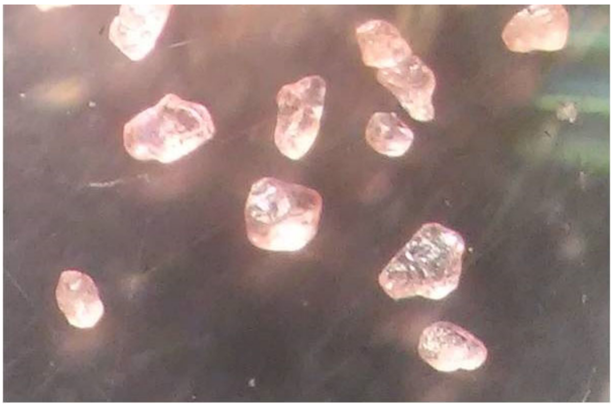
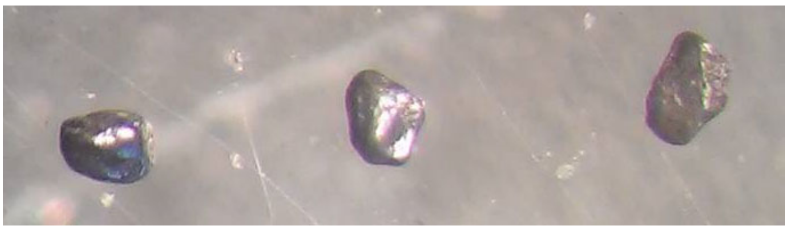


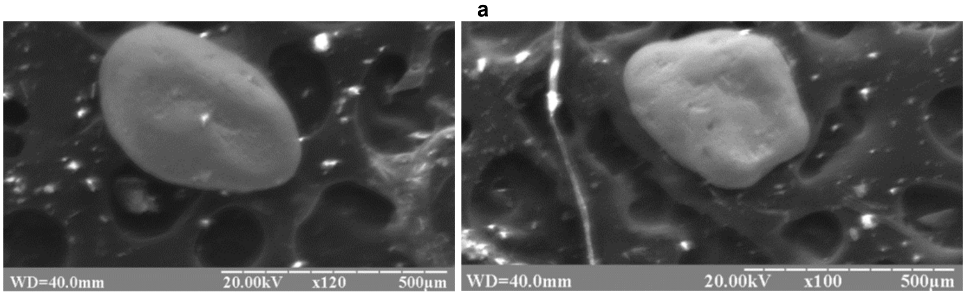
Fig. 13. Almandin fraction 0.25–0.5 mm

Fig. 14. Garnets of the almandine spesartine series, 0.25–0.5 mm fraction

Fig. 15. Almandin-Pyro series garnets, 0.25–0.5 mm fraction



a



b

Fig. 16. Ilmenite: binocular (a); electron microscope (b)

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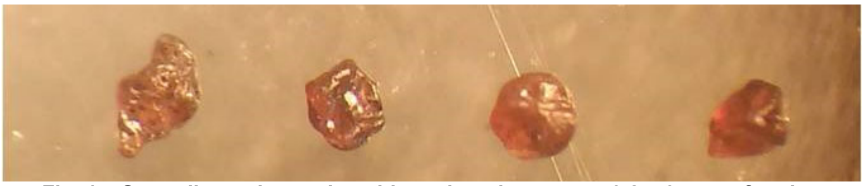

Fig. 17. Stavrolite grains under a binocular microscope, 0.25–0.5 mm fraction

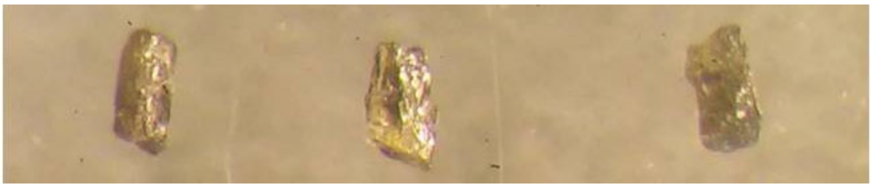

Fig. 18. Actinolitic crystals under binocular microscope, 0.25–0.5 mm fraction

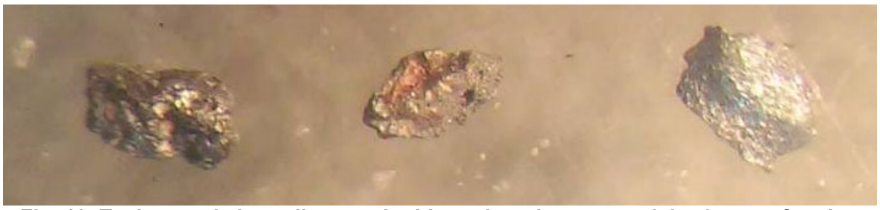

Fig. 19. Technogenic iron alloys under binocular microscope, 0.25–0.5 mm fraction

Conclusions. The accumulative coastal-beach deposits of the Black Sea in the area between the Danube and the Dniester form along the entire coastal zone. The main part of the shoreline is formed along the entire coastal zone and is represented by the deposits of over- and near-shore beaches. The main part of the beach deposits is on the peninsula and barrier beach, and the part of near-shore beaches makes up not more than 20 % of the surveyed territory.

The material for the formation of shoreline deposits in the surveyed area comes from several sources. In our opinion, a significant amount of washed material, which forms the beach deposits of over- and under-ice, comes from bench, which is in direct contact with them or is located close to them. From the benches to the shore there come both quartz, sand and a significant amount of detritus, which we constantly find near the water level. The other important source is the sediment delivery from the Dniester estuary, which, taking into account the downstream direction, is deposited on the beaches of the whole coastal beach zone all the way to the Zhebryivsky cove. The third source is skeletal shore rocks, which are actively fouling. However, considering their lithologic structure (loam and clay), their frost products replenish the balance of only the nearest beach deposits and in rather limited quantities. Most of them, due to dispersion, are carried to the depth of the aquatorium by hovering processes. The fourth source is the Danube's solid stream. However, despite the considerably greater volume of discharge than the Dniester, its material is deposited mainly in the Zhebrjevo Bay and below it, on the side of the Romanian coast. Again, this is caused by a coastal current running from Odessa to the Danube.

The tumultuous processes in the coastal zone lead to a constant rearrangement of different fractional matter within different segments of the beach, but the main tendency of this rearrangement is preserved for a long time, as our research and the research of previous years have shown.

Among all types of beach deposits fractions 0,25–0,5 mm prevail which is 66 % and 0,1–0,25 mm – 30 %. The smallest quantities include coarse-grained and siliceous fractions. The main places of localization of drilled-grained psammite and aleuropelitic fractions are areas only with reduced influence of coastal tidal processes.

Beach sediments are 90–95 % quartz. Other mineral deposits include calcite, feldspar, technogenic formations. Ore minerals are represented by magnetite, lime spheroids, ilmenite, acerbic garnets, stavrolite, actinolite.

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ЛІТОЛОГО-МІНЕРАЛОГІЧНИЙ СКЛАД АКУМУЛЯТИВНО-ПЛЯЖНИХ ВІДКЛАДІВ ДУНАЙСЬКО-ДНІСТРОВСЬКОГО СЕГМЕНТУ ЧОРНОГО МОРЯ

Досліджено акумулятивно-пляжні відклади північно-західного узбережжя Чорного моря на ділянці від с. Лиман (коса Катранка) до смт Кароліна Бугаз (Одеська область). Довжина берегової лінії на ділянці дослідження становить близько 85 км. Тут поширені такі форми пляжних відкладів: коси, пересипі, присхилові пляжі. З усіх типів пляжних відкладів за єдиною методикою в літній період відібрано та проаналізовано 35 проб. Відбір проводився на всіх доступних для відбору місцях пляжних відкладів із середньої частини у присхилових пляжах (між урізом води та берегом) та на відстані 5–7 м від урізу води на пересипах та косах у період відсутності штормів. Для цього використовувалися стандартні пластикові контейнери ємністю 1 л. Проби відбиралися із глибини 30 см від поверхні з площею зачистки 30×30 см. У кожній точці проводився опис будови берегової зони та характеру пляжних відкладів, які фіксувались у журналі та були прив'язані до координат системою GPS.

Проведено гранулометричний та мінералогічний аналізи. Встановлено, що в гранулометричному складі серед усіх типів пляжних відкладів переважають фракції 0,25–0,5 мм, що становить 66 % та 0,1–0,25 мм – 30 %. У мінімальних кількостях наявні крупнозернисті та алевропелітові фракції. Основними місцями локалізації дрібнозернистих псамітових та алевропелітових фракцій є ділянки з пониженим впливом уздовж берегових хвилеприбійних процесів. Проте в періоди збільшення гідродинамічної активності (осінь – зима) відбувається додатковий перерозподіл матеріалу, що спричинює вимивання з відкладів дрібних фракцій і їх відганяння в бік моря.

Пляжні відклади на 90–95 % складені кварцом. Другорядні – кальцит, польовий шпат, слюда, техногенні утворення. Рудні мінерали представлені магнетитом, залізними сфероїдами, ільменітом, акцесорні – гранатами, ставролітом, актинолітом.

Основними джерелами теригенного матеріалу для формування пляжних відкладів на досліджуваній ділянці узбережжя є: підводний бенч, річковий стік Дністра та берегова абразія. Вирішальною у розподілі наносів є направленість уздовж берегової течії у напрямку від м. Одеса в бік Дунаю.

Ключові слова: Чорне море, пляжеві відклади, гранулометричний склад, мінеральний склад.