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## The maritime para-dynamic as a phenomenon of the formation of the landscape space

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**Abstract.** The coastal zones are characterized with the considerable variety and the specificity of the landscapes. Their properties and the structure are determined with the interaction of the water area and the dry land. Here the natural and the anthropogenic components of the landscapes come into the close interaction with each other with the useful

(microclimate, energy potential of breeze) and the inauspicious (storms, coastal abrasion, high corrosive activity) consequent for the landscape structures and the maritime nature use. The determination of such interaction and their consequences are the aim of this article. The method of the analysis and the synthesis of the empirical data is determined. This is due to the considerable dispersion of the geophysical and the geochemical data by the branches and the spheres of the research. So, the collection of the diversified data, their processing and the interpretation have become the important component of the method. The method of the conjugate analysis of the components has given the possibility to catch out the dependence between the processes and the appropriateness in the “process-result” chain. It is studied out that the unity of the dry land and the marine components of the coastal zones is insufficiently studied. It is explained with the complicated character of the interaction between the coastal landscapes and the considerable versatility of the interaction between the coastal dry lands and the water area of the seas. The fragmentary character and the dispersion of the primary information on the dynamics of the coastal landscapes complicate the process of the research of such interaction. It should be noted, that the integration between the theories of the research of the dry land and the sea is still weak. The main complexity is that for now the structure of the process monitoring in the dry land and in the sea is different and it does not promote the integration of these researches. It is installed that the different in the structure and the functioning of the landscape has been formulated in the coastal zone of the seas. It is caused with the combination of the natural factors (microclimate, coastal abrasion and accumulation, infiltration of the marine waters, salt metabolism) with the maritime activity of the human (fishing, recreation, sea transport, tourism). It has been proved that all kinds of the dynamics between the contrasting environments, including the coastal areas, we can attribute to the para-dynamics. The processes of the interaction of the dry lands and the water areas within the coastal zones are determined with their geomorphological, microclimatic and migratory components. They can be happened through the migration of the ions, the salts and their solutions, the display of the breeze circulation, humidity of the air, the migration of the living organisms and others. The variety of the interaction is heightened with the high dynamism of the coastal processes. It is caused the high variability and the dynamic lithomas, which are connected with the surfing and the increase or the decrease of the water activities of the sea water. The surfing of the sorting of the bottom sedimentary and the formation of the zones of the variegated sedimentary in the different distance of the coastal are happened. The move of the coastal-marine drifts along isobathes of the coastline slope is found, which on the dry land physically cannot be in progress. More intensive comparatively with dry land migration of the soil solution is installed, which slows the formation of the soil coverage of the coastal zone. It is installed, that in the basic of the paradigm lies the material, the energetic and the informational exchange between the dry land and the sea. The number of the multidirectional material-energetic flows and the transpositions is disclosed in the coastal zone such as longitudinal and diametrical. The availability of the hydrogenous, the wind-circulation, and homogeneous interactions were analyzed and reinforced with the examples. The result of such interaction is the diversified formation such as from the features of the relief to the increase of the concentrates and the complexes of the living organisms. The features of the energy paradigms in the coastal areas of the sea are revealed. The large number of the energy flows is directed from the dry land near the sea.

**Keywords:** interaction of the dry land and sea, contrast environment, coastal zone, substance, para-dynamics, energetic interaction, the Sea of Azov

## Приморська парадинаміка як феномен формування ландшафтного простору

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**Анотація.** У межах берегових зон ландшафти та акваландшафти більш різноманітні. Їх властивості і структура визначаються взаємодією акваторії та суходолу. Тут природні та антропогенні складові ландшафтів вступають у тісні взаємодії між собою з корисними (мікроклімат, енергетичний потенціал бризів) та несприятливими (шторми, берегова абразія, висока корозійна активність) наслідками для ландшафтно-ї структури та приморського природокористування. Встановлення таких взаємодій та їх наслідків є метою даної статті. З'ясовано, що єдність суходільної та морської складових берегових зон до цих пір є слабо вивченою. Це пояснюється складним характером взаємодії між прибережними ландшафтами та значною багатогранністю взаємодій між прибережними суходолом і акваторією моря. Фрагментарний характер та розпорошеність первинної інформації по динаміці прибережних ландшафтів ускладнюють процес дослідження таких взаємодій. Встановлено, що у прибережній зоні морів формуються відмінні за структурою і функціонуванням ландшафти. Це спричинено поєднанням природних факторів (мікроклімат, берегова абразія та акумуляція, інфільтрація морської води, сольовий обмін) з приморською діяльністю людини (рибальство, рекреація, морський транспорт, туризм). Доведено, що усі види динаміки між контрастними середовищами, в тому числі й прибережної, слід відносити до парадинаміки. Процеси взаємодії суходолу та акваторії у межах прибережної зони визначаються їх геоморфологічною, мікрокліматичною та міграційною складовими через міграцію іонів, солей та їх розчинів, прояв бризової циркуляції, вологість повітря, міграцію живих організмів та ін. Різноманіття взаємодій посилюється високою динамікою прибережних процесів. Встановлено, що в основі парадинаміки лежать речовинні, енергетичні та інформаційні обміни між суходолом та морем. У прибережній зоні виявлено ряд різноспрямованих речовинно-енергетичних потоків і переносів – поздовжніх і поперечних. Проаналізована і підкріплена прикладами наявність гідрогенних, вітроциркуляційних, хемогенних взаємодій. Виявлені особливості енергетичної парадинаміки у прибережній зоні моря.

**Ключові слова:** *взаємодії суходіл-море, контрастні середовища, берегова зона, речовинна парадинаміка, енергетична взаємодія, Азовське море*

**Introduction.** The coastal water surfaces and the maritime territories are the important for the preservation of the landscape and the biological diversity, for the development of the traditional nature use. The coastal zones diversify the landscapes of the earth surface. The natural and the anthropogenic components of the coastal zones enter close interaction with each other with the different consequences, mostly with useful for the maritime nature use (the coastal energy, the industrial fishing, the maritime transport and the trade, the recreation and the tourism, the microclimate), and in some cases it is unfavorable (the storms, the coastal abrasion, the high corrosion activity of the maritime environment and others).

Despite the main role in the nature and the economy, the coastal zones in the unity of their dry land and the marine components still remain not enough studied spatial structure. This is due to the complex character of the interaction between the coastal landscapes and the significant versatility of the interactions between the coastal dry land and the water surface of the sea. It is the weak elaboration of the methodological-methodical bases of the research of the para-dynamic interactions and the properties of the landscapes which are caused by them. The difficulties of the study are largely due to the fragmentary character and the scattering of the primary information as for the dynamics of the coastal landscapes in its wide understanding.

The coastal zone of the sea as one of the brightest contacting zones of the geographical space is researched for many decades by the representatives of the different branches of the scientific directions (geomorphology, geology, climatology, hydrology, soil science, geochemistry, geophysics, botany, zoology, etc.) in the unity of its terrestrial and the

water composition. Despite this, in the geophysical, the geochemical and in the landscape relations, it as an integral natural-economic complex has been partially researched to date. This is due to the fact that until recently, the shore, as the part of the dry land, and the coastal zone of the sea, as the part of the water surface have been considered separately by the specialists - even within the different classes of the landscapes.

The same belongs to the borders of the Ukrainian Pryazovia, where the scientific investigations have often the isolated component character. Even in the grounded works on the problems of the Sea of Azov and its basin, the geomorphological interactions are highlighted more. And in some cases the sea is considered detached from the surrounding dry land. Instead, the sea-coast of the Sea of Azov has its own unique territorial and the aquatorium landscape features, formed as the result of the common conjoint interaction of the contrasting natural environments and the anthropogenic factors.

It should be noted that among the significant diversity of the scientific and the popular science works on the Sea of Azov and the adjacent to it the dry land, there are many publications that reflect one or another aspect of their interaction. The geological interactions (Shnyukov, 1974; Shujskyj, 2001), the geomorphological (Artyukhin, 2007; Ivanov, 2008; Mamykina, 1980; Shujskyj, 2015; Zenkovych, 1980), the hydrological (Bronfman, 1979; Bronfman, 1985; Symov, 1989), the hydro-meteorological (Ilyin, 2016; Ilyin, 2009), the biogenic (Matyshov, 2011; Aleksandrov, 2011; Vynogradov, 2012), the processes of the pollution (Bespalova, 2007; Ivliyeva, 2007) and others have been explored and have been highlighted in the literatures.

The basics of the research of the interaction

between the contrasting environments, including in the coastal zone of the sea has been put in the article of A.O. Grygorjev (1952). Later, this idea as for the interaction of the oceans and the continents have been developed by K.K. Markov (1968). The basics of the doctrine of the paradynamic-paragenetic interactions, including in the coastal zone of the sea have been formulated and have been developed in the works of F.M. Milkov (1966, 1977, 1981).

In our opinion, the best individual direction of the interaction of the dry land with the water surface of the sea through the shoreline have been reflected in the works of V.P. Zenkovich (1958, 1967, 1980), T.A. Ajzatullin and with the co-authors (Ajzatullin, 1984), G.G. Matyshov (2000, 2008, 2010, 2011), Yu.M. Gargopa (2003), V.O. Dergachev (1987), I.V. Agarkova-Lyax (2006), Yu.A. Zhdanov and with the co-authors (Zhdanov, 1987). The role of the anthropogenic factors in the development of the coastal zone of the sea is highlighted in the works of E. Bird (1990), Yu.V. Artyukhin (1989, 2007), V.I. Lymaryev (1986).

The idea of the existence of the para-dynamic connections between the contrasting environments of the landscape complexes was formulated by F.M. Milkov in 1966 and was improved until the 90s of the last century. At present, the development of the idea of F.M. Milkov about the para-dynamic landscape complexes has been connected with the scientific researches of the scientific schools under the guidance of F.M. Milkov in Russia and his student G.I. Denysyk in Ukraine. The theory of the para-dynamic connections in the positional-dynamic landscape territorial structures has been formulated and has been developed by M.D. Grodzynskyi (1993). The paradynamic connections and the properties in the landscapes have been explored by V.B. Mikhno, K.M. Diakonov, V.I. Fedotov, G.I. Denysyk, A.V. Hudzevych, M.V. Dytchak, G.S. Khaietskyi, I.V. Kravtsova, Yu.V. Yatsentyuk and others.

The research of the connections between the individual components of the landscapes and within the certain regions of the Azov sea-coast has been investigated by G.G. Matyshov (2010), S.V. Hryshko (2017), V.O. Demchenko and the co-authors (Demchenko, 2015).

The analysis of the modern publications has shown that most scientific researches direct to the management of the nature use and the resources in the coastal zone (Hildebrand, 1992; Kooiman, 2008), which are closely related to the manifestation of the natural processes of the interaction and their anthropogenic modifications. It emphasizes on the complexity of the observation of the natural

component of the interaction between the dry land and the sea and the importance of taking it into account (Schlüter, 2020). It is also difficult to detect the interdependencies between the social and the ecological systems, between the subjects and the managerial risks. At the same time, many scientists (Pittman, 2016) determine that the integration between the theories of the research of the dry land and the sea is still too weak. The main difficulty is that at present the structure of the observations of the processes in the dry land and in the sea is different and it does not help to the integration of these researches. In addition, in the interaction of the dry land and the sea has been detected high variability and the contradictions of the natural boundaries, which emphasizes more the aspect of the interdependence between the dry land and the sea through the shoreline. These boundaries are difficult to detect due to the variability in the natural, the ecological and the social environment.

It is clear to the scientists that if you want to use the coastal theory of the management, it should be understood the peculiarities of the coastal zone through the physico-chemical interactions between the dry land and the sea and their intensity. However, it can help in the development of the effective structure of the management which can provide not only the quality of the environment, but also its stableness.

**The purpose of the article** is to reveal the peculiarities of the coastal zone of the sea as a part of the integral landscape space, which are caused with the manifestation of the para-dynamics on the border of the contrasting environments.

**The material and the methods of the research.** The methodical basis of the article has been the number of the methods and the rules formed in the modern landscape science, the landscape ecology and the coastal science. The main research methods have been: the analysis and the synthesis of the empirical data, the method of the analogies, the field researches, the cartographic, the leading factor, the conjugate analysis of the components, the remote research, the method of the scientific generalization.

The use of the method of the analysis and the synthesis of the empirical data is associated with the significant scattering of the geophysical and the geochemical data, which confirm the existence of the interaction. Therefore, the collection of the diversified data, their machining and the interpretation have become the important component of the research. The method of the analogies has given the possibility to compare the types and the nature of the interaction in the different areas of the coastal zone, to detect the reasons of the differences. The field researches are applied for the specification of the available

cartographic information and the results of the decipherment of the satellite images of the studied surface. The method of the leading factor is applied for the detection from the significant diversity of the para-dynamic interactions of the main, which determines the course of the processes and their results. The conjugate analysis of the components has given the possibility to reveal the dependences of some processes on others, and also to detect the appropriateness in the chain of the “process-result”. The remote research has been mainly related to the explorations of the dynamics of the shores, the changes of their configuration in the space and the time, and also in the identification of the places of the separation along the coastal drifts of the deposits. The method of the scientific generalization is applied for the final stages of the research and during the formulation of the conclusions.

**The results and their analysis.** In the coastal zone of the seas and the Sea of Azov in particular, the landscapes are formed that, at first sight, are similar to other landscapes of the dry land, but this is not entirely true. Here the number of the natural processes is arisen and the factors are appeared, caused the interaction of the water surface and the adjoining dry land which modify the individual properties and the components of the landscapes. It includes the microclimatic, the geophysical and the geochemical interactions, the coastal abrasion and the accumulation of the sediments, the infiltration of the seawater in the reduced areas of the dry land, the salt metabolism, the migration of the living organisms and many others. Within the coastal zone, the consequence of the interaction of the contrasting environments is the significant increase of the biotope and the landscape diversity, accompanied with the appropriate increase of the bio-productivity.

Together with it, in the coastal zone, the favorable conditions for the development of the maritime types of the anthropogenic activities have been created with the nature such as the fishing, the marine transport, the recreation and the tourism, and so on. The combination of the natural and the anthropogenic factors of the development of the maritime areas makes the latter as one of the most diverse and the valuable in the ecological, the social and the economic relations of the area of the landscape space.

The “Para-dynamic” (para-genetic) interactions between the contrasting environments, for the first time, have called and have introduced into the scientific circulation in geography by F.M. Milkov (1966), and the awareness of the priority of the consideration of the process component during the separation of the landscape systems has led in 1977 F.M. Milkov to the

formulation of the idea of the existence of the para-dynamic landscape complexes and the necessity of their research within the new perspective direction of the landscape science (Milkov, 1981).

This name is caused with the fact that “para” means “near”, and “dynamic” is the movement, the interaction. So, it is a phenomenon caused with one or more processes. Thus, in the maritime zones, this movement is caused with the interaction between the contrasting environments such as the part of the marine water surface and the part of the dry land which is adjacent to the contact shoreline.

The coastal marine zone has been determined with the resolution of the World Conference on the Coastal Zones (1993) as the specific geographical space, which is characterized with the concentration of the coastal environments and the appropriate natural and the anthropogenic systems which are close contacted. In the widest understanding of this term, the coastal marine zone is a part of the dry land which depends on the close location to the sea and it affects the sea, and also that part of the sea that feels proximity of the dry land. It is characterized with the originality of the geological, of the geographical, of the meteorological, of the energetic, of the physicochemical, of the biological phenomena and the processes and it generates the unique style of the coastal economic activity of the human (Pittman J, 2016).

So, the coastal zone of the sea we mean as the zone of the mutual influence of the territory and the water surface, the peculiarities of which are determined with the processes of their interaction such as the geomorphological, the microclimatic, the process, the migration. It stretches along the contact shoreline. Most often, this interaction is determined geomorphologically (Zenkovich, 1980), with the result of the manifestation in the form of the beach. The manifestation of the microclimatic, the process and the migratory interactions in the coastal zone of the sea is also distinguished with its specifics through the migration of the ions, the salt and their solutions, the manifestation of the breeze circulation, the humidity of the air, etc.

Acting in the coastal zone of the sea the processes and the forces, the forms of the relief, the nature of the deposits, the bioproductivity and the biodiversity, the forms of the economic use of the shore are so peculiar (Dergachev, 1987, Vedeld, 1994) that its secretion into the separate natural-economic object is not only undoubted, but it is also quite necessary. The main peculiarities of their functioning is the high variability and the dynamics of the litomas, associated with the increase and the decrease of the level of the water activities of the seawater. As a result, there is a rapid



reforming of the coastal relief and its variability in the space and the time. The movement of the coastal-marine sediments along the isobaths of the coastal slope is a common phenomenon for the maritime coastal zones, which cannot physically occur directly on the dry land. Besides, the migration of the soil solutions in the coastal zone is more intense compared to the dry land, which causes the slow formation of the soil cover. The biological productivity of the coastal zone of the sea is also more high for the adjacent dry land or the deep of the surface water: here the manifestation of the “biological effect” is taken place such as the highest biological productivity and the concentration of the biological diversity of the plants and the animals due to the intensive metabolism of the substance and the energy.

In the coastal zone of the sea there are overall phenomena of the para-dynamics such as the material, the energetic and the informative. Here the system of the contacts between the dry land and water is extremely complex. This is due to the significant concentration within it of the multidirectional material-energetic flows and the transfers as both longitudinal and the transverse (Vorovka, 2013; 2018). The last are caused with many factors: the microclimatic differentiation, the complex configuration of the shoreline and the peculiarities of its spatial orientation, the predominance of the wind currents of the certain direction and their strength, the presence of the mouths system of the river, the character of the circulation of the water masses, the peculiarities of the relief of the dry land and the seabed and others. The consequence of such contact is diversity formations such as from the peculiarities of the relief to the increased concentrations and the totality of the living organisms.

At the same time, the significant number of the anthropogenic objects are concentrated within the coastal zone of the sea, which form their own system of the para-dynamic connections. The existing and rather complex structure of the natural connections is more complicated with the para-dynamic connections of the anthropogenic origin, which unite the components due to the manifestation of the appropriateness of the anthropogenic (social) objects. In fact, the coastal zone of the sea has become as the natural-economic complex, formed with the diversity of the environments, the conditions and the resources (Dergachev, 1987).

The natural, the natural-anthropogenic and the anthropogenic para-dynamic connections within the coastal landscape system are often manifested together and it is difficult to distinguish clearly. The

natural is most often manifested in the conditionally unchanged environment. The natural-anthropogenic is the synthesis of both types of the interactions. The anthropogenic is manifested mainly between the different types of the anthropogenic landscapes. The natural complexes can disappear and can modify under the influence and the domination of the anthropogenic connections.

The closest interactions are manifested in the breakers zone. With the distance from it, the connection and, consequently, the impact weaken. The appropriate change of the properties of the environment of the coastal zone of the sea gives the right to call it as the transitional zone of the geographical space, or the geoecotone, it is with the set of the properties that is manifested within certain limits on both sides of the shoreline (Vorovka, 2018). The contrast of the environments and the presence of the close contact between the active components within the coastal marine zones cause the formation of the active surfaces (Ajzatullin, 1984), or the surfaces of the interaction, which underline the ecotonic contents of the coastal marine zones. The most active surfaces of the interaction in the coastal zone of the sea are the contact surfaces of the “water-air”, of the “dry land-air”, of the “water-dry land”, of the “water-bottom”, of the “solid substrate-biota”, of the “bottom-biota”, of the “water -ice”, of the “river-sea “. They arise on the contact of the dry land and the water, the air and the water, the air and the dry land, the coastal pond (limans, gulfs) with the water surface of the sea, the river mouths and the water surface of the sea, the water with the seabed, the living organisms with the abiotic components of the coast, the anthropogenic objects with the natural components of the coast.

Among the peculiarities of the interaction of the contrasting environments in the coastal zone of the sea, which affect the structure and the functioning of the landscapes, the following peculiarities should be singled out (Vorovka, 2013):

- the complex spatially-temporal movements of the water, the solid and the gaseous substance in the coastal zone;
- the intensive phase transitions of the substances such as the freezing of the water, the melting of the ice, the dissolution of the salt and their crystallization from saturated solutions, the dissolution and the secretion of the gas, the saturation of the water with the oxygen during the swash;
- the intensive photo- and chemosynthesis;
- the destruction of the organic and the inorganic substances, the mineralization of the organic substances;

- the intensive migration of the organic substances and the living organisms;

- the intensive and the close interaction of the hydrosphere, the lithosphere, the atmosphere and the biosphere.

In the coastal zone of the sea, the para-dynamics is caused with the processes that are represented mainly with the hydrogenous, the gravitational, the aeolian, the flotation, the hemogenic, the biogenic, the phase and the anthropogenic groups (Fig. 1). The group of the hydrogenous is represented with the breakers migration of the sediments, the differentiation of the sediments on the seabed and the river runoff. The gravitational group is represented with the different intensity of the migration of the sediment on the different speed slopes, the coastal gravitational processes and the sedimentation of the solid and the suspended substances from the water. The group of the aeolian processes is associated with the migration of the substances between the sea and the dry land in the wind flow (the breeze circulation, the continental transfer, the sedimentation from the atmosphere). The hemogenic and biogenic processes in the para-dynamic interaction have extremely large diversity, among which the brightest are the salt and the ionic exchange, the migration of the biogenic substance, the interchange of gas, the changes of the bioproductivity, and others. The significant role in the functioning of the coastal landscapes and the aqua-landscapes is played with the phase transformations of the substances such as the evaporation and the condensation of the moisture, the crystallization

of the salt and the water, the transformation of the energy, the formation and the decomposition of the organic substance, and others. The energy processes are accompanied by the inflow, the release and the storage of the energy during all the above-mentioned processes.

The most widely material-energetic flows from the dry land to the water surface of the sea are represented due to the higher hypsometric position. However, there is the specific phenomenon among the interactions of the sea and the dry land in the breakers zone such as the movement of the parts of the different sizes in the opposite directions under the influence of the surf activity: the volumetric and the coarse-grained parts of the biogenic origin (mostly the shells of the dead mollusks) move towards the shore, while small low-like abiogenic are carried out to the sea. This fact plays the main meaning for the formation of the unique features of the breakers zone of the Sea of Azov such as the presence of the sandy-shell beaches, the bars and the accumulative spits. Each of these accumulative formations is the result of the close interaction of the sea and the dry land, as the spatial appropriateness of the distribution of their granulometric compositions are evidenced.

The sorting and the bottom differentiation of the sediments as the result of the combined action of the wind waves and the gravitational processes cause the regular formation of the tiered strips of the multigrained sediments of the bottom as mainly terrigenous origin such as from the sand (fraction is 1-0.1 mm) in the zone of the swash to

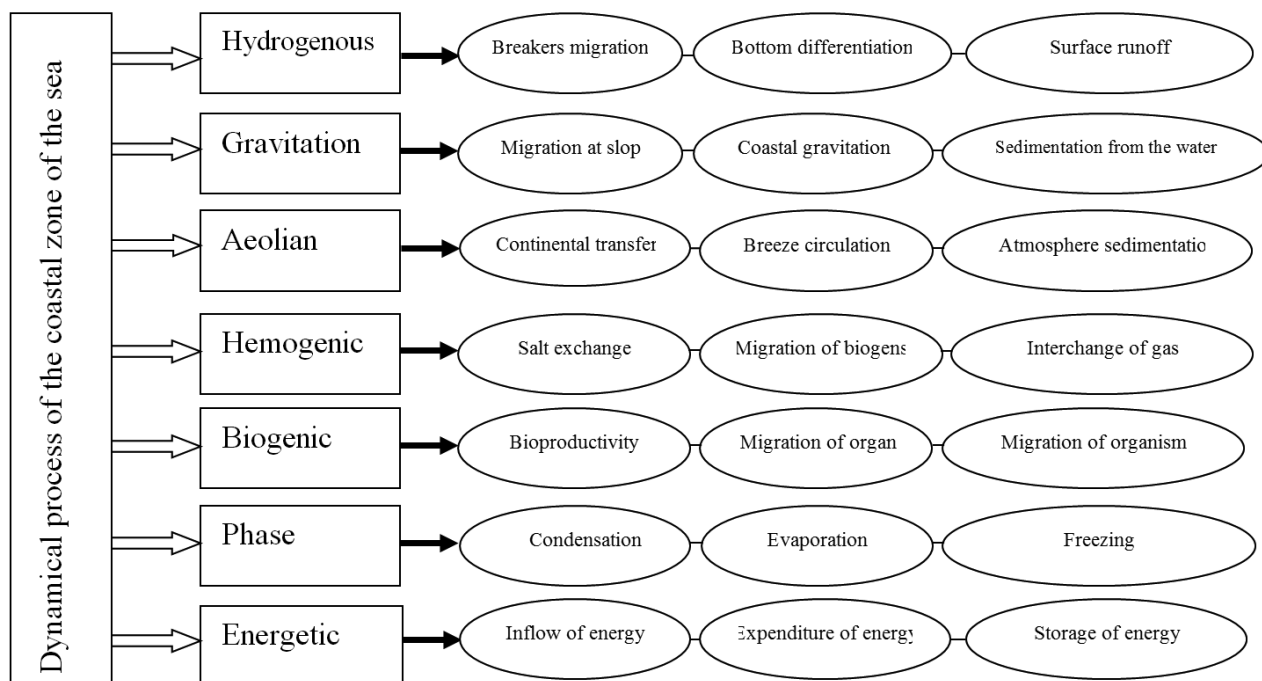


Fig. 1. Scheme of the dynamical processes in the coastal zone of the sea (Vorovka, 2018)

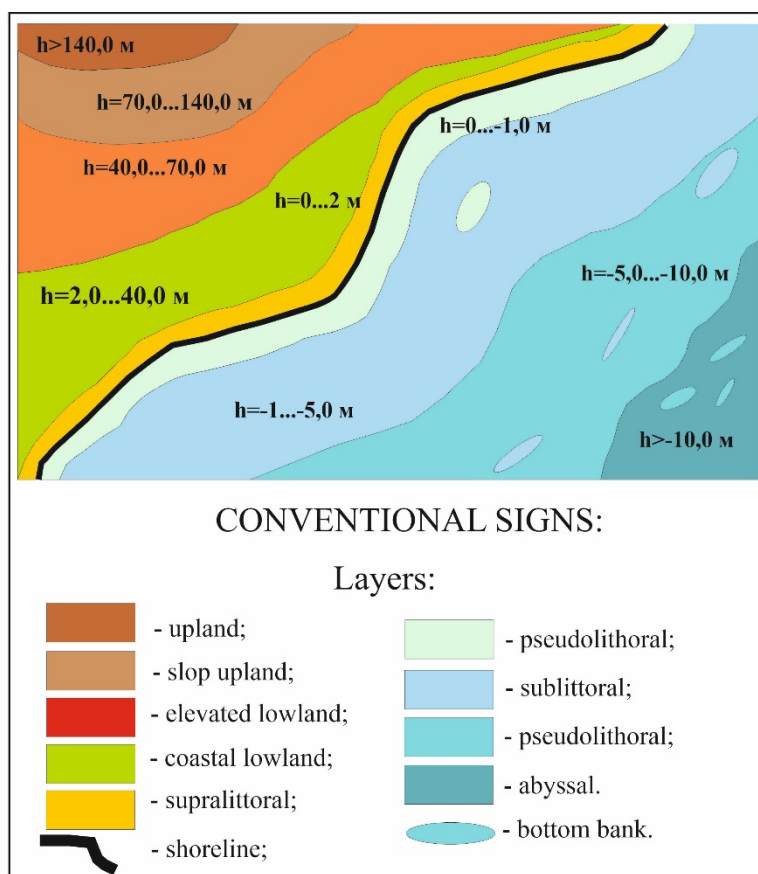


Fig. 2. Tiered structure of the coastal zone of the Sea of Azov (Vorovka, 2018)

the depth of 5-6 m, with their gradual transition to the aleurite (fraction is 0.1-0.01 mm), at the depths of 5-9 m and the pelitic (fraction is 0.01-0.001 mm) in the deep water calm areas (Fig. 2). This “striped” of the bottom is also the consequence of the para-dynamics of the dry land and the bottom with the water surface and the typical feature of the shallow and the stormy Sea of Azov. Similar layers are formed on the dry land and they are caused with the different intensities of the gravitational processes. The highest its intensity is in the coastal zone (the coastal gravitation), where the bedrock banks are destroyed under the influence of the waves, and depending on the composition of the rocks, it crumbles or it collapses. The high intensity of the gravitational processes is typical of the steep slopes of the Pryazovia crystalline massif, the sod of which crumbles and gradually slides down the slope.

The surface of the Pryazovia coastal plain is the main supplier of the terrigenous material to the bottom within the Northern Pryazovia. The dominant role of the process of the abrasion of the shores in the inflow of the terrigenous sediments is the typical feature of the sedimentation at the bottom of the Sea of Azov (Fig.2). The total value of the supply of the material of the abrasion to the seabed changes from 2.0 to 17.0 million tons with its average value until the 80's of

the XX century of 6-7 million tons (Mamykina, 1980). During the period from the 90s of the XX century until today, the change of the wind circulation regime and the constant annual lift of the level of the sea by 2 mm has affected the intensity of the geomorphological processes in the coastal strip of the sea and it has caused the acceleration of the abrasion processes and the increase of the volume of the substance of the abrasion by 1.5 times, so to the size of 10-11 million tons (Matyshov, 2008). It is contributed the warming of the climate, due to which the level of the Sea of Azov is constantly rising and according to the different scenarios by 2100 year it can rise to 115 cm.

It should be noted that the high molluscos bioproductivity of the sea is also closely related to the adjacent dry land and the surface runoff from it. The hydro-carbonate class of the river runoff (Bronfman, 1985; Ivanov, 2008) of the Ca group promotes the income into the water surface of the sea of the significant amounts of the calcium, it is the main element for the construction of the shells by the mollusks. Although after the regulation of the runoff with the reservoirs and the ponds, the water of the rivers of the Azov Basin have been significantly impoverish the ions of  $\text{HCO}_3^-$  and  $\text{Ca}^{2+}$ , and there has been some decrease of the coefficient of the carbonate, and the

terrigenous source of the income of the calcium into the water surface is still the main. Also the main thing is the terrigenous runoff of the biogenic substances (mostly the nitrogen and the phosphorus compounds), which are the basis of the bioproductivity of the Sea of Azov. If before the regulation during the period of the spring vegetation, the sea has received about 70% of the annual amount of the biogenic substances and in the modern period, it is about 45% due to their accumulation in the creation of the anthropogenic ponds during the 50-80s of the XX century.

The wind-circulation interactions are the important in the manifestation of the para-dynamic interactions in the coastal zone of the Sea of Azov. The aeolian processes are caused with both climatic peculiarities of the region and the breeze manifestations. The significant part of the bottom sediments of the Sea of Azov consists of the products of the aeolian transfer of the terrigenous origin from Kalmykia, Krasnodar territory and Rostov region, which arrive through the “wind tunnel” between Donetsk chain of the hills, Pryazovia crystalline massif and the northern offshoot of the Caucasus. Partially the aeolian material is supplied to the water surface with the west wind from the steppe zone of Kherson region and the Steppe Crimea and with the northern wind, it is from the territories of Zaporizhzhia and Dnipropetrovsk regions.

The peculiarity of the breeze relations of the dry land and the sea is due to their daily dynamics and the manifestation in the warm period of the year, starting from March. The changes of the direction of the wind during the breeze are accompanied with the special daily course of the temperature and the humidity of the air due to the advection of the warm and the moisture due to the transfer from the sea or from the shore. In the coastal zone of the seas, the breeze circulation increases the total radiation due to the increase of the line by up to 10% (Rybchenko, 2007). Due to the action of the breeze circulation on the coast, the wind speed increases from 1.5 to 4.0 m / s (it is the important for the wind energy) and the periodic changes of its direction. Another important consequence of the breeze circulation is the less frequency of the calm and more number of the days with the strong winds. The breeze circulation is accompanied with the removal of the marine ions which are saturated with the wind flow from the zone of the swash. From the maritime salted depressions, the breeze wind carries out the salt crystals both towards the sea and the deep into the dry land. This causes the significant salinity of the landscapes of the coastal zone of the sea.

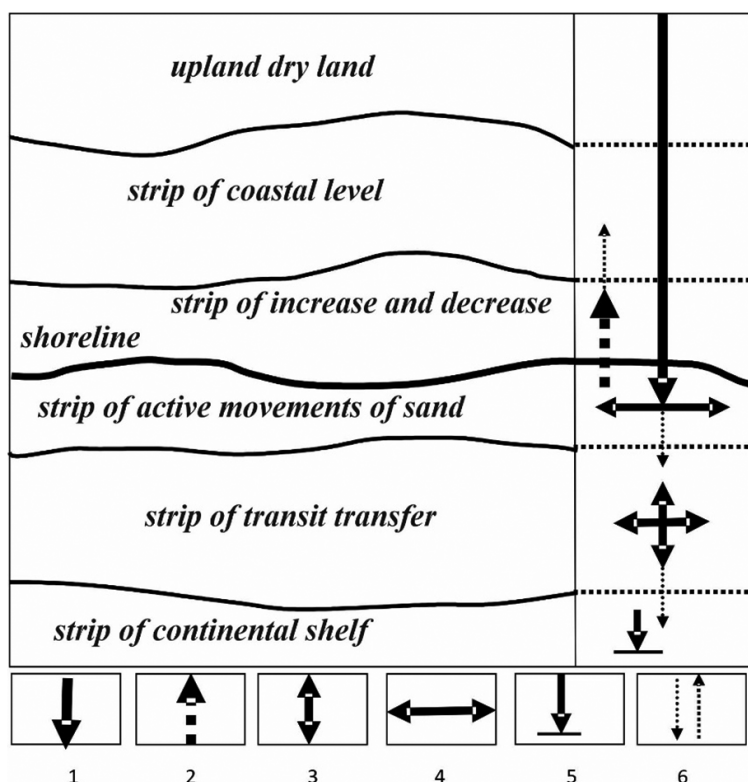
The creation in the warm period of the year over the water surface of the Sea of Azov unfavorable conditions for the occurrence of the convection is accompanied with the increase of the number of the cloudless days. As a result, within the coastal zones of the sea the less number of the sedimentation is fixed compared to the other areas of the dry land, and more dry landscapes are formed. However, in the cold and the transitional periods, due to the high temperature contrast between the sea and the dry land, the fog forms here for several days in succession (Shaxnovych, 1983).

The hemogenic processes also determine the peculiarities of the maritime para-dynamic interactions and the landscapes in general, significantly affecting the course and the intensity of the interaction between the dry land and the water surface, regulating the bioproductivity, the biodiversity and the self-cleaning capacity of the geosystems. They are primarily associated with the aeolian migration and the river runoff, which cause the removal of the chemical elements ( $\text{SO}_4^{2-}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ) and the salt from the sea surface and the zone of the swash at the dry land and on the contrary. If mainly the chloride compounds arrive from the sea to the dry land, so mainly carbonate compounds come from dry land to the sea. With the wind currents come mainly the solid parts due to the deflation, the chemical substances as the transpiration salt, the products of the atmospheric emissions of the industrial enterprises and the motor transport (Khrustalov, 1999; Sorokina, 2006; Symov, 1989).

The hemogenic interactions between the strata of the water and the muddy sediments of the bottom form the mechanisms of the geostasis of the phosphorus and the nitrogen, which play the main role in the bioproductivity of the aqua landscapes of the Sea of Azov. Thus, the lack of the phosphorus in the strata of the marine water is compensated with its regeneration from the muddy sediments, and the surplus is with the adsorption and the supply in the bottom biogenic mud. Through the processes of the anaerobic ammonification and the nitrification in the surface sediments of the bottom, the regulation of the contents of the nitrogen in the strata is taken place.

Together with the substance in the detected interactions there is an energy-informative exchange between the dry land and the sea, which differs in its specifics. It is manifested both during the connection of the dry land with the sea (the mineral and the material composition of the terrigenous sediments, the physical and the chemical indicators of the river runoff, the biogenic runoff, the volume and the peculiarities of the pollutants, etc.) and on the





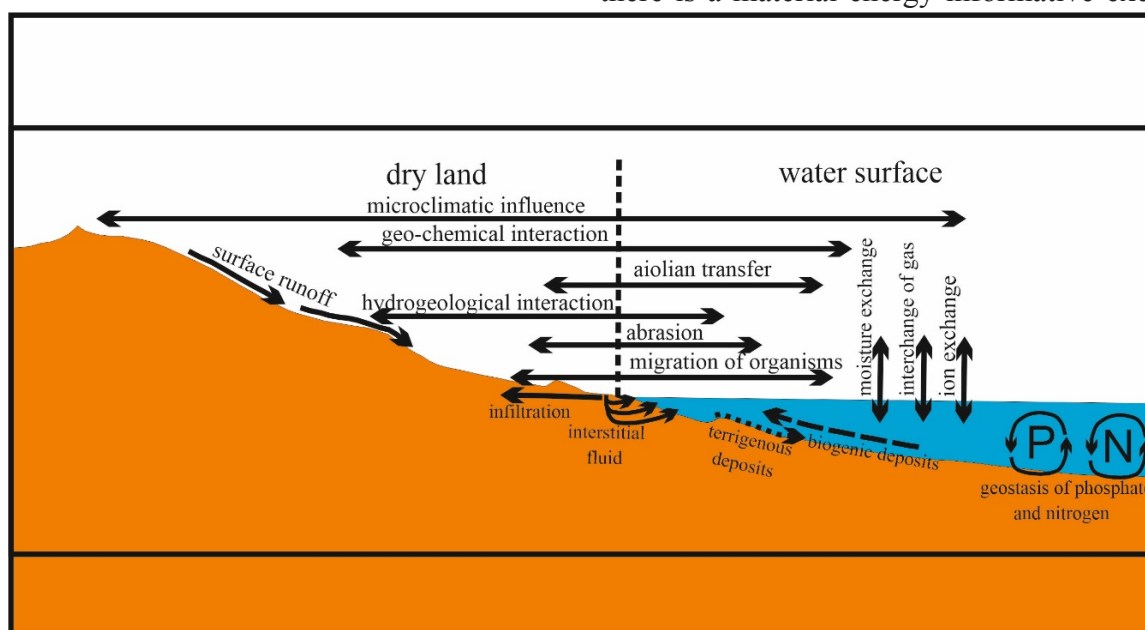
**Fig. 3.** Scheme of energetic interactions in the coastal zone of the sea:

1 - energetic flow from dry land; 2 - energetic flow from the water surface; 3 - transverse energetic interactions; 4 - longitudinal energetic interactions; 5 - energy storage zone; 6 - transition of energy between strips (Ortiz-Lozano, 2007).

contrary (the volume and the composition of the shell sediments of the shore, the changes of the level of the water in the coastal depressions due to the infiltration, the microclimatic indicators, etc.). The energetic flow, as the material, is directed mainly from the dry land to the sea, where it is redistributed between the strips, and also its transformation and the storage are occurred (Fig. 3). The most intensive energetic interactions are occurred in the close proximity to the shoreline. With

the distance from it there is a transformation of the energy and its attenuation, and within the deep strip of the continental shelf it is its accumulation.

In fig. 4 the attempt to visualize the diversity of the para-dynamic phenomena has been done by the author which are occurred in the coastal zone of the sea. As it can be seen, it is a complex system of the interactions, as a result of which there is a material-energy-informative exchange



**Fig. 4.** Generalized scheme of interactions in the coastal zone of the Sea of Azov (Vorovka, 2018)

between the contrasting environments of the sea and the dry land. All these types of the interactions are different in the scale and the intensity, they appear in the different periods of the time, they have their own limit of the spread. Due to the high variability of these interactions, the limits of the spread of one or another phenomenon change.

Based on all diversity of the interactions, the boundaries of the coastal zone of the Ukrainian part of the Sea of Azov on the dry land and in the water surface are grounded by the author (Hryshko, 2017). Within the determined boundaries, the landscape map of the para-dynamic system has been compiled (Fig. 5). The proof of the close interaction between the dry land and the water landscapes of the coastal zone of the sea is the configuration of the boundaries, which is, in most cases, are “tied” to the contours of the coast, including the accumulative spits, the gulfs and the limans. The exceptions are the landscapes of the river valleys, the landscapes of the Pryazovia crystalline massif with its slopes and the foothill landscapes of the Crimea. Despite this, they also take the active part in the processes of the interaction which have been described above.

**Conclusions.** So, in the coastal zone of the sea there is the significant number and the diversity of the maritime natural and the anthropogenic para-dynamic interactions, which determine the peculiarities of the formation of the coastal landscape space. Their specifics is caused with the high intensity of the abrasion-accumulation processes; the significant dynamics of the migration of the organic and the inorganic substances; the intensive wind, the runoff and the subsoil transfer of the salt; the significant salinity of the soil horizons; the intensive longitudinal and the transverse migration of the biogenic and abiogenic substances; the peculiarities of the coastal microclimate and the wind circulation processes, including the coastal breezes; the natural-anthropogenic and the anthropogenic interactions. As a result of the manifestation of the para-dynamic interactions within the landscapes and the aqua-landscapes, the strips of the intensity of the influence are formed. With distance from the shoreline, the intensity of the interaction decreases. The intensity of the interactions determines the specifics of the structure and the peculiarities of the functioning of the coastal landscapes and the aqua-landscapes.

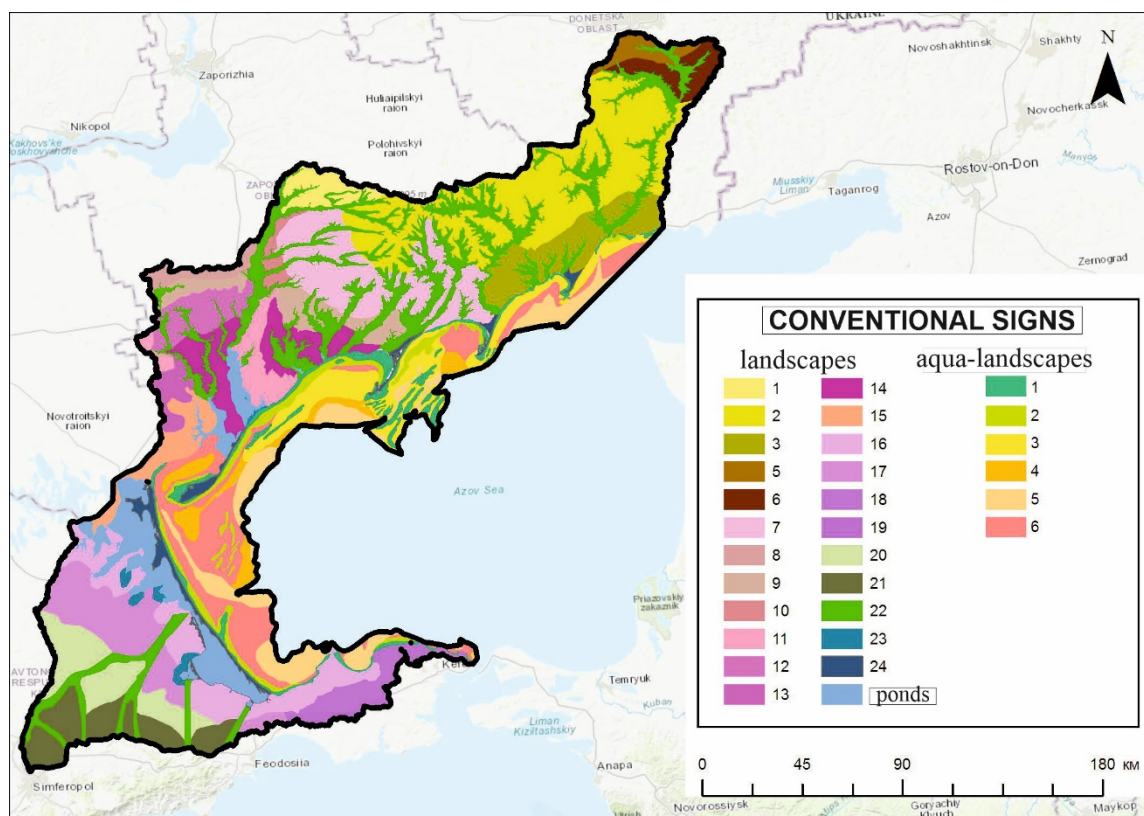


Fig. 5. Map of landscapes and aqua-landscapes of the Pryazovia para-dynamic landscape system

**It is landscapes: North-steppe:** 1 - loess strongly dissected slopes of the upland and the elevated plains with the anthropogenic cover on the low-power strata of Paleogene-Neogene sandy-clay deposits, which is recovered the crystalline foundation with the chernozems ordinary low-humus, with the gulches and the balks, embedded to the crystalline rock with the widespread of the agrocenosis under the forb-fescue-feather vegetation; 2 - strongly dissected upland and the hills with the

low-power anthropogenic cover in the crystalline foundation with chernozems ordinary low-humus, with the gulches and the balks, embedded in the crystalline rocks, with denudation farewell rocks (stone graves) with the widespread of the agrocnosis at the place of the forb-fescue-feather vegetation; 3 - loess weakly dissected lowland plains with the anthropogenic cover on the Neogene limestone deposits with the chernozems ordinary low-humus deep micellar under the agrocnosis at the place of the forb-fescue-feather vegetation; 5 - loess strongly dissected the upland and the hills with the Hercynian folded base, covered with the Meso-Cenozoic sediments of the various lithological composition with the chernozems ordinary low-humus, with the gulches and the balks, embedded to the carbon deposits, with the agrocnosis at the place of the forb-fescue-feather vegetation; 6 – wavy-hilly dissected structural-denudation uplands with the Hercynian folded base with the chernozems ordinary low-humus in the combination with chernozems and the sod soils on the eluvium of the dense carbonate-free rocks with the widespread of the agrocnosis at the place of the forb-fescue-feather vegetation. **Medium-steppe:** 7 - strongly dissected slopes of the loess uplands with the low-power anthropogenic cover on the Precambrian crystalline rocks, with the chernozems southern low-humus with the denudation farewell rocks (stone graves), with the gulches and the balks, embedded to the crystalline rocks, with the developed agrocnosis at the place of the fescue-feather vegetation; 8 - loess weakly drained low plains with the strong anthropogenic cover on the Neogene limestone and the sandy-clay deposits with the chernozems southern low-humus in the combination with the meadow-chernozem, the sod gley soils and the gley-solod padings with the developed agrocnosis at the place of the fescue-feather vegetation cover; 9 - loess low plains with the strong anthropogenic cover in the Neogene limestone and the sandy-clay deposits, dissected with the steppe balks, with chernozems southern low-humus, with the developed agrocnosis at the place of the fescue-feather vegetation cover; 10 - terraced loess low plains with the strong anthropogenic cover on the Neogene limestone and the sandy-clay deposits, with the chernozems southern low-humus in the complex with the solonetzic with the widespread agrocnosis at the place of the fescue-feather vegetation. **South-steppe:** 11 - weakly drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits, with the chernozems southern solonetzic in the complex with dark-chestnut solonetz-like soils and in the combination with the meadow-chernozem gley soils, gley-solod padings with the widespread agrocnosis at the place of the wormwood-cereal vegetation; 12 - drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits with the chernozems southern weakly solonetzic in the complex with the dark-chestnut solonetz-like soils, with the widespread agrocnosis at the place of the wormwood-cereal vegetation; 13 - weakly drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits with the dark-chestnut solonetz-like soils in the complex with the solonetz and in the combination with the meadow solonetz-like soils and the gley-solod padings with the widespread agrocnosis at the place of on the wormwood-cereal and solonetzic vegetation; 14 - drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits, with the dark-chestnut solonetz-like soils with the widespread agrocnosis at the place of the wormwood-cereal vegetation; 15 - weakly drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits with the chestnut medium- and strongly solonetz-like soils in the complex with the solonetz and in the combination with the meadow solonchaks with the widespread agrocnosis at the place of the wormwood-cereal and solonchaks vegetation. **The Crimean analogues of the steppe landscapes:** 16 - low loess plains of the edge depressions with the anthropogenic cover on the Neogene sandy-clayey rocks, with the chestnut and the dark-chestnut solonetz-like soils in the complex with the solonetz and the meadow solonchaks with the widespread agrocnosis at the place of the wormwood-cereal and solonetzic vegetation; 17 - low loess weakly dissected plains of the edge depressions with the anthropogenic cover on the Neogene sandy-clayey rocks with the chernozems southern solonetzic in the complex with the dark-chestnut solonetz-like soils and the solonchaks with the widespread agrocnosis at the place of the wormwood-cereal and solonetzic vegetation; 18 – lowland hilly wavy-bald mountain plains of the foothill depressions with the surface deposits of the dislocated Paleogene-Neogene sediments, with the chernozem and the dark-chestnut solonetz-like soils in the complex with the solonchaks on the eluvium of the shale clay, the marl and the limestone under the agrocnosis at the place of the wormwood-cereal and fescue vegetation; 19 - lowland sloping denudation plains of the foothill depressions with the surface deposits of the dislocated Paleogene-Neogene sediments, with the chernozem and the dark-chestnut solonetz-like soils in the complex with the solonetz on the clay eluvium under the agrocnosis at the place of the wormwood-cereal and fescue vegetation; 20 - lowland weakly dissected loess plains with the anthropogenic cover on the Neogene limestone, with the chernozems southern low-humus carbonate (micellar) under the agrocnosis at the place of the wormwood-cereal and fescue vegetation; 21 – lowland weakly dissected accumulative-denudation plains with the anthropogenic cover on the Neogene limestone with the chernozems on the eluvial-deluvial carbonate deposits, under the agrocnosis at the place of the wormwood-cereal and fescue vegetation; 22 – flood-plain, meadow-steppe and the solonetzic-solonchaks floodplain landscapes of the plains under the agrocnosis at the place of the meadow vegetation; 23 – maritime landscapes of the liman-marine solonchaks plains with the vegetation of the salted meadows; 24 – maritime landscapes of the shell-sand bars, the spits and the islands with the underdeveloped sod-chernozem solonetz-like soils and the solonchaks, under the rarefied vegetation of the maritime spits and the bars. **Aqua-landscapes:** 1 - coastal shallow dynamic areas (0-6 m) and bottom ridges (6-9 m) with the medium and close-grained sand (fraction is 1-0.1 mm > 70%) with the significant contents of the shells and the grouping of the mollusks *Balanus* and *Cerastoderma*; 2 - coastal dynamic (6-7 m) with the aleurite -muddy sands (it is 1-0.1 mm - 50-70%), with the moderate contents of the shells and the grouping of *Cerastoderma* and *Balanus*; 3 - medium-deep (6-8 m) with the aleurite-muddy-sandy mixed sediments and the contents of each fraction of 30-40% with the small part of the shells and the shell detritus; 4 - deep (8-10 m) with the moderate hydrogenous differentiation of the sediments and the predominance of the aleurite (fraction is 0.1-0.01 > 70%) with the small part of the shells and the shell detritus with the widespread of the mollusk grouping of *Abra*, *Cerastoderma*, *Balanus* and with the small part of the groping of *Hydrobia*; 5 - deep (9-10 m) with weakly hydrogenous differentiation of the sediments and the predominance of the muddy aleurite (fraction is 0.1-0.01 mm - 50-70%) with the widespread of the grouping of *Hydrobia*, *Abra*, occasionally - *Anadara*; 6 - deep (9-10 m) with the balanced processes of the hydrogenous differentiation and the gravitational deposition, the dominance of the muddy sediments (fractions is <0.01 mm > 50-70%) with the admixture of the sand-aleurite fraction and the widespread of the mollusk grouping of *Abra*, *Hydrobia*.



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