9 Black Sea

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Abstract

Key issues of physical geographical properties of the Black Sea with ecological and economic problems are described in this chapter. The protection of the Black Sea coast of Georgia and the management of the processes on this coast should be in the hands of the state. There should be appropriate legislation that prohibits the acquisition of materials from the river confluences and riverbeds for construction purposes, construction in the wave influence zone, etc. Any protective measure should be considered in relation to the whole dynamic system.

The Black Sea, as part of the Mediterranean Sea, played an important role in geographical research from the Antique period. Its systematic-methodological study started in the nineteenth century.

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The Black Sea is a typical inland sea. In the west, its shape is formed by the eastern edge of the Balkan Peninsula, in the east—by the Caucasus Mountains and the Kolkheti Lowland, in the north-east—by the eastern European plain, and in the south—by the mountains of Asia Minor.

The length of the sea coastline according to various authors is 4020–4100 km.

The Black Sea is a continental sea of the Atlantic Ocean. The Bosporus Strait connects it to the Marmara Sea, and the latter is connected to the Mediterranean Sea by the Dardanelles strait. In the northern part of the sea, the Kerch Strait connects it to the Azov Sea. The Azov Sea can also be considered a shallow bay of the Black Sea. The sea area is 420,325 km^2 (462,000 km^2 including the Azov Sea). The northernmost part of the sea is the Berezan Liman near the Ochakov (46° 33′ N), the eastern—a shore between Batumi and Poti (41° 42′ E), the southern—Giresun, to the west of Trabzon (40° 56′ N) and the western edge—the Burgas Bay (27° 27′ E). The maximum length of the sea is 1175 km, the average depth is 1271 m and the volume of water in the sea is 537,000 km^3.

In general, the Black Sea shores are less fragmented. The north-western and the northern shores are more fragmented. There are located two large bays—Odessa and Karkinit. The Novorossiysk Bay is the largest bay on the Caucasus coast; Sinop, Samsun, and Vona Bays are largest along the Turkish coast. On the coast

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of Bulgaria, there are located two bays of Burgas and Varna. There are several peninsulas on the Black Sea coast, including Crimea, the largest one (Kos'yan 1993).

In the Georgian Soviet Encyclopedia the following explanation is given on the Black Sea bottom: "The shelf, continental slope, and deep-sea basin are distinguished in the relief of the bottom. 110–160 m depth shelf reaches the north-western part (Fig. 9.1). In other areas the shelf depth is less than 110 m, the width is from 10–15 to 2.5 km (at the Turkish coast). The continental slope is strongly fragmented with underwater gorges and canyons. The average inclination of the slope is 5°–8°. The system of submarine ranges is extended along the shore between Sinop and Samsun with the length up to 150 km. The bottom of the basin is a flat accumulated plain, to the center of which the depth of the sea increases up to 2000 m and more (max depth is 2210 m)" (Black Sea … 1986).

In geological terms, the bottom consists of sections of different types of different materials. A large part of the Black Sea depression is located in the Alpine folded zone. The earth crust under the depression consists of sediment (thickness of 10–16 km) and "basalt" layers ("granite" layers are on the peripheries). The Black Sea's north-western part includes the southern edge of the east European platform and Epi-Paleozoic platform. Some researchers link the formation of the Black Sea depression to the "oceanization" processes of the earth's continental crust. Some believe that the depression is a remnant of the ancient Tethys Ocean basin. The contour of modern depression was conceived in Oligocene, when due to the tectonic ascensions in Asia Minor the Black and Caspian Seas were

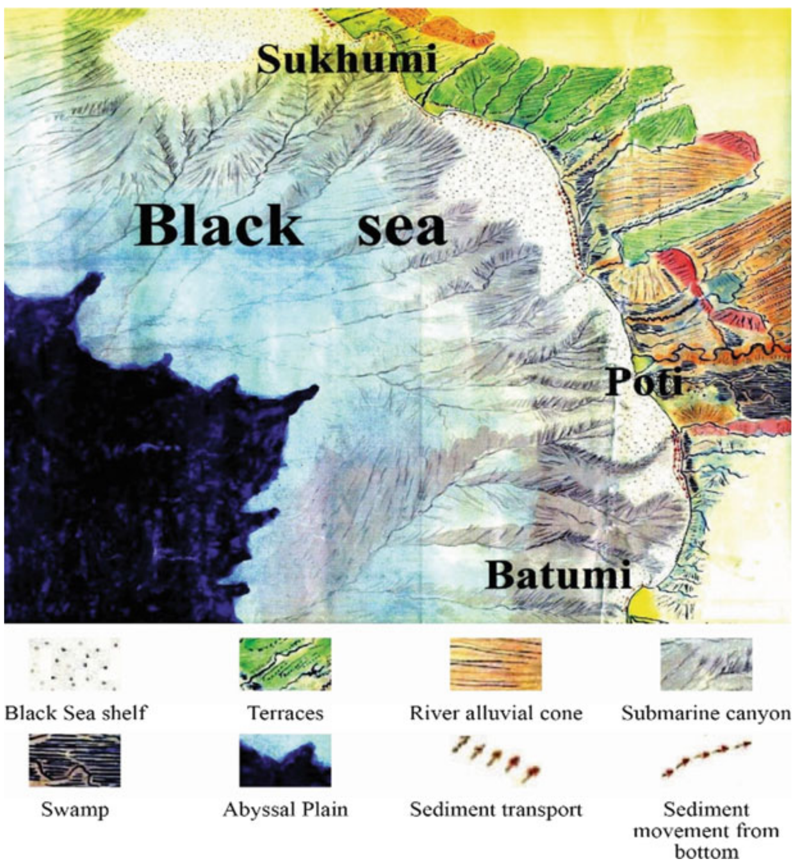

Fig. 9.1 Geomorphological map of east part of Black Sea from riv.Gumista to riv. Chorokhi, By D. Tabidze and G. Lominadze

gradually separated from the ocean. In the Late Miocene it was a part of the fresh sea-lakes (Sarmatian basin) of the Black Sea. After a short-term connection with the Mediterranean Sea, in the Meotian times, the fresh Pontian Lake was formed. At the end of the Pontian Stage, the connection between the Black Sea and the Caspian Sea was cut off.

It is likely that during the Middle and Late Pliocene it was a freshwater lake. In the Middle Pliocene the Black Sea was connected with the Mediterranean Sea two times and its water was more saline. During the last glaciating, a very freshwater New-Euxine lake-sea was formed, which connected to the Mediterranean Sea with straits 6–7 thousand years ago. This gave an origin to the modern Black Sea. Tectonic activity is manifested in earthquakes, the epicenters of which are located on the peripheries of the depression. In the coastal zone dominate the rough-fragment sediments: gravel, pebbles, and sands. At a distance from the shore, they are replaced by fine-grained sands and aleurites.

The Black Sea has been experiencing the continental polar, marine polar, and tropical air masses' influence throughout the year. Continental polar air prevails. Its intrusion in winter is accompanied by strong northern and north-eastern winds, temperature decrease, and precipitations. These winds are particularly strong in Novorossiysk region (see bora). The marine polar air intrusion from the Atlantic Ocean causes active cyclone action. The southwestern winds bring marine tropical air from the Mediterranean Sea to the Black Sea. Winter is warm and summer is hot and dry in the most parts of the Black Sea. In the central part of the sea, the average temperature in January is about 8 °C, at the eastern shores—6 °C, at the north-western shores—3 °C, and at southern and south-eastern shores—6–9 °C. Minimum temperature in the northern part is 30 °C. During the summer times, the Azor anticyclone branch extends over the Black Sea, which stipulates sustainable, clean, and warm weather. The average temperature in July is 22–24 °C, maximum—30–35 °C. Precipitation in the western and north-western parts is 300–500 mm per year, in the southern part—750–800 mm, and in the eastern part—1800–2000 mm. The compound part of the Black Sea water balance is the atmospheric sediments (230 km^3/y), continental runoff (310 km^3/y) and the water incoming from the Azov Sea (30 km^3/y), evaporation from the sea surface (360 km^3/y), and the water incoming from the Bosphorus strait into the Mediterranean Sea (210 km^3/y).

The cyclone circulation of the atmosphere and continental runoff determine the water cyclone circulation (clockwise direction). The speed of the water flow on the surface of the Black Sea is up to 1 km/h, which can reach 5–6 km/h in separate areas during strong winds. The excess of the inflowing in the Black Sea freshwater constantly flows through the Bosporus Strait in the Marmara Sea by its upper stream (up to 40 m deep); by the lower stream, the Mediterranean saline waters flow into the Black Sea, which fills the deep layers of the sea. Due to this, vertical water circulation is blocked in the Black Sea (GSE 1986).

The western rhumb winds and waves are dominated over the marine waters of Georgia just like over the entire Black Sea. In winter times, along with the western winds, the action of north-western winds is observed as well. During the whole year, the waves of 1–3 points of strength prevail over the marine waters of Georgia. Strong surfs are characteristic of the coastal zone of the central part of the Kolkheti Lowland (recurrence of about 20%). The maximum height of the waves varies within 3.5–6.5 m; it reaches 8 m at c. Poti and 9 m—at Batumi (Kiknadze et al. 2000).

In the last millenniums, the average level of the Black Sea is rising, which is caused by global warming. Annual pace of sea-level rise is 1.5–2.0 mm.

As a result of the water tides, the levels fluctuate within 40–60 cm on the Crimea coast, in the north-western part—up to 1.5 m. During tides, change in levels does not exceed 10 cm, during seiches—60 cm, and during the low tide, surface temperature of the water at the shore sometimes decreases from 25 to 10 °C and lowers just in several hours due to flowing out of deep waters. In winter the temperature of the upper layer of water (up to 60 m) decreases to 6–7 °C, in the north-western part—to 0.5 °C, and in the south-eastern part—to 9–11 °C. In summer the water surface is heated up to 24–26 °C, and at the coast—up to 29 °C. During the year-round the water temperature is around 7 °C at the depth of 60–80 m and deeper. The salinity of surface water in the open sea is 17–18‰, at the river confluences—less than 9–3‰; the salinity reaches 19–20‰ at the depth of 60–80 m, and at the bottom—22–22.5‰. In the winter the water density at the surface is 1.013–1.015 g/cm^3, and in summer—1.0085–1.0120 g/m^3. Diluted oxygen is only in the upper layer of water (8–9 ml/l). More than 150–200 m deep water is "poisoned" with sulfur-hydrogen, concentration of which reaches 11–14 ml/l. The color of the water in the central and eastern parts of the sea is greenish-blue, and in the north-western part—bluish-green. Water transparency is 16–22 m on average; it is 6–8 m at the shores, and in some areas, it decreases to 2–8 m.

There is no life at the depth of 150–200 m in the Black Sea (except for the anaerobic bacteria). Among the vegetation, about 350 species of phytoplankton algae are distributed there.

The Black Sea fauna is about three times poorer than the Mediterranean one. The bottom species (up to 1700 species) are dominant; about 2000 species of animals are found there (GSE 1986).The character of the terrain of the coastal zone is stipulated by the joint action of various factors, such as the sea wave mode, the volume of clastic material brought into the coastal zone, its granulometry and distribution along the coast, the geological structure (rocks sustainability to abrasion) of the coastal zone, the latest tectonic movements and character, etc. The intensity of these factors, both in time and space, is different in different areas of the coast and, therefore, their morphodinamical modes are different as well (Dzaoshvili and Papashvili 1993; Dzaoshvili 2003).

The formation and development of the coastal zone are mainly in progress at the expense of solid river runoff and fractions relevant to marine coastal sediments. Their movement along the coastline is caused by the wavings of the prevailing western rhumbs (Figs. 9.2 and 9.3).

The coastal zone, its water surface zone (beach), and the underwater coastal slope are in dynamic equilibrium until the energy generated by wave deformation and disintegration is discharged only on the transportation of the sea-coastal sediments. When there is a deficiency in the sediment budget of the coastal zone, the residual wave energy is used to deepen the underwater coastal slope and the wash-off and degradation of the shore. Otherwise, there is an accumulation of "excess" sediments and terrestrial growth at the expense of the sea. Exactly of such an origin are the capes of Bichvinta, Sokhumi, and Anaklia, located in the south of the confluence of the rivers of Bzipi, Gumista, Kodori, and Enguri (i.e., in the direction of deposits motion). The confluence of the Chorokhi River and the coastal location of Batumi (Burun-tabie) Cape is due to the opposite direction of the alongshore motion of the sedimentary stream (Fig. 9.4).

The clastic sediments transported by the alongshore submarine streams will be shifted to the coastline by the influence of the breaking waves, resulting in the origination and development of the beach line continuously. The full-profile beachline is such a natural formation that ultimately destroys the energy of the surf and protects the shore from erosion (Fig. 9.2).

It is also noteworthy that the full-profile beach is not only an essential element for seaside resorts and cities, but it is also a natural self-regulation means of sea and terrestrial interaction. Its sustainability is of particular importance for the accumulative type of shores that react sharply to every unreasonable and incorrect technogenic impact. That is why, the conditions of the coastal zone of Georgia, intensively growing at the expense of the sea as a result of sediment accumulation processes in the past, has been deteriorating over the last 100–120 years. This is mainly related to the anthropogenic factors, namely to the port groins breaking the alongshore movement of the sediments, the regulation of riverbeds falling into the sea, the construction of "shore protection" constructions,

Fig. 9.2 The emergency section on the southern periphery of the Batumi city coast 2005 (photo by G. Lominadze)

the improper placement of number of settlements, resorts, transport and communication networks, etc., as well as to the taking away tens of millions of m^3 gravels and sands from coastal areas and riverbeds, etc.

In the second half of the twentieth century, the Poti and Batumi ports were built on the Black Sea coast of Georgia. As a result, the Batumi Port facilities blocked the flow of beach-generating materials directed from Chorokhi confluence to Kobuleti and the wash-off process began in the north of the port from Bartskhana to Kobuleti. Their width was sharply reduced and the shore obtained such parameters that the small rivers of this section—Chakvistskali and Korolistskali have provided its feeding (Lominadze et al. 2015). The Kobuleti beaches had previously been fed by the average fine-fraction material transported from the north and large-scale fraction material transported from the south. A small number of materials transported from the north from the confluence of the rivers of Supsa and Natanebi, cannot provide the sustainability of the beaches and as a result, the seashore is intensely washed away (Fig. 9.5).

The Poti port construction completely changed the natural functioning of the Kolkheti Lowland beaches built with the sand of the Rioni River. Since the location of the main riverbed of the Rioni River threatened the sustainability of the port building at the southern entrance (due to the activity of existing underwater canyon), the main bed was artificially moved to the north of the port, to the Nabada area.

To the south of the port, passing through the area of the city, a low capability channel cannot provide (during floods) the passing through of the required amount of sand, and as a result, the Grigoleti coast is being washed away. In the north of port, in the territory of Nabada, the area adjacent to the new main riverbed of the Rioni River was intensely increasing. The new delta split into two flows more and more intruding deeply into the sea. Materials transported by waves to the south and north of the delta, simultaneously threaten two ports—Poti port and

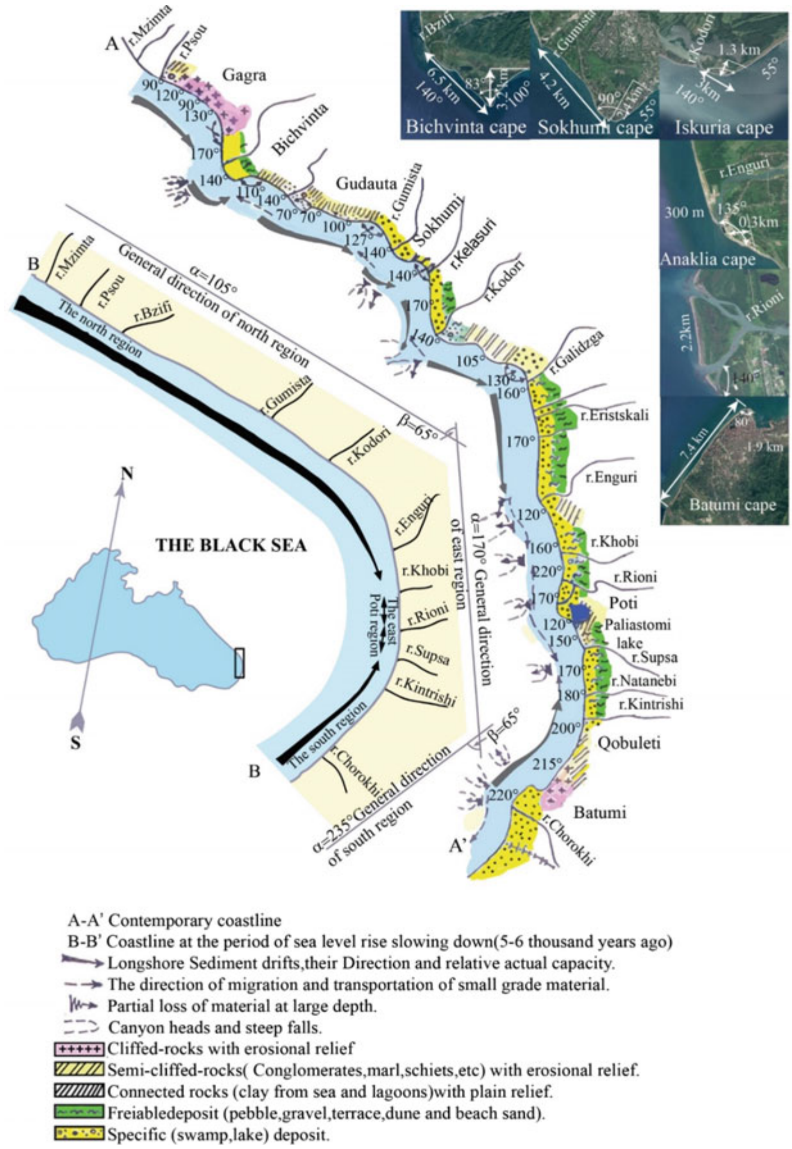

Fig. 9.3 Lithodonamic scheme of the Black Sea coast of Georgia according to A. Kiknadze (Kiknadze et al. 2000)

newly built Kulevi port (Papashvili et al. 2015) (Fig. 9.6).

From the 50s to the twentieth century, an intensive resort construction started on the eastern coast of the Black Sea. Ballast of millions of cubic meters removed from riverbeds and from the beaches directly was used as building material. In order to protect the resort areas from flooding, almost all the rivers have been placed in the frames, which has been fundamentally changed the established for thousand years distribution regime of materials brought out from the sea by river during flooding (Fig. 9.7).

This caused intensive washings of all the beaches on the eastern coast of the Black Sea. In danger appeared urban areas, farmlands, and especially railway lines near the coast. The problem of protection of the coast has been raised on the agenda. The shore protection was independently maintained by the Union Railway and separate Ministries of that time. The coastal protection measures carried out by them brought

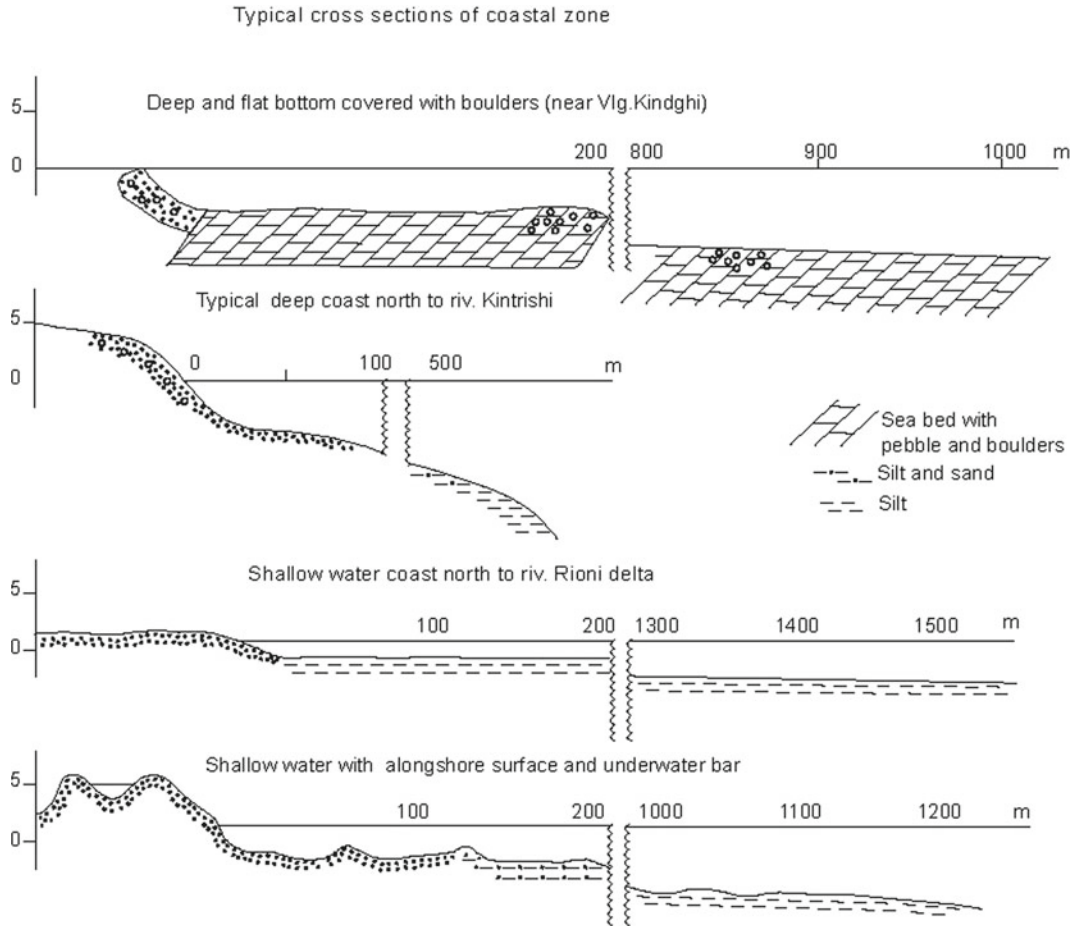

Fig. 9.4 Typical cross sections of Black Sea-coastal zone of Georgia (National Atlas of Georgia, 2012)

further disaster to the sea coast, since all organizations defended only their territory and only with concrete structures such as dykes, groins and breakwater piers.

These systems of protection were taken from the experience of foreign countries. In our reality, the coastal protective structures were very quickly damaged, and even in case they withstood the breaking waves, they were causing to washing the surrounding areas. For example, the groins and dykes hindered the distribution of materials in neighboring territories; and the breakwater piers reflected the waves and reinforced the backflow of the water, thus facilitating beach material to be washed into the sea. Finally, there remained washed and distorted beaches blocked with concrete fragments (Peshkov 2005) The construction of the dams on the rivers has greatly affected the coastal area, which significantly reduced the amount of beach constructing materials brought into the sea. This happened in the background of natural rising of sea level (transgression) when the amount and thickness of the materials brought into the sea by the rivers should have been reduced anyway (due to the reduction of the riverbed sloping). Naturally should have been changed the location of confluences and redistribution of the output materials on the coast as a result. For example, the confluence of the Chorokhi River was shifting to the

Fig. 9.5 Washed of sea shore 4 km south from Enguri river-mouth 2018 (photo by G. Lominadze)

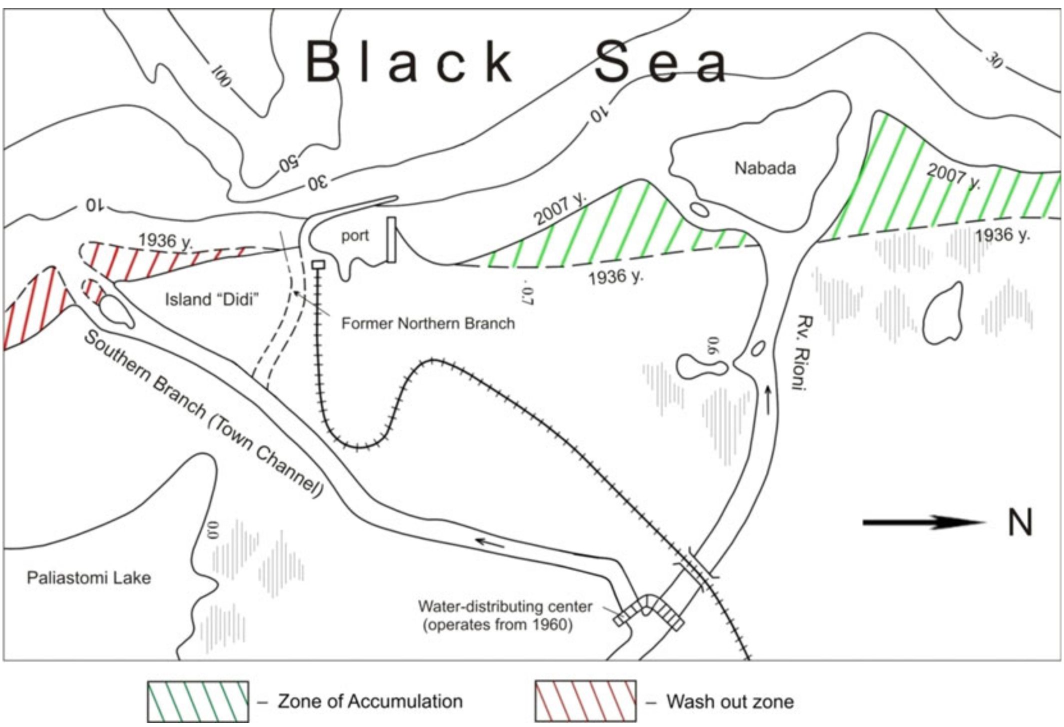

Fig. 9.6 Costal dynamics of r.Rioni river-mouth 1936–2007 (figure by Gr. Russo)

Fig. 9.7 Washed of seashore north from Supsa river-mouth 2009 (photo by G. Lominadze)

Batumi Cape during the regression of sea level, and during the transgression, it returned to the current condition.

In this case, the natural dislocation of the confluence has coincided with the real one that we cannot say about the other rivers of the Black Sea coast. The river confluence has been fixed at the location, where it was at the time of construction of frames.

The developed events in recent decades have put the final point on the natural development of the eastern coast of the Black Sea. According to the distribution areal of the main rivers that feed the beaches and the materials brought by them, this coast is divided into seven dynamic systems. In the northernmost, it is bordered by the northern dynamic system (the same Mzimta-Psou), and in the south—the Chorokhi dynamic system (Figs. 9.8 and 9.9).

Besides the Poti (Rioni) dynamic system, which has only sandy beaches, all the rest of the dynamic system beaches are composed of the gravelites-sandy mixture, where in most cases sands are not more than 30%. Among these dynamic systems, only the Bzipi dynamic system has less suffered the devastating impact on humans, if we do not take into consideration the fixation of the river confluence, which has a negative impact on the redistribution of the riverine material in the system. All the rest of systems are blocked with concrete structures, and to maintain the beaches the artificial feeding by riverine material is required in most cases.

The natural feeding of the beaches should be made by renewable sources, the river runoffs. Today we completely lack these circumstances on the Chorokhi and Enguri Rivers; on the Chorokhi River—due to the dam built by the Turks by our consent, and on the Enguri River—due to the dam built by us. The entire Kakhaberi Lowland is created by the Chorokhi River deposits. Today Chorokhi no longer deposits anything. There are no floods in the riverbed. The beaches are under the threat of washing away from the river confluence to the Batumi Cape. They can be maintained only by artificial

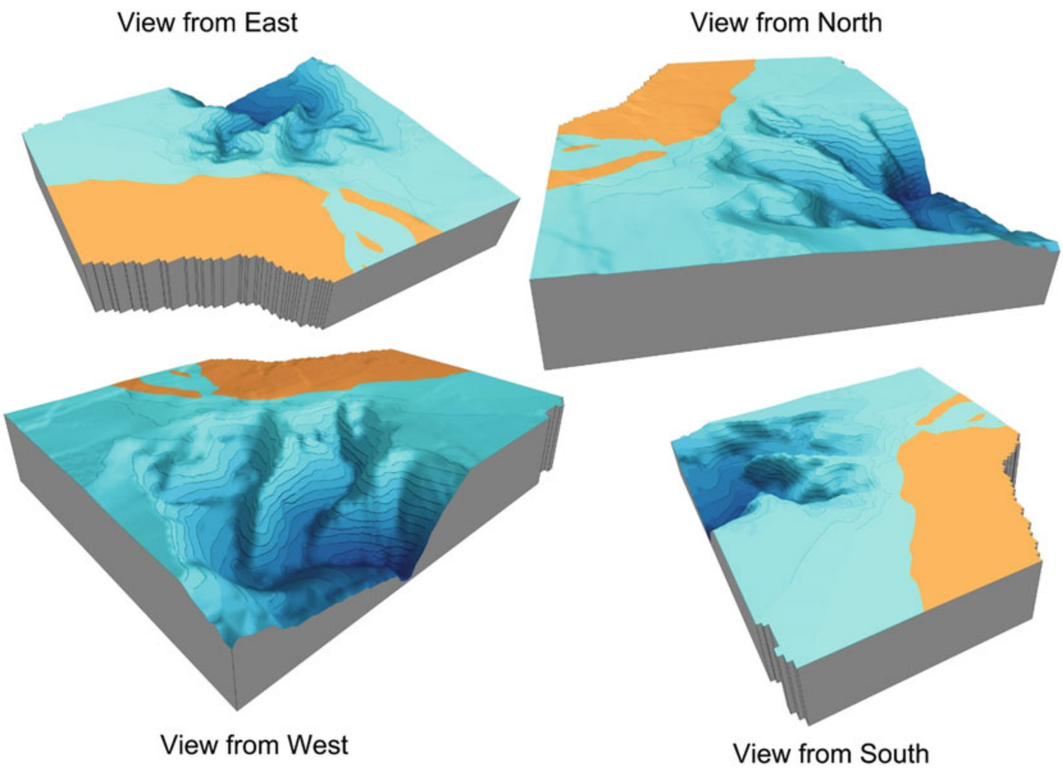

Fig. 9.8 riv.Enguri Canyon 3D. By G. KavlaShvili

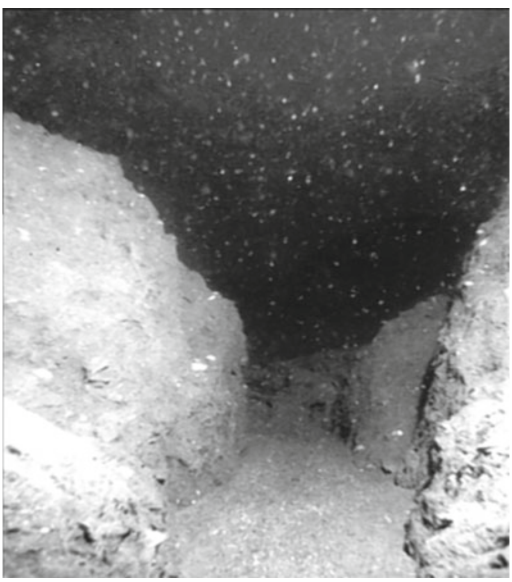

Fig. 9.9 Chorokhi Submarine canyon 50 m depth (photo by V. Menshikov and Gr. Russo)

feeding. The same situation is on the coast located to the south of the Enguri River (Anaklia—Khobi River) The feeding of the beaches of this coast with large materials was provided by the materials of the Mokvi and Ghalidzga Rivers, while the sand was supplied directly from the Enguri River. Since the port line of the Mokvi River and the Ochamchire dykes completely blocked the possibility of moving materials from the north and Enguri no longer deposits anything due to the dam, the feeding of the Khobi section beaches is possible only artificially.

For artificial feeding of beaches is required to include the same composition or the same thickness of the materials that build the beaches. The cheapest is the material of rivers that feed them. Unfortunately, this material is used for construction today. Almost in every river bed, one or several quarries are opened. The most disturbing is the fact that the quarries function on rivers where the material is no longer renewable. For example, on the Enguri River, at a distance of 15 km from the confluence, where the large gravelites are being extracted, this reserve will be exhausted in the nearest future, and then the price of the supply of beach material from hundreds of kilometers will be cost gold. The same situation is on the Chorokhi River and surrounding areas. Although the amount of materials is much more here, how the feeding of Adlia coast (the southern periphery of city Batumi) food requires five times -eight times more material than the Anaklia coast.

We can conclude that the unwise intervention of humans has almost destroyed the eastern coast of the Black Sea. Naturally, the rivers brought the beach building material to the sea coast, and its further distribution on the beaches was done by stormy waves; i.e., that waves have not a devastating function but of the creator. At present, this mechanism is completely disintegrated. Instead of the river, we ourselves should input the materials obtained from the quarry on the beaches and redistribute is by ourselves too, and then wait for a storm with excitement of the heart.

Today some of the yet active beaches should not deceive us. The beaches are washed and destructed during large storms, but sometimes the "preparation" for this washing is underway for several years. It cannot be seen by eyes because the deficit of the material first affects the underwater slope. It is washed and deepened, and this process almost is not noticeable on the surface beach. Once by all means the devastating storm occurs, the waves of which on the deepest underwater slope, approach the shore almost without deformation and break in the immediate vicinity. In this case, a large wave usually breaks hundreds of meters away; that is when the coast retreats by a dozens of meters.

In order to save the Black Sea coast of Georgia today, we should recall the principles under which the organization "Saknapirdatsva" ("Georgian Coast Protection")—where it is possible, dynamic systems should be restored in natural form.

The protection of the Black Sea coast of Georgia and the management of the processes on this coast should be in the hands of the state. There should be appropriate legislation that prohibits the acquisition of materials from the river confluences and riverbeds for construction purposes, construction in the wave influence zone, etc. Any protective measure should be considered in relation to the whole dynamic system.

Coast protection measures should be preventive and continuous, as it is cheaper and more correct. We do not have to be behind the events.

It should be remembered that the beaches of Georgia are unique and there is no analogy in the world.

95% of the world's accumulative shores are fed by sands brought out from the bottom, 5%—by sediments brought by rivers. From here the so-called Mediterranean type of shores are distinguished with gravels and gravelites along with sands, but neither the Mediterranean Sea nor the Black Sea coast, except the eastern Black Sea coastline, has no beaches built of such a large and vast stone-gravel-sandy mixture. Stormy waves on our coast are much stronger than on the Mediterranean Sea coast (the wave mileage is higher), the rivers bring much more materials and waves transport more materials along the shore. The coast protective breakwater piers that our tourists like very much on the Mediterranean coast are compulsory measures in the conditions of the deficit of beach forming material. Their shores are abrasive-accumulative and small beaches are stuck between capes, i.e., that the natural feeding of beaches is made by a small amount of riverine sediments and the abrasion material of the shores. The breakwaters protect the shores from this abrasion because the narrow beach cannot extinguish the wave. Due to above mentioned, the direct copying of experience of other countries in the field of coast protection is absolutely inadmissible toward the seashores of Georgia.

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