OUTLOOK ON GEOLOGICAL SETTING AND SEAWATERS DYNAMICS FACTORS FOR THE ALBANIAN ADRIATIC COASTLINE DEVELOPMENTS

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Abstract

Results of integrated offshore and onshore geological-geophysical surveys, and hydrographical studies in Albanian Adriatic Littoral are presented in this paper.

According to the seismic and geoelectrical marine and onshore surveys, geological onshore mapping and underwater offshore sampling, boreholes and oil and gas depth wells, geodesic and bathymetric mapping, evaluation of the discharge regime in Albanian rivers system and its impact on the hydromorphology of Adriatic Sea, the river bed deformation, migration and new river mouths investigations, were classified the segments which have different geomorphology with in mainland and in marine area of Albanian Adriatic Shelf. Accumulative coastlines are extended at plain areas. Beautiful sandy beaches and dunes are main elements of these areas. Marine Quaternary deposits from plain sea floor up to some kilometres in the land have e thickness from some to hundred meters. Narta, Karavasta and Kune-Vaini Lagoons are located in plain area of the littoral. These lagoons are formed in some sea bays, which are closed by solid sediments transported by rivers to the sea. Erosive coastlines are extended in the hilly base of some capes. The hills are presented northwestern part of the Neogene anticlines. Sandstone banc are extended in the sea floor. Neotectonics development at the present has caused submergence of two sectors within the accumulative areas.

1. Introduction

The Albanian coastal area on the East of the South Adriatic and North Ionian has a length of 447 km long. This area represents the Easter side of Otranto Strait. River mouths and deltas, lagoons system, abandoned riverbeds, marsh labyrinths, sandy beaches, dunes covered with vegetation, dense forests represent Albanian littoral.

According to the studies conclusions results and geomorphologic classification, trhe Albanian coastal area consist of two principal major paleogeographic zones (Fig. 1):

1- Adriatic Coastline of Peri-Adriatic Depression in the central and northwestern part of Albania. There are three different segments:

- Accumulative segments, which represent main part of the coastline.
- Erosive segments, and
- Submerged areas, where is observed marine transgression toward the mainland.

The Adriatic coastline dynamics geomorphology is conditioned by geological setting of the western side of Albanides, by the neotectonic developments, by the dynamics of the seawaters, solid material discharge from Albanian River network to the Adriatic Sea, and their deposition along the coastal zone.

- 2- Erosion Coastline of Ionian tectonic zone in the southwestern part of Albania

\- **2. Material and methods**

\- Marine and onshore integrated surveys and studies for the investigation, monitoring and estimation of the physical characteristics of the Albanian coastal area have been performed during the period 1958-2005.

2.1. The integrated geological-geophysical onshore surveys of the Albanian littoral areas have begun since 1958. Offshore geological-geophysical surveys on the Albanian Adriatic shoal shelf have started from 1976. Marine geological mapping has been performed using submarine surveys, shallow mapping boreholes and dredge's sampling. Integrated offshore geophysical surveys have been carried out using reflection seismic of shoal littoral shelf, marine electrical soundings and profiling of apparent resistivity, marine magnetic recognition surveys and marine radiometric surveys. Offshore geological-geophysical surveys were performed in the shoal littoral shelf, with a width of 5-10 km parallel to the coastline. Electrical soundings have a depth of investigation is about 1000-1500 meters, and influence depth is up to 3000 meters.

2.2. Hydrological, hydrogeomorphological, were based on the information of the Albanian hydrometric network that consists more than 220 meteorological and hydrometric stations, during the observed period of 20-100 years data of Albanian Hydrometeorological Institute. There are also 8 coastal stations and 12 other stations installed in the flow of the most important Albanian rivers near the sea.

2.2.1. Hydrological studies: Multi annual hydrometric observations on water levels, temperatures, water discharge into the Adriatic Sea, suspended material discharge; alluvial granulometric composition, water chemical composition etc. were performed in main Albanian rivers. Water potential and run-off discharge regime of the Albanian Mountainous River System have been evaluated by a specific way for two categories of river basins (Pano N. 1984, 1998):

1) Drini, Mati, Ishmi, Semani , Vjosa River systems, etc., where the run-off discharge depends from the altitude of the water level river section.

2) Scutary Lake-Drini River-Buna River water system, where the discharge of the Buna River, which flows away from the Scutary Lake (Q_2) to the sea, depends from the level of the water (H_2), and by the Drini River discharge in to the Buna River (Q_4):

$$Q_2 = \left\{ 0.025 \cdot \left[H_2 - \frac{Q_2^2}{(0.0073 \cdot H_2^{1.61413})^2} \right]^{1.85} - Q_4 \right\}$$

The calculations have been performed for the models of dry and wet characteristic years. The evatranspiration potential have been calculated by different well-know methods.

Several physical-chemical parameters have been measured: the water velocity and discharge of the rivers and from the lagoons to the Adriatic Sea and to the Ionian seas, and the chemical water content.

2.2.2. Hydrogeomorphological studies *w*ere performed to evaluate the geomorphologic characteristics, the evolution and the migration of Albanian Adriatic coastline. The wave refraction in the coastal area is analyses by wave refraction diagrams. Determination of littoral sediment transport and coastal sedimentation, the classification of erosion and accumulation processes under the wave refraction etc. are studied by analyzing of marine and onshore surveys data.

2.2.3. Limnological observations on the Albanian lagoon system were performed in hydrometric stations and by periodical expeditions for study of the water physic-chemical characteristics, measuring the discharge in the water channels with the sea, sediment granulometrical analyses, and the evaporation of the lagoon water surfaces

2.2.4. Oceanographic studies: Water levels, temperatures and chemical content atc., formation and circulation of the water mass, wave and wind regimes of the Adriatic and Ionian coastline have been study in the hydrometric station network since 1958. Two Albanian oceanographic expedition "Saranda-1963" and "Patos-1964" were organized in the Southern Adriatic and Northern Ionian.

2.4.5. Climate change was analyzed by inversion of the ground surface temperature history, using the temperature record in the deep wells and shallow boreholes, and by the meteorological observations data. Have been study the climate change impact on the Adriatic Sea hydrology and on the erosion process in the Albanian River Network.

3. Regional geological settings of the Albanides

The Albanides represents the assemblage of the geological structures in the territory of Albania form the southern branch of the Mediterranean Alpine Belt. The Albanides are formed by two major palaeogeographic domains: the *Internal Albanides* in the eastern part and the *External Albanides* in the western part of Albania. The Internal Albanides are characterized by the presence of the immense and intensively tectonised ophiolitic belt. The External Albanides developed on the western passive margin and continental shelf of the Adriatic plate.

Albanian Adriatic Littoral area is located in Albanian Sedimentary Basin, which extends widely into the Adriatic Sea (Aliaj Sh. 1989, Frasheri A. 1991, Leci V. et al. 1986, Papa A. 1985). Towards the East, in the mainland, Albanian sedimentary basin is superposed to the western board of Albanides orogen. In Adriatic shelf, this basin is superposed to the Pliocene-Quaternary platform, which has a basin facies. Albanian sedimentary basin represents a foredeep depression filled with Miocene and Pliocene molasses, and covered by Quaternary deposits (Geological Map of Albanian, 1984). Sandstone-clay Serravalian (N_1^{2s}) deposits transgressively overlies older layers. Tortonian and Messinian sections are represented by sandstone and clay. Pliocene deposits consist of clay and sandstone conglomerate. Quaternary deposit (Q) are represented by different genetic types: -clay-silt-sand of marine deposits, which have a thickness which ranges up to 200 meters in the Albanian Adriatic littoral areas. The Albanian Adriatic coastline has many beautiful sandy beaches. These beaches have different geomorphology, depend on the geology and tectonics of the area.

In Adriatic Sea Shelf are located some molasses Neogene asymmetric anticlines. The Neogene geological structures of the Peri-Adriatic Depression continued from mainland to the Albanian Adriatic shelf for 5-10 km.

Evolution of Albanian Adriatic coastline has a very intensive dynamics. There are observed old and present shoreline migrations up to 5-7 m/year, during the period from 1918 up to 1998. According to submarine geological mapping and geoelectrical survey data, has been determined that marine deep erosion is developed in accumulation littoral of Adriatic shoal. The sandstone banks have been mapped in western submarine anticline limbs.

The Ionian Sea littoral is represented western edge of the Çika anticline belt in Ionian tectonic zone (Io). This zone represents the southwestern part of Albania and developed in a deep pelagic environment the Upper Triassic. The Permian-Triassic evaporites are the oldest rocks in this zone. Overlying are thick deposits formed by Upper Triassic-lower Jurassic dolomitic limestones and Jurassic-Cretaceous-Palaeogene pelagic cherty limestones. The limestones are overlain by Palaeogenic flysch, an Aquitanian flyschoidal formation and a thin section of Burdigalian-Langhian. Structures are fractured by longitudinal tectonic faults on their western flanks, with thrusting of 5-10 km horizontal displacement.

Paleomagnetic studies have demonstrated that assemblage of the Albanides margin has supported a clockwise rotation with amplitude about 45^{o}, after upper Oligocene. Shkoder-Peje transversal is represented a transition zone between the clockwise rotation of the Albanides and Hellenides and counterclockwise of the Dinarides. Horizontal displacement is about 173 km in southern Albania, for the rotation pole located at Shkoder-Peje transversal.

4. Regional hydrographic outlook on the Albanian Littoral

The Albanian coastal area lies from Shengjini to Vlora bays and Northern Ionian Sea, from Vlora to Saranda bays at the south (Fig. 1).

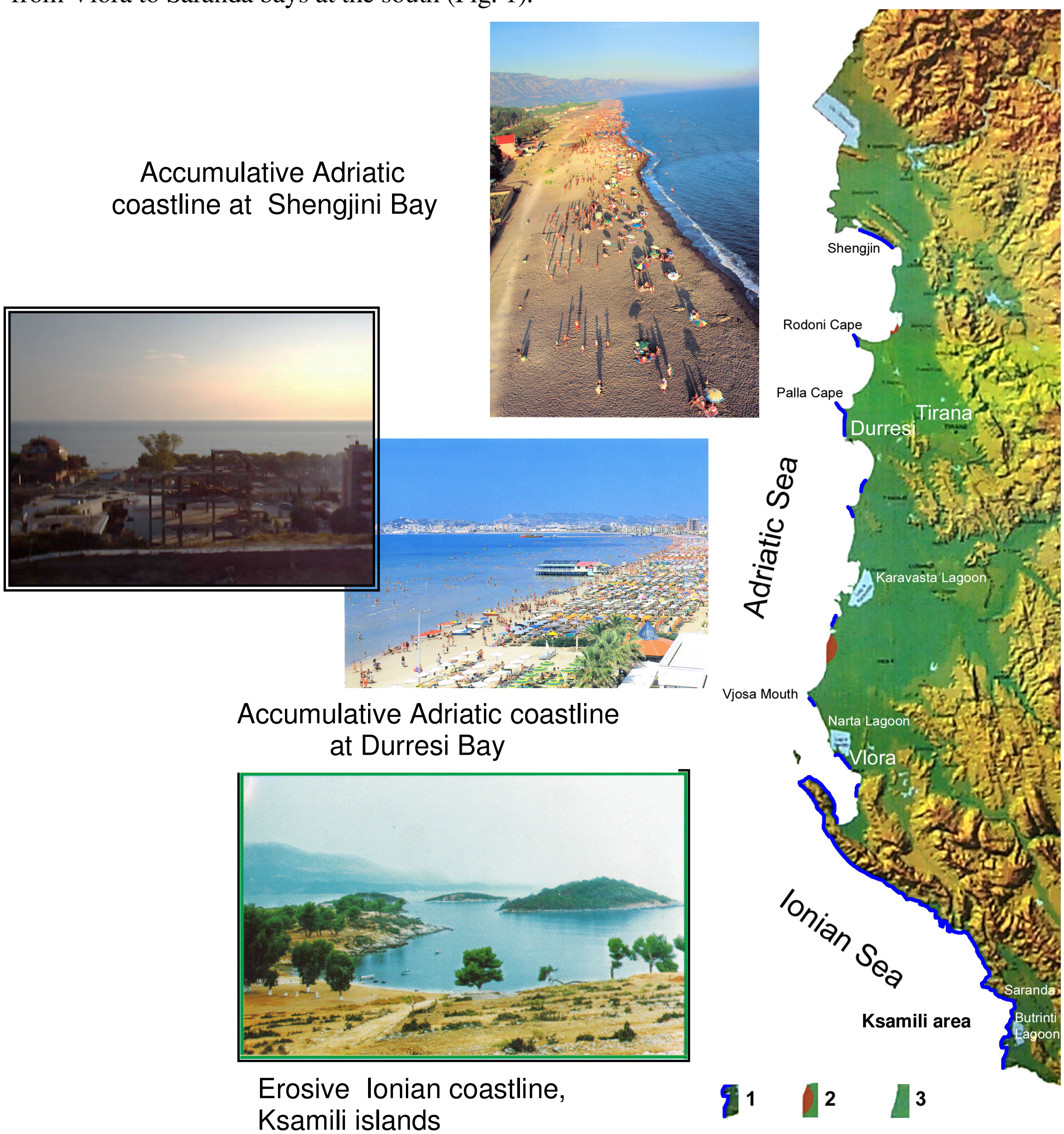

Fig. 1. Albanian littoral

1. Erosive coastline; 2- Submerged sector; 3- Accumulative coastline

4.1. Adriatic coastline

Adriatic coastline is lies over the Neogene Peri-Adriatic Depression, covered by Quaternary deposits, in western plain areas of Albania. Flattened accumulative coast is general characteristic of this coastline. There are also some marine caps with cliffed coast. The caps are located in the sectors where the Neogene structure of the Peri-Adriatic Depression are abrupt by coastline and continues in the Adriatic Sea.

Mouth of Buna River at the north to Rodoni Cap coastline. This unit has a length about 60 km and consists for almost 90% of beaches fed by fluvial imputs. The remaining 10% is clifts. Four rivers outflow within this area: from north to south Buna, Drini, Mati and Ishmi rivers All together they discharge on average 796 m^3/sec of water. The total solid load of the last three rivers is about 21,680x110^3 tons/year. Intensive change dynamics were observed in this area (Pano N. 1998).

Rodoni Cap, Durresi Bay up to Shkumbin River mouth coastline. Cape Pallës, Cape Turrës, Lalëzi Bay, Durresi Bay and Shkumbini River mouth are main zones of this lithoral area. Lalëzi Bay has a length of coastal line of 32 km, and 65% consists of sandy beaches fed by the sediment load of Erzeni River. The remaining 35% consists of rocky cliffs. Durrësi Bay has a length of 35 km from Cap Pallës to the Cap Turrës. Main part of the bay, about the 54% has sandy beaches, frequently with dune ridges vegetable by pine trees. Sediment inputs in to the bay are provided by Darçi River and from beach and cliff erosion.

Shkumbin-Seman-Vjosa river mouths up to Zvërneci hills coastline, is located in southern part of Central Albania, and have 40 km length. It expands in the western part of Ardenica and Divjaka hills. Karavasta Bay and Karavasta Lagoon are also part of this littoral area. From the geological viewpoint, this territory represents a new soil, constituted at the end of Pliocene and during Quaternary. The coastline in this region has a very intensive dynamics.

Vlora Bay is represented southeastern edge Otranto Strait (Photo 1). The *Upper* Cretaceous-Triassic limestones mountains are encircled southwestern and southeastern shores of the bay. In the north, the mountain chain is continued with Neogene deposits hills. Limestone coast of the Adriatic Sea in Vlora Bay is generally abrupt (Photo 2). At the northwestern direction of the Vlora City, there is a coastline of the Albanian Adriatic Shelf. Configuration the Vlora Bay has started to form from the Pliocene age, when the molasses of the Panaja Hills have been outcropped at surface (Fig. 2-a). Actually, Later Quaternary Marine deposits (Q_4^m) are created the present Vlora Bay (Fig. 2-b). Offshore these deposits (Q_4^m), according to the marine electrical soundings and boreholes, have 190 m thick.

Photo 1. Vlora Bay (Photo Frashëri N.)

Vlora Bay has a length of 36 km and 10 km width (Fig. 3). The maximal depth of this bay is 57 m. The coastline of Vlora Bay-Vjosa River Mouth area has continuously modified its configuration by sedimentation of alluvium transported by Vjosa River water and the swell of the Adriatic Sea. The coastal area is characterized by prevalence of winds blowing from the NW direction with a maximal speed 35-45 m/sec. The tidal range in this part of Adriatic Sea is low, reaching a maximum of 30-50 cm. The wave action is characterized by calm in 35% of the cases, by wave with a higher of less than 0.5 m in 20% of cases and waves higher than 2.00 m in 3% of cases.

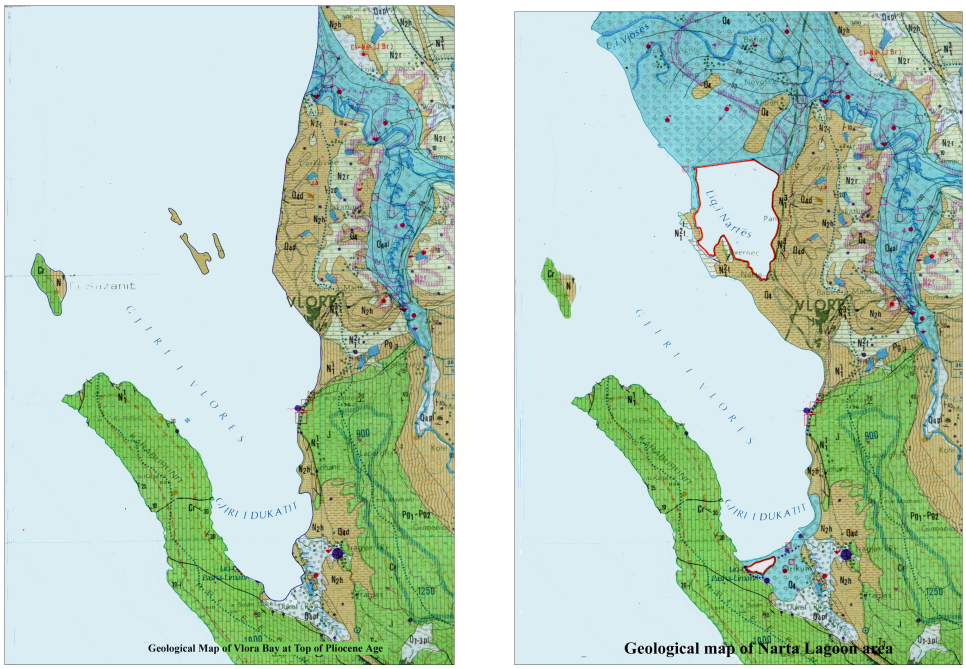

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Fig. 2. Paleographical development of Vlora Bay from end of Pliocene Age (A) to Present (B) (According to the Geological and Hydrogeological Map of Albania, at scale 1: 200 000, 1985).

Photo 2- Abrasive coastline, Vlora Bay

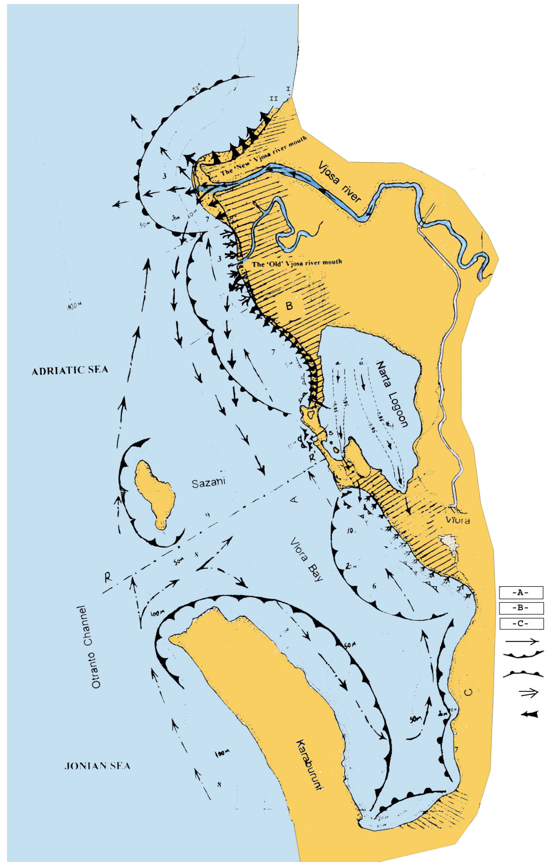

Fig. 3. General Evolution Map of the Vlora Bay-Narta Lagoon-Vjosa River Mouth coastline, during the period 1870-2001.
1) Coastline in 1870;
2) Coastline in 1992;
3) Sediment contribution;
4) “Old” Vjosa River Mouth;
5) “New” Vjosa River Mouth;
6) Coastal erosion;
7) Coastal sediemntation;
8) Sea current direction;
9) Line zero sediment transport.

4.2. Ionian coastline

Vlora Bay to Saranda Bay coastline represents Albanian Riviera. Mostly erosive coastline is lies along 112km of Lower-Upper Jurassic and Upper Cretaceous limestone, and Oligocene flysch formation piedmonts. There are predominating emerged coast and estuary coast in some sectors of streams. High mountains rise up to 2045 m, immerged coast and very clear marine blue water are presented a very beautiful area. Cliffed coast by outcropped limestone layers are characterized western side of the caps Photo 3). In the beautiful along the some sectors of the coastline are lies, mostly Quaternary proluvial, gravel beaches (Photo 4). Butrinti Lagoon and Pavlës River represents southern edge of the Albanian Ionian litoral.

Photo 3. View of the cliffed Ionian coastline (Photo Dyrmishi C)

Photo 4. View of Ionian erosion coastline at Himara Town (Photo Frashëri N.)

4.3. Outlook on Albanian Littoral hydrology

The water flow of the hydrographic network of the Albanian rivers to the seas varies in wide limits. The discharge of the Albanian rivers into the Mediterranean Basin varies in very wide limits, from Q_o=700-850 m^3/s for the hydrological years of a lower precipitation to Q_o=1850 2150 m^3/s for the years of a higher precipitation. The volume of suspended material, which is transported through river network, is 65,7. 10^6 ton/year, while the turbidity Q_o=1 260 g/m^3 (Pano N. 1984).

The river suspended matter deposits itself the river mouth in the Adriatic Sea. This process is very dynamic, making the Albanian river's mouths very active. Many changes of the riverbeds position formation of the coastal lagoon, etc. are observed time after time in these mouths. The wind regimes, wave refraction, sea currents, littoral sediment transport, have determined the general dynamics of the change of the Albanian coastline (Pano N. 1994). The period with the wave height of H_1=(0,1-0,2)m represents about 80% of the general cases, while the height of H=(0.2-4.5)m about 20% of them for the average multi annual year. The highest waves have a direction from Northwest to West and a maximum wave height about h=3.5-4.5 meters near shore (Pano N. et al. 1974, Meçe B. 1978). Sea level has an average daily amplitude 0,30-0,40 meters and a multi annual maximal amplitude h=1,14-1,53 meters.

The winds in the Adriatic Sea change their direction and speed during a year period as a result of the typical Mediterranean climate. Intensive winds with their maximal speed of 40 – 45m/s particular of NW, W and SW direction were observed in the coastal area. Winds with varying speed form 10 to 20 m/s, have a bigger frequency on waving process. The average annual temperature of the water varies from t=17,7°C in Shëngjini to 19,2°C in Saranda bays (Alanian Climate (Tables) 1978, Mici A. etc. 1975).

5. Analyze and results

5.1. Albanian Adriatic Sea Littoral and Quaternary Evolution

Adriatic coastal line from southern city Vlora up to Shëngjini Bay, in the north, have the marine accumulation flattened coast, the marine erosion coast, and the submerged areas, where is observed marine transgression toward the mainland. In some areas there are cliffed coastline.

5.1.1 .Accumulative areas represent main part of the coastline

In the accumulation coast the flat shelf sinks gradually up to the depth 100m. Over there, the majority of deposits represents by sand and silt. At the depth of 100-200 m bottom deposits represents by mainly silty clay. Accumulative areas of the Albanian Adriatic Sea Littoral are extended over the edge of western Albanian plains. This littoral is characterized by presence of the different Quaternary (Q) deposits genetic types: loose sand in the coastal line and clay mud far from coastline marine deposits, lagoons and coastal marsh deposits, and alluvial deposits-clayey earth (Frasheri A. et al 1991, Leci V. et al. 1986, Ostrosi 1977). Sandy littoral belt along the accumulative littoral have a width up to 5 km. Sand dunes are situated along this belt (Photo 5). Sand dunes belts have a length of 25 km and an average width more of 50-100 m. Generally, the granulometry of quartzite sand deposits represented by very fine up to medium sand. Very beautiful sandy beaches are extended in the Shëngjini Bay, Drini, Lalezi, and Durrësi bays (Photo 6), Divjaka, Semani and Vjosa River mouths and at the Vlora Bay.

Photo 5. View of accumulative Adriatic coastline. Sand dunes at Semani area.

In this accumulative coastline area there are some relatively small erosion sectors. Typical is Golemi-Karpen beach sector in the Durrësi Bay. There are observed intensive erosion, with an erosion rate of 0.5 m/year. Other separately sectors are observed in river mouths and in eastern shore of the Vlora Bay.

5.1.1. Erosive zones

Marine deep erosion zones were developed over some sectors in accumulation littoral of Adriatic shoal.

Durrësi–Palla Cape area is one most typical erosive segment of the Albanian Adriatic littoral. Durrës- Palla Cape coastline is extended along the western flank of the Neogene molasses anticline. Northern periclinal and western fold flank are lies under the Adriatic Sea waters. The structure is asymmetric and eastern flank is tectonically abrupt. Anticline top is located under the seawater, about 1600 m at the west of the shoreline. Molasse deposits are covered by different kinds of the Quaternary loose deposits. Seashore is abrupt and the sandstone banks have been mapped in western submarine anticline limbs (Photo 6, fig. 4, 5) (Frashëri A. 1987, Leci V. et al. 1986, Papa A. 1985).

Photo 6. View of Durresi beach

Photo 7. View of the erosion coastline at Durrësi- Palla Cape sector

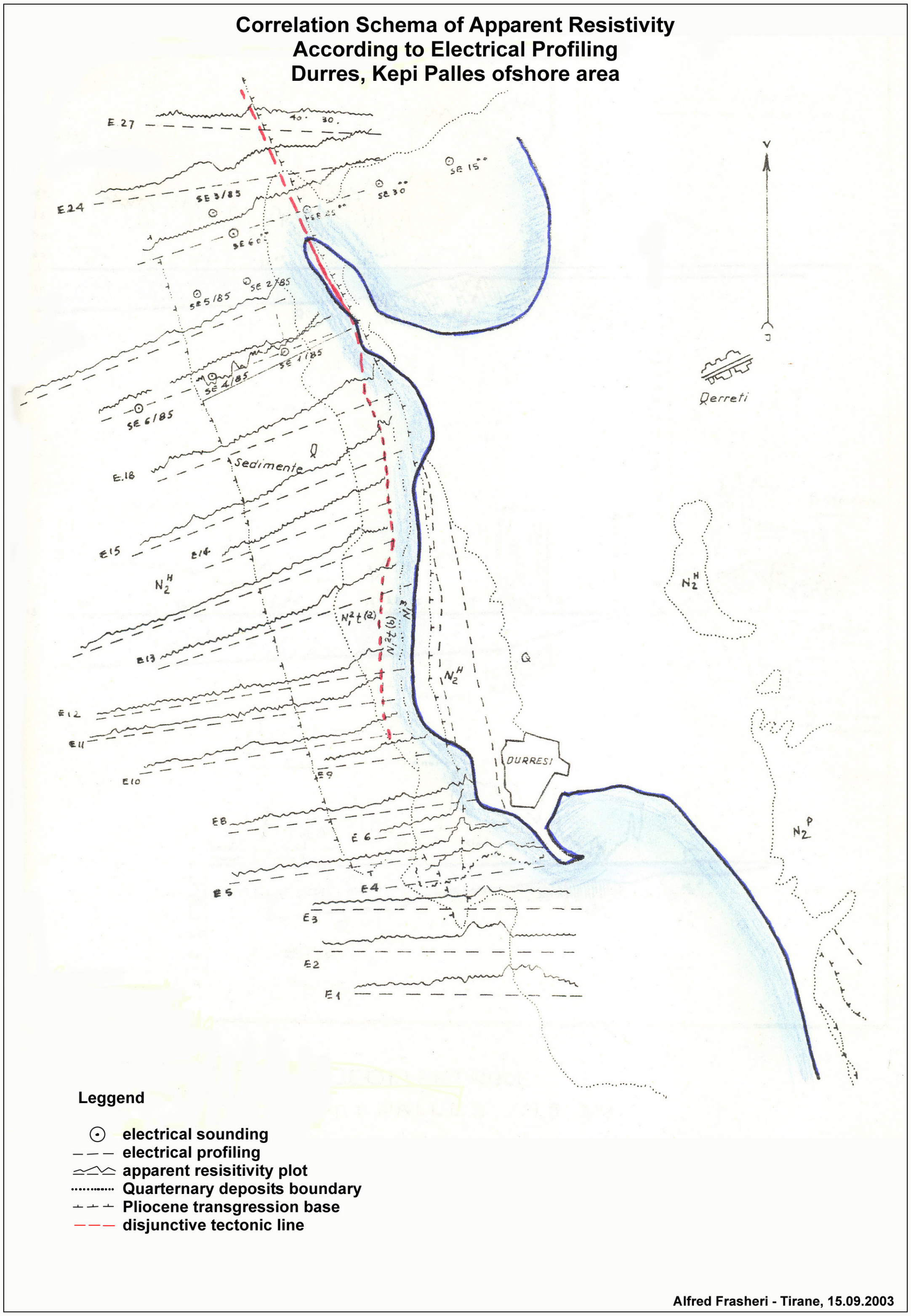

Fig. 4. Geoelectrical Map of offshore erosive littoral at Durresi-Palla Cape area

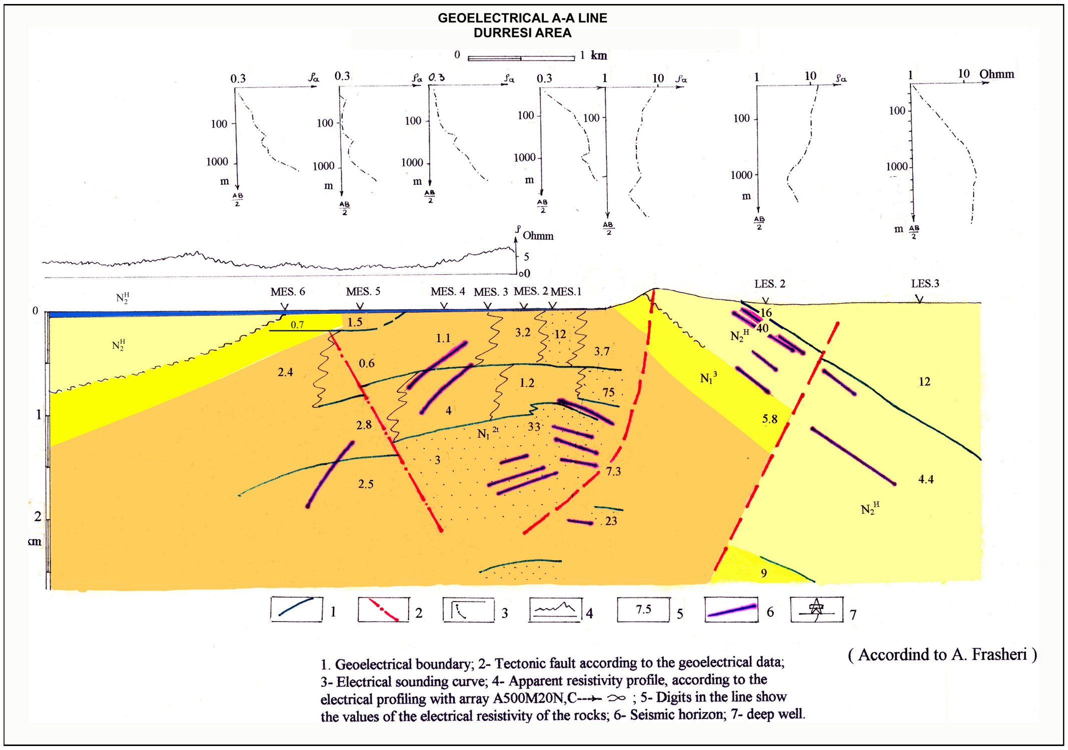

Fig. 5. Geoelectric Line, erosive littoral at Durresi-Palla Cape area

Zvërneci hilly zone is located at northwestern direction of Vlora Bay (Fig. 2, 3). The Tortonian molasse Zvërneci hills chain from the isle separated Narta lagoon from the Adriatic Sea. The southward shift of the Vjosa River mouth during the XX century has created serious erosion problems in the northern coast of the Narta lagoon. The sediments input to the old delta ceased, the latter has almost been completely eroded and the sediment was removed to create a spit, which formed an accumulative zone in the southern part of the Vjosa River old mouth (Fig. 3).

5.1.2. Submerged areas, where is observed marine transgression toward the mainland

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Photo 3. View of the Semani submerged area

Semani beach at western Albanian region and Patoku beach in the southern side of the Drini Beach represent submerged areas within accumulative coastline (Photo 8). So many objects, which 20-30 years ago have been constructed at the mainland, at the present are located in the seawater. Submerged process is caused by the neotectonics activity, consequently are observed a marine transgression

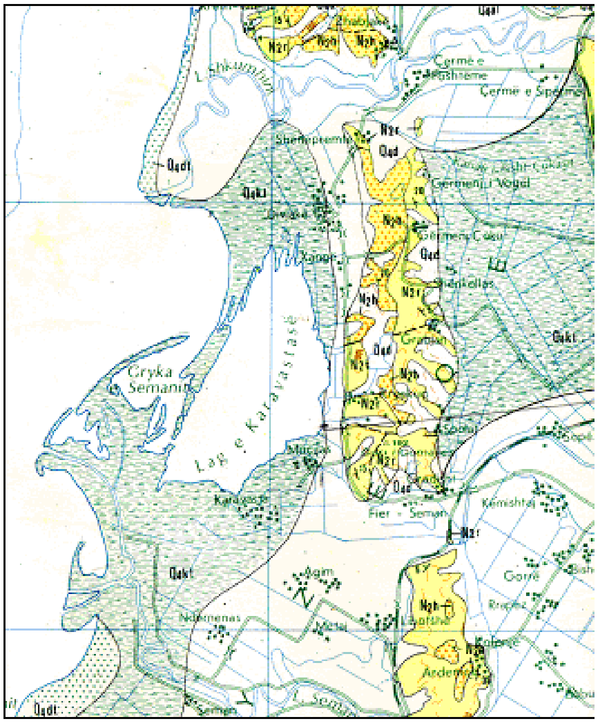
5.1.3. Lagoon area

Lagoons have a total surface of about 150 km^{2,} while the volume over 350-million m^3 water. Albanian lagoons represent crypto-depressions, with the floor under the level of the sea's bottom. The lagoons represent the new lakes. Its creation started during Pliocene Period, some 4-5 million years ago, and its creation lasted during the Quaternary Era till our days.

Karavasta Lagoon, is the biggest and the most important lagoon system on the Albanian coastal area (Photo 9). It is located between the mouths of Shkumbini river (in the north) and Seman river (in the South) and is boarded by the Adriatic Sea in the west and by Divjaka Hills in the east. The Karavasta lagoon has a surface of 43,3 km^2, with a maximal depth of 1.5m. A component part of this lagoon is another small lagoon named "Godulla". That has a surface of 8.5 km^2 with a maximum depth of 3.8 m. It communicates with the Adriatic Sea through three short channels (Pano N. et al. 2004). In the deltaic coastal of Karavasta area, the evotranspiration potential is E=1050 mm, the real evotransporation is 720 mm and the evotranspiration deficit is 330mm. The annual precipitation rate is about 870 mm, with its minimum in July (25mm) and maximum in October (145 mm). A layer of water with an annual average about 1100 mm evaporated in this lagoon, with its maximum in July (180 mm) and minimum in January (20 mm). The highest values in water salinity inside the lagoon are observed in summer because of the market evaporation rate. The maximum observed values are in excess of 45-55‰$_0$ in the eastern part of the lagoon. The minimum salinity values about 20 - 30 ‰$_0$ are observed in winter in the western part of the lagoon, where the tidal influence is weaker.

Photo 9. View of the Karavasta Lagoon

Karavasta lagoon is located on western flank of the Miocene Divjaka brachyanticline (Fig. 6-A). Pliocene molasses are outcropped in the top of the structure.. The Pliocene molasses are covered by Quaternary deposits in the Karavasta lagoon and plane coastal area around. Lagoon deposits are presented by sand on top of the geological section, the sandy silt, in the middle part of the section, clay material at the section base. The silt represents fluvial deposits, in particularly far from the coastline. The lagoons have a neotectonic origin. They were created during the closing of old marine bays by sandy belts. The Karavasta lagoon is one of the youngest natural water objects in the hydrographical network of Albania. It is formed during the last centuries as results of the accumulation of solid discharge of Semani and Shkumbini Rivers.



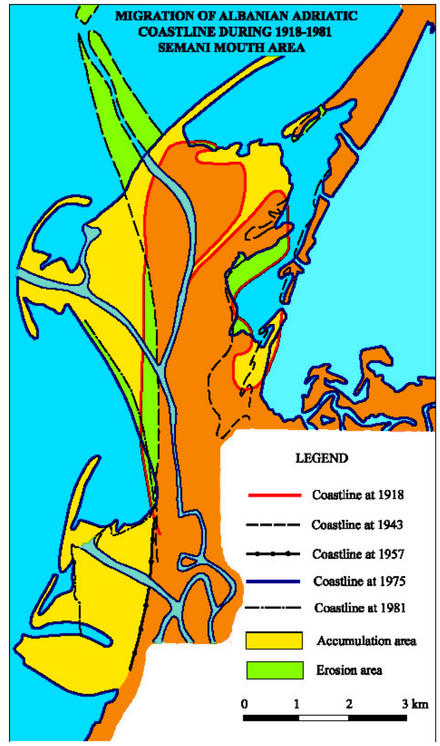


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Fig. 6. Geological Map of Karavsta area (A) and General Map of the evaluation of the coastline from 1870 to 1994 in the Karavasta area (B)
(A and A1–old river mouths; B'–actual river mouths; A A' A''–sources of coastal sediments; 1–marine currents; 2–wave processes; G–erosion processes; K–accumulation processes)

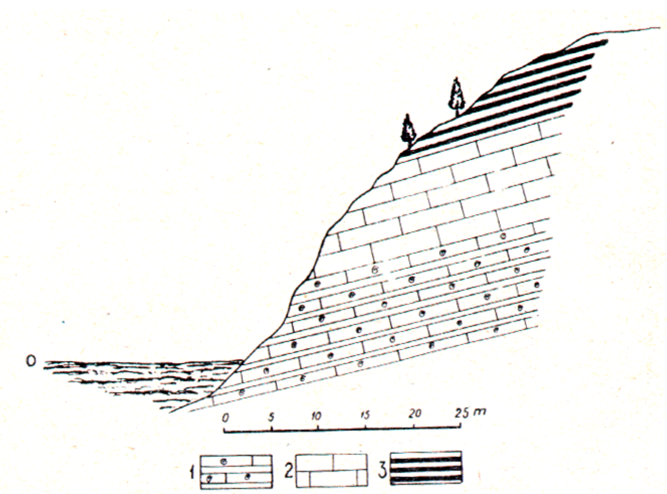
Narta Lagoon, is situated in the northern part of the Vlora Bay, about 3 km from Vlora City. Two islands are located in the south part of the lagoon, with an approximate surface of 7 ha (Photo 10). Narta Lagoon has a surface of 41.8 km^2, the maximum depth 1.5 m and the average depth is 0.7 m. The principal limniological characteristics of Narta Lagoon are as following: the annual precipitation rate is x_o=949 mm, with its minimum in July (22 mm) and maximum in November (148 mm). A water layer with an annual average of Z_o=1271mm evaporates in this lagoon, with its minimum in January (32 mm) and maximum in July (208 mm). Water exchange process between Narta lagoon and the Adriatic Sea is realized through two channels. The mean average discharge of this process is 1-5 m^3/sec (Pano N. 1983).

Lagoon was formed in a sea bay, which is closed by solid sediments transported by Vjosa River to the sea. The neotectonic phenomena also characterize the lagoon area. Around the Narta lagoon side, the lagoon's Quaternary deposits (Q_4^1) are extended. These deposits are represented by sky-blue-gray color silt, with silstone interbeds of gray color. Thickness of these deposits varies from 0.5-1 m up to 20-30 m. Lagoon deposits have covered marine Quaternary deposits (Q_4^m). Marine deposits are represented in the form of sand beach and dune belts.

Photo 10. View of Narta Lagoon

Butrinti Area is located at southwestern part of Albania. This area represents most beautiful part of Albanian Ionian Rivera (Photo 11). There is the anticline structure with a carbonate core (Fig. 7).

Photo 11. View of Butrinti Lake area and ancient Butrinti City



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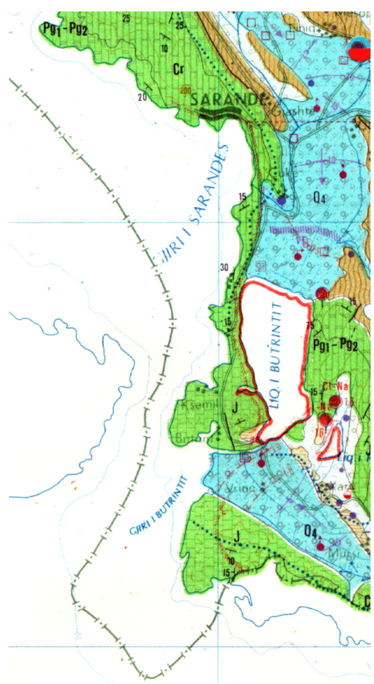

Fig. 7. Cliffed Ionian Sea coastal line

A-Fgeological section of Ammonitico Rosso facie

B- Geological Map of Butrinti Area.

B

Around 200 million years ago and later, Ionic zone has been a marine trough. This trough has represented a community of small local basins, separated by steps. In this trough there was deposited carbonate mud. Jurassic System limestones are representatives of most of older formations, which are outcropped at Earth surface. Carbonatic deposits of Lower Jurassic are extended along the seashore. The ancient Butrinti City has been built in this area. A chain of hills separates Butrinti Lake from Ionian Sea (Photo 8).

Shores around these hills represent rocky and abrupt lakeside. Laksati stream and other small streams run to the Butrinti Lake. Butrinti Lake is connected to the sea through a channel with a length about 1.8 km and 120 m width. In the southern side of lake, through the Vrina plane runs to Ionian Sea the Pavlë River. Butrinti Lake has a tectonic origin. It represents water filled graben. It is a new lake. Its creation started during Pliocene Period, some 4-5 million years ago. And its creation lasted during the Quaternary Era till our days.

Adriatic coastline has an intensive changes and continuously modifying its shape (Boçi S. 1981, Pano N. 1994, Simeoni U. et al. 1997, Shuitsky Yu. D. 1999). There are presented three more representatives areas:

Drini Bay. Intensive change dynamics, Viluni Lagoon and Shëngjini portal town characterized this lithoral area. The decreased sediment load of the Drini River, caused by its diversion into the Buna, has triggered coastal recession between Shëngjini and Tale, with greater intensity on the southern lobe of delta. Moving southwards, the coast becomes part of the sedimentary system of Mati River. The coastal area between Tale and Patok can be considered as having a positive sediment budget (Pano N. 1998).

Karavasta Bay. The Seman and Shkumbini rivers are the main source of coastal sediments in Karavasta Bay. The average water discharge is 62 m^3/s. The average annual water discharge of the Semani River (Q_o) to the Adriatic Sea is $0.9 m^3/s$; and the annual load sediment discharges is R_o=399kg/s, which has a correlation with the water discharges-Q_o (in $m^3 s^{-1}$) for two main branches (Pano N. et al. 2003, 2004):

$$R_o=0,605.Q_o^{1.46} \text{ - for Osumi River, and } R_{o.2}=0,219.Q_o^{1.69} \text{ ; - for Devolli River}$$

The total sediment discharge by this river to the Adriatic sea is W_T= 15,7.10^6tons/year. About 19% of total sediment load is equivalent to W_F=3,15.10^6 tons/year is carried bad load, and 81%, equivalent to W_F=12,6.10^6 ton/year, is suspended sediments. The wave highest in the Seman River mouth observed along the coastline, have a deep-water direction from the NW and the W and a maximum wave height of 4.0 m seashore. The dominant winds are southeasterly, easterly, and northwesterly winds. Maximum waves converge towards northeastern zone of coastline. This coastline corresponds to an extensive delta coast (microtidale: 0,50 tidal range) with a large alluvial plain of Myzeqe.

In ten last years, the coastline has advanced some hundred meters. Semani River mouth has changed in position in the last centuries six times and this displacements have covered on area of the littoral about 15-20 km long in a direction North-South; South-North during period 1870 to 1994 years. In these conditions in the coast area there are two important sources of coastal sediments: the actual rivers mouth and the olds rivers mouths (Fig. 6). The outlet of Semani River was shifted from position A and A_1, the old mouths, to the actual position B”, that is up date position. The old mouths of this river (coastal area A' and coast A") is undergoing on important erosion process under the wave action

Vjosa River mouth-Vlora Bay. The general evolution map of coastline during the period 1870-2001 is presented in fig. 3 (Pano N. 1994). Vjosa River Mouth has changed its position in the last century two times and these replacements have covered an area of the littoral about 10 km long in the northern direction. The outlet of Vjosa River was shifted from position "A"- the old mouth to position "B"- the new mouth. The old mouth of this river is undergoing on important erosion process under the wave action. There are two sources of coastal sediments: first, the present Vjosa River Mouth, and second the old Vjosa River Mouth.

5.3. Impact of the climate change on Adriatic Sea Hydrology

Ground surface history after geothermal inversion and meteorological data were observed a climate worming for about 1^{o}C during the first half of XX century. Thirty quart of this century has been characterized by a cooling for 0.6^{o}C. Later, up to present a worming for 1.2^{o}C is observed (Frashëri A et al. 2004). The warming period in Albania is accompanied with changes of the rainfall regime, wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200-400 mm. This warming is part of the global Earth warming during the second half of XX century. These climate changes have their impact on country water system, on and water resources, and in the erosion processes (Pano N. et al. 2004). Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea (Frashëri A. and Pano N. 2003).

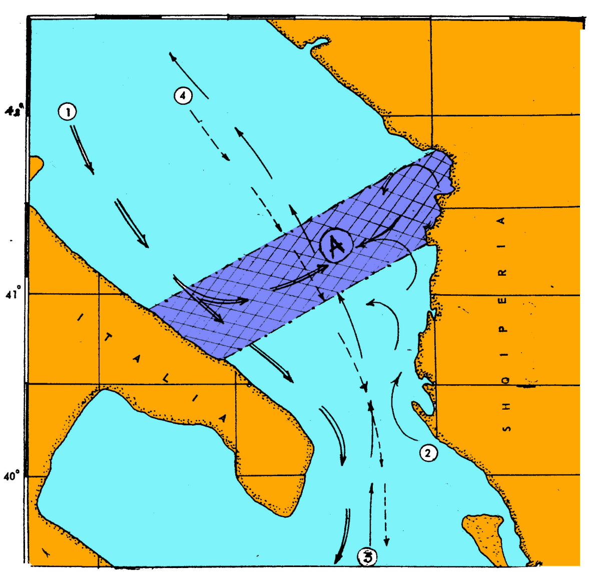

Fig. 7. "The Bridge" of continental water in the Adriatic Sea.
1. Adriatic Deep Water Mass;
2. Eastern Adriaric Superficiel Water mass;
3. Intermediate Levantine Water mass;
4. Northern Adriatic Water mass

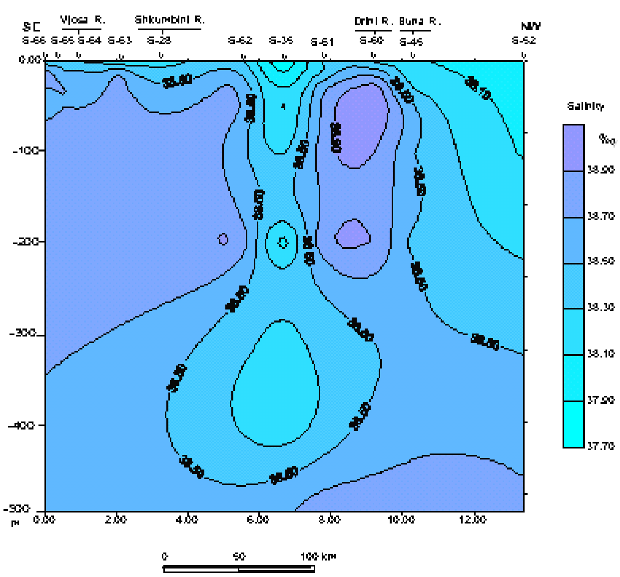

Fig. 8. Vertical salinity section 1-1, Adriatic Sea, wet hydrographical year 1963.

Based on two Albanian Oceanographic Expedition "Saranda-1963" and "Patosi-1964" data have arguments that the total discharge of the Albanian rivers system in the Adriatic and

Ionian Seas have a minimal discharge is 700-800 m^3/s for the hydrological dry years of low precipitation and maximal values 1900-2200 m^3/s for the hydrological wet years of high precipitation (Pano 1974, 1984, 1994). Buna River, together with Po River in Italy, is determinant in the water balance of the Adriatic Sea (Photo 11). The oceanographically situation of the wet years 1963-1964 has been characterized by formation of "The Bridge" of continental water with low salt content and density of the seawaters in the Adriatic Sea (Fig. 7, 8). This "Bridge", includes not only the surface layer, but also the Levant Intermediate Water (LIW) up to 600 m. depth. This phenomenon has a complex and an important influence on many dynamics aspects of the formation Adriatic Deep Water (ADW), and the monitoring mechanism of water into Otranto Street. All these peculiarities have impact also on the seawater temperature distribution in this area. It is important to observed that under "the bridge" is located also a heat flow density anomaly at the sea bottom (Geothermal Atlas of Europe, 1992) (Fig. 9). The "Bridge" direction is corresponds also with the prolongation of well-known Scutary-Pec regional tectonic transversal fault over the Albanides onshore.

6. Conclusions

- Albanian littoral has two major units: accumulative Adriatic coastline and erosive Ionian seaside.
- Albanian Adriatic coastline has an intensive change and continuously modifying its shape.
- Submerged process, caused by neotectonics activity, is observed in some sectors within accumulative Adriatic coastline.
- The climate at coastal plane region of Western of Albania has a warming of 0.6 K occurred, from last quarter of 19th until present-day. These climate changes have their impact on country water system, on and water resources, on the erosion processes, and on the hydrographic regime of the Adriatic Sea.
- The oceanographically situation in the Adriatic Sea is characterized by the formation of "The bridge" with continental water in the Adriatic Sea. "The bridge" is closely linked with the intensity of the Albanian rivers flow to the sea.

Photo 11. View of the Buna River discharge to Adriatic Sea (Photo Frashëri N)

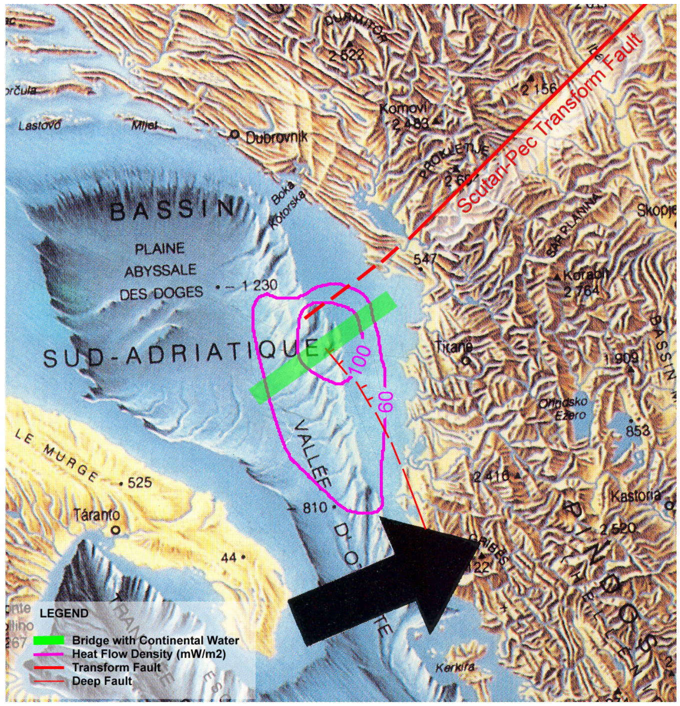

Fig. 9. Correlation of "The Bridge" of continental water Adriatic,
Heat Flow Density anomaly (Geothermal Atlas of Europe, 1992)
and. Scutary-Pec regional tectonic tranvesal fault.

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