Sedimentological Study of the Quaternary Deposits of Saranda Area, Albania

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Abstract

The quaternary and fresh deposits are present along 225-230 km of the Albanian coast (approximately 50% of Albanian coast length) and extend 30 – 60 km into the continent. They are located from Velipoja-Lezha-Patok-Ishem depression to Lalzi flat and Durres-Vlora depression and in alluvial fan areas of lowlands between Vlora and Saranda coast.
In this paper we will focus on southern part of Albania, in Saranda region, since this area presents great potentials for development of tourism sector. The study of the Quaternary deposits in this area will support the integrated management of land use and the sustainability of coastal ecosystems.
Vertical Electrical Sounding (V.E.S) has been the basic methodology, measuring electrical resistivity (Ωm), by using mainly Schlumberger array with the longest spacing (AB-540m). In This study we applied the geo-electrical modelling of electrical measurements, for lithologo -facialo-sedimentological identifications, definition of intrusion of sea water into fresh water. Furthermore we identified the Quaternary deposits basement, as well as defined and prepared geo-electrical maps of deposit thickness.
Based on the results of this study and of the previous one as well, two regional cycles (mega-sequences) could be clearly identified in whole Albanian coastal areas. The first cycle of sedimentation was formed during the Lower – Middle Pleistocene and is represented by intercalations of gravel-sand (alluvial fan) facies and marine clay ones. The second cycle of it was formed during Upper Pleistocene – Holocene, and is represented mainly by intercalations of gravel-sand, sand, sand-silt, clay, peat-clay and clay-peat facies, formed on deltaic environment river, lagoon marshland, and littoral environments.

KEYWORDS: Quaternary deposits, sedimentological cycles, Vertical Electrical Sounding (VES)

INTRODUCTION

Geographically, Saranda area lies at the south-western part of Albania, close to the Greek border. The Saranda coastal area of 426 km^2 is composed by three genetic units (Durmishi and Moisiu, 2008): 1. Kakome Bay unit, 2. Qefali-Saranda Cape unit 3. Finiq-Ksamil-Butrint-Stillo Cape unit. According to Durmishi *et al.* (2011) and Oikonomou et. *al.* (2005), the area is one of the most attractive regions of Albania, for its unique landscapes, natural resources and the archaeological-historical background. In 1948 the Butrint antic City (Buthotum) was proclaimed by the State a National Cultural Monument. While in 1992 and 1999, UNESCO proclaimed Butrint as a World Heritage City and in 2003 the Ramsar Convent proclaimed the Butrint wetland as protected area.

Saranda region is part of the community structures of the Ionian Zone, representing a deep setting zone, mostly carbonate faces with cherty intercalations from Jurassic to Eocene (Durmishi *et al.,* 2004; (Papazachos *et al.*, 2001) (Figure 1).

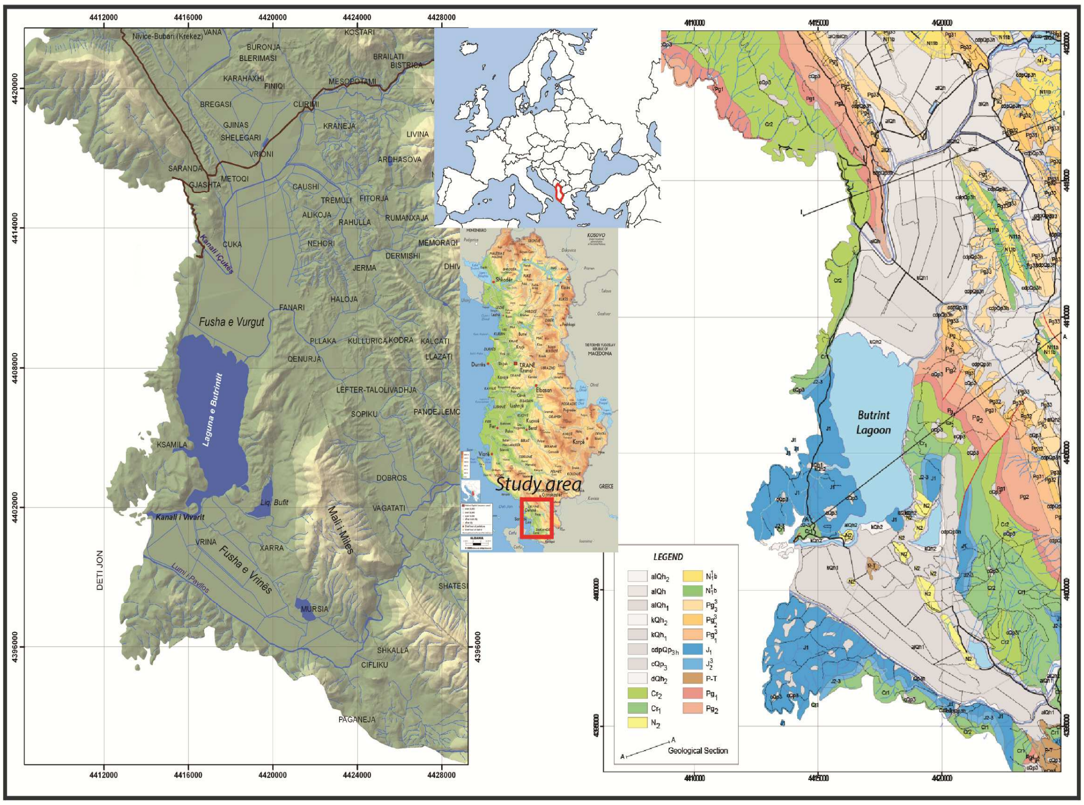


Figure 1 Topographic and geological maps of study area

Later, these formations were covered from terrigenous flysch deposits of Oligocene – Aquitanian. This deep basin was preceded from a lagoon - marine platform during the Permian – Triassic with halogens like gypsum, anhydrites~~)~~ , and followed later on from typical dolomitic facies of the Upper Triassic. These halogens deposits are encountered as décollement in the surface, near the thrust planes. In the Ionian zone structures, straight direction is SE – NW, while the fault is directed over the SW dipping into NE. Tectonic style, all over this zone, is characterized mostly by asymmetric structures, rarely overturned and shearing from the thrust in the western flank. It has also in regard a few complicated cases in the eastern flank as backthrust types.

The structures of the Ionian Zone are organized as anticlinal and synclinal belts. Nowadays, the opionin (Aliaj, Sh., 2012) is that all these structures of the Ionian Zone, like the carbonate formation from Jurassic – Eocene, as well the terrigenous flysch deposits of the Oligocene – Aquitanian, are “completely” displaced to the west over the Palaeozoic basement according to a definite décollement plane, that has at the base gypsum - anhydrites of the Permian – Triassic age, which thanks to their plastic ability have helped the carbonate formation to move towards the west.

Major folding of the Ionian Zone has been occurred in Middle Miocene, before Seravalian – Tortonian, but partial folding has been occurred as well as before. While in the south of the western side, major folding has been occurred just before the Burdigalian, that is documented with discordant disposition of the premolassic deposits over terrigenous flysch deposits of Oligocene – Aquitanian (seen in Vurg).

The deposits of Quaternary are very widespread at the area Saranda – Butrinti and follow the deposits of Pleistocene (2.6 – 0.01 Ma) and Holocene (0.01 Ma to present) (Moisiu and Durmishi, 2008). They occur almost all over the plain area south and north of Butriniti lagoon, forming the plains of Manastiri, Vurgu, Vrion – Xarre – Mursi Peke, Konispoli, etc. The deposits of Quaternary of the area are marine and continental formations represented by the deposits of Pleistocene and Holocene.

The Butrinti graben consists of Pliocene - Quaternary sediments. The marine Pliocene sediments, some 200 m thick, overlie the evaporites in Vrina Plain and outcrop in Vrina, Xara and Mursi hills (N_2). The Quaternary sediments outcropping on Vrina and Vurgu plains consist of alluvial and lagoon deposits, up to 80 m thickness. Two fundamental geological features are presented: tectonic and subsidence phenomena (Hallaçi *et al.*, 2001).

Due to local extensional tectonics during Pliocene, a horst - graben structure was created at the edge of the Ionian thrust front, where marine Pliocene formed in submerged grabens. This way, for instance, the Butrinti graben took place, from Vrina Plain to Butrinti Lake and further northwards. This extensional tectonics was still active in the Quaternary, when Lake Butrinti was formed. The above -mentioned local extension during the Pliocene-Quaternary was conditioned by evaporite tectonics.

MATERIALS AND METHODS

Vertical electrical sounding was applied to estimate the stratified soils and sediments (Barker, 1990). Quaternary deposits at scale 1:25000 were studied using Vertical Electrical Sounding (VES) method during the period 2000 to 2005. Electrical electro-sequential and sedimentological interpretation of VES curves make possible the identification of geo-electrical facies, electro-sequences, mega-sequences, the morphology of sedimentary bodies, the sedimentation environment as well as the regional cycles of sedimentation. Geophysical and sedimentological investigations make possible the decoding of horizontal and vertical evolution of quaternary depositions.

The study consisted in: (i) describing or designating sedimentary facies based on electrometrical data for Quaternary deposits and mapping of geophysical - sedimentological sections throughout all areas; (ii) determination of the thickness of Quaternary deposits and its mapping; (iii) reassessment of the structural geology on the basis of the geophysical and geological data.

Principally, it was used the Schlumberger array with longest spacing (AB ÷ 540 m). Only in some sectors (Vurg-Finiq area) with low electrical resistivity it was switched to Werner array (penetration ~ 0.18 x AB m). After the first measurement, electric schema was extended up to the detection of quaternary basement. Great attention was paid to the calibration of the geo-electric model using geological and hydro-geological data encountered in this study area. In each area were done 1-2 SEV for the determination of anisotropy. SEV's grid was ranked from 250 m x 500 m to 1000 x 1000 m. The number of VES in the studied area is some 68 measurements (Durmishi *et. al.*, 2005) (Figure 2).

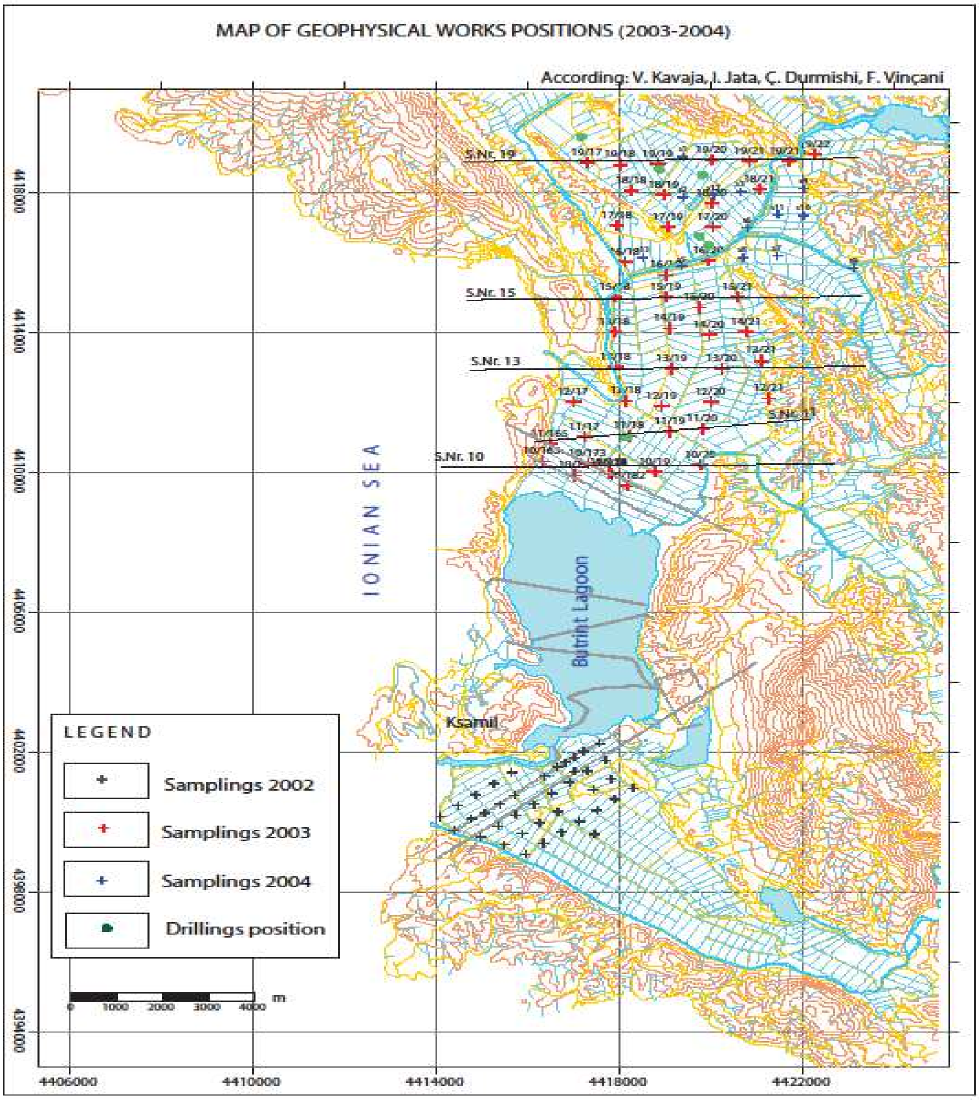


Figure 2. Map of geographic positions of geophysical investigations in Saranda region by using vertical electrical soundings VES.

During the interpretation of the VES data, it was supposed that the underground layers were laid horizontally, which is common for the deposits of Quaternary. In addition to geophysical data, the sedimentological evolution of the Quaternary deposits has been modelled based on the historic geological documents (Durmishi *et al.*, 2008),. The tectonic map of area is of scale 1: 50 000, and the data is gathered from field observations during 2011-2005 period. It was recognised that facies under clay, coal, shale, and sandstone may be helpful in finding the mode of origin or in prescribing the model of sedimentation. For this reason, one important source for obtaining the geological data of the Quaternary deposits and specially the data related to lithological facies, was the "Evaluation of coals on the molasses deposits in Xarra region and its surroundings" report (Hallaçi *et. al.,* 2001).

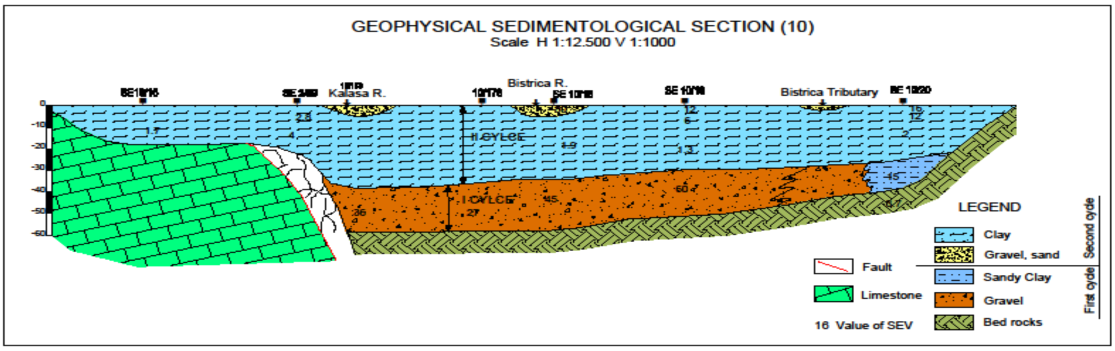
The SEV's curve interpretation was done with the program REZIST version1.0 (Vander Velpen 1988). The program provided solutions to the models up to 10 layers/strata with 30 iterations. In cases where the SEV-s were conducted close of the drilling points, curves models were held in the same way, in order to identify the real thicknesses of the layers , and iteration was performed for the exact calculation of resistances. The Root Mean Square (RMS) errors for the analysis were very low (0-2%).

RESULTS

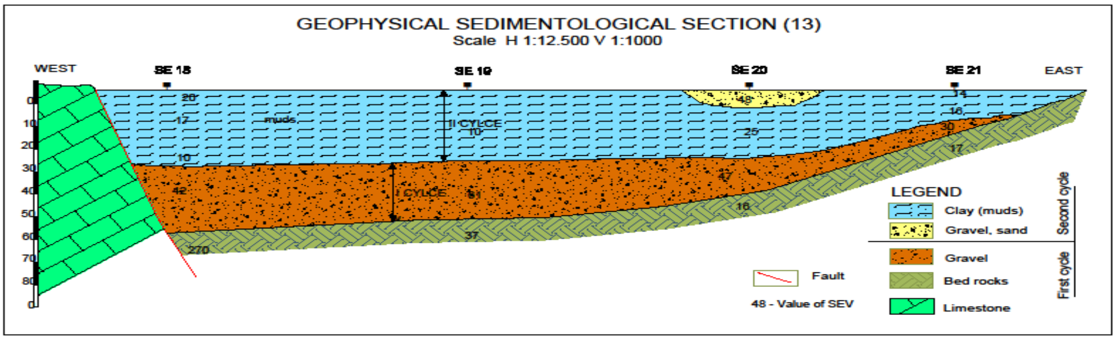
The Electrical markers and sedimentological interpretations of VES curves made possible the identification of the geoelectrical facies, electrosequences, megasequences, and the morphology of sedimentary bodies, as well as of the sedimentation environment and their regional cycles of sedimentation. Meanwhile geophysical and sedimentological profiles made possible the decoding of the horizontal and vertical evolution of the Quaternary deposits. The VES program offers up to 10 – layer solution.

The Quaternary deposits were formed in the typical graben depression of the area, where an important role in its geomorphology, besides the neotectonic movements, is attributed to the diapirism phenomenon. For the first time (Hallaçi *et al.*, 2001), a sedimentological – geophysical interpretation on the area of the Vrine – Xarre – Mursi depression, were obtained based on the VES data. In this area also, the deposits of Quaternary show the same nature of the facies identified according VES. The electric geophysical works covered a territory from the lagoon of Butrinti (the southern margin) to the village of Finiqi (the northern margin) an area of about 36 km^2. The sections of west – east direction, covered the entire area of the deposits of Quaternary, from the limestones of Cuka and Saranda (Jurassic – Cretaceous) up to the hills in front of the flyschoidal formations of Palaeogene (Figure 3/a, b, c, d, e). In this area also, the interpretation of the soundings is based on the standardization of the geophysical models with lithological formation and the geological – hydrogeological data as well. The maps of Quaternary deposits (Figure 4) and the maps of lithological developments of the sequences from 0 m to 100 m below the surface have been compiled. This map shows the unified thickness of two cycles of sedimentation in Quaternary deposits. The thickness of the deposits in the SEV points range from 10 to 80 m.

The greater depth was measured in the central part of the valley, along Pk 18-20, with values that range from 60 to 77 m. The maximum depth was measured in Section 11 with 77 m. This can be spotted easily on profiles (Figure 3/ a, b, c, d, e).



a)



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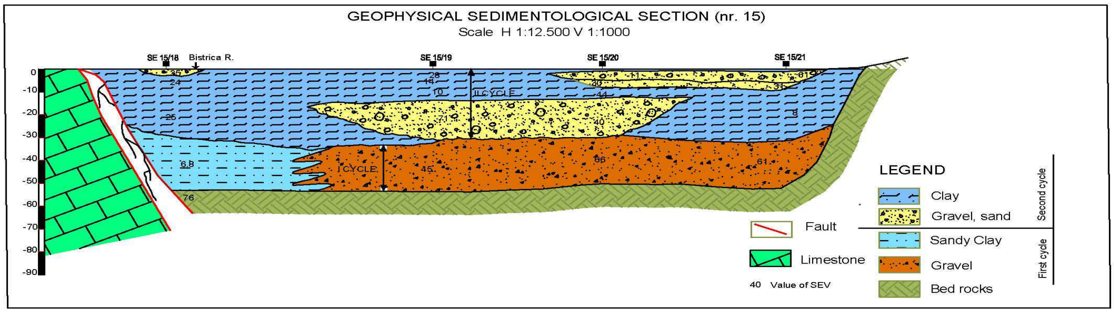

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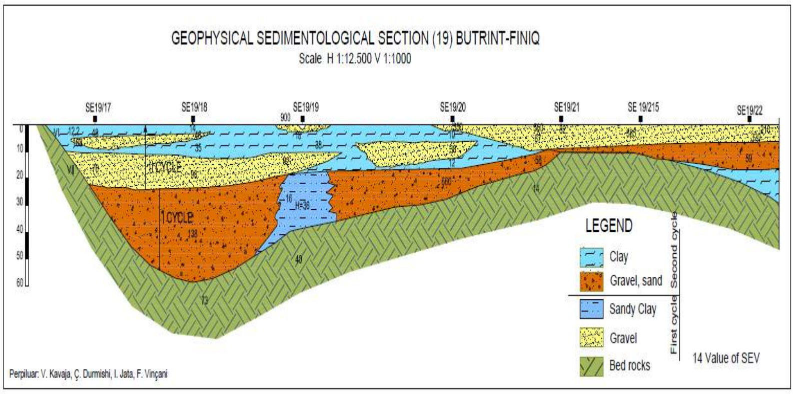

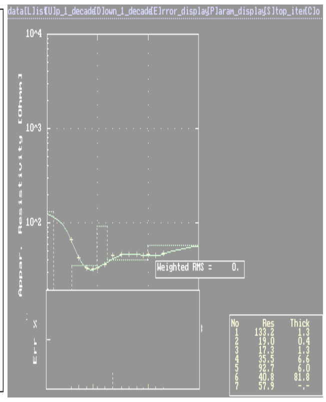

d) e)

Figure 3. The geophysical–sedimentological section e- Model of VES 18 in Butrinti region: a) section 10; b) section 13; c) section 15; d) section 19; and e) curve of 7 layers model of VES 19 (8 layers).

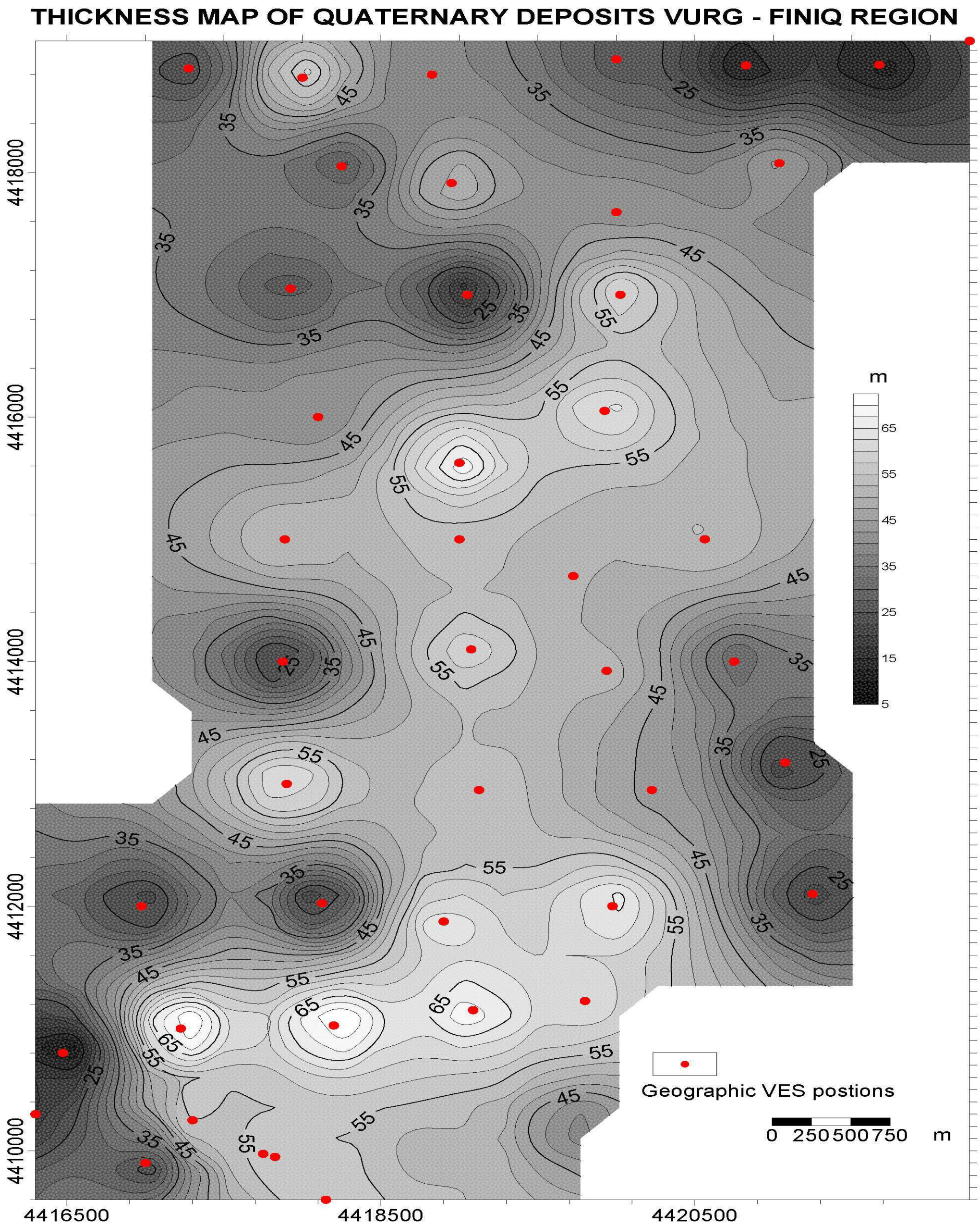

Figure 4 Thickness map of Quaternary Deposits of Vurgu-Finiq region.

DISCUSSION

The data obtained by the sequential analysis and the sedimentological sections for the Quaternary deposits of Saranda region (Finiq – Vurg – Butrint area; and Mursi – Xarre – Vrine area), lead us in two conclusions:

- With the beginning of the Quaternary period, the area was characterized by the marine transgression which reached all the contours of the tectonic – graben depression, contoured at the end of Pliocene period.

- The deposits of Quaternary, formed in different sedimentation environments and accompanied by neotectonic movements and related subsidences of the basin of Quaternary, represented a total thickness that ranges from 10 – 20 m to 120 – 140 m. The interpretation of the sedimentological formation has shown the presence of the conglomeratic, gravel, sandy and silty to silty – clayey facies up to massive carbonatic clays.

Application of the sequential analysis on the vertical and lateral distribution of facies and rock lithology as well, showed that the deposits of Quaternary have been the result of their development through two cycles of sedimentation. This depends on the conditions of the related sedimentation environments. (Figure 5)

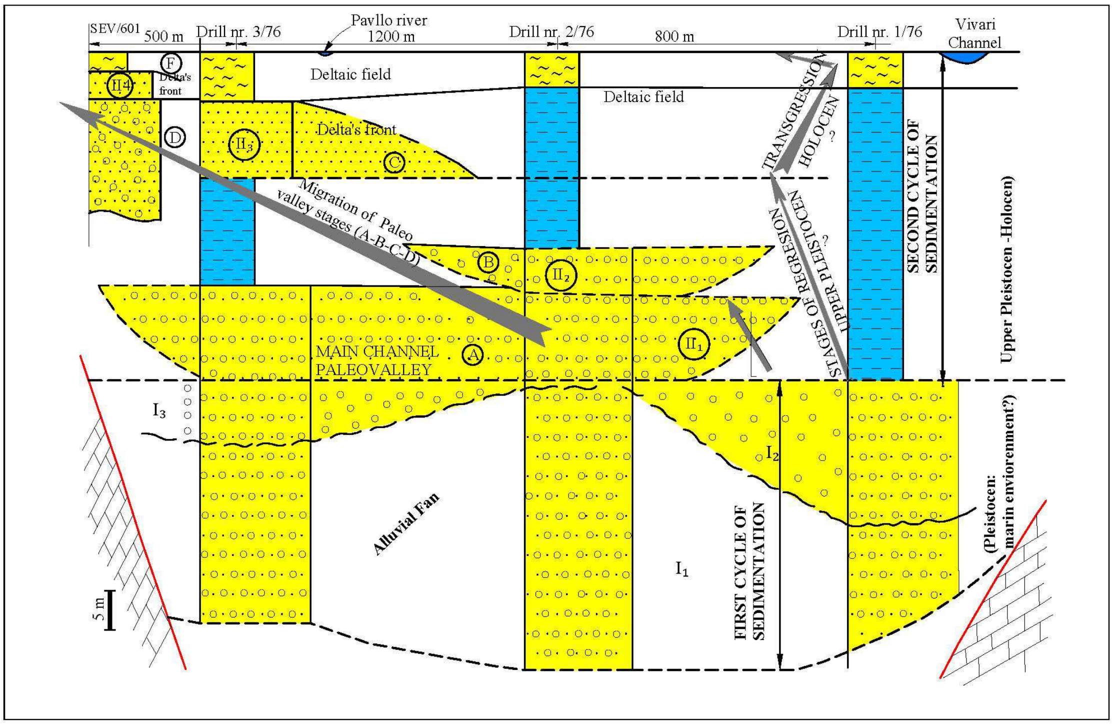

Figure 5 The general geological sedimentological scheme of Quaternary deposit.

- ***The first cycle of sedimentation*** is in accordance with the beginning of the quaternary deposits in this area, and it is mainly represented by conglomeratic, gravel, silty – clayey facies which thickness varies up to 35 – 40 m. The deposits of this sedimentation cycle belong to the marine environment of fans or submarine colluvial fans (Figure 6). This suggests that the deposits of the first cycle could have been formed during Lower – Middle Pleistocene.
- ***The second cycle of sedimentation*** is characterized by a lower energy and hydrodynamics of sedimentation than the one of the first cycle, and it consists mainly of gravel, silty clays, clays and sandy facies. With the beginning of the second cycle, the fluvial, deltaic, littoral and marine environments develope, occur all over the area of Saranda region. During the second cycle of sedimentation, two microbasins of Quaternary have been distinguished:

- The micro basin of the Finiq – Vurg – Butrint plain, developed in NE – SW direction. Here it is supposed that it was the beginning and the development of the fluvial environment of Kalasa – Bistrica, formation of Butrint lagoon and the actual geomorphology features.
- The micro basin of the Mursi – Xarre – Vrion plain, with development toward east – west. In this direction there is the beginnings and the developments of the fluvial environment, delta and littoral of the River Pavllo. The related interrelationships between Butrint lagoon, the Vivari Channel and the actual environment of the Ionian sea was occurred during the second cycle of sedimentation.

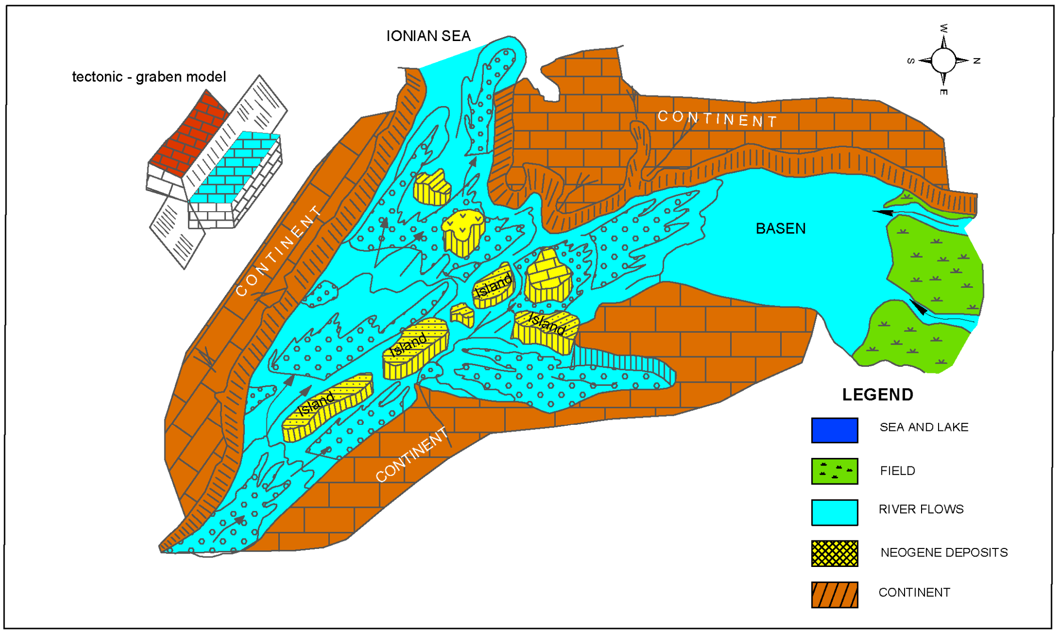

Figure 6 Schetch of first paleenvironmental sedimentological cycle during Quaternary – Pleistocen period.

The deposits of the second cycle were formed mainly during the Upper Palaeocene, Holocene up to the present.
With the beginning of the second cycle of sedimentation, the interpreted data show that there was the beginning of a regression, and the development of a fluvial environment with the related characteristics and sub-environments (Figure 5) and the interrelation and interconnection with the related deltaic environment.
On the basis of the sedimentological data and the geomorphology of the fluvial environment, as well as of the data of the sequential analysis of the borehole data and electro-sedimentological ones, it has been deduced that there were two stages of the fluvial environment development in time and space:
- The first stage, (A or II -1), of the fluvial environment development has been characterized by a potential development of the fluvial environment and of a delta of constructive character where the front of delta and related littoral has been more advanced than present. Meander character of the river type was present as well.

- The second stage, (B or II – 2), of the fluvial environment development (Figure 7) shows that its intensity was decreased in comparison with the one of the first stage. This was reflected on the reduction of the geometry of the distribution channels, but its delta still maintains the features of a constructive delta.

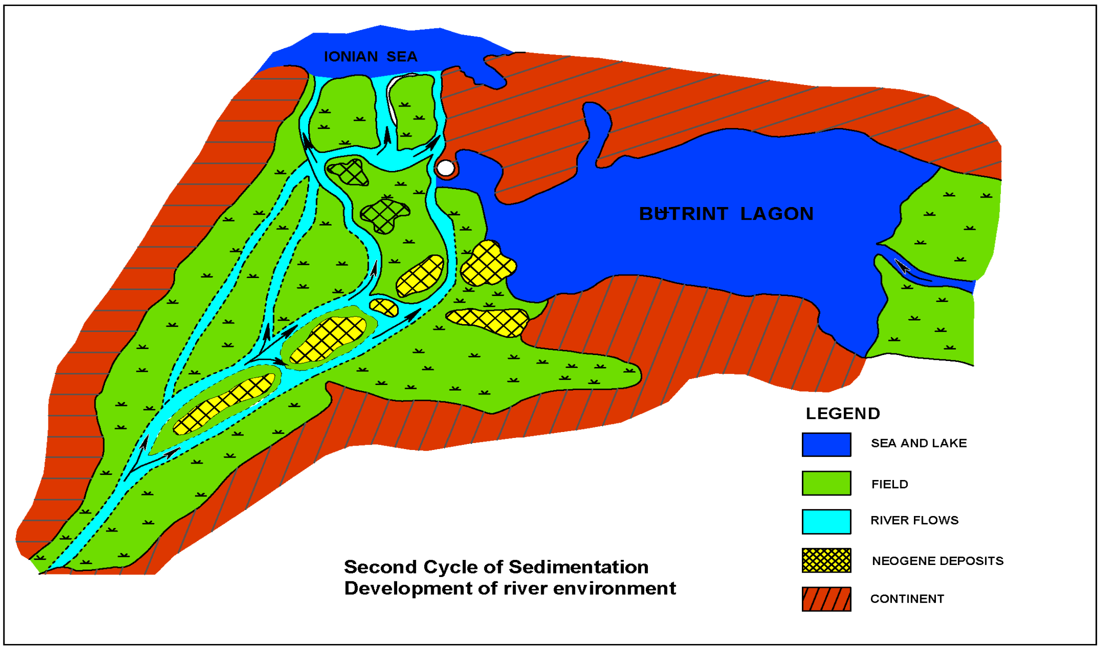

Figure 7. Schetch of second paleenvironmental sedimentation cycle during Quaternary – Pleistocen (Moisiu and Durmishi, 2008).

This suggests that the development of the first and second fluvial stages happened and developed during the Upper Pleistocene (Q_3). At the end of two stages (II 1^{st}, II – 2^{nd}) of the second sedimentation cycle, there was a “slight” transgression in the considered area.
The stage D, which has been more potential at the stage F, the occurrence of the above transgression, was considered to belong to the end of Upper Pleistocene and the stage F to Holocene (Q_4).
Concerning the above mentioned, during the stage II – 3^{rd}, II – 4^{th}, the data of the sequential analysis and the character of the geometrical forms suggested the presence of a marine – littoral – deltaic environment and the fluvial one. Physics – geography features, created during the development of the stage II – 4^{th} cycle (Figure 8) belong~~s~~ to the same time of development of civilization at Butrinti area.
Such a development and interpretation of the palaeosedimentology and geomorphology of the sedimentation environments, should also contribute to a better orientation on further exploration of the ancient civilization of this area. After Holocene, there was a new regression that coincides with the present deposits and it has affected the present geomorphology of the area.

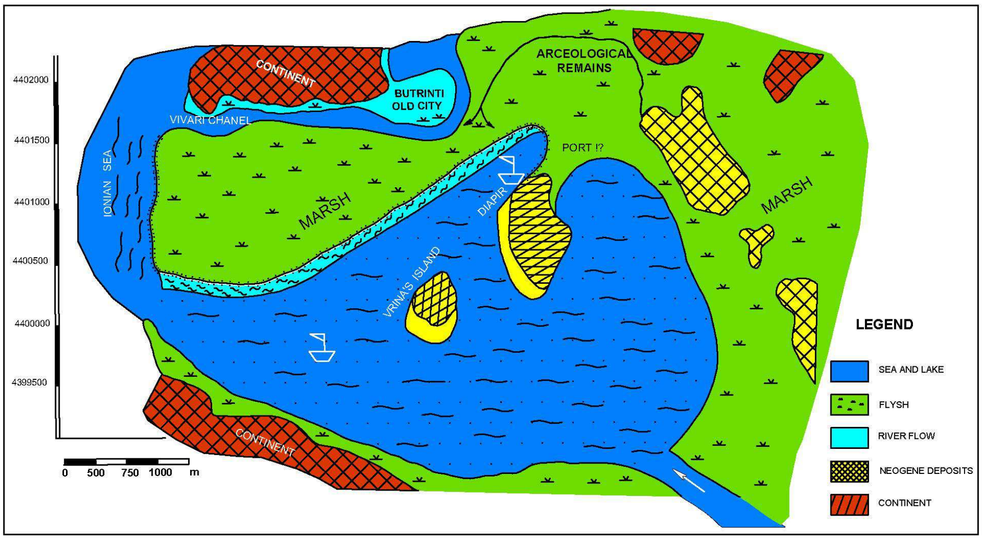

Figure 8. Schetch of fourth paleenvironmental sedimentation cycle during Quaternary – Pleistocen was happen in the same time with the development of civilisation at Butrint area (Moisiu and Durmishi, 2008).

CONCLUSIONS

1. The deposits of Quaternary were formed in the typical graben depression, where an important role in its geomorphology, apart the neotectonic movements, belongs to the phenomenon of diapirism.
2. The Quaternary deposits of Saranda region (Finiq – Vurg – Mursi – Xarre – Vrine) have been of the same nature as of all quaternary depostis on costal area. These deposits were formed during two stages of sedimentation:
   a. The first cycle of sedimentation represent the deposits formed during Upper and Middle Pleistocene (Q_1- Q_2). This cycle, some 50 – 40 m thick from the basement to the depth, belongs to the sedimentation environment of alluvial fans deposited in a marine environment and consisting of gravel – sandy facies.
   b. The second cycle represents the deposits of Upper Pleistocene – Holocene (Q_3-Q_4) to recent deposits. This cycle, some 50 – 40 – 30 m thick , consists mainly of intercalations offluvial – lagoon – marshy – deltaic – littoral environments.
   c. In the second cycle, there was the beginning and the development of the present rivers of the area, Bistrica river, Pavllo river as well as the formation of the Butrinti lagoon and its typical interconnection with the Ionian sea through the Vivari Channel.
3. Nine (9) geo-electrical facies were identified on the study area: Gravel, sand-gravel, sand, silted, sand, silt clays, wetland clays, clay peat and peat clay.

References

Aliaj, Sh., (2012) Neotectonic of Albania Monograph “Neotektonika e Shqipërisë, Monografi, Tirana, Albania

Barker, R. D. (1990) Improving the quality of resistivity sounding data in landfill studies. In S.H. Ward (eds.) "Geotechnical and environmental geophysics, Vol. 2. Environmental and groundwater applications": pp. 245-251.

Durmishi, Ç., Daja, Sh., Moisiu, L., Alla, B. (2011) "Genetic zoning of costal area – a crucial element for a sustainable planning of the urban area and development of territory." Scientific conference, Tirana, Albania: pp. 235- 244.

Durmishi, Ç., Moisiu, L., Kavaja, V., Jata, I., Sinojmeri, A. (2008) Sedimentological and Geophysical study of Quaternary deposits (Holocen-Pleistocen) of Albanian coastal area. Littoral 2008. Abstracts Book of the 9th International Conference: Achanging coast: Challenge for the environmental policies, Venice Italy: pp. 42.

Durmishi, Ç., Moisiu, L. (2008) Geo-environmental Units zoning of Albania coastal at 1:200000 scale. Littoral 2008. Abstracts Book of the 9th International Conference: A changing coast: Challenge for the environmental policies. Venice, Italy: pp. 53.

Durmishi, Ç., Beshku, H., Moisiu, L., Kavaja, V. (2005) Sedimentological and Geophysical study and monitoring of Albania coast area: Impacts in environment, infrastructure and tourism. Final report Albanian Geological Survey (AGS) Archive, Tirana, Albania, 450 p.

Durmishi, Ç., Kapsimalis, V., Anagnostou, Chr., Moisiu, L., Kavaja, V. (2004) Human Impact on evolution of costal area, lays between Pavllo (Albania) and Kallamas (Greece) rivers. Final Report of Bilateral project between AGS - Albania and HCMR Greece. Albanian Geological Survey (AGS) (Archive), Tirana, Albania, 200 p.

Hallaçi, H., Durmishi, Ç., Kavaja, V., (2001) Geological – geophysical–sedimentological features in Butrint region. Final Report, Albanian Geological Survey (AGS) (Archive), Tirana, Albania: pp. 250.

Moisiu, L., Durmishi, Ç. (2008) Geo-environmental sub-units zoning of Saranda coastal area at 1:50000 scale (Albania). Littoral 2008. Abstracts Book of the 9th International Conference: A changing coast: Challenge for the environmental policies, Venice, Italy: pp. 54.

Oikonomou, C., Kapsimalis, V., Durmishi, Ç. (2005) Optimum management strategies for the environment improvement of Butrint Lagoon, SW Albania". Abstracts Book of the ICCCM'O5 International Conference on Coastal Conservation and Management in the Atlantic and Mediterranean, Tavira, Portugal: pp. 299-302.

Papazachos, B. C., Savvaidis, A. S., Papaiouannou, C. A., Kiratzi, A. A., Mocu, B., Kociou, S., Sulstratova, E. (2001) Atlas of isoseismical maps for shallow earthquakes in Albania and surrounding area (1851–1990). Geophysical Laboratory Publication, Vol. 10. Aristotle University of Thessaloniki.