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STRATIGRAPHY AND TECTONIC EVOLUTION OF LATE MIOCENE-QUATERNARY BASINS IN EASTERN ALBANIA: A REVIEW

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Abstract

The new stratigraphic data and tectonic evolution of the Late Miocene-Quaternary basins developed in Eastern Albania are presented. The reviewed stratigraphic data for deposits filling the Ohrid, Prespa and Devolli basins show that they began to form in Late Miocene. The stratigraphic evidences from eastern Albania are confronted with the stratigraphic data from the lake basins in western North Macedonia and northwestern Greece that all show the same age of infilling. The Cenozoic tectonic evolution of Eastern Albania consists of two phases of extensional deformations, the first in Middle Eocene-Late Miocene (Pannonian/Tortonian) and the second starting in Late Miocene (Pontian s. l.). The two phases are separated by a short compressive phase at the Late Miocene (end of Pannonian/Tortonian) or pre-Pontian s. l. time. In Late Miocene (Pontian) began forming the system of the Ohrid, Prespa and Devolli basins developed along the Drini fault zone. The Korça, Kolonja, Kukesi and Tropoja basins began to form since Pliocene and the Peshkopi Basin since Early Pleistocene. Finally, only the Ohrid and Prespa lakes are still active. The Late Miocene-Pleistocene basins were filled by lacustrine, lacustrine-fluvial and terrestrial sediments of the great thickness and of varied lithology: conglomerates, gravels, sandstones, sands, claystone and marls with lignite seams. Molluscs, microflora and flora, ostracods and vertebrates are found. The Lake Ohrid is a tectonically active graben formed during two main phases of deformation: (1) a trans-tensional phase which generated a pull-apart basin, and (2) an extensional phase which leads to its present geometry. All basins in Eastern Albania are situated in a basin and range-like (graben and horst) geodynamical setting. The inferred stratigraphic and tectonic evolution of Late Miocene-Quaternary basins in Eastern Albania as well as the relief formation and thermochronological data show *that the Late Miocene-Quaternary period which led to the recent geological structure of Albania and its rapid relief formation, can be accepted as 'Neotectonic period'.*

Keywords: *Late Miocene-Quaternary basins, Eastern Albania, stratigraphy and tectonic evolution*

ΠΕΡΙΛΗΨΗ

Σε αυτή την εργασία παρουσιάζονται νέα στρωματογραφικά δεδομένα καθώς και η γεωτεκτονική εξέλιξη των Άνω Μειοκαινικών –Τεταρτογενών λεκανών για την Ανατολική Αλβανία. Τα εξεταζόμενα στρωματογραφικά δεδομένα από τις αποθέσεις που πληρώνουν τις λεκάνες των Ohrid, Prespa και Devolli φανερώνουν ότι αυτές άρχισαν να διαμορφώνονται κατά το Άνω Μειόκαινο. Τα στοιχεία αυτά από την Ανατολική Αλβανία συγκρίνονται με τα στρωματογραφικά δεδομένα από τις λιμναίες λεκάνες στη δυτική Βόρεια Μακεδονία και την βορειοδυτική Ελλάδα οι οποίες στο σύνολο τους δείχνουν ίδια περίοδο ιζηματογένεσης. Η γεωτεκτονική εξέλιξη της Ανατολικής Αλβανίας στο Καινοζωικό αποτελείται από δύο φάσεις εφελκυστικής παραμόρφωσης, η πρώτη κατά το Μέσο Ηώκαινο – Άνω Μειόκαινο (Παννόνιο Τορτόνιο) και η δεύτερη κατά το Άνω Μειόκαινο (Πόντιο s.l.). Οι δύο φάσεις αυτές χωρίζονται από μια σύντομη φάση συμπίεσης κατά το Άνω Μειόκαινο (τέλος Παννόνιου/Τορτόνιου) ή το προ-Πόντιο s.l. Κατά το Άνω Μειόκαινο (Πόντιο) άρχισε να σχηματίζεται το σύστημα λεκανών των Ohrid, Prespa και Devolli κατά μήκος της ζώνης διάρρηξης του Drini. Οι λεκάνες των Korça, Kolonja, Kukesi και Tropoja άρχισαν να σχηματίζονται από το Πλειόκαινο και η λεκάνη του Peshkopi από το Κάτω Πλειστόκαινο. Τέλος, μόνο οι λεκάνες των λιμνών Ohrid και Prespa είναι ακόμη ενεργές. Οι Άνω Πλειοκαινικές – Πλειστοκαινικές λεκάνες πληρώθηκαν με λιμναία, ποταμο-λιμναία και χερσαία ιζήματα μεγάλου πάχους και ποικίλης λιθολογίας: κροκαλοπαγή, χαλίκια, ψαμμίτες, άμμοι, πηλόλιθοι και μάργες με λιγνιτικές ενστρώσεις. Βρέθηκαν επίσης απολιθώματα από ασπόνδυλα, χλωρίδα και μικροχλωρίδα, οστρακόδερμα και σπονδυλωτά. Η λίμνη Οχρίδα είναι μια τεκτονικά ενεργή κοιλάδα σχηματισμένη κατά τη διάρκεια δύο παραμορφωτικών φάσεων: (1) μια οριζοντιο-εφελκυστική φάση που δημιούργησε μια pull-apart λεκάνη και (2) μια εφελκυστική φάση που οδηγεί στην σημερινή της γεωμετρία. Όλες οι λεκάνες στην Ανατολική Αλβανία σήμερα βρίσκονται σε ένα γεωδυναμικό περιβάλλον λεκανών και ράχεων (graben and horst). Η Άνω Μειοκαινική – Τεταρτογενής στρωματογραφία και γεωτεκτονική εξέλιξη των λεκανών της Ανατολικής Αλβανίας σε συνδυασμό με την δημιουργία αναγλύφου και θερμοχρονολογικά δεδομένα δείχνουν ότι αυτή η Άνω Μειοκαινική – Τεταρτογενής περίοδος που οδήγησε στην πρόσφατη γεωλογική δομή

της Αλβανίας και στην ταχεία δημιουργία του αναγλύφου της, μπορεί να γίνει δεκτή ως «Νεοτεκτονική περίοδος».

Λέξεις - Κλειδιά: *Άνω Μειοκαινικές – Τεταρτογενείς λεκάνες, Ανατολική Αλβανία, Στρωματογραφία και τεκτονική εξέλιξη*

1. Introduction

The objective of this paper is to present an integrated study of the stratigraphy and tectonic evolution of the Late Miocene-Pleistocene freshwater basins in Eastern Albania. This work is based on the results of the many years of field surveys and research by the authors and unpublished drilling and exploration data. Having an economic importance due to the existence of the lignite bearing deposits in Devolli, Bezhani and Alarupi basins (Dimo et al., 1982, 1989), they have been the subject of detailed geological-stratigraphic studies. Many geologists have published their results (Bourcart, 1922; 1925; Melo, 1964; Pashko, 1967; 1970; 1975; Pashko et al., 2012; 2013a, b; Aliaj, 1996; 1998; Meço et al., 2004). The biostratigraphical data are based on molluscs (Pashko, 1968; 1984), while the palynological analyses were performed by Samoilovich (1958), Kumati et al. (1997), the ostracods by Kumati et al. (1997), the flora by Kleinholter (2004). The limited mammal fauna of Albania (Bourcart, 1922 and Dodona et Kotzakis, 1985) is poor and includes the occasional founds and mostly obsolete species identification, but a tentative correlation between those species and mammal fauna of Greece (Koufos, 2016) may be possible. Albanian-Thessalian Basin (ATHB) filled by the Middle Eocene-Middle Miocene marine molasse was affected by the rapid uplift and marine regression due to a pre-Late Miocene (pre-Pontian) short compressional event. The fresh water Late Miocene (Pontian)-Pleistocene sedimentary fill in Devolli Basin unconformably overlies the Langhian and Serravalian marine molasse deposits of ATHB (Pashko, 1977; 2018; Pashko et al., 1973).

The Ohrid, Prespa and Devolli basins were developed in N-S direction during the Late Miocene (Pontian)-Quaternary, parallel to the Drini fault zone. The reviewed stratigraphic data of the Late Miocene-Pleistocene basins developed in Eastern Albania, and superimposed on the area of the ATHB (Ohrid, Prespa and Devolli basins) discussed in this paper show they are Late Miocene (Pashko, 1970; Pashko et al., 1973) and not in Pliocene. The stratigraphic evidences from Albania are confronted with similar basins in North Macedonia and NW Greece. The reappraisal of some mammalian fossils in North Macedonia has shown that the fauna previously regarded as Pliocene in age is indeed Late Miocene (Dumurdzanov et al., 2004; Krstic et al, 2012). On the other hand, the stratigraphic successions of the Florina-Ptolemais Basin in NW Greece belong to Late Miocene (Pontian *sensu lato*) to early Pliocene (Pavlides and Mountrakis, 1987; Steinbrink et al., 2000, 2006; Iordanidis et al., 2003; Metaxas et al., 2007; Oiconomopoulos et al., 2008).

Although in the previously stratigraphic investigations on the Ohrid, Prespa Lakes and Devolli basins the basin infill is documented as Late Miocene-Quaternary in age (Pashko, 1970; Pashko et al 1973, 2012; 2013a; 2013b) in literature commonly it have been considered of Pliocene-Quaternary age (Biçoku et al., 1967; 1970; Shehu et al., 1990; Meço and Aliaj, 2000; Xhomo et al., 2002; Aliaj, 2012 etc.). The stratigraphy of the Late Miocene and Pleistocene fresh-water deposits is based mainly on the mollusks fossils and less on vertebrate fossils, palynomorphs, leaf imprints and ostracods. The stratigraphic data show the Late Miocene-Pleistocene age of deposits filling the lake basins in Eastern Albania, western part of Republic of North Macedonia and in NW Greece and are of special interest for better defining the last extensional phase in this sector of the Southern Balkan region.

2. Geological Setting

Pashko (2018) presented the more detailed biostratigraphy of the ATHB deposits showing that it consists of ~ 4.5 km thick basin infill of Middle Eocene to Middle Miocene marine molasse deposits overlain by Late Miocene (Pontian)-Pleistocene deposits in the Devolli Basin. The evolution of the ATHB was characterized by two main tectonic compressional events: 1) an important inversion at the Eocene/Oligocene transition; 2) a minor tectonic phase related to the Aquitanian/Burdigalian boundary and marked by the unconformity of Burdigalian deposits on the oldest basin formations. As consequence of these deformational events, three periods of regional extension could be recognized associated to three distinct marine molasse cycles: the first Eocene (Late Lutetian-Priabonian) cycle; the second Oligocene-early Miocene (Aquitanian) cycle and the third Early Miocene (Burdigalian)-Middle Miocene (Serravallian) cycle. The Neogene extensional period affected the low relief surface of the ATHB conditioning gradual subsiding graben and half-graben basins. These -diachronically formed continental, generally long-lived basins- were filled by the fresh-water lacustrine and fluvial-lacustrine deposits of great variety in lithology and thickness, reflecting syn-sedimentary tectonics and variable palaeogeographic conditions.

The early fresh-water Middle Miocene Librazhdi Basin is marked by the massive influx of highly clastic mostly reddish deposits, sandstones and conglomerates, transgressively overlying the marine Oligocene-Aquitanian molasse of the ATHB (Mokra and Gora area) or Mesozoic basement (Pashko, 1970; 1975; Pashko et al., 2012; 2013a, b), and terminates with the marine deposits of the Serravallian marine ingression of the Pre-Adriatic area. The Late Miocene (Pannonian/Tortonian, 11 Ma) deposits of the Burreli Lake Basin are represented mostly by the lacustrine massive sandstones, conglomerates and clays-marls with Pannonian molluscs (Pashko, 1967; 1968; 1995; 2019). The Librazhdi and Burreli basins can be considered as the NW continuation of the western Mokra area part of the ATHB mainly developed in lacustrine conditions, quite different from the overall marine molasse deposits of Morava Mountain section, southeastern part of the ATHB.

The basins of the Prespa, Ohrid, Piskupstina, Peshkopi, Skavica and Kukesi grabens, as well as the Devolli, Korça and Kolonja half-grabens are aligned along the Drini graben fault zone, N-S striking, or parallel to it (Fig. 1). The Drini fault zone follows the valley of Drini i Zi River from the Lake Ohrid to the north up to Kukesi and to the south towards the Korça and Kolonja (Erseka; Aliaj, 1996). They developed obliquely to the main Middle-Late Miocene (Pannonian) basin NNW-striking.

The molassic basins in the interior of the country are: Albanian-Thessalian Basin (AT), Librazhdi basin (L) and Burreli basin (B), and in its exterior: Pre Adriatic basin (PA), and Butrinti basin (Bu). The Late Miocene-Pleistocene lake basins are: Devolli basin (D), Ohrid basin (Oh), Prespa basin (Pr), and Pliocene-Pleistocene Kolonja basin (Ko), Peshkopi and Scavica basins (Pe), Kukesi basin (Ku) and Tropoja basin (T), (Pashko, 1970; 2012; 2013a; 2013b; Pashko et al., 1973). The Pliocene marine basins are: Shkodra basin (Sh) and Kashnjeti basin (Ka) (Tershana et al., 1985). The Skavica and Tropoja Pliocene-Quaternary basins are aligned respectively along the Kurbnesh-Skavice and Shkoder-Tropoje dextral strike-slip faults.

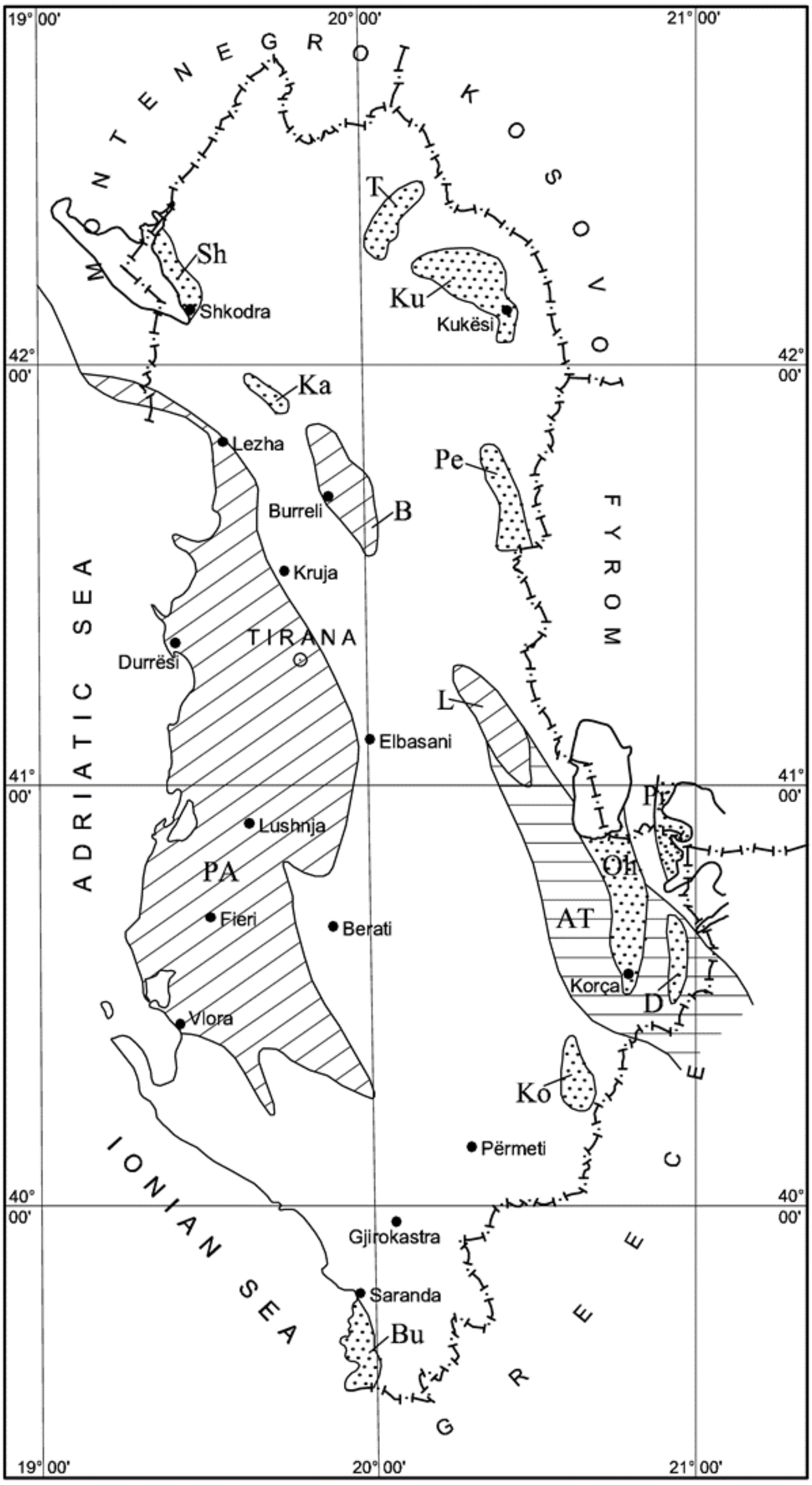

Fig. 1: Sketch-map of the Tertiary molasse basins in Albania showing their location (after Aliaj, 2000b).

The Lake Ohrid graben Basin is located at the boundary between the Mirdita ophiolite zone and Korabi zone/Western Macedonian zone, where the formations of Korabi zone overthrust the ophiolites of Pogradeci massif, belonging to the Mirdita zone. The Korabi zone in the Ohrid and Prespa lakes area is characterized by the Palaeozoic metamorphic schist overlain by Triassic-Jurassic limestones and together generating a large-scale anticline structure, developed between the Ohrid and Prespa Lakes. From Ohrid Lake Basin towards the north follows the Piskupstina graben Basin which cuts obliquely terrains of Western Macedonian Zone (= Korabi zone) in the territory of Republic of North Macedonia up to the Dibra graben Basin. Towards the north the graben basins are developed partly on the terrains of Krasta and Kruja zones windows from Dibra e Madhe in North Macedonia to Veleshica River in Albania, up to the Kukesi graben Basin at the contact between the Kukesi ultramafic massif belonging to the eastern ophiolite belt of Mirdita ophiolite zone and the Triassic-Jurassic carbonates of the Korabi zone.

From Ohrid Lake graben towards the south, the Korça, Devolli and Kolonja half-graben basins superimposed on the terrains of the Albanian-Thessalian Basin (Devolli and Korça ones**)**, of the Mirdita ophiolite zone and of Gramosi half-window in the Krasta zone (Kolonja Basin).

3. Stratigraphy of the Late Miocene-Quaternary Basins

The sedimentary reconstruction of Devolli, Prespa, Ohrid, Piskupstina and Dibra basins is based on surface exposures and drill holes data from Albania and Republic of North Macedonia (Dumurdzanov et al., 2004; 2005; Krstic et al., 2003; 2008; 2012). All these basins began forming in Late Miocene time. The lithostratigraphic units of Ohrid, Prespa and Dibra basins are correlated with the respective lithostratigraphic data of such basins partly developed in southern North Macedonia close to the border, as well as with the stratigraphic data from Florina-Ptolemais graben basin in Northwestern Greece (Pavlides and Mountrakis, 1987; Iordanidis et al., 2003; Steenbrink et al., 2000; 2006; Metaxas et al., 2007; Oiconomopoulos et al., 2008) (Fig.2). The stratigraphic data for the Piskupstina, Prespa and partly Peshkopi graben basins are shortly described below based on the data of Dumurdzanov et al. (2004). As far as Late Miocene-Quaternary basins have a common evolution in border regions of Eastern Albania, Western North Macedonia and Northwestern Greece in the following we brevity recall the stratigraphy of the Florina-Ptolemais basin in NW Greece (Pavlides and Mountrakis, 1987).

The Neogene-Quaternary sediments which fill the Florina-Ptolemais graben basin unconformably overlie both Palaeozoic metamorphic rocks and the Mesozoic limestone of the Pelagonian zone, and are divided into three lithostratigraphic units. The lower unit consists of basal conglomerates passing upwards into marl, sandy marl, sand, clay and lignite layers belonging to the Late Miocene (Pontian sensu lato) to Early Pliocene. The middle unit is argillaceous and contains some thick lignite beds alternating with clays, marls, sandy marls and lacustrine calcareous marls belonging to early Ruscinian to late Ruscinian one (upper sandy bed is considered as Pliocene in age). The upper unit consists of continental fluvial conglomerates, lateral fans and alluvial deposits and represents the Quaternary continental sedimentation. The Florina-Ptolemais basin is subdivided by ridges and hills into several sub-basins trending NE-SW, almost perpendicular to the main direction of the major basin. Two main fault systems were evidenced in the area of Florina-Ptolemais basin, the first with a NW-SE strike and the second with a NE-SW strike (Pavlides and Mountrakis, 1987).

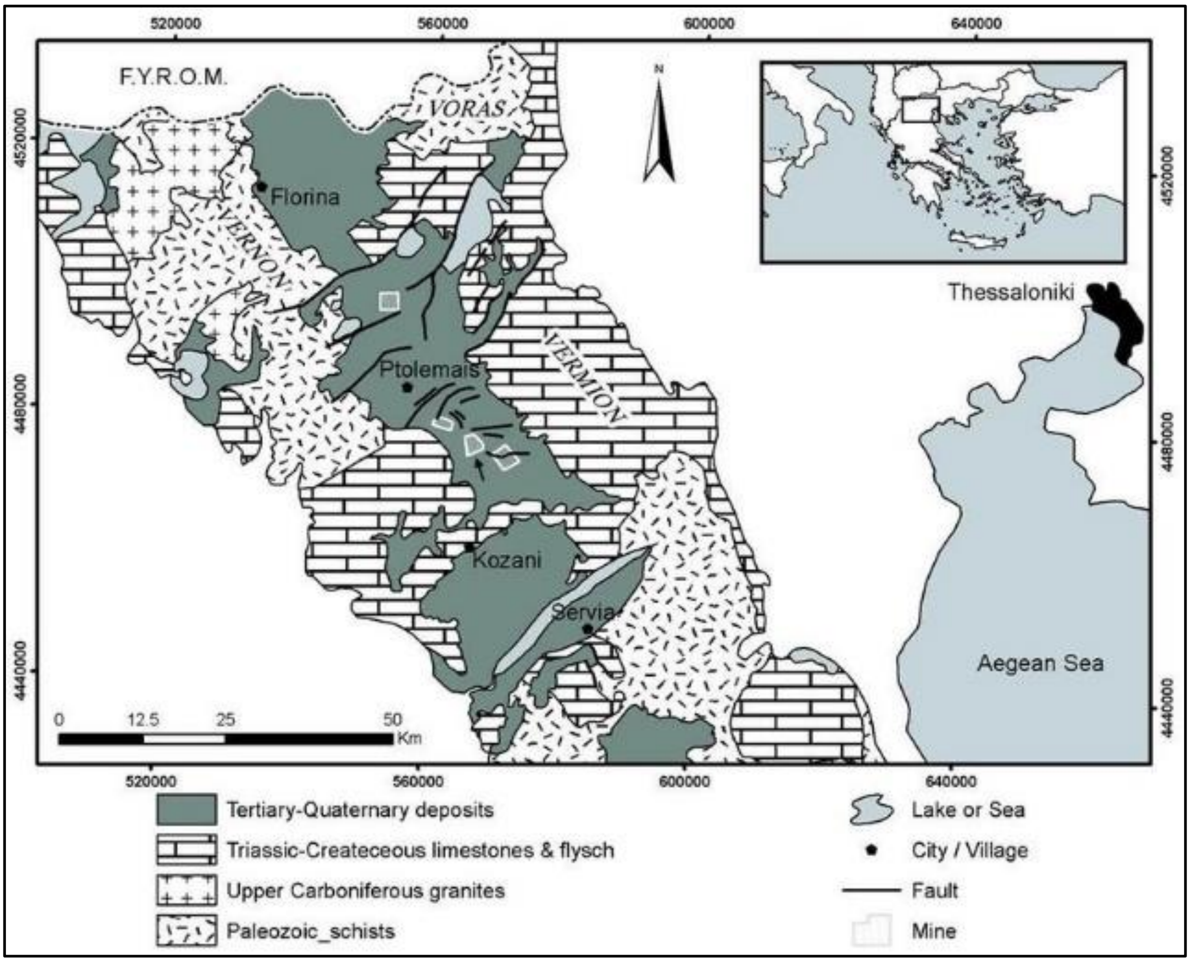

Fig. 2: Simplified geological sketch map of the Florina-Ptolemais-Servia Basin (after Pavlides and Mountrakis, 1987).

<u>Devolli Half-Graben Basin</u>.

The Devolli Basin is located in SE of Albania, along the border with northern Greece, forming a half-graben structure, oriented N-S (Figs. 3 and 4). The stratigraphic and palaeontological data show that, the basin started forming at Late Miocene, Pontian s. l. stage, and continued through Pliocene and Pleistocene. Its persisting subsidence caused a continuous sedimentation of up to 750-800 m thick of predominantly lacustrine marls, clays and sands, and siliciclastic fluvial deposits with alternating coal and clays layers. The Devolli fresh water sedimentary fill begins with sands and less conglomerates unconformably overlying the marine Middle Miocene deposits. It presents a half-graben structure, limited by a major normal fault along its SE border.

Based on the unpublished drilling data and stratigraphic observations (Pashko al., 1973; 2012; 2013a; 2013b; Pashko, 2018), the thick fresh water sedimentary succession of the Devolli Basin consists of two transgression-regression cycles (Late Miocene and Pliocene-Pleistocene) and it can be is subdivided into Late Miocene (Pontian), two Pliocene, Pleistocene and Holocene stratigraphic units. The Basal Pontian Unit, termed Menkulas Coal Formation, up to 250 m thick is composed of predominantly lacustrine compact marls-clays, diatomaceous marls, friable sandy lenses and some low-quality coal seams, unconformably overlying the Langhian and Serravallian marine molasse deposits of ATHB. The stratigraphic section starts with 50-60 m thick basal alternation of predominantly grayish fine grained, friable fluvial-lake sands with grayish-greenish clay layers. It is grading upwards into an about 200 m thick succession of lacustrine grayish to blue, compact clays and marls with some coal seams, which indicates the coal formation environments. The coal-bearing seams are maximum 4-6 m in thickness and are present in the lower part of the sequence. This coal-bearing sequence contains three coal layers of usually 0.7-1.4 m (maximum 2.76 m), separated by 1.8-2.2 m thick clay intervals. The upper part of the unit shows predominantly clays alternating with thin coal seams. The top of the coal seams followed by up to 2 m thick calcareous silt contains the following scattered mollusks *Planorbarius cornu* Linnaeous, *Bithynia tentaculata* Linnaeous (Fig.4).

The Second Unit of early Pliocene age, termed Ziçishti Sands, consists of predominantly sands 200-220 m thick. At the base of it there is 40 m thick of coarse-grained series deposits, unconformably lying on marine Langhian-Serravallian molasse along the NW margin of the basin.

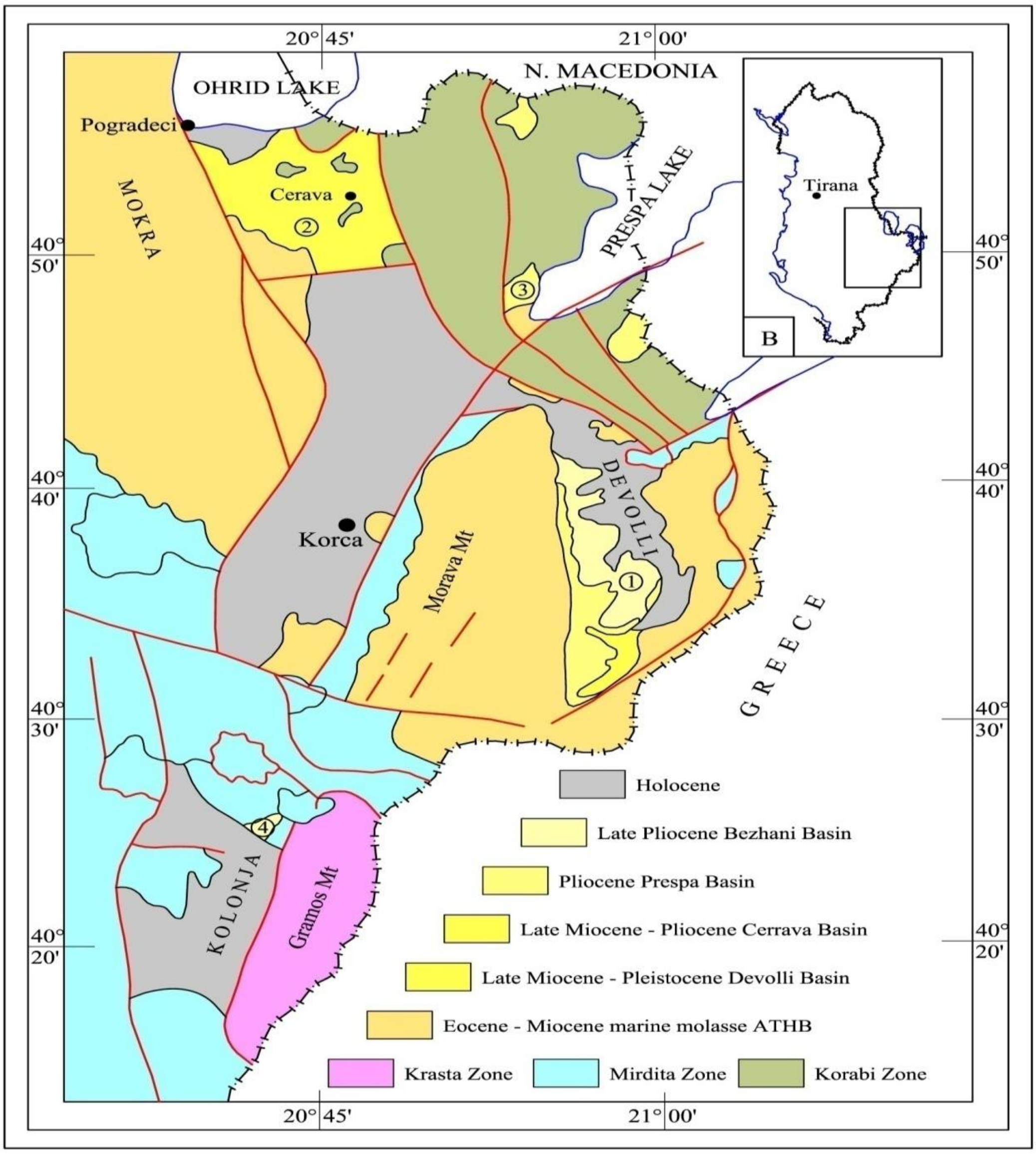

Fig. 3: (A) Geological map of southeastern Albania showing the studied Neogene basins (modified after Geological Map 1:200 000 of Albania): 1 Devolli Basin; 2 Alarup-Cerava Basin; 3 Prespa Basin; 4 Bezhani Basin; and (**B**) location of the studied area.

This predominantly coarse-grained series consists of massive, concretionary, friable sands, mostly grayish light colour with ferruginous ripple, from 4-6 m up to 15 m, with thin clay layers, followed upwards by a gradual shift towards predominantly grayish clays intercalated with 0.3-0.4 m layers of friable, grayish light sands, for about 37 m thick. The next upper interval (130 m), consist of three quartz sand layers, up to 8 - 10 m each, separated by 40-50 m thick grayish clays.

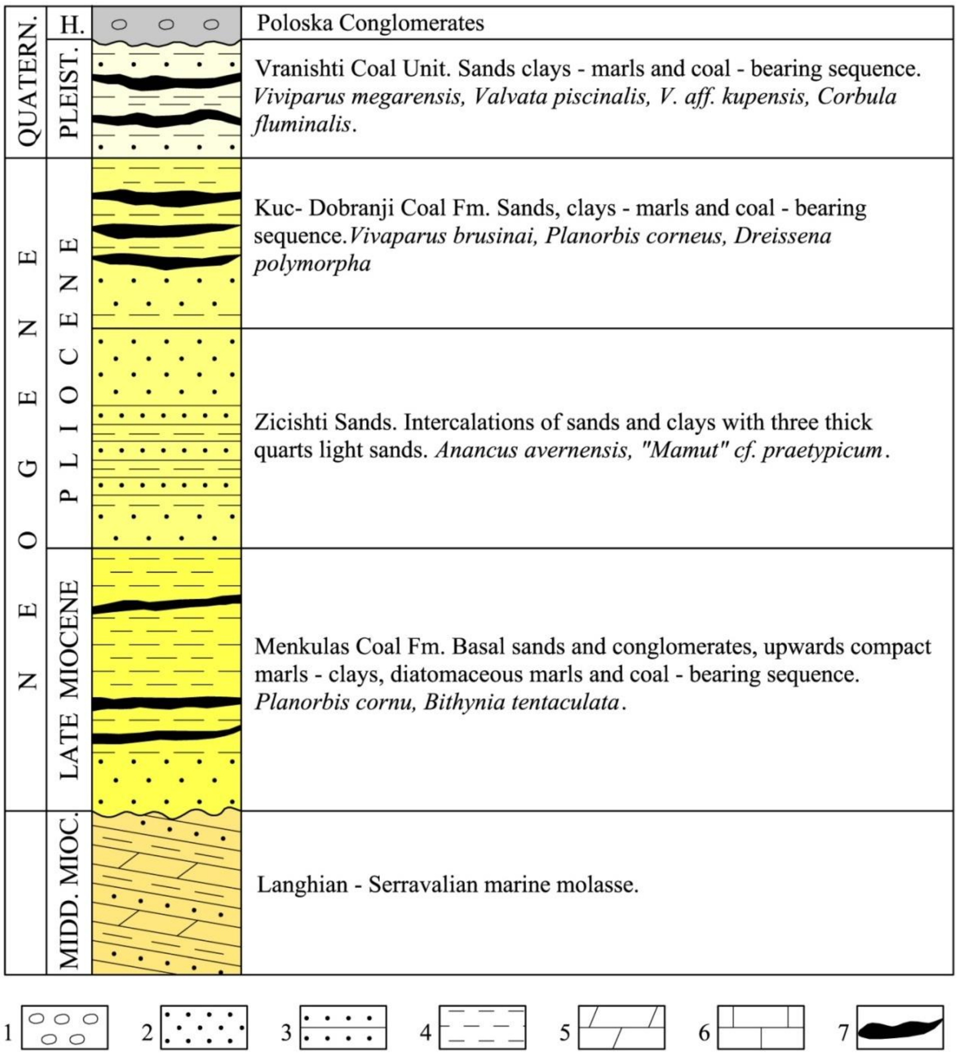

Fig. 4: Representative stratigraphic column of the Late Miocene-Quaternary sequence of the Devolli Basin. 1 conglomerates, 2 sands, 3 quartz sands, 4 clays, 5 marls, 6 carbonates, 7 coal seams.

Within this quartz sand layers, vertebrate fossils, such as proboscideans *Anancus arvernensis* (Croiszet & Jobert) and *"Mammut" cf. praetypicum* (Schlesinger) have been discovered. Siliceous wood pieces and plant remains were also found. Based on proboscideans species, the age of this unit corresponds to the have been determined as Ruscinian stage (early Pliocene) (Dodona & Kotsakis, 1985).

The third Unit termed Kuç-Dobranji Coal Formation of mostly Middle-Late Pliocene age (150 m), dominates the outcrops of the basin, and starts with 10-12 m sandy-clays deposits, grading upwards into coal-bearing succession (135-140 m), characterized by predominantly grayish to blue clays and light thin siliceous sands with three coal-bearing packs. Only one of these coal-bearing packs reaches the 3 m thickness. The mollusks assemblage encountered within the coal-bearing deposits consists of unsculptured *Viviparus brussinai* Neymar, *Planorbarius corneus* Linneaeus, *Dreissena polymorpha* Pallas, and ostracods.

The fourth Coal Unit of Pleistocene age is well developed along the NW part of the basin, where outcrop the Vranishti fluvial-lake sands and grayish clays with more extensive coal seams up to 90-100 m thick. Three of coal-bearing packs are maximum 8 m thick and comprise 4-5 coal seams intercalated with clay layers. The coal-bearing deposits bear freshwater molluscs, such as *Viviparus megarensis* Fuchs, *Valvata piscinalis* Muller, *V.* aff. *kupensis* Fuchs gastropods, gastropod operculum, bivalvia *Corbicula fluminalis* Muller, Ostracods, Chara (Fig.4). In the Bistrice valley at southern part of the basin, within the light medium grained sands, Hilber V. (1894) has discovered mammal fossils *Mammuthus meridionalis* and *Equus stenonis* (Bourcart, 1922, p. 96), that follows Koufos (2016) indicate a similar age of Willafranchian (late Pliocene-Pleistocene) age. The fluvial-terrestrial Poloska conglomerates represent the Holocene sediments of the Devolli Basin. A marked similarity in the lithostratigraphy and age between the Devolli Basin and the Florina Basin suggest that they probably were a unique lake basin.

Prespa Graben Basin.

In Albania, the deposits of Pliocene age are very rare exposed along the southern, (in Cerje), and western margin (in Pustec and Gorice) of the Great Prespa Lake, where only some limited sands and conglomerates outcrop. That is why we judge to integrate here the almost full description of Prespa graben taken from the paper of Pantic et al., 1973, particularly Dumurdzanov et al., 2004 (see Fig. 5), because the Pontian-early Pliocene age of lower formation of stratigraphic section has been well determined based on the drill hole data.

The N-S trending Prespa graben is 35 km long and 13 km wide and extends southwards into Albania and northern Greece. The sedimentary section of the graben fill in Albania is rarely exposed (Fig. 3) and most information on its lithostratigraphy comes from drill holes data. The sequence is ~330 m thick and can be divided into two formations and undifferentiated Quaternary sediments (Fig.5). From partial exposures and drill holes data, the Piskupstina Formation (PiF) can be divided into three units: The lowest unit consists of 50 m of gravel, sandstone, and siltstone that unconformably rests on Palaeozoic metamorphic rocks and Triassic carbonate and clastic rocks. The middle coal-bearing unit is~70 m thick and is composed of 15-20 m siltstone and silty claystone with two coal layers present within 15-20 m part of the section and the upper unit is ~80 m thick and consists of siltstone and marly claystone with diatomite.

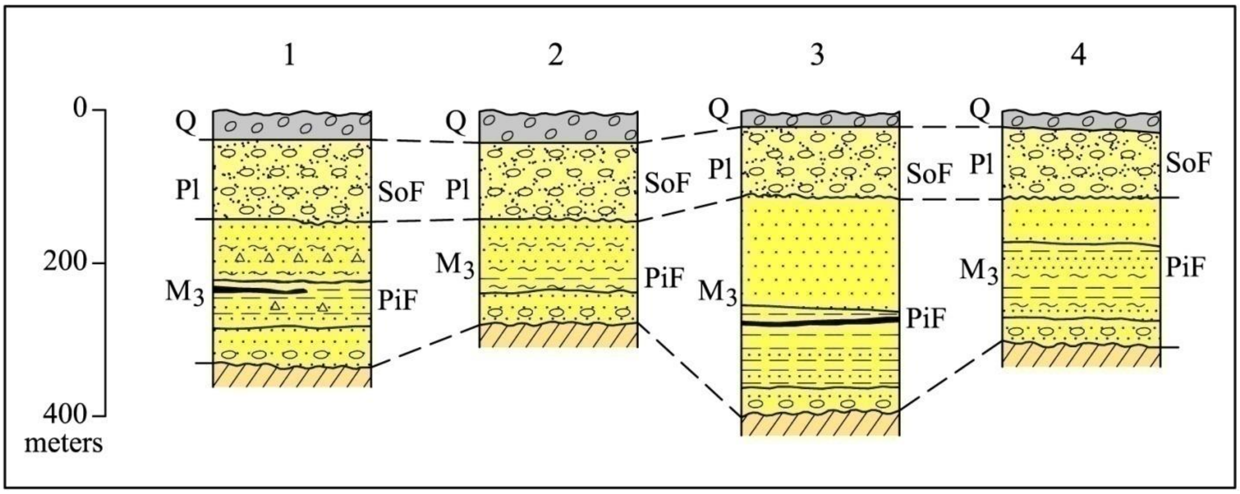

Fig. 5: Stratigraphic sections of the Prespa (1), Ohrid (2), Piskupstina (3) and Debar (4) grabens. Q- Quaternary. Pliocene (Pl): SoF- Solnje Formation. Miocene (M): (PiF)- Piskupstina Formation (from Dumurdzanov et al., 2004). Stratigraphic symbols as in Fig. 4.

Probably during Pontian time, lacustrine sedimentation became more widespread. In one small uplifted block on the eastern slopes of the Galicica Mountain, near the village of Leskovec, in yellowish diatomitic and marly claystone a fossil flora was discovered from which the different forms of gender *Aulacoseira* of Pontian–early Pliocene age are determined. This age determination confirmed with a rich leaf macroflora containing, for example, *Betula prisca*, *Caprinus grandis*, *Castanea atavia*, *Quercus cf.*, *Quercus pseudocastanea*, *Juglans acuminata*, *Caria serreofolia*, *Zelkova ungeri*, *Ulmus longifolia*, and *U. caprinoides*. The Solnje Formation (SoF) consists of ~100 m of gravel and sandstone. Its Pliocene age was assigned based on correlation with similar strata in the Skopje and Kumanovo grabens. The Quaternary sediments (Q) consist of 50–60 m of lacustrine gravel, sandstone, sandy claystone, and mixed lacustrine-marsh sediment at the northern end of the lake.

<u>Ohrid Graben Basin.</u>

Located in SE Albania at the boundary between the Mirdita ophiolite and the Korabi-Pelagonian zones and represents N-S trending a tectonically active graben structure limited by the normal faults along their eastern and western margins. The Ohrid Basin established in the Late Miocene, developed continuously to the present time (Ohrid Lake) and extends from Çerava area south of Pogradeci town to the north of Ohrid town in North Macedonia, forming an extensive unique long-lived basin lake (Figs. 3 and 6).

In the Albanian terrain the Late Miocene-Early Pliocene sedimentary succession, outcrops mainly to the south of the present Ohrid Lake and termed Alarup and Çerava Formations (Fig. 6). Its basin sedimentary infill represents a gradual transgression cycle spread toward basin margins, especially toward the SE part, and consists of predominantly coarse-grained deposits, conglomerates, sandstones accumulated mainly within fluvial-deltaic environment and interrupted by a series of grayish-bluish clays with several coal seams. The sedimentary succession is about ~550-600 m thick and is divided into three lithostratigraphic units. The Lower Unit consisted of up to 100 m thick of the basal alluvial sediments, a mixture of friable poorly sorted conglomerates containing Mesozoic carbonate pebbles of basements and Palaeozoic metamorphic rocks such as gneiss, quartz, granite, crystalline schists of 4-6 cm diameter, within a coarse-grained sandstone matrix. It unconformably overlies the Triassic-Jurassic marine limestone of basements. Bourcart in conglomerates found *Hipparion gracile* (Bourcart, 1922) that the most possible indicate a similar age of Pikermi mammal fauna (Koufos, 2016) probably dated to the MN 12 zone. The Middle Unit, termed Alarupi Coal Unit shows enormous lenses, from up to 4 m to ~50 m thick and 3 km long of grayish and greenish plastic clays with a coal-bearing sequence accumulated in lake-swamps environment and toward the northeastern basin margin unconformably lie on the Triassic-Jurassic

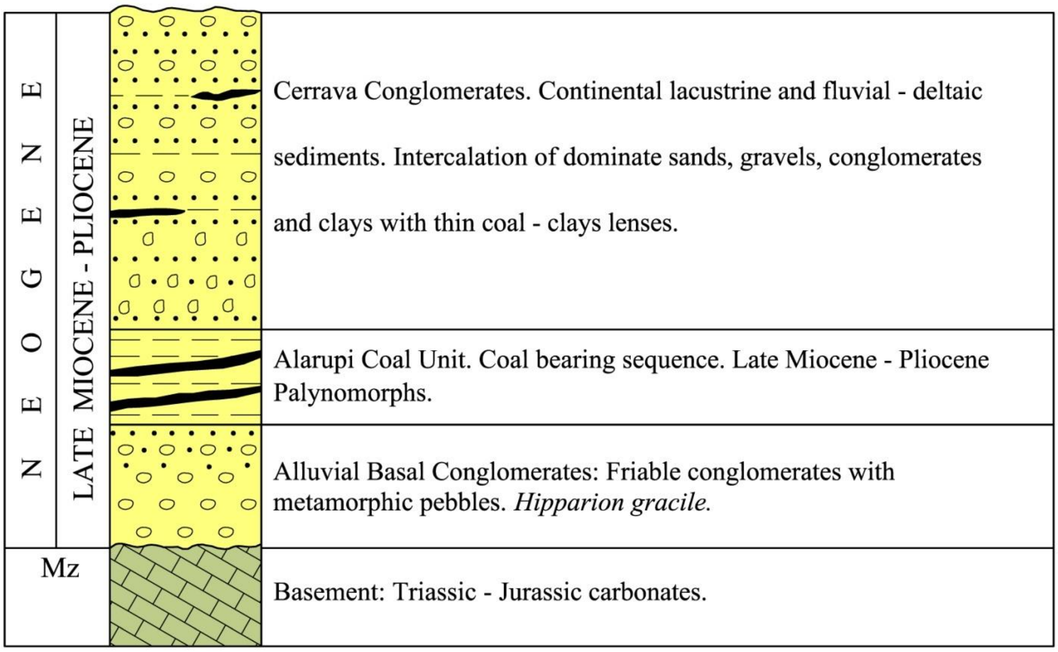

Fig. 6: Representative stratigraphic column of the Late Miocene-Pliocene sequence of the Alarup-Çerava Basin. Stratigraphic symbols as in Fig. 4.

carbonate basements. The Unit occurs in northeastern part of the basin and reduces toward the south and southwestern margin of the basin. Remarkable are two distinct coal seams that are exploited. The lower coal seams comprise a scarce coal to 2.9 m, medium 1.21 m thick, whereas, the upper one reached to 3.9 m, medium 2.12 m thick. On the top of the coal seams plant remains and plant leaves as imprints occur. The rare fossil fauna consists of the scarce specimens of mollusc *Viviparus* sp. and *Dreissena* sp. The leaf imprints of *Quercus pseudocastanea*, *Betula* sp., *Stratiotis* sp. etc. are dated the "(Lower-) Pliocene" age (Kleinholter in Meco et al., 2004). The palynomorphs assemblage of *Coniferae, Tsuga, Abies, Picea, Cedrus* cf. *deodora*, as well as the deodorant mesofile wide foliage forms *Fagus* cf. *orientalis, Quercus* cf. *robur, Carpinus* cf. *betulus, Ulmus laevis* etc have been determined identifying "Upper Miocene to Pliocene boundary" (Samoilovic, 1958).

The Upper Unit termed Cerava Conglomerates of 250-300 m thick cover large part of the basin and at the time, overlies discordantly Triassic-Jurassic basement. Its lower boundary shows an abrupt change of deposition in the sequence and is marked by an erosional surface on top of the Alarupi Coal Unit. The lacustrine and fluvial-deltaic lithostratigraphic sequence represented by intercalations of dominantly highly coarse-grained, characteristically yellowish to brown sands, gravels, conglomerates, containing mostly pebbles of metamorphic rocks. Grey plastic clays with thin coal lenses intercalated into this coarse-grained sequence. This clastic intercalation shows installation of terminate phase of the basin and the presence of the metamorphic pebbles indicates that the clastic material derived from various metamorphic rock of the eastern Korabi (Pelagonian) zone. According to the mammal fossil fauna *Hipparion gracile* (Bourcart, 1922) that indicate a similar age of Pikermi mammal fauna (Koufos, 2016) probably the MN 12 zone, palynomorphs assemblage indicating "Upper Miocene to Pliocene boundary" (Samoilovic, 1958) and "(Lower-) Pliocene" leaf imprints (Kleinholter, 2004) the Alarup-Cerava Formation is of late Miocene-Pliocene age.

Piskupstina Half-graben Basin.

We judge to integrate here the short description of Piskupstina half graben (Dumurdzanov et al., 2004), as northern part of the Great Ohrid Basin, which has a similar stratigraphic sequence. The Piskupstina graben, a small graben 6–8 km long and 1–2 km wide, is bounded on its west side by a fault that probably is continuous with the fault along the west side of the Ohrid graben. The Neogene section of 380 m thick is well exposed in a large open pit of coalmine, and its deeper parts are known from drill holes. Two formations are distinguished.

The Piskupstina Formation (PiF) consists of 280 m terrigenous coal bearing strata subdivided in: 30–40 m thick basal conglomerate and sandstone overlies folded Palaeozoic and Triassic rocks, 100 m coal-bearing unit and 140–150 m of poorly cemented grey siltstone and sandstone with *Alnus cf. adscendens* (Goepert) and Zastavniak-Walther, Pontian age of upper unit. The Solnje Formation (SoF) transgressively overlies the different stratigraphic levels of the Piskupstina Formation and consists of 130 m thick characteristically yellow-brown intercalated with layers of poorly sorted gravel that grade into sandstone overlainby10–15 m thick Quaternary alluvial and proluvial sediments (Fig. 5).

Peshkopi Graben Basin.

The stratigraphic section of Peshkopi Basin in Albania is badly exposed and drill holes aren’t carried out there. In N. Macedonia drill data for Dibra graben indicate a sequence 300 m thick consisted of two formations. While in Albania the obtained data from surface exposures north to Peshkopi show only most upper part deposits belonging to Pliocene-Pleistocene (Pashko, 1984; Hoxha et al., 2011) (Fig. 7). That’s why we considered including here stratigraphic description of Dibra graben section from Dumurdzanov et al. (2004).

The Dibra graben in North Macedonia lies north of and along the trend of the Piskupstina graben and farther to NW it enters Albania where it has a slightly more northerly trend. It is 20 km long and 7 km wide. Graben sediments unconformably overlie Palaeozoic schist, Triassic carbonate rocks, Upper Cretaceous carbonate rocks, and claystone. The upper part of the Neogene section is mostly exposed and drill holes provide data on the deeper part of the sequence. Drill holes data indicate the sequence is 300 thick and consists of two formations and undifferentiated Quaternary sediments.

The Peshkopi graben Basin in Albania represents a wide graben filled by the 50-60 m typical lake deposits cropping out along of both margins of the Drini i Zi valley, from Shupenza towards the north, forming a hilly relief (Figs. 2, 8 and 9D). The lake deposits consist of the gray clays, sometimes plastic and sometimes sandy clays, with the yellow sands and light conglomerates, mainly at the basal layers, which overlies with unconformity on Silurian-Devonian black shale and Mesozoic rocks. The Peshkopi Basin represents a lake basin established after the recent Ohrid Lake. Based on the molluscs assemblage of *Pisidium amnicum* (Muller), *Dreissena polymorpha* Pallas f.

angustiformis and f. *commans*, *Valvata media* Pashko and *Pyrgula albanica* Pashko the deposits of Peshkopi Basin considered as Pliocene-Pleistocene in age (Pashko, 1984).

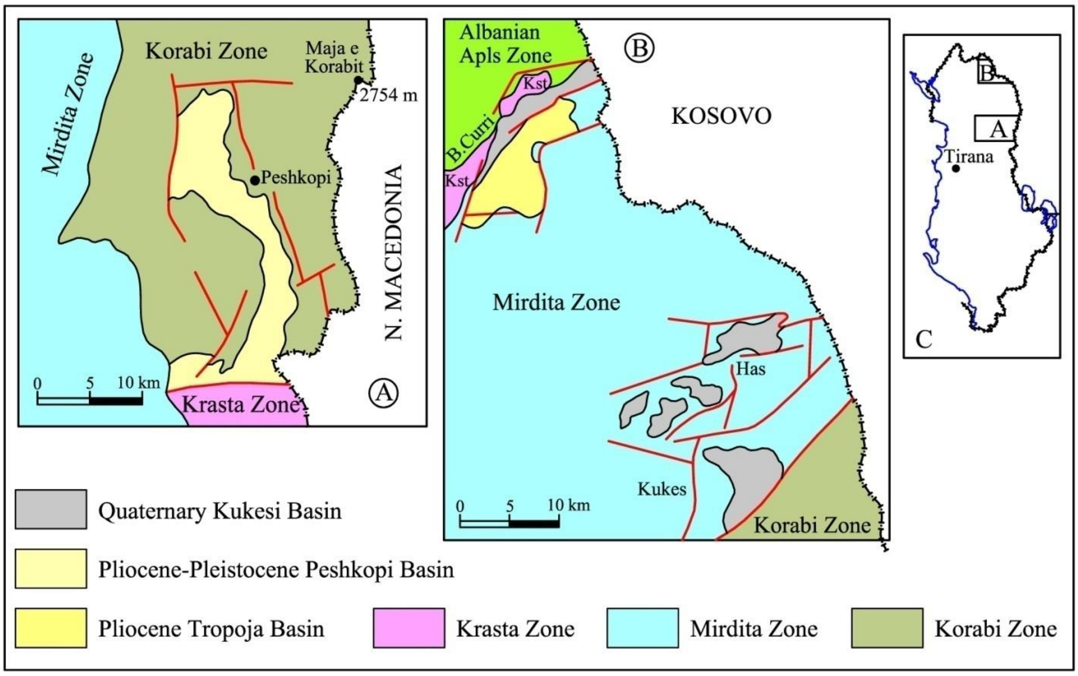

Fig. 7: Geological map of the northeastern Albania (modified after Geological Map Albania 1:200000 of Albania) showing the Peshkopi Basin (A) Kukesi and Tropoja Basins (B), and its location (C).

4. Stratigraphy of the Pliocene-Quaternary Basins

The Kolonja, Korça and Tropoja basins can be considered that they began forming in Pliocene time and developed during all Pliocene-Quaternary time (Figs. 4, 7, 8 and 9).

Kolonja Half-graben Basin.

The Kolonja Basin located in the southeastern marginal part of Albania bounds on the east by a normal fault at the foot of the Gramos Mountain. In the Kolonja Basin sediment infill comprises the Bezhani Coal Formation of around 160 m thickness unconformably on the Gramosi Flysch (belonging to half-window of Krasta-Cukali Zone) and up to 200 m thick continental clastic sequence of the Kolonja Formation (Figs. 1 and 2). The Bezhani Coal Fm consists of predominantly fine grained sediments clays-marls, often rich in organic matter (plant remains or imprints plant leaves) less greenish diatomaceous marls, fine grained sands coal seams overlies by thick continental conglomeratic sequence of Kolonja Fm. The sedimentary infill of the basin can be subdivided into three lithostratigraphic units: the lower two of the Bezhani Coal Formation and upper Kolonja Conglomerate Formation (Fig. 8). The Lower Unit of the Bezhani Coal Fm comprises 41-70 m thick transgressive basal series and starts with up to 7-8 m thick of breccias and conglomerate pebbles scattered into silt-clay and sands matrix unconformably on the Gramosi Flysch and upward passes in grayish silts-marls and clays with plant remains. The uppermost part of the unit of 26-35 m thick consists of dominant grayish clays with conglomerate layers containing predominantly fine-grained sandstone pebbles of Gramosi Flysch.

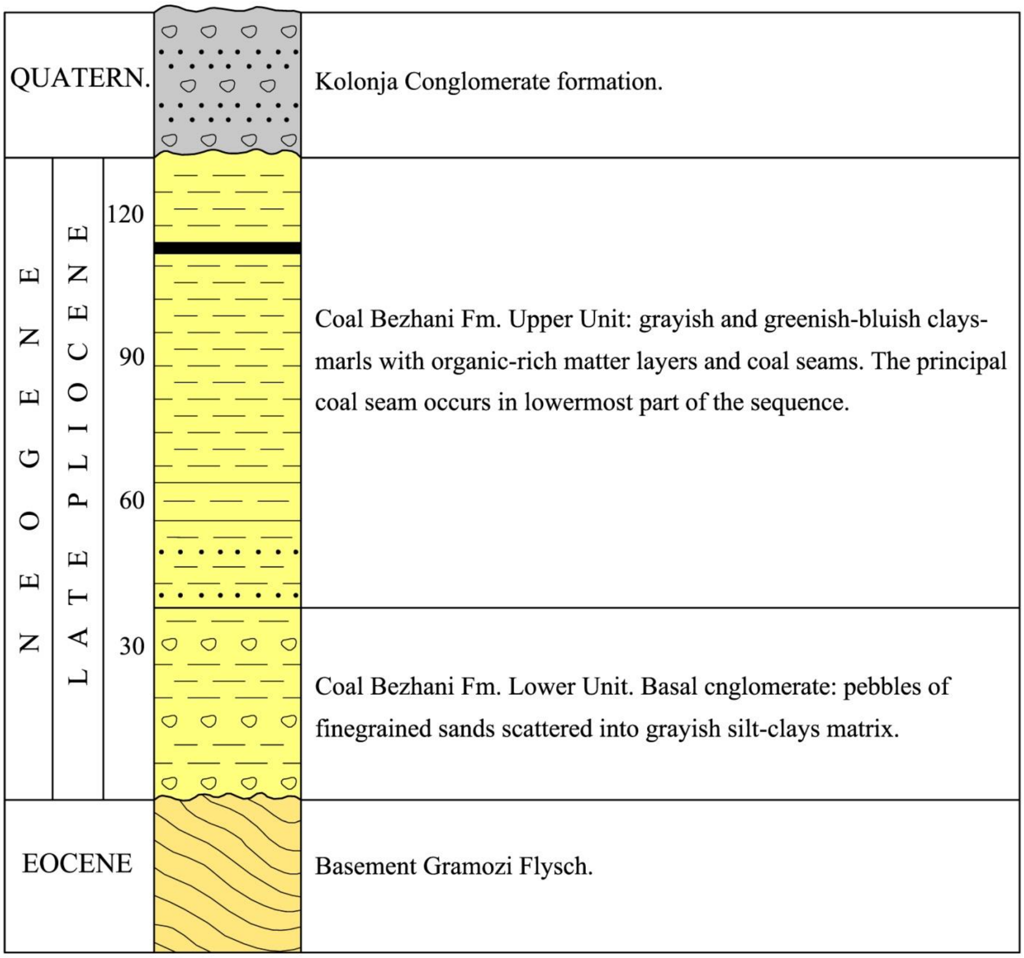

Fig. 8: Representative stratigraphic column of the Late Pliocene sequence of the Kolonja Basin. Stratigraphic symbols as in Fig. 4.

The middle Unit of 68-96 m thick, represent the coal-bearing sequence with two lower scarce coal seams in lower part and main coal layer in uppermost part of the sequence. Starts with an 6-10 m thick rich-organic clays-marls with thinner coal inter-layers grading upwards into a 11-12 m thick interval of the same clays-marls with gastropod shell remains scattered in the clays-marls matrix and comprise an 2 m thick grayish fine-grained sands in base and an one other about 1 m thick on top of the interval. The overlying interval of 7.2-9.5 m thick starts with about 1 m thick coal seam, followed by 5.5 m thick clay with organic rich brownish clays and subsequently is covered by second 1.2 m thick coal seam. Upwards, the following interval of about 50 m mostly consists of the monotonous sequence of grayish-bluish clays-marls with organic-rich layers with scattered gastropods shells and subsequently covered by the main coal seam reaching 3.5 to 8-9 m thickness. The latter includes smaller and larger clay-marl lenses rich in organic matter is the best coal seam that exploited by Bezhani mine. The top of the coal-bearing succession reaches thickness up to 20 m consists of gray sandy clays and compact grayish-bluish marls and organic-rich layers with leaf remains and scattered gastropod shells.

The Bezhani Coal Fm dated of Late Pliocene age on basis of the occurrences of leaf fossils *Rununculus aquatilis* (Linneaeus), *Myriophyllum alterniflorum* Decandolle (Kleinholter, 2004). The Pliocene mammal remains *Capreolinae* are found in the coal layers (Pashko al., 1973).

The Kolonja Conglomerate Fm represent the Upper Unit and consists of up to 200 m thick of friable, poorly sorted and poorly stratified thick conglomerate packs intercalated with yellow-brown coarse-grained sands, unconformably on Bezhani Coal Fm and Mirdita and Krasta basement. It is accumulated into a proluvial-fluvial and terrestrial (alluvial fan built to Osum River) environment and cover the large part of the basin area. Its lower boundary is marked by an erosional surface on top of the Bezhani Coal Fm.

Korça Half-graben Basin.

The Korça Basin is bounded on the east and northeast by a normal fault and it generates the Korça Plain (Figs. 1, 3 and 9A). The sedimentary succession starts with ~600-700 m of predominantly lacustrine deposits (Pojani Formation), mostly developed further to N and NW part of the basin, which unconformably rest on the marine Burdigalian-Langhian molasse deposits containing pelagic mollusks *Vaginella austriaca* Kittl.

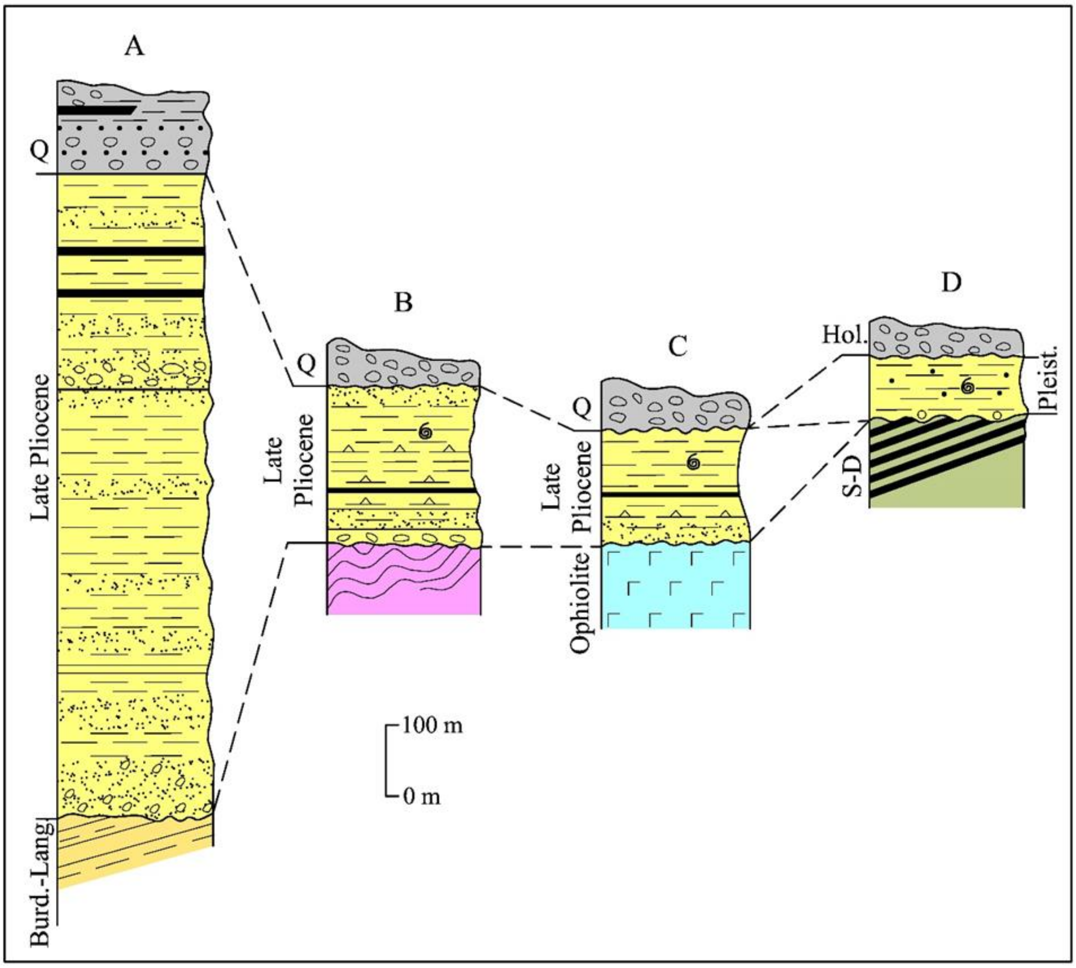

Fig. 9: Stratigraphic correlations of the fresh-water deposits of the Pliocene-Quaternary deposits of the Korça (A), Kolonja (B), Tropoja (C), and Pleistocene Peshkopi (D) lake Basins. Stratigraphic symbols as in Figure 4.

It mainly consists of the grayish clays and sands with conglomeratic lenses (up to 8 m) including coal and coal-clayey bearing levels, including 7 coal seams of 0.4-0.7 m thick (Fig. 9A). Their Pliocene-Pleistocene age is determined by the presence of ostracods *Candionella mirabilis, Illiocypris gibba, Candona sp., Cytherella* sp. (Kumati et al., 1997). It follows stratigraphically the Turani Formation, (250-300 m) starting with 40-50 m conglomerates and sandstones, followed by ~ 200-250 m grayish clays and sands, probably of Pleistocene age covering through all the basin extent. On top are the Quaternary deposits consisting of gravels and sands (45-75 m) that accumulated in terrestrial, lateral fans, fluvial-terrestrial and marsh (Maliqi Lake) environments.

Kukesi Graben Basin.

The sedimentary succession infilling the Kukesi basin consists of thick coarse-grained materials deposited in a graben structure N-S trending, from Nanga to Drini i Bardhe valley (Figs. 1, 7 and 9A)**.** The sequence up to 250 m thickness includes heterogeneous polygenic conglomerates (10-20 m up to 60 m) levels and poorly coarse-grained sandstones (10-12 m thick), mainly at the upper part of the section. The sandy clays dark brown and gray in parts, some meters thick, occur in the southern part of the basin at Gostil village. The topmost part of the section consists of a package poorly consolidated gray carbonate sands (15 m), cropping at the both sides of Stream Lumes discharge. The lithology of these sediments (mainly conglomerates) and their discontinuous lateral extension document a fluvial and deltaic activity. Towards the north in the Has area, the conglomerate levels are 25-30 m up to 90-95 m thick. There are not direct faunal evidences for dating this formation, therefore supposed as Quaternary (Pleistocene-Holocene) age.

Tropoja Graben Basin.

The Tropoja Pliocene Basin is located along the Shkoder-Peje transform Fault during its neotectonic development. It has not any connection with other lake basins previously described which instead are located along the Drini fault zone (Fig. 7B and 9 C). Three lithostratigraphic units are distinguished in the sedimentary succession up to 280 m starting with 10 m basal loose medium sized to coarse-grained sandstones, reddish clays and sands unconformably overlying the ophiolites. It follows an intermediate Unit (120-130 m) consisting of clays, marls and sands containing low quality coal seams. The Upper Unit (up to 140-150 m) consists of light grey and blue clays and marls rich in leaves diatoms (diatomaceous marls), predominantly in the southern part of the basin with some intercalated coal seams and fine-grained sandstones (Fig, 9 C). Their Pliocene age was determined by the presence of the molluscs assemblage of *Bythynia labiata* Neymar, *Pyrgula incisa* Fuchs, *Vivipara megarensis* (Fuchs), *Valvata sp.*, *Staja adiophora* Brusina, *Unio litoralis* Lamarck, *Dreissena polymorpha* Pallas, *Congeria slavonica* (Andrussov) (determined by Dr. Marku D. and present author, unpublished). The spores and polynomorphs contain 0.4% of the fernspores, 90% of the *Gymnospermae* pollens and 9.6% of the *Angiospermae.* The stratigraphic successions ends with Holocene conglomerates, ~ 60 m thick, accumulated into fluvial environment (terraces of Valbona river bed).

5. Tectonic Evolution of Late Miocene-Quaternary Basins

The South Balkan Extensional System consists of normal faults and associated sedimentary basins within the southern Bulgaria, North Macedonia, eastern Albania, northern Greece, and northwestern Turkey (Burchfiel et al., 2008a, 2008b). During Late Cenozoic time, E-W striking normal faults and associated sedimentary basins in the eastern part of the South Balkan Extensional System propagated westward in tandem with westward migration of N-S striking normal faults and sedimentary basins from western Bulgaria into the eastern Albania. This migration was caused by evolution of the Hellenic subduction zone.

Active extension and basin formation within the South Balkan extensional system consists of two parts (Burchfiel et al., 2008 a, b): (1) a western part, where east-west extension in eastern Albania and western North Macedonia is related to slab rollback along the northern Hellenic subduction zone marked by a narrow belt of shortening, and (2) an eastern part, consisting of north-south extension in central and southern Bulgaria, eastern North Macedonia, and northern Greece related to the slow southward movement of the South Balkan extensional system lithosphere, pulled southward by rapid south-southwest movement (Fig. 10). The Cenozoic tectonic evolution of Eastern Albania consists of two periods of extensional deformations, the first in Middle Eocene-Late Miocene (Pannonian) and the second in Late Miocene (Pontian)-Quaternary, separated by a short compressive phase at the end of Late Miocene (Pannonian/Tortonian) or pre-Pontian time. The extensional tectonism in Eastern Albania began in Middle Oligocene time when ATHB began forming that was developed as intermountain piggyback basin above the ophiolite nappe during their westward travelling upon the cold accretionary prism. The main ATHB and its satellite ones: Librazhdi and Burreli basins were folded and closed by the pre-Late Miocene (pre-Pontian) compressional event.

The last extensional period began forming the system of the Ohrid, Prespa and Devolli lake basins in the Late Miocene (Pontian) time along the Drini normal fault zone N-S striking or parallel to it. The evolution of Lakes Ohrid and Prespa basins system shows that they are fault-controlled grabens and half-grabens.

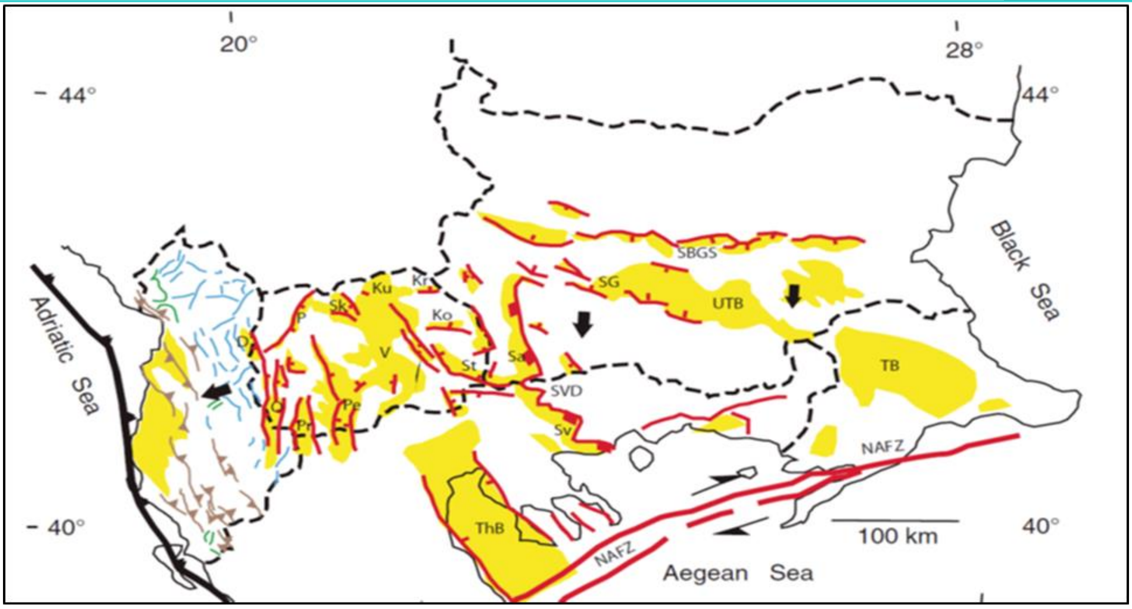

Fig. 10: Tectonic setting in latest Miocene-early Pliocene time with the location of sedimentary basins (yellow) (after Burchfiel et al., 2008b). Thick red lines are normal faults, single tick line shows direction of dip on moderate to high-angle normal faults, and red square shows dip direction for low-angle normal faults (detachment fault). Blue lines are normal faults taken from unpublished Albanian map (see Fig. 11). Brown lines are thrust faults within the zone of shortening related to the North Hellenic subduction zone of this age. Large black arrows show direction of relative extension. The northern branch of North Anatolian fault zone (NAFZ) propagates in to the north Aegean Sea. North-south extension propagates into eastern Macedonia and north-central Greece where it overlaps with eastern part of east-west extension. Shortening related to subduction along the North Hellenic subduction zone is shown in brown. Probable normal faults in eastern Albania are shown in blue. The Strymon Valley detachment fault (SVD) becomes progressively less active. D-Debar basin, Ko-Kocani basin, Kr-Kriva basin, Ku-Kumanovo basin, O-Ohrid basin, P-Polog basin, Pe-Pelagonian basin, Pr-Prespa basin, Sa-Sandanski basin, Sk-Skopje basin, St-Strumica basin, Sv-Strymon Valley basin, SBGS-South Balkan Graben System, SG-Sofia graben, TB-Thrace basin, ThB-Thermaikos basin, UTB-upper Thrace basin, V-Veles basin. Large black arrows show direction of relative motion to European plate to the north.

The Lake Ohrid basin represents well the Late Miocene-Quaternary tectonic evolution of Eastern Albania. The lake is one of the oldest lakes of Europe and the deepest lake in Balkans with a maximum depth of almost 290 m. Biological studies on endemic fauna give hints on a Pliocene age (Hoffmann et al., 2010; Reicherter et al., 2011). With a length of 30 km and a width of 15 km it covers an area of 360 km^2 that is larger than the neighbouring lakes of Great Prespa and Small Prespa. The neotectonic history of the Lake Ohrid Basin has investigated by means of integrated multidisciplinary approach (Reicherter et al., 2011). The Lake Ohrid Basin is a N-S trending graben structure associated with the Korça, Erseka and Dibra basins. The Ohrid Basin is a graben caused by the E-W extension, while the associated Korça and Erseka basins are half-grabens bordered by a normal fault on their eastern side (Aliaj, 1998; Aliaj et al. 1995; Aliaj & Grazdani, 2008; Tagari 1988; Tagari et al. 1993). The stratigraphy of the Lake Ohrid Basin includes late Miocene (Meotian-Pontian) and Pliocene deposits (Dumurdzanov et al., 2004). In the Piskupstina half-graben basin, the Solnje Formation (SoF) of Pliocene age overlies different stratigraphic levels of the Piskupstina Formation of Meotian-Pontian age. This may also be the case in Albania of some Pliocene lake basins as Kolonja, Korça and Kukesi basins. The above-observed transgressional sedimentary relations show a shortening event at the last Pontian. Basins initiated in pre-Pliocene all show continued subsidence during the Pliocene (Dumurdzanov et al., 2005). Interpretation of multichannel seismic cross sections and bathymetric data reveals that Lake Ohrid is a tectonically active graben formed during two main phases of deformation: (1) a trans-tensional phase which opened a pull-apart basin, and (2) an extensional phase which led to the present geometry of Lake Ohrid (Lindhorst et al., 2015). The north-south alignment of Late Miocene-Quaternary graben basins occur in the area between the eastern Albania-western North Macedonia and northwestern Greece: a) the western alignment of Ohrid-Korça-Kolonja basins, b) the central alignment of Prespa-Devolli basins, and c) the eastern alignment of Pelagonia Basin (in North Macedonia) - Florina-Ptolemais-Kozani-Servia basins (in NW Greece). All basins in Eastern Albania are situated in a basin and range-like (graben and horst) geodynamical setting similar to that described for Thessaly region by Caputo and Pavlides (1993). The entire area of Ohrid and Prespa basins alignments are controlled by present day E-W extension, while the area of Pelagonian Basin-Florina-Ptolemais-Servia alignment is nowadays by NW-SE extension (see Figs.1 and 2; Fig. 11). Normal faults are shown in eastern and northeastern part of the country, while reverse ones in its western part. The Dumre and Korab evaporite diapir domes are marked on the map. Chronology of activity is shown by different colours (Fig. 11): Blue lines show faults activated during Middle Pleistocene-Holocene or Quaternary, green lines faults activated during Pliocene-Lower Pleistocene or Pliocene-Quaternary (see Ganas et al., 2020; Aliaj, 2020), green lines faults activated during Pliocene-Lower Pleistocene or Pliocene-Quaternary, and red lines faults activated during pre-Pliocene, active maybe during Pliocene-Quaternary.

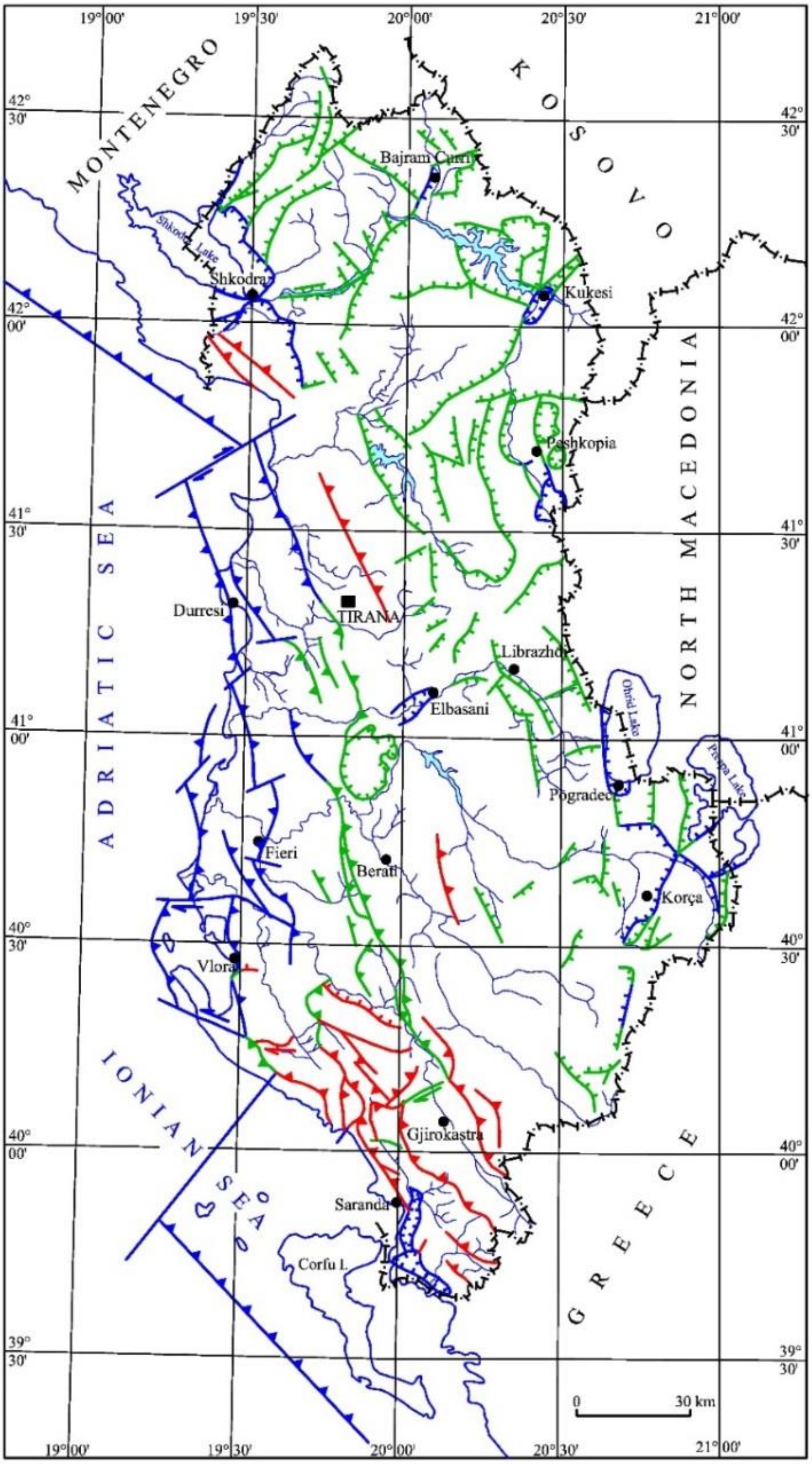

Fig. 11: Active Faults in Albania (after Aliaj, 2000a).

The geologic structure formed during the Late Miocene-Quaternary period is characterized by normal faulting and lake basin formation in the interior of the country, and by reverse faulting and folding in the external area including the Pre-Adriatic Basin (Figs. 1 and 11). The basin and horst structures along the Lake Ohrid Basin alignment from Dibra Basin in the north to Kolonja Basin are obliquely setting to the main pre-Latest Miocene (pre-Pontian) structure NW extending (Aliaj, 1996; 2012). Meanwhile in Western Albania, the Pre-Adriatic Foredeep Basin began to form in the Middle Miocene (Serravalian) after the folding and thrusting of External Ionian Zone and it was filled with Middle Miocene-Pliocene molasse (Aliaj, 1998; 2012). The Kavaja section (south of Durresi) in Pre-Adriatic Foredeep Basin represents the most continuous and complete sequence of the Messinian succession from onset of Messinian salinity crisis up to Pliocene marine sedimentation unconformity (Pashko, 1973; Pashko et al., 2017) (Fig. 12). A salt unit about 32 m thick found in Kavaja section is overlain by an unconformably conglomeratic layer 1.0-1.5 m thick. This erosional surface corresponds to the Messinian erosional surface (MES) that separates two main evaporitic successions and shows an important intra-Messinian tectonic phase (Roveri et al., 2008).

Fig. 12: Messinian Erosional Surface (MES) in Kavaja section (after Pashko, 1973 and Pashko et al., 2017).

The Pliocene molasse transgressively and with angular unconformity is overlain on Miocene molasse of Pre-Adriatic Foredeep Basin and on the Kruja and Ionian tectono-stratigraphic units. So, in Povelca seismic line the strong unconformity between Miocene and Pliocene molasses is well observed. The Quaternary (marine or continental) sediments unconformably overlies on the folding structures of Pre-Adriatic Basin (Aliaj, 1998; 2012).

The late Miocene-Quaternary basins in Albania were structurally evolved through the same pre-Pontian or mid-Messinian, Miocene-Pliocene boundary and end of Pliocene tectonic phases. During the Late Miocene-Pliocene time was accelerated the relief formation in Albania. Only at the end of Pliocene the Pre-Adriatic marine Basin and continental lake basins in the country interior were closed. Only the Lake Ohrid and Prespa lakes remain active up to nowadays. The most parts of the Albanian relief formed during Late Miocene-Quaternary, only small parts formed in Pliocene-Quaternary and some others in Quaternary (Aliaj & Melo, 1987; Aliaj, 1990). The mountainous-hilly relief formed during Late Miocene to Quaternary, but the rapid uplift of it occurred in Late Miocene-Pliocene time. The plain and hilly relief of the western Lowland from Vlora to Shkodra and of the internal lowlands, those from Erseka to Ohrid Lake, in Peshkopi lowland, and from Kukesi to north-west generally following the Drini River formed in the Quaternary.

Thermochronological data help to clarify the cooling history of the internal zones of Albanides. In Korabi zone are obtained AHe (Apatite He) ages ranging between 4.5-6.5 Ma. The Korabi zone was still at about 7-8 km depth until 20 Ma. The new thermal modeling using both AFT (Apatite fission-track) and AHe data has documented in more detail the relatively slow cooling between 16 and 6 Ma which is followed by rapid cooling beginning at about 6 to 3 Ma in the eastern internal Albanides (i.e. in Korabi zone). Exhumation of the Korabi zone rocks accelerated since 3-6 Ma reaching a rate of about 1.2 km/My (Muceku et al., 2006; 2008).

The two following definitions for the term “Neotectonics” are well known.

V. Obruchev (1948), the first scientist, who introduced the term “Neotectonics” as “*recent tectonic movements occurred in the upper part of Tertiary (Neogene) and in the Quaternary which played an essential role in the origin of the contemporary topography*”. S.B. Pavlides (1989) suggested the following definition: “Neotectonics is the study of young tectonic events which have occurred or are still occurring in a given region after its orogeny or after its last significant tectonic set-up”. The inferred stratigraphic and tectonic evolution as well as the relief formation and thermochronological data show that the Late Miocene-Quaternary period, which led to the recent geological structure of Albania and its rapid relief formation, can be accepted as “Neotectonic period”. The term ‘Neotectonics’ is used for the study of geologic structures formed between the end of Miocene and the present.

6. Conclusions

Based on the reviewed stratigraphic data and tectonic evolution of the Late Miocene-Quaternary basins developed in Eastern Albania presented in this paper we can make the following main conclusions:

1. The reviewed stratigraphic data for deposits filling the Ohrid, Prespa and Devolli basins show that they began to form in Late Miocene. The Kolonja, Korça, Skavica, Kukesi and Tropoja basins began forming since Pliocene time.

2. The Miocene-Pleistocene basins were filled by lacustrine, lacustrine-fluvial and terrestrial sediments of the great thickness and of varied lithology: conglomerates, gravels, sandstones, sands, claystone and marls with lignite seams.

3. The Cenozoic basin evolution in Eastern Albania consists of two periods of extensional deformations, the first in Middle Eocene-Late Miocene (Pannonian) and the second starting in Late Miocene. The two phases are separated by a short compressive phase at the end of Late Miocene (end of Pannonian/Tortonian) or pre-Pontian time. The Albanian-Thessalian Basin with its satellite Librazhdi and Burreli basins, developed during the first extensional phase, were closed at the end of Late Miocene (Pannonian/Tortonian).

4. In Late Miocene (Pontian) began forming the system of the Ohrid, Prespa and Devolli lake basins that developed along the Drini normal fault zone N-S striking or parallel to it. The Ohrid Basin is a full-graben, while the associated Korça and Erseka basins are half-grabens bordered by a normal fault on their eastern side. The entire area of the Ohrid and the Prespa basins is controlled by present day E-W extension. The Lake Ohrid is a tectonically active graben formed during two main phases of deformation: (1) a trans-tensional phase which opened a pull-apart basin, and (2) an extensional phase which led to its present geometry.

5. The inferred stratigraphic and tectonic evolution of Late Miocene-Quaternary basins in Eastern Albania as well as the relief formation and the thermochronological data show that the Late Miocene-Quaternary period, which led to the recent geological structure of Albania and its rapid relief formation, can be accepted as ‘Neotectonic period’.

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