THE BOREHOLES AT SOUTHERN BASE OF Mt. OSTROVICA REVEAL ITS NAPPE EMPLACEMENT

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ABSTRACT

The boreholes at southern base of Mt. Ostrovica reveal the nappe emplacement of Cretaceous limestones over the Lower Oligocene flysch of Dajti subzone, Kruja Zone. Two small syncline nappes of Cretaceous limestones of Krasta Zone were discovered: the main one, 160 m wide and 30 m thick, and the second, 90 m wide and up to 8 m thick. The latter presents the upper part of the main one westwards thrusting. The main small syncline nappe of Cretaceous limestone revealed from the TAP Route boreholes at the southern base of Mt Ostrovica presents the lowest centroclinal part of big regional Ostrovica syncline nappe. The recent geological findings obtained from the TAP boreholes at southern base of Mt Ostrovica syncline prove that the big Ostrovica Mt syncline structure presents a nappe structure of Krasta Zone over the underlying flysch sequence, in distinction from its presentation without nappe setting in Geological Map of Albania at the scale 1:200.000 (2005). That's why are reviewed the geological framework for the Ostrovica Mt area, separately the stratigraphy for the flysch sequence that encounters beneath the Ostrovica Mt and its surroundings, and for the Kruja and Krasta zones in the region under study. The *Pseuhastigerina micra and Globigerina linaperta-Globigerina ampliapertura* planktonic zones, found in "Frasheri Flysch" rock samples near to Greva and Moglica villages and in Turbehova stratigraphic section, determine their Lower Oligocene age. The Lower Oligocene flysch sequence beneath the Mt Ostrovica nappe and on its surroundings is the direct southeast continuation of Tervolli anticline that belongs to the Dajti subunit of Kruja Zone. The so-called "Frasheri Flysch" developed to the east of the Turbehova-Koblara-Leskoviku thrust fault and from the south of Devolli ophiolite massif to southern Albanian border, along a narrow belt before the front of the ophiolite nappe, belongs to the Dajti subunit of Kruja Zone. The Krasta Zone to the south of Elbasani outcrops in the Lleshani and Ostrovica nappes, and along a narrow belt before the ophiolite nappe, from Mt Liseci-Mt Griba to Mt. Lenie, and it reappeared only in the Mt Gramos half-window. The Mirdita ophiolite nappe covers the whole Krasta Zone and partly the Kruja one to the south of Ostrovica nappe.

Keywords: Southern base of Mt Ostrovica, small syncline nappe emplacement, big Mt Ostrovica syncline nappe," Frasheri Flysch", extent of Kruja and Krasta units to the south of Devolli ultramafic massif.

1. INTRODUCTION

Zuber (1943) pointed out that the imbricated Mt. Ostrovica structure belongs to the Krasta zone into which he distinguished the $K_{1-2,}$ K_2 and K_3 sequences. It is important to underline that east of Tomor-Kulmak-Postenan anticlinal line is developed the so-called "Frasheri" Flysch of Lower Eocene-Aquitanian age in front of Krasta zone (Zuber 1940).

Biçoku *et al*., (1967) also included the Mt. Ostrovica area in the Krasta unit, distinguishing the $Cr_2 - Pg_2 K_2$ and $Cr_2 - Pg_2 K_3$ sequences, based on Zuber division of Krasta zone.

Belostockij (1978) reported in details the nappe structures around the Devolli ultramafic massif, where he distinguished a pile of nappe sheets (two Pindos nappes and one ophiolite nappe on the top). The Moglica tectonic window, NE of Ostrovica, consists of the Oligocene flysch of Kruja zone, is mentioned by him for the first time.

The geological building of Mt. Ostrovica area, as it is currently known, was presented for the first time in the Geological Map of Albania at the scale 1:200.000 (Shehu *et al*., 1983), based on the geological mapping of Krasta zone south of Elbasani area carried out by Gjata and Aliaj from 1979 to 1980. West of Ostrovica Mt carbonate formation of Cretaceous age, the Krasta unit flysch formation thrusts the Middle Oligocene Flysch of Kruja zone (Shehu *et al*., 1983).

Xhomo *et al*., (2005) emphasized that the Mt. Ostrovica area belongs to the Krasta unit, and its geological structure is shown the same as it was presented into the Geological Map of Albania at the scale 1: 200.000 (Shehu *et al*., 1983).

Gjata *et al*., (1982) have presented the Mt. Ostrovica carbonate structure as a horst-syncline which delimits in both flanks by high dipping angle faults that conditioned its uplifting position in comparison with its west and east deep Krasta structures covered by the Upper Eocene flysch.

The Mt. Ostrovica nappe consists of the Upper Cretaceous pelagic limestone and Maestrichtian-Eocene Flysch, which built a west verging syncline nappe, overlying the Oligocene Flysch of Kruja zone (Aliaj, 1994). It has a 20 km long extension, from north of Qafa e Martes in the south, to the Dushar and Vrepcke in the north (Fig. 1). An asymetrical syncline with flysch deposits in the center continues as a whole from the Mt. Ostrovica to the Mt. Çuka e Bofnjes, with a maximum width of 9 km. Its fragments alone, mainly consisting of limestones could be seen northwards. Some transverse normal faults cut its structure subsiding northwards the nappe structure of Mt. Ostrovica. The Ostrovica nappe is squeezed from below the Voskopoja ophiolite nappe (Aliaj 1994).

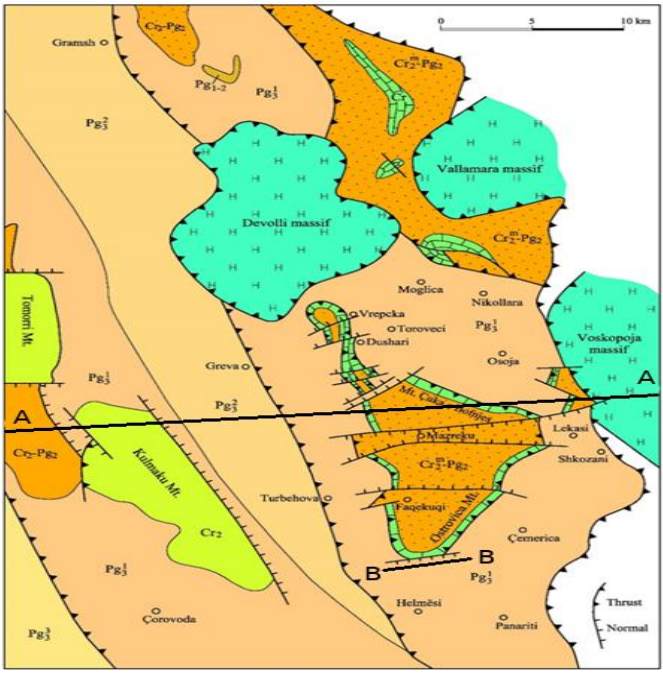

Fig. 1: Geological map of Tomorr-Ostrovica Mts area. Kruja Zone: Cr_2-Pg_2- Carbonate platform formation of Kruja zone, Pg_3^1- Lower Oligocene flysch sequence of Tervolli anticline, Pg_3^{1-2}- Lower-Middle Oligocene flysch sequence of Tomorri and Kulmaka anticlines. Krasta Zone: Cr – Cretaceous pelagic limestones, Cr_2^m-Pg_2- Maestrichtian-Middle Eocene flysch sequence. Mirdita ophiolite Zone: Devolli, Vallamare and Voskopoja ultrabasic massifs. A-A-line of geological cross section shown in Figure 2.

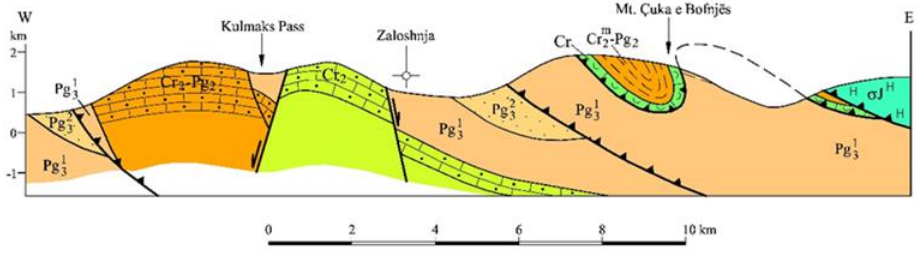

Fig. 2: W-E trending geological cross section Kulmaka Pass – Mt. Çuka e Bofnjes according to A-A line shown on Figure 1.

Two nappe structures of Krasta zone could be noted in the southern Albania: Lleshani nappe, around 8 km south-east of Elbasan, and Ostrovica nappe, both overthrusted on the Oligocene flysch of Kruja zone. The Krasta

Zone, south of Devolli ultrabasic massif, composed by the Upper Cretaceous pelagic limestone and Maestrichtian-Middle Eocene flysch, outcrops in the Mt Ostrovica nappe, along a narrow belt before the ophiolite nappe front, at tectonic window of Rungaje and in the half-window of Mt Gramos (Aliaj 1994). The ophiolite nappe covers almost the whole Krasta nappe and a part of Kruja one in southern Albania.

A drilling campaign at southern base of Mt Ostrovica was carried out on May-December 2018 by (Allkja and Xhagolli 2019). The borehole's geotechnical investigations at southern base of Mt. Ostrovica reveal the nappe emplacement of Cretaceous limestones over the flysch formation.

At the southern base of Mt Ostrovica were drilled the following 19 boreholes: BH-3, BH-5, BH-6, BH-7, BH-9, BH-10, BH-11, BH-13, BH-14. BH-16, BH-26, BH-27, BH-29, BH-30, BH-31, BH-32, B H-37, BH-39 and BH-40 (Figure 1 line B-B and Figure 3).

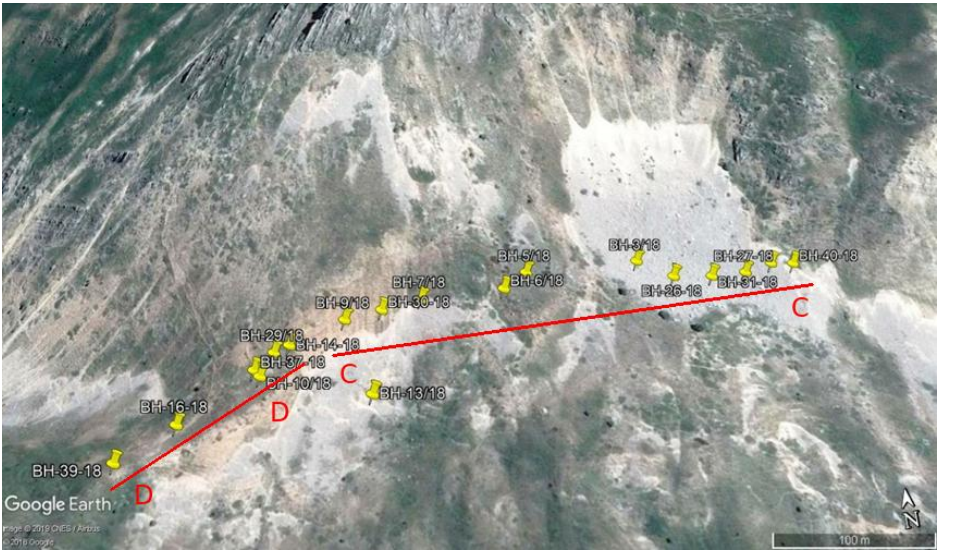

Fig. 3: Location of the boreholes at southern base of Mt Ostrovica.

Two geological cross-sections were compiled based on the logs of boreholes shown in the location map: i) An W-E geological cross-section passing through the boreholes: BH-14, BH-9, BH-30, BH-7, BH-6, BH-5, BH-3, BH-26, B H-27, B H-32 and B H-40, (line C-C in Figure 3); and ii) an SW-NE geological cross-section passing through boreholes: BH-39, BH-16, BH-37 and BH-29 (line D-D in Figure 3).

2. Nappe emplacement of Mt. Ostrovica limestones

The drilled boreholes discovering a depth of about 100 m at the southern base of Mt. Ostrovica show the nappe emplacement of the Upper Cretaceous limestone over the underlying flysch sequence. Such flysch deposits crop out from 1800 to 1000 m above sea level to the east and west of the big Ostrovica syncline.

Two local nappe synclines consisting of Cretaceous limestone are shown in the W-E Geological cross-section passing from the BH-14 to BH-40. The main nappe syncline structure of about 30 m thick and 160 m wide from west of BH-3 to BH-40, and another thin nappe syncline of about up to 8 m thick and 90 m wide from west of BH-9 to east of BH-7, consist of Cretaceous limestone overlying the Lower Oligocene flysch (Fig. 4). The carbonate rocks of the Upper Cretaceous consist of the moderately strong with fractures white limestone at first syncline nappe and by the moderately highly weathered limestone at second syncline one, which show that the second syncline nappe presents an upper part of the first one thrusting to the west that caused its limestone weathering.

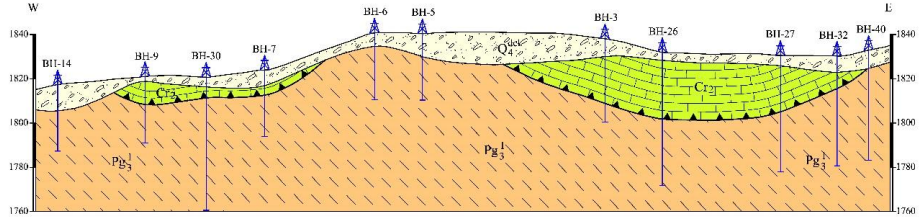

Fig. 4: W-E trending geological cross section from BH-14 to BH-40.

Q_4^{del}- Rock debris with a little silty clay or silty-clayey gravels, Pg_3^1- Lower Oligocene Flysch sequence composed by sandstone, siltstone and mudstone with limestone layers.

Some transversal normal faults E to NE striking cut the nappe structure of Ostrovica Mt. subsiding it northwards and to its southern base. The main small syncline nappe of Cretaceous limestone revealed from the TAP Route boreholes at the southern base of Mt Ostrovica presents the lowest centriclinal part of big regional Ostrovica syncline nappe from which it was separated through a normal fault (Fig. 1).

The flysch deposits are only shown in the SW-NE Geological cross-section passing from the BH-39 to BH-29 (Fig. 5). The Flysch formation comprises the sandstone, siltstone and claystone alternations with limestone layers. The limestone layers are found in BH-3, BH-26, BH-29, BH-30 and BH-37, alternating with clastic flysch components.

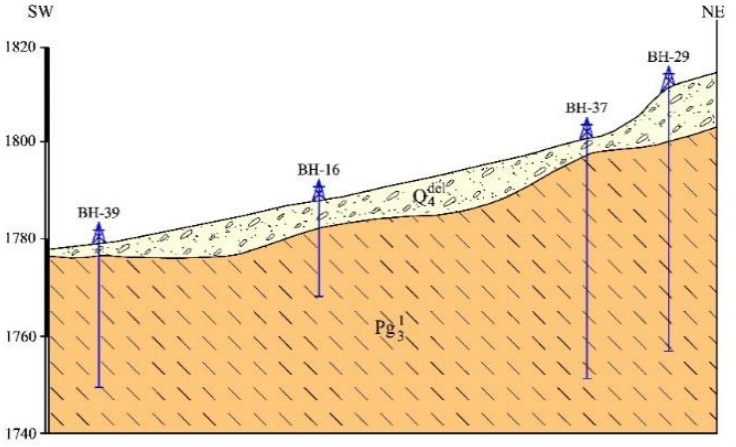

Fig. 5: SW-NE trending geological cross section from BH-39 to BH-29.

3. Geological structure in the Gramsh-Helmesi region

The recent geological findings obtained from the TAP boreholes at the southern base of Mt Ostrovica syncline prove that the big Ostrovica Mt syncline structure presents a nappe structure of Krasta Zone over the underlying flysch sequence considered of Middle Eocene age. That's why we reviewed the geological framework for Ostrovica Mt area separately from the stratigraphy for the flysch sequence that encounters beneath the Ostrovica Mt and its surroundings, and for the Kruja and Krasta zones in the region under study.

3.1 Stratigraphy of Ostrovica Mt. Syncline

The results of stratigraphic sections carried out across the structure of Mt Ostrovica are in the following paragraph reported.

The Qafa e Veshsit stratigraphic section was carried out by Gjata *et al*., (1982) at the eastern flank of Ostrovica syncline. Many stratigraphic levels from the Albian-Cenomanian level to Lower Eocene one are identified in it: i) the Albian-Cenomanian level, consisting of marl and limestone of red color, with *Ticinella (Heldbergella), Pithonella ovalis* etc., ii) the Turonian-Upper Senonian level, consisting of pelagic limestone, with *Globotruncana lapparenti, G. stuarti, G. contuse, Globigerinidae, Orbitoides sp., Leporbitoides sp.* etc., iii) the Maastrichtian level, consisting of limestone, marl and sandstone, with *Globotruncana conica, G. contusa, Orbitoides media, Leporbitoides* minor etc. , iv) the Paleocene level, composed

consisting of siltstone and sandstone alternating with a sandstone sequence, with *Globorotalia aff. angulata, G. sp. p., Globigerina triloculinoides, G. sp. p.* etc. , and v) the Lower Eocene level, consisting of siltstone and sandstone with rare limestone layers, with *Alveolina sp., Nummulites sp.p.. Globorotalia crassata, G. aff. aragonensis* etc.

The Faqekuqi stratigraphic section was carried out at the western flank of Mt. Ostrovica syncline. A rich pelagic microfauna is found in the rock samples 1550-1559, made of marl and pelagic limestone, as follows: *Globotruncana stuarti, G. Gansseri, G. stratiformis, Pithonella ovalis* etc. dating the Maastrichtian age. In the samples 1560-1580, composed by sandstone, marl and pelagic limestone alternations, are found *Morovozella pseudobullolides, M. angulata, M. velascoensis, Planorotalites compresa, Globorotolie angulata, G. sp*. dating the Paleocene age. In the rock sample 1610, consisting of sandstone, are determined Acarinina bullbrovski, A. sp. dating the Middle Eocene age. The above faunas identify the stratigraphic levels from the Upper Senonian (Maastrichtian) to Paleocene and Middle Eocene age (Sadushi 2014). Faqekuqi unit according to Lula et al. (1981) follows up to Ypresian (Lower Eocene).

The Mt. Ostrovica syncline nappe consisting of by the Upper Cretaceous pelagic limestones and Maastrichtian-Lower to Middle Eocene Flysch.

3.2 Stratigraphy of Flysch Sequence Underlying the Mt Ostrovica Syncline

The forthcoming paragraphs inform about the Turbehova stratigraphic section (Sadushi 2014) and the rock samples from the “Frasheri Flysch” that encounters near Greva and Moglica villages (Gjata *et al*., 1982) as well as from the upper part of “Frasheri Flysch”, in Moglica village (Xhomo *et al*., 2002).

The so-called “Frasheri Flysch”, consisting of claystone with sandstone and limestone layers passing upwards into the sandstone-conglomerate sequence, is developed to the east of the Turbehova-Koblara-Leskoviku fault that thrusts the Middle Oligocene flysch sequence of the Kulmaka anticline. The conglomerate-sandstone sequence of “Frasheri Flysch” constitutes the flysch upper part of Dajti subunit, located at the front of Krasta Zone.

Many boreholes were drilled at Moglica village for the Moglica Upper Headrace of Devolli Hydropower Plant, which show that the “Frasheri Flysch” sequence could be here met. Below is given the BH-MO-13 log of 155 m depth, into which the following lithological horizons some tens meters thick: i) claystone, siltstone and sandstone alternations, ii) conglomerate and claystone alternations, iii) conglomerate, iv) claystone, and v) strong conglomerate (Allkja 2000) could be distinguished. The BH-MO-13 log

lithological section shows the presence of the conglomerate-sandstone "Frasheri Flysch".

The Turbehova stratigraphic section has started from the Turbehova village and passed towards E-NE, at western side of Mt. Ostrovica syncline. It consists of some different lithological intervals as follows: Sandstones in samples 1 to 20, limestones in samples 21 to 27/3 and sandstone, marl and limestone intercalations in samples 27/4 to 209/1 (Sadushi 2014).

The Turbehova section rock samples investigated by (Sadushi 2014) show that Paleocene-Eocene, Middle-Upper Eocene and Lower Oligocene age levels. So, in the samples 8, consisting of sandstone, are examined *Nummulites sp., Discocyclina sp., Miliolidae* that dates the Paleocene-Eocene age. In the sample 23/1, consisting of marl limestone, are found *Globigerina linaperta*, G. sp., *Morovozella crassata*, *Turborotalia gr. cerroazulensis, Globigerapsis sp.* etc. dating the Middle-Upper Eocene age. In the samples 28/1 and 28/2, consisting of marl, are found *Pseudohastigerina micra, Globigerina linaperta, G. kugleri, G. sp., Acarinina bullbrovcki, Morovozella crassita* etc. dating the Lower Oligocene age. In the samples 163/1, 183/2, 191/2, 197/4 and 197/5, consisting of sandstone, are determined *Globigerina linaperta, G. sp., Morovozella crasssata, nummulites sp., Discocyclina sp., Alveolina sp.* etc. dating the Lower Oligocene age. In the sample 203, consisting of limestone, are determined *Globigerina linaperta, G. kugleri, G. sp., Acarinina bullbrocki, Discocyclina sp.* etc. dating also the Lower Oligocene age.

The "Frasheri Flysch" outcropped near Greva and Moglica villages consist of the siltstone-claystone sequence with rare sandstone, limestone or clayey marl intercalations which pass upward into the conglomerate sequence (Gajta *et al*., 1982). From the claystone-siltstone sequence underlying the conglomerate one many planktonic foraminifera such as *Globigerina linaperta, G. ampliapertura, G. venezuelana, Globorotalia sp*. etc., which determine the Lower Oligocene age are found.

From the upper part of "Frasheri Flysch" at Moglica village consisting of clayey-marly sequence following planktonic and bentosic complex: *Globigerina ampliapertura, G. linaperta, G. officialis, G. aff. tripartita, G. venezuelana, Pseudohastigerina micra, Globorotalia spp., Bulimina ovata, B. inflata, B. alazanensis, Uvigerina sp., Lenticulina sp. Nummulites spp., N. fabianii, Discocyclina sp., D. archiaci, D. marthae* etc. are found. They are typical of the Upper Eocene and passing to Lower Oligocene age (Xhomo *et al*., 2002, page 174), although *Pseudohastigerina micra* and *Globigerina linaperta-Globigerina ampliapertura* zones date the Lower Oligocene age.

The age determination for the flysch sequence underlying the Ostrovica Mt syncline nappe, considered up to nowadays of Middle Eocene age, here it is based on the findings of the planktonic foraminifera. The Lower Oligocene

age of flysch deposits in Kruja and Ionian tectono-stratigraphic zones are now determined by the following planktonic foraminifera zones: *Pseudohastigerina micra* and *Globigerina linaperta-Globigerina ampliapertura* zones (Xhomo *et al*., 2002).

The "Frasheri Flysch" located beneath and around the Mt Ostrovica nappe, based on findings of above shown planktonic foraminifera dating of Lower Oligocene age, and it belongs to the Dajti subunit of the Kruja Zone (Figure 1 and 2).

The "Frasheri Flysch" encounters from the Devolli ophiolite massif to southern Albanian border, along a narrow belt, before the front of the Mirdita ophiolite nappe, as for instance in Greva and Moglica villages, in Frasheri area, in Mt Qelqes and Radovicka village, in Mt Rodomi and Mesiçka village, in Mt Piskali and Lashova village (Aliaj 1991).

3.3 Structure of Krasta and Kruja Units

The Kruja and Krasta tectono-stratigraphic units build the main part of the Gramsh-Helmesi region under study. The Devolli, Vallamara and Voskopoja ultrabasic massifs of Mirdita ophiolite Zone take place there too (Figure 1).

Krasta Zone to the south of Elbasan-Diber transverse starts with Liseci Mt, follows with Griba Mt ending to Lenie Mt anticlinal structures N-NW striking. To the south encounters only the Ostrovica Mt synclinal structure overlying the Middle Eocene flysch that follows southwards (Shehu *et al*., 1990; Xhomo *et al*., 2005).

The stratigraphic section of Krasta Unit starts with the so-called earlier Flysch of Albian-Cenomanian which continues up to Turonian (Melo and Kanani 1978). The next deposits are the Upper Cretaceous pelagic limestones and the flysch of Maastrichtian to Lutetian in age (Lula *et al*., 1981; Meço and Aliaj 2000; Melo 2002).

The Mt. Ostrovica nappe is composed by the Upper Cretaceous pelagic limestone and Maestrichtian-Eocene Flysch, which built a west verging syncline nappe, overlying the Oligocene Flysch of Kruja zone. It extends for 20 km from north of Qafa e Martes in the south to the Dushar and Vrepcke in the north (Fig. 1). An asymetrical syncline with flysch deposits in the center continues as a whole from the Mt. Ostrovica up to the Mt. Çuka e Bofnjes with a maximum width of 9 km and further northwards are seen only its fragments, built mainly by limestone. Some transverse normal faults E to NE striking cut its structure subsiding northwards the nappe structure of Mt. Ostrovica. The Ostrovica nappe is squeezed from below the Voskopoja ophiolite nappe (Aliaj 1994).

The geological-tectonic structure of the Ostrovica Mt area and its southwards is drawn into Krasta subzone (=Krasta Zone) by Xhomo and Kodra (2002) and Xhomo *et al*., (2005) (Figure 6), i.e. the Ostrovica Mt

syncline structure does not have any nappe setting over the underlying Middle Eocene flysch. Some west verging anticlinal structures of Krasta subzone are imaged there in depth (IX Geological Cross-section of Geological Map of Albania, 2005).

Xhomo *et al*., (2005) took into consideration the interpretation of Gjata *et al*., (1982) who have presented the Mt. Ostrovica carbonate structure as a horst-syncline which delimits in both flanks by high dipping angle reverse faults that conditioned its uplifting position in comparison with its west and east deep Krasta structures covered by the Upper Eocene flysch.

It is important to note that in all the geological maps of Albania at the scale 1:200.000 (Zuber 1943; Biçoku *et al*., 1967, Shehu *et al*., 1983 and Xhomo *et al*., 2005), the geological building of the Krasta unit to the south of Devolli ultramafic massif has the same image with that shown on the last Geological Map of Albania (2005) and into its explanatory text (Fig. 6).

The Kruja Zone in the south of Elbasan-Diber transverse consists of two subzones with typical stratigraphic and structural features: a) the Tomorri subzone including the Tomorri, Kulmaka and Qeshibeshi brachyanticlines, and built by the Lower Cretaceous (Late Albian) to Eocene carbonate rocks of the external platform and Lower-Middle Oligocene flysch, and b) Dajti subzone including the Valesh and Tervolli crest anticlines, and built by Cretaceous to Eocene internal platform limestones and Lower Oligocene flysch. The Dajti subzone crops out from Renci and Kakariqi anticlines in the north and it follows with Dajti anticline up to the Valeshi and Tervolli one in the south (Sadushi *et al*., 2015).

To the northwest of Devolli ultrabasic massif and to the east of Gramshi town is located the Tervolli crest anticline with the overturned western flank and soft dipping eastern one; it belongs to the Dajti subunit of Kruja Zone. Tervolli anticline is built by the Upper Cretaceous-Middle Eocene platform limestones and Lower Oligocene flysch deposits (Sadushi *et al*., 2015). The socalled “Frasheri Flysch” outcropping below and in surroundings of the Mt Ostrovica nappe presents the southward continuation of Tervolli anticlinal line (Fig. 1).

The Tomorr-Kulmaka and Tervolli west verging anticlinal lines are delimited by regional thrusts on their western overturned flanks (Figure 1 and 2).

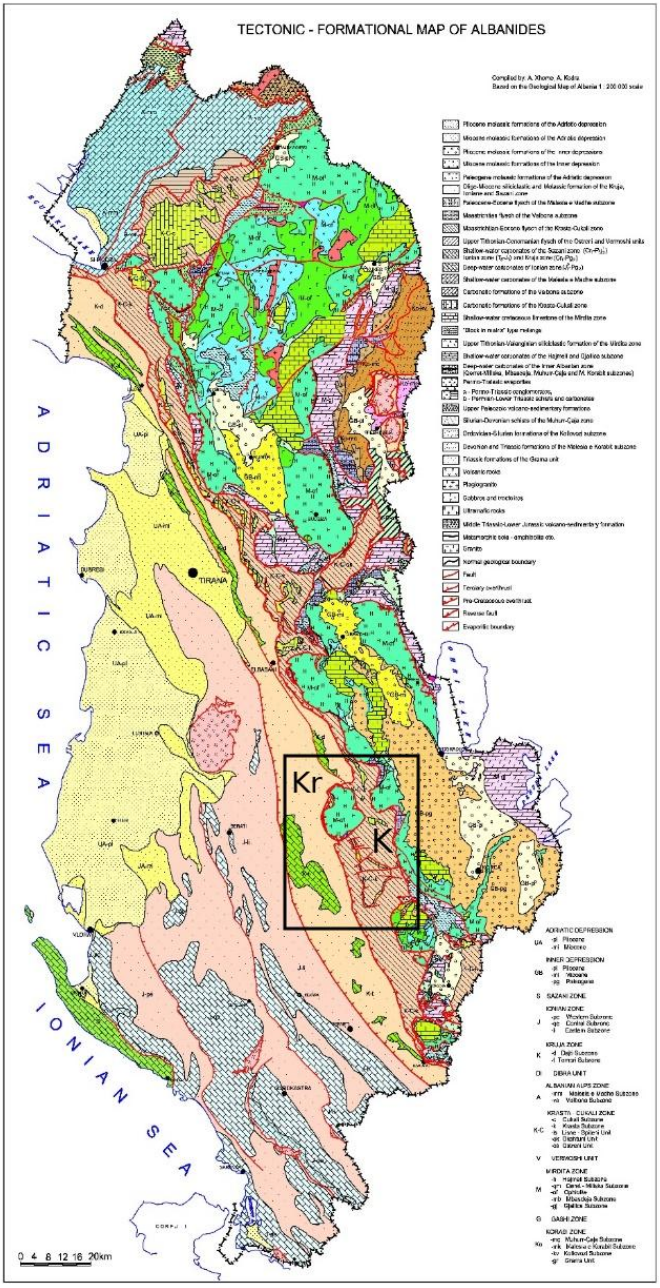

Fig. 6: Tectono-Formational Map of the Albanides with some details for the Mirdita Zone at the scale 1:200.000 (Xhomo and Kodra, 2002). Black rectangle indicates the area presented in Figure 1, with Kr for Kruja and K for Krasta tectonic zones.

The above inferred stratigraphic and tectonic data show that the flysch deposits underlying the big Mt. Ostrovica syncline structure are of the Lower Oligocene age and belong to Dajti subunit of the Kruja Zone.

The “Frasheri Flysch”, which could be met from the Devolli ophiolite massif up to southern Albanian border, along a narrow belt, before the front of the Mirdita ophiolite nappe, belongs to the Dajti subunit of Kruja Zone (Figure 7).

The Krasta Zone to the south of Elbasani town outcrops in the Lleshani and Ostrovica nappes, and along a narrow belt before the ophiolite nappe from Mt Liseci-Mt Griba to Mt. Lenie, and only in Mt Gramos half-window it reappeared. The Mirdita ophiolite nappe covers the whole Krasta zone and partly the Kruja one to the south of Ostrovica nappe.

Based on the inferred data for the extent of Kruja and Krasta tectono-stratigraphic units in Southern Albania some corrections are drawn in Tectonic Map of Albania (Fig. 7).

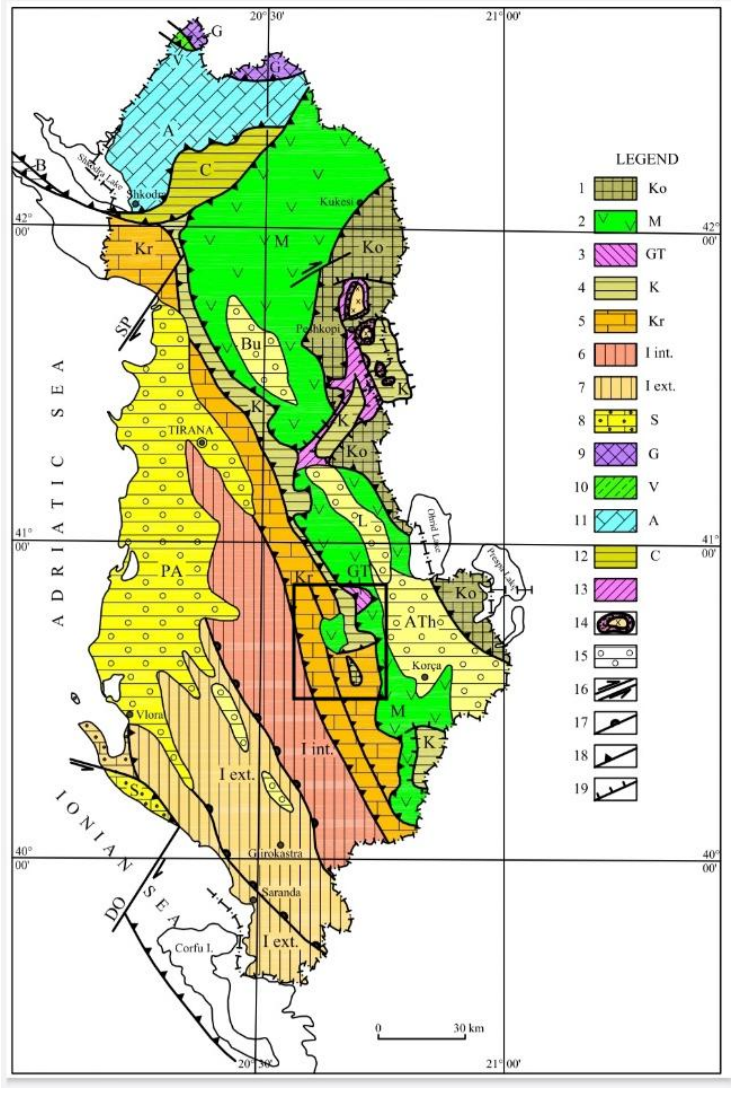

Fig. 7: Tectonic Map of Albania (from Aliaj and Bushati 2019) with corrected extent for the Kruja and Krasta zones to the south of Devolli ultramafic massif. Black rectangle indicates the area presented in Figure 1. Tectonostratigraphic units: 1- Korabi, 2- Mirdita, 3- Guri i Topit, 4- Krasta, 5- Kruja, 6- Internal Ionian, 7- External Ionian, 8- Sazani, 9- Gashi, 10- Vermoshi, 12- Cukali. 13- Upper Jurassic-Lower Cretaceous marly flysch underlying Korabi nappes, 14- Kruja zone evaporite dome surrounded by the Upper Eocene-Lower Oligocene flysch. 15- Molassic basins: ATh- Albanian-Thessalian, L- Librazhdi, Bu- Burreli and PA-Periadriatic basins. 16- Dextrat and sinistral strike slip faults, 17- Reverse fault, 18- Thrust, 19- Normal fault. SP- Shkoder-Peja Transform Fault, DO- Dhermi - Othoni Island dextral strike slip fault.

4. CONCLUSIONS

Based on the above inferred data for the Tomorr-Ostrovica Mts area, the following conclusions could be drawn:

i) the recent geological findings obtained from the TAP boreholes at southern base of Mt Ostrovica syncline prove that the big Ostrovica Mt syncline structure presents a nappe structure of Krasta Zone over the underlying flysch sequence considered of Middle Eocene age. That's why the geological framework for Ostrovica Mt area, separately the stratigraphic data for the flysch sequence that encounters beneath the Ostrovica Mt and its surroundings, and for the Kruja and Krasta zones in the region under study are reviewed,

ii) the *Pseuhastigerina micra and Globigerina linaperta-Globigerina ampliapertura* planktonic zones, found in "Frasheri Flysch" rock samples near to Greva and Moglica villages and in Turbehova stratigraphic section, determine their Lower Oligocene age. The Lower Oligocene flysch sequence beneath the Mt Ostrovica nappe and on its surroundings is the direct southeast continuation of Tervolli anticline that belongs to the Dajti subunit of Kruja Zone,

iii) the so-called "Frasheri Flysch", consisting of claystone with sandstone and limestone layers passing upwards into the sandstone-conglomerate sequence, is developed to the east of the Turbehova-Koblara-Leskoviku fault that thrusts the Middle Oligocene flysch sequence of the Kulmaka anticline. It encounters from the south of Devolli ophiolite massif to southern Albanian border, along a narrow belt before the front of the ophiolite nappe, and belongs to the Dajti subunit of Kruja Zone,

iv) the regional Mt. Ostrovica syncline nappe is 20 km long, extending from north of Qafa e Martes in the south to the Dushar and Verpcke in the north. In addition, it consists of the Cretaceous pelagic limestone and Maestrichtian-Middle Eocene flysch. It is a west verging syncline nappe, overlying the Lower Oligocene flysch of Kruja Zone. The main small syncline nappe of Cretaceous limestone discovered by the TAP Route boreholes at the southern base of Mt Ostrovica presents the lowest centroclinal part of regional Ostrovica syncline nappe from which it was separated through a normal fault. The regional syncline structure of Mt Ostrovica and the main small one discovered by boreholes show the same nappe emplacement of Cretaceous limestone over the flysch sequence of the Dajti subzone, Kruja unit,

v) the Krasta Zone to the south of Elbasani outcrops in the Lleshani and Ostrovica nappes, and along a narrow belt before the ophiolite nappe from Mt Liseci-Mt Griba to Mt. Lenie, and only in Mt Gramos half-window it

reappeared. The Mirdita ophiolite nappe covers the whole Krasta Zone and partly the Kruja one to the south of Ostrovica nappe, and

vi) the Ostrovica Mt structure and the underlying it Middle Eocene flysch sequence is drawn into the Krasta subunit (=Krasta Zone) by Xhomo *et al*., (2005), i.e. the Ostrovica Mt syncline hasn't been a nappe structure. In all geological maps of Albania at the scale 1:200.000 (Zuber 1943; Biçoku *et al*., 1967; Shehu *et al*., 1983; Xhomo *et. al*., 2005), the geological framework of the Krasta unit to the south of Devolli ultramafic massif up to southern Albanian border has the same image with that shown in the last Geological Map of Albania (Xhomo *et. al*., 2005).

We would recommend further field geological mapping works at the scale 1: 50.000 for the area to the south of Devolli ultramafic massif up to southern Albanian border.

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FIGURE CAPTIONS

Fig. 1: Location map of Trans Adriatic Pipeline boreholes at southern base of Mt Ostrovica.

Fig. 2: W-E trending geological cross section from BH-14 to BH-40.

Q_4^{del}- Rock debris with a little silty clay or silty-clayey gravels, Pg_3^1- Lower Oligocene Flysch sequence composed by sandstone, siltstone and mudstone with limestone layers.

Fig. 3: SW-NE trending geological cross section from BH-39 to BH-29.

Fig. 4: Harta Tektono-Formacionale e Albanideve me disa detajime për zonën e Mirditës (from Xhomo A, and Kodra A. 2002).

Fig. 5: Geological map of Tomorr - Ostrovica Mts area.

Kruja Zone: Cr_2.Pg_2- Carbonate platform formation of Kruja zone, Pg_3^1- Lower Oligocene flysch sequence of Tervolli anticline, Pg_3^{1-2}- Lower-Middle Oligocene flysch sequence of Tomorri and Kulmaka anticlines. *Krasta Zone:* Cr – Cretaceous pelagic limestones, Cr_2^m-Pg_2- Maestrichtian-Middle Eocene flysch sequence. Mirdita ophiolite Zone: Devolli, Vallamare and Voskopoja ultrabasic massifs. A-A line of geological cross section shown in Figure 6.

Fig. 6: The W-E trending geological cross section Kulmaka Pass - Çuka e Bofnjes Mt. according to A-A line shown on Figure 5.

Fig. 7: Tectonic map of Albania (from Aliaj and Bushati 2019) with corrected extent of Kruja and Krasta zones to the south of Devolli ultramafic massif. Tectonostratigraphic units: 1- Korabi, 2- Mirdita, 3- Guri i Topit, 4- Krasta, 5- Kruja, 6- Internal Ionian, 7- External Ionian, 8- Sazani, 9- Gashi, 10- Vermoshi, 12- Cukali. 13- Upper Jurassic-Lower Cretaceous marly flysch underlying Korabi nappes, 14- Kruja zone evaporite dome surrounded by the Upper Eocene-Lower Oligocene flysch. 15- Molassic basins: ATh- Albanian-Thessalian, L- Librazhdi, Bu- Burreli and PA- Periadriatic basins. 16- Dextral and sinistral strike slip faults, 17- Reverse fault, 18- Thrust, 19- Normal fault. SP- Shkoder-Peja Transform Fault, DO- Dhermi - Othoni Island dextral strike slip fault.